Om vattenkraft och näringsretention

Christoph Humborg

1) Background
2) Undisturbed river systems
3) Regulated river systems
4) Effects in the Sea

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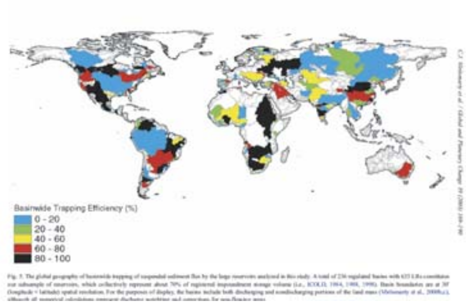
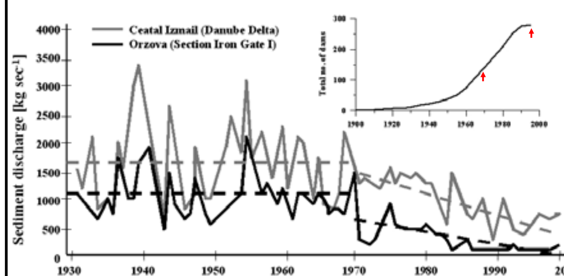
Global Implications

Basinwide Sediment Trapping Efficiency Due to Large Reservoirs

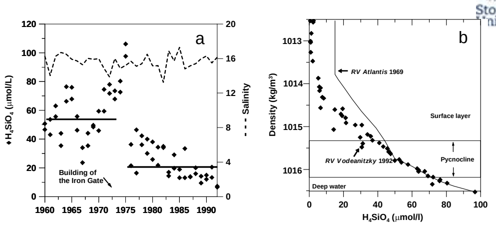


Damming of the lower Danube (1970-1972)



(Raducu, 2003)

Black Sea DSi concentration



- coastal:
decrease to 1/3
~140 to 60 µM in the Danube

inner basin:
DSi depletion

Humborg et al. Nature 1997,

Regime shift in NW Black Sea Phytoplankton

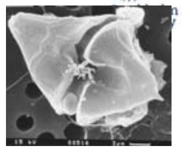
	1960-1970		1980-1990	
	cell densities (10^6 cells l^{-1})	number of blooms	cell densities (10^6 cells l^{-1})	number of blooms
Diatoms	7-21	8	5-300	19
Dino-flagellates	17-51	4	5-810	14
Prymnesio-phytes	-	-	220-1000	3
Eugleno-phytes	-	-	5-108	6
Total blooms		12		42

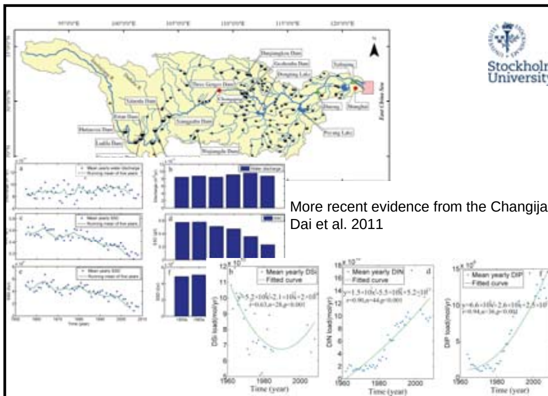
Humborg et al. Nature 1997

siliceous

non-

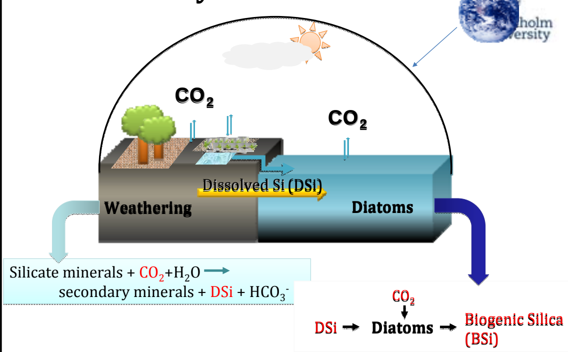
siliceous



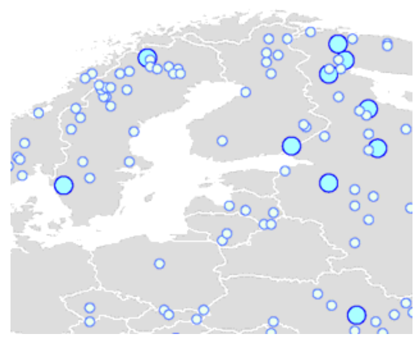


More recent evidence from the Changjiang
Dai et al. 2011

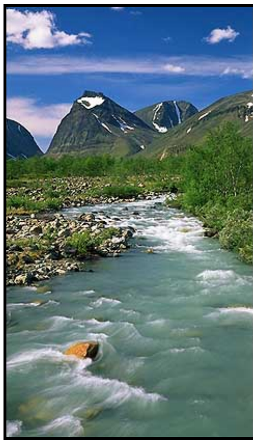
The Si vs. C cycle



Major dams Baltic Sea Catchment



Effect of hydrological
alterations in
a) oligothrophic
b) eutrophic rivers
with varying degree
of damming



