

Eutrofiering – 4 nøkkelementer

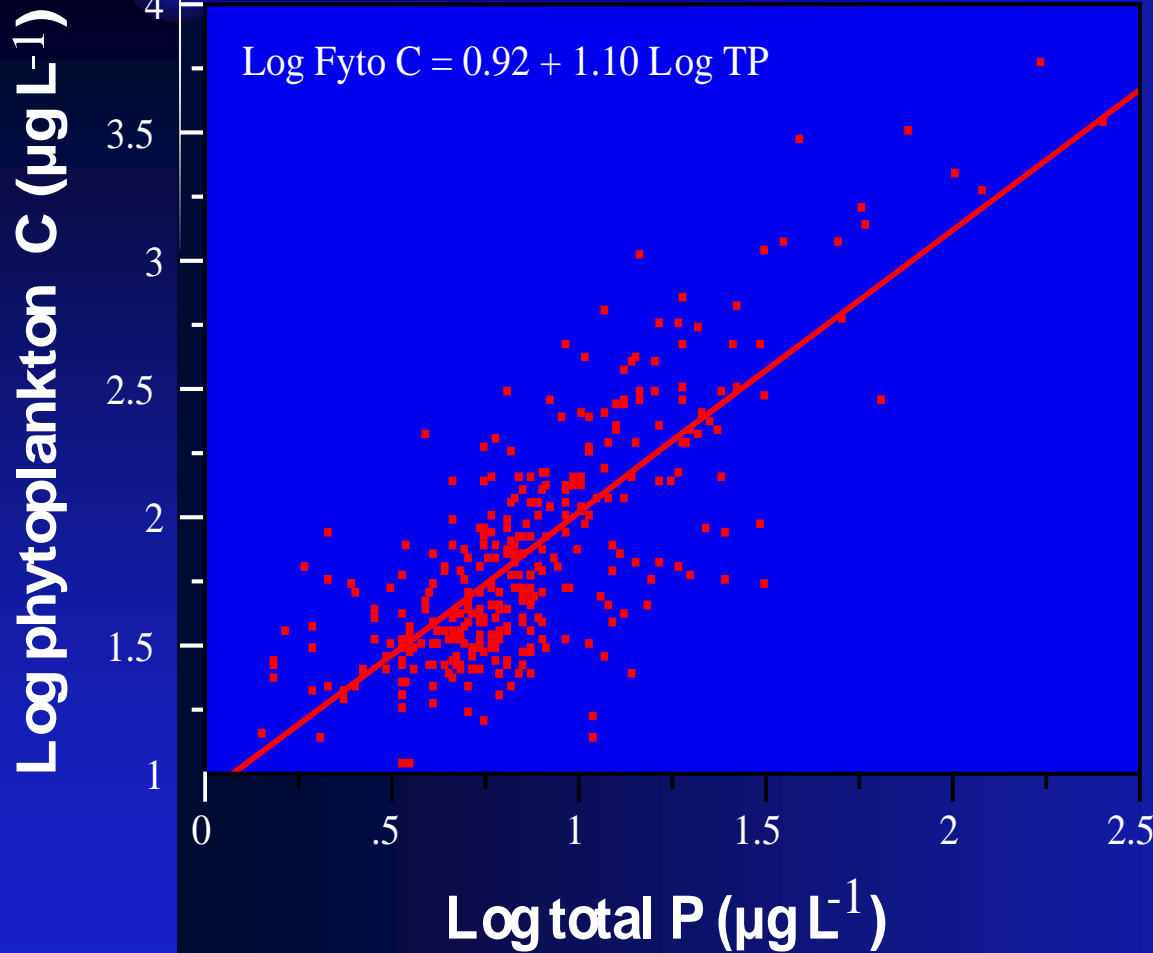


Elements needed for growth

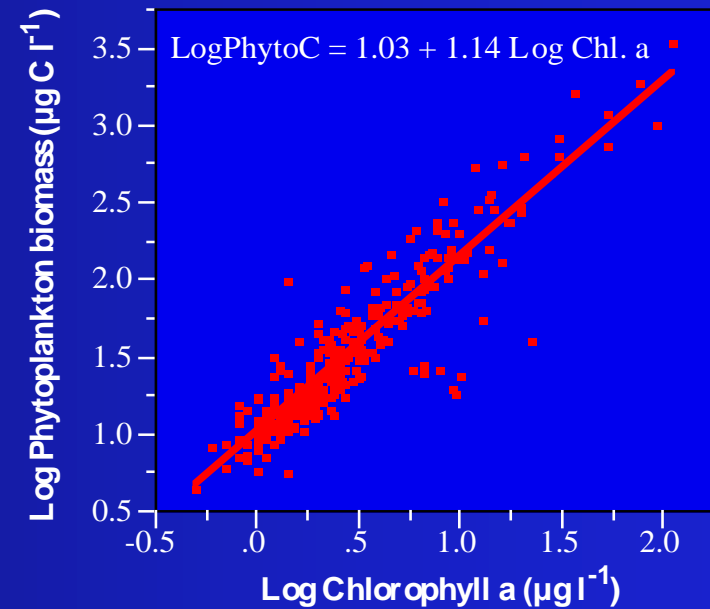
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

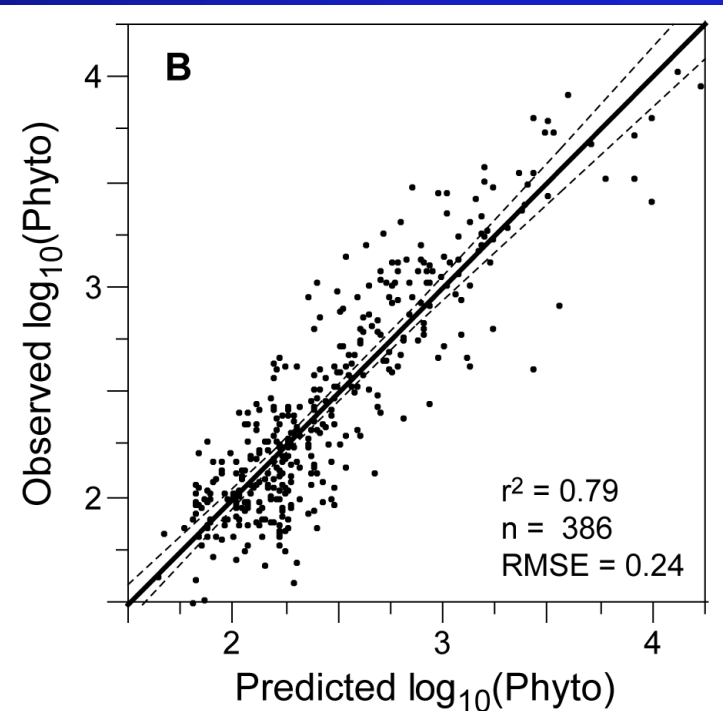
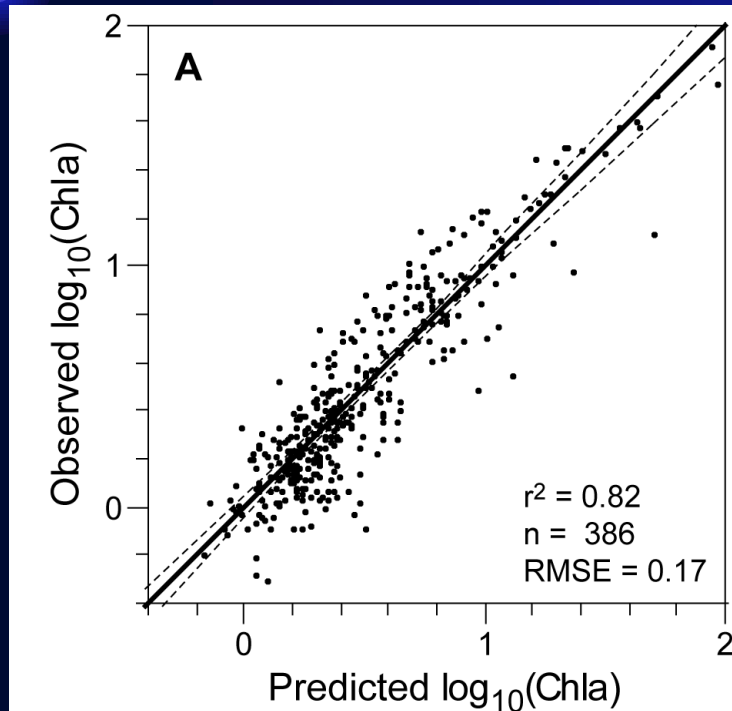
P og alger



Strong correlations at
the base of the food web ...