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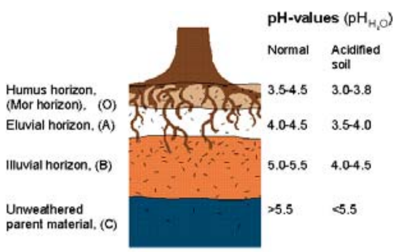
Weathering and organic matter



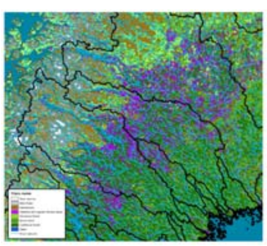
Source: Swedish Environmental Protection Agency report 4421

Weathering and organic matter

$4Na_{0.5}Ca_{0.5}Al_{1.5}\mathbf{Si}_{2.5}O_8 + \mathbf{6H_2CO_3} + 11H_2O \rightarrow$

$3Al_2Si_2O_5(OH)_4 + 2Na^+ + 2Ca^{2+} + \mathbf{6HCO_3^- + 4H_4SiO_4}$

Primary mineral plus carbon acid (from soil CO_2) → Secondary mineral plus DSi plus alkalinity



Smedberg et al. HESS 2009

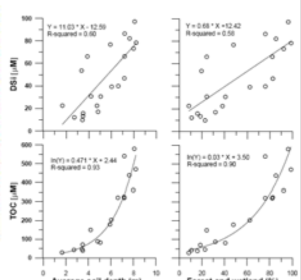
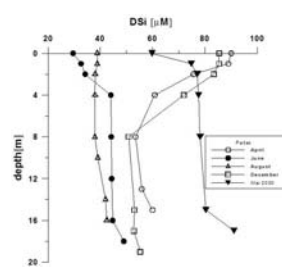
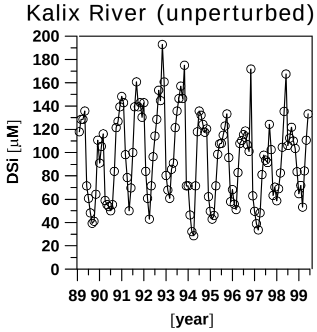


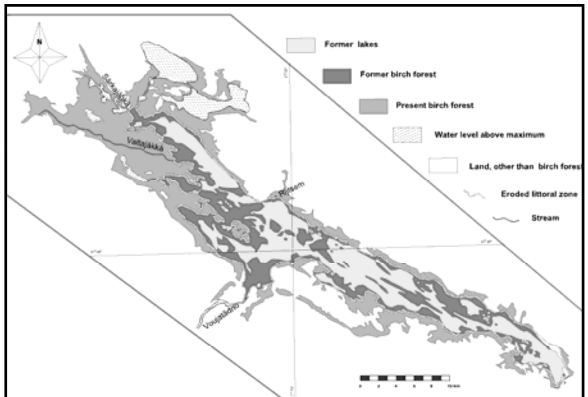
Fig. 4. In stream TOC and DSi discharge-weighted mean concentrations plotted against vegetated area percentages and soil depths, respectively. Vegetated area includes forest (deciduous, mixed and coniferous), wetland and herbaceous.

DSi Concentrations in Lake Paittas (pristine)



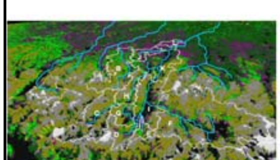
DSi (dissolved silicate) Concentrations in Kalix River (unperturbed)

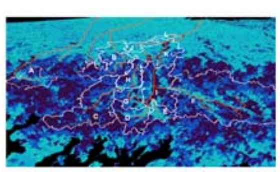




Catchment	Area in ha lost due to regulation	Deciduous forest area lost due to regulation (ha)	Mixed forest area lost due to regulation (ha)	Coniferous forest area lost due to regulation (ha)	Wetland area lost due to regulation (ha)	Herbaceous area lost due to regulation (ha)	Hydrological status
Sitas	2816	0	0	0	0	2816	Dammed
Akka	12 700	10 000	0	0	2700	0	Dammed
Teusajaure	64 960	3640	4511	6453	2130	23 492	Bypassed
Stora Lulevatten	12 700	10 000	0	0	2700	0	Dammed
Total Porjus	93 176	23 640	4511	6453	7530	26 308	Dammed