Mest P, men et lite bidrag fra N

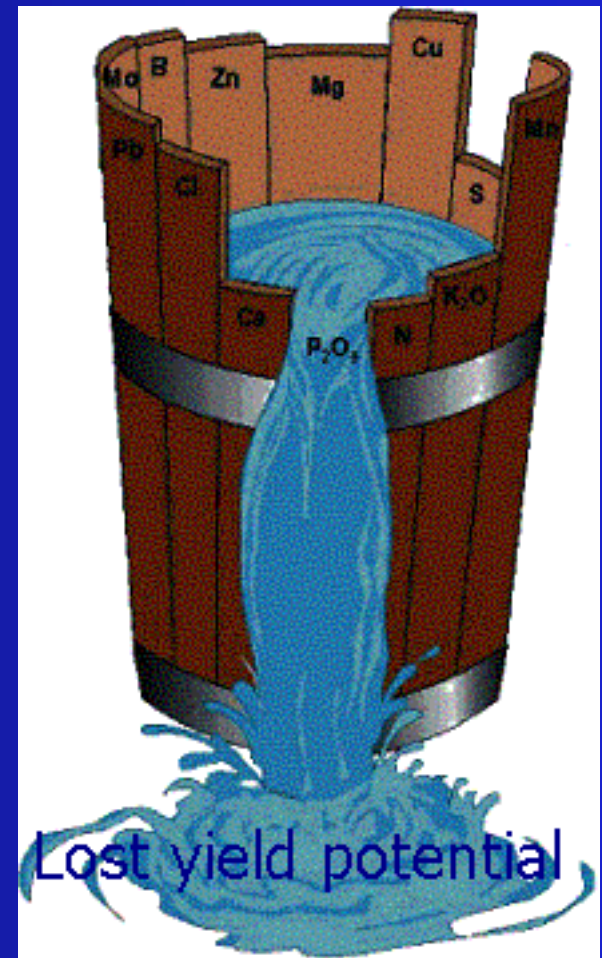


	Scaled estimates	t Ratio	Prob > t
Intercept		44.70	<0.0001
$\log_{10}(\text{alt})$		-2.72	0.0068
$\log_{10}(\text{Ca})$		3.06	0.0023
$\log_{10}(\text{TP})$		21.99	<0.0001
$\log_{10}(\text{TN})$		3.97	<0.0001
$\log_{10}(\text{TP}) * \log_{10}(\text{TN})$		4.45	<0.0001

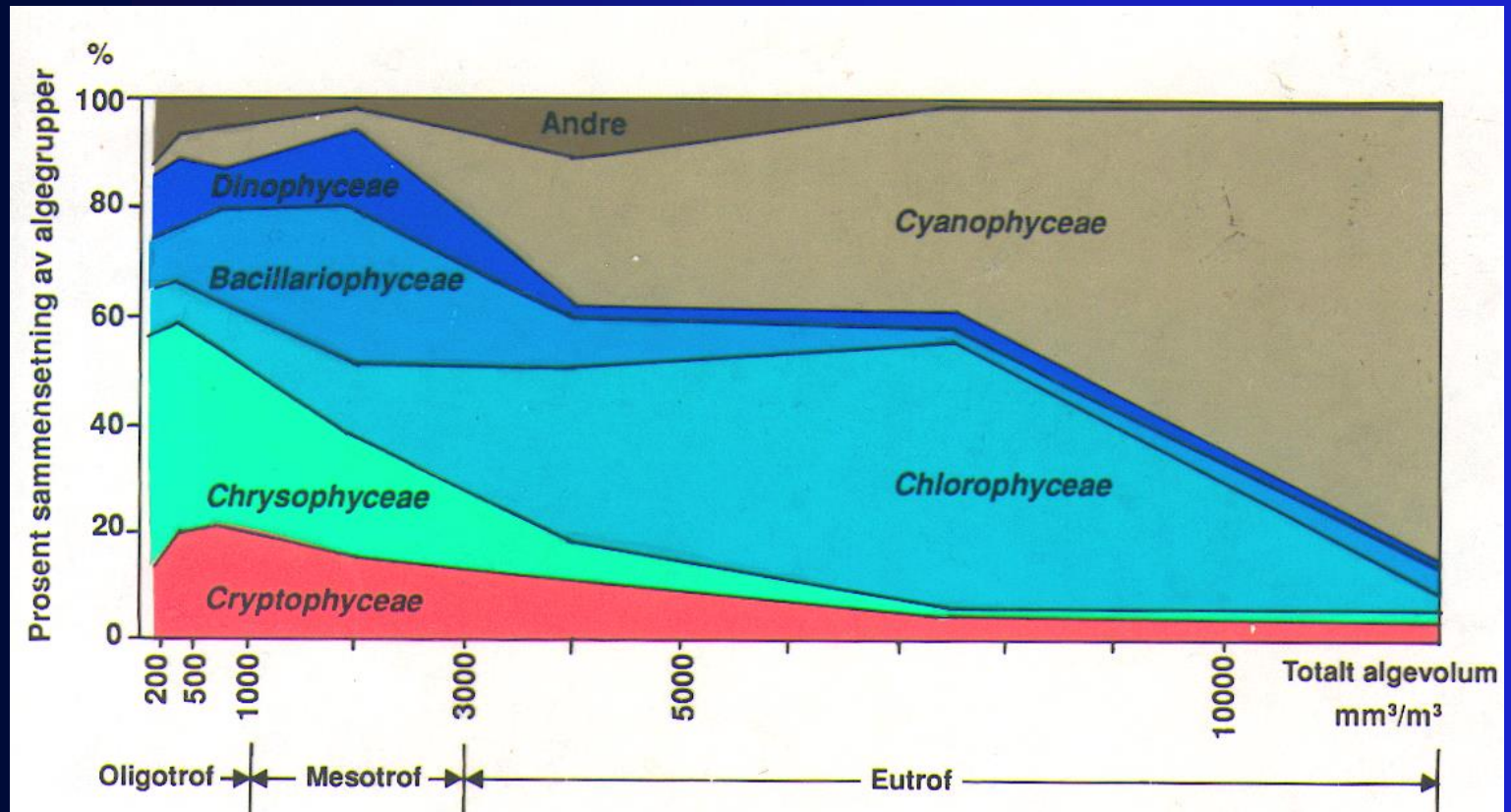
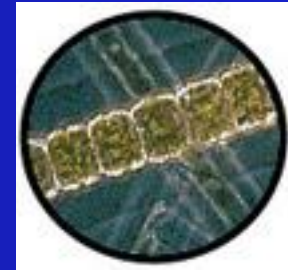
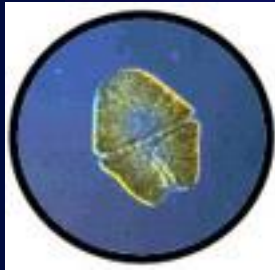
	Scaled estimates	t Ratio	Prob > t
Intercept		165.17	0.0001
$\log_{10}(\text{alt})$		-4.61	<0.0001
$\log_{10}(\text{Ca})$		8.27	<0.0001
$\log_{10}(\text{TP})$		17.95	<0.0001
$\log_{10}(\text{TN})$		2.23	0.0263
$\log_{10}(\text{TP}) * \log_{10}(\text{TN})$		2.76	0.0060

Liebig's minimums prinsipp

- One principally limiting element
- Often close to co-limitation
- Macro-nutrients vs. micro-nutrients
- Productivity vs standing stock: different elemental demands