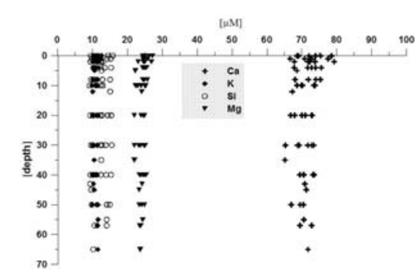
Only 3% of the headwater areas have been inundated by reservoirs,
some 10% of the soils and
some 37% of the deciduous forests along riparian zones have been lost.

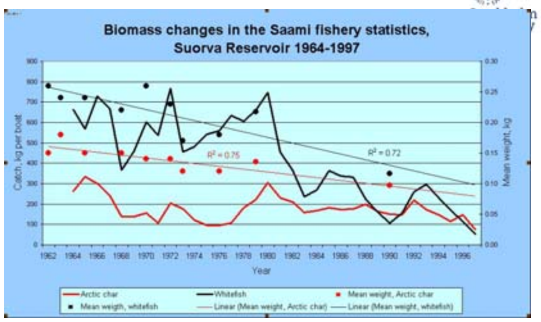




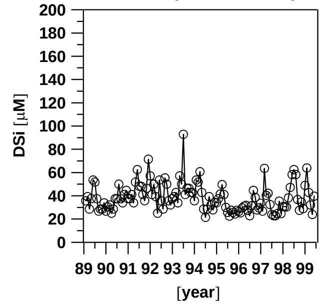
Smedberg et al. HESS 2009

Major Element concentration in Lake Akka (reservoir)





DSi Concentrations in Lule River (dammed)

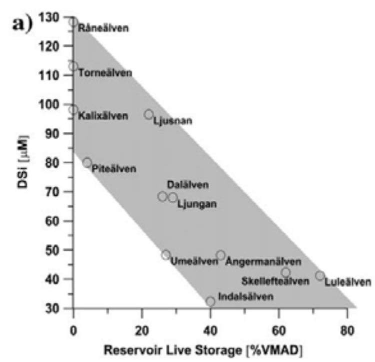


River Kalixälven	TOC	Ca	K	Mg	Na	DSi	PO4
Headwaters	100	24,5	2,1	9,9	9,2	23,4	0.01
Unregulated							
River mouth	400	123,4	18,2	49,7	91,9	96,5	0.20

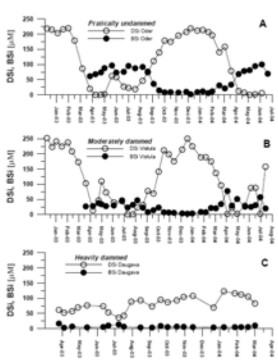
River Luleälven	TOC	Ca	K	Mg	Na	DSi	PO4
Headwaters	100	71.3	10.9	24.4	41.7	12.3	0.01
Regulated							
River mouth	198	73.5	11.5	27.8	64.5	38.5	0.08

Concentrations in µM

Humborg et al., GBC 2002

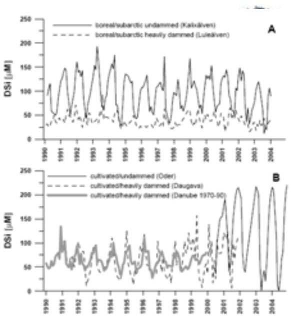


Effect of particle trapping in eutrophic river systems



Humborg et al. 2006 Biogeochemistry

Combind effects of hydrological alterations and particle trapping



Humborg et al. 2006 Biogeochemistry

DSi concentrations in the Baltic Proper

Stockholm University

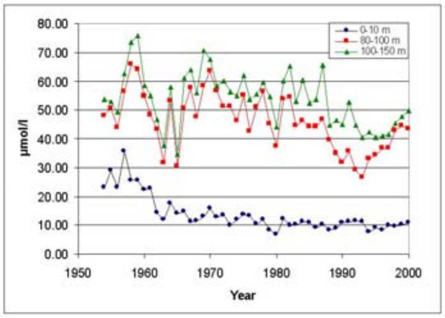


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Table 7. DSi annual inputs and potential missing DSi loads divided by Baltic Sea subbasin (BB=Bothnian Bay, BS=Bothnian Sea, GF=Gulf of Finland, GR