Endringer i phytoplankton samfunn, morfologi, beitbarhet og kvalitet

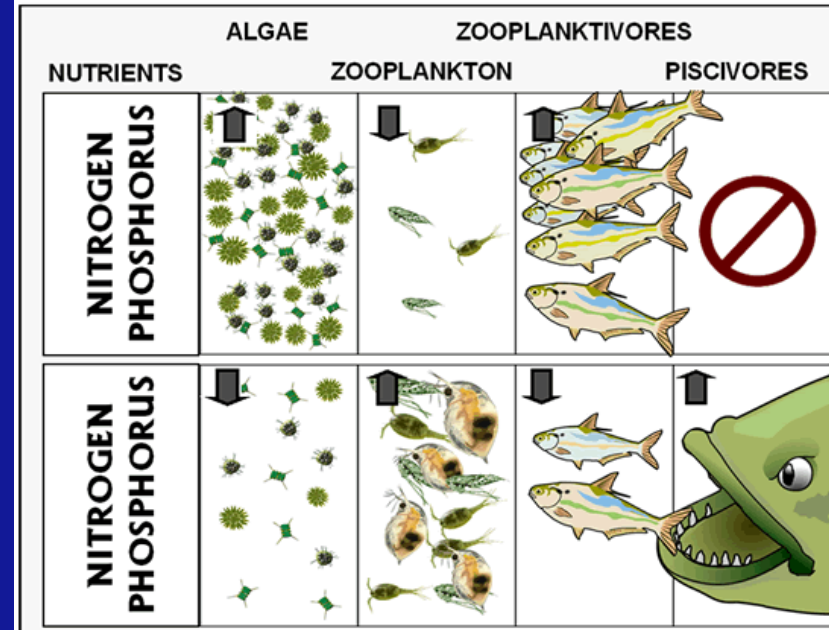


Samfunnsendringer og trofiske kaskader

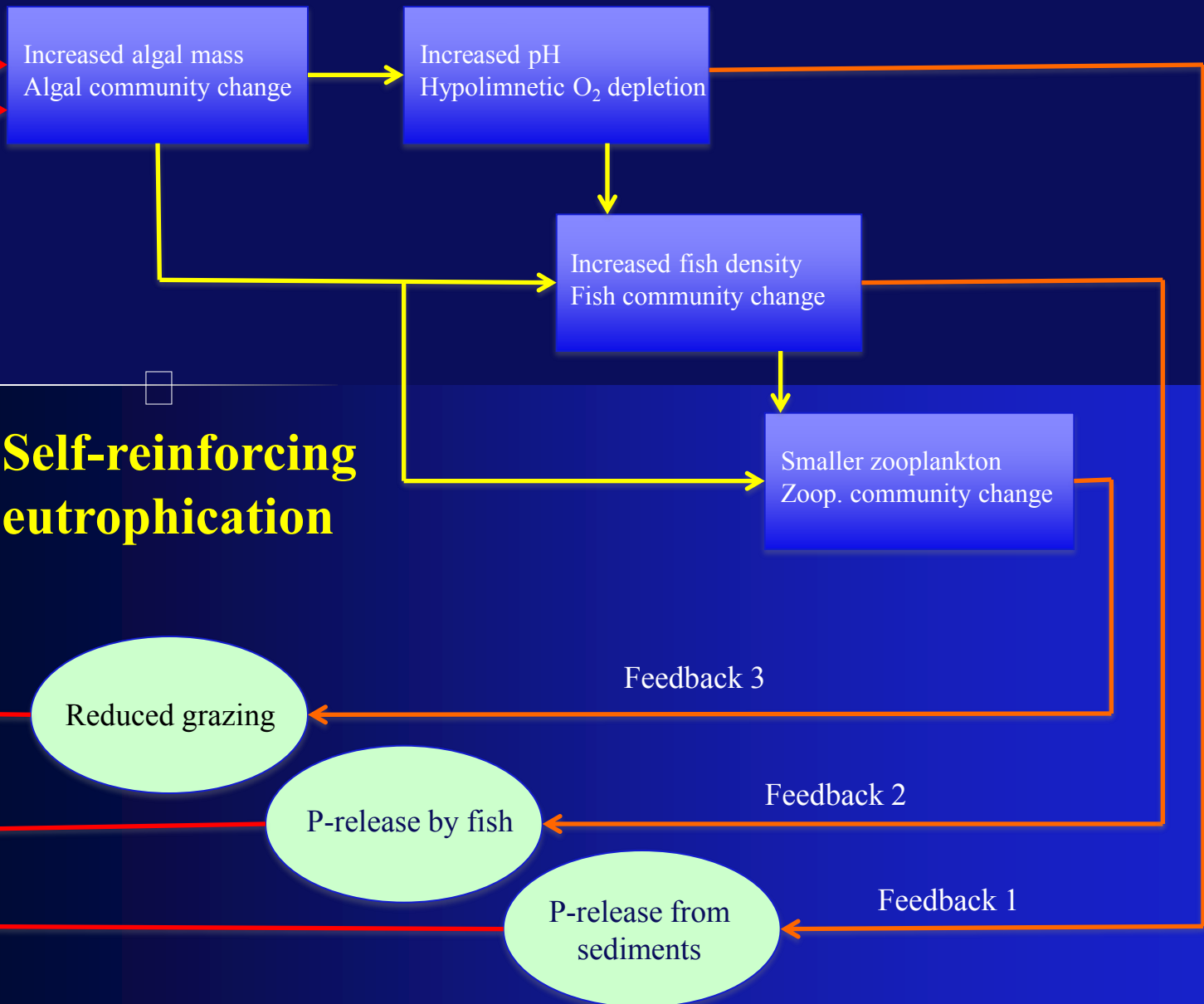
- Typical shifts from large-bodied to small-bodied species
- Change from large cladocerans (*Daphnia*) to small copepods
- Reduced grazing pressure
- Shift from salmonids to cyprinids
- Importance of top predators and the trophic cascade



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Increased
nutrient load



Self-reinforcing eutrophication

Reduced grazing

P-release by fish

P-release from sediments

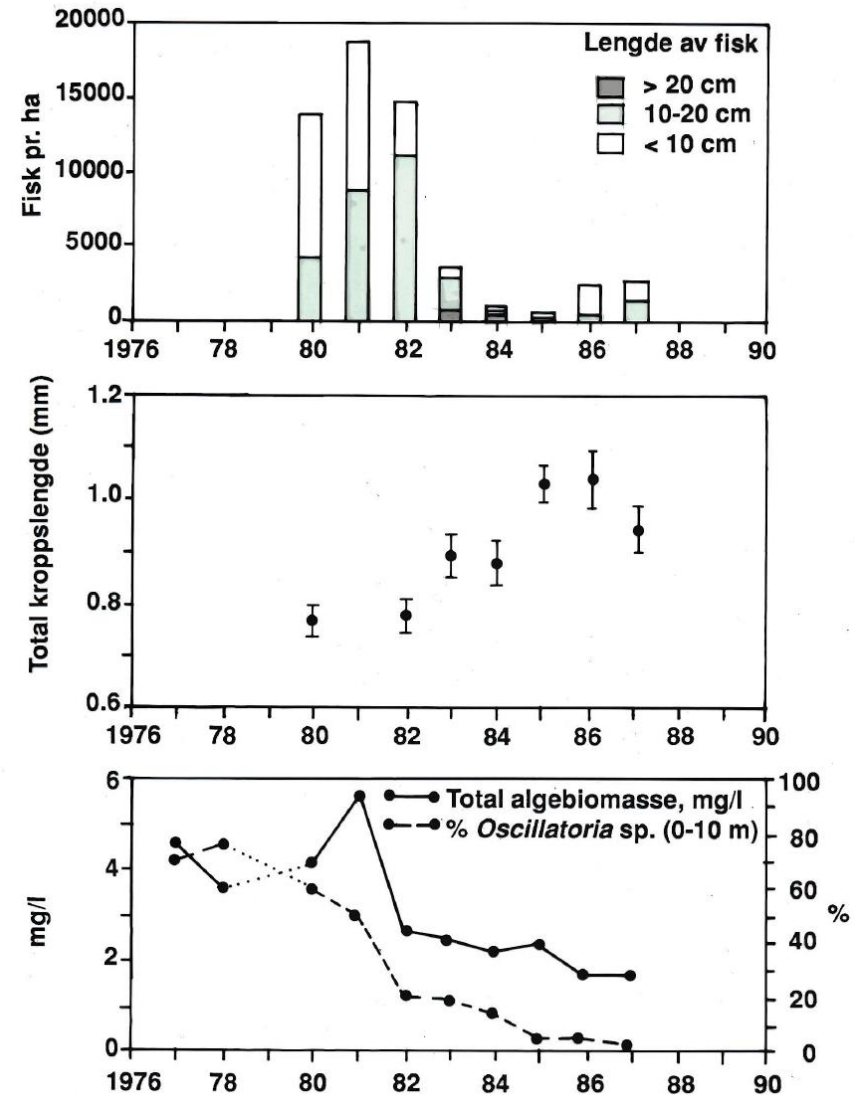
Feedback 3

Feedback 2

Feedback 1

Tilfellet Gjersjøen ...

- Originally a oligotrophic lake
- Became eutrophic from the -60ies due to increased P-loads
- Sewage plants were built but agricultural runoff continued
- Changes in fish and zooplankton communities, massive cyanobacterial blooms - poor water quality.
- Internal fertilization
- Pike-perch was added in 1980
- Roach vanished, conditions improved – a top-down story?



Hvorfor fungerte kaskaden i Gjersjøen?

- Fosfor (og N) var allerede kraftig redusert
- Mort spilte en avgjørende rolle for å opprettholde den interne P-gjødsling
- Rask og vedvarende effekt av utsetting av gjørs (1981)
- Umiddelbar skremseffekt som fikk cyprinider til å skifte habitat (til littoral)
- Langvarig effekt ved økt bestand av gjørs
- **Gjørsen kom på rett sted til rett tid!**

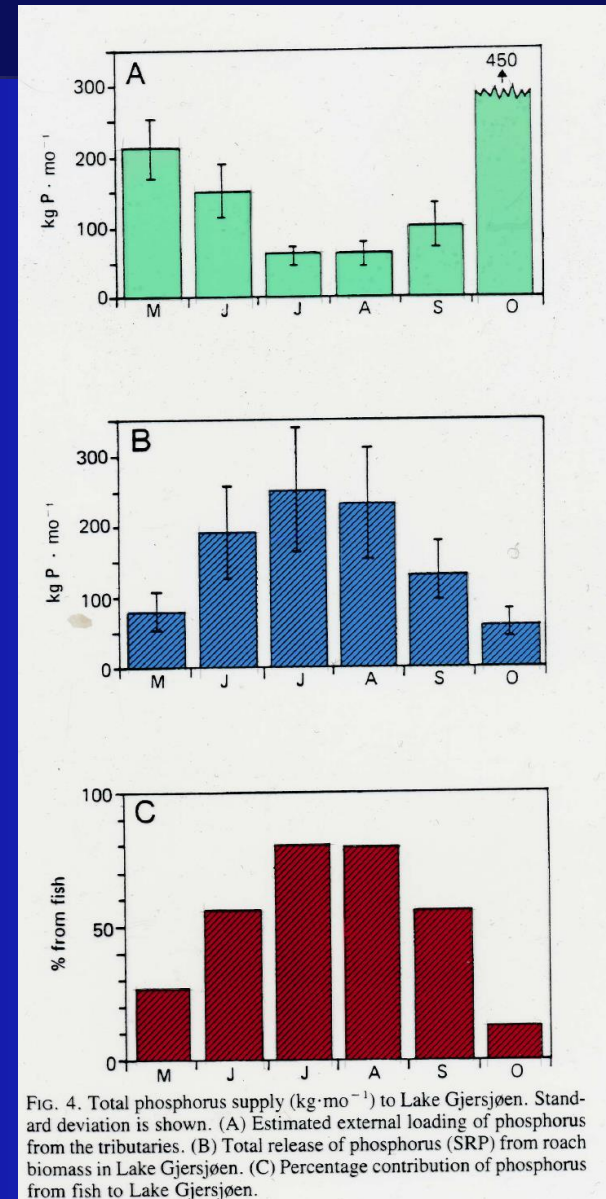


FIG. 4. Total phosphorus supply ($\text{kg} \cdot \text{mo}^{-1}$) to Lake Gjersjøen. Standard deviation is shown. (A) Estimated external loading of phosphorus from the tributaries. (B) Total release of phosphorus (SRP) from roach biomass in Lake Gjersjøen. (C) Percentage contribution of phosphorus from fish to Lake Gjersjøen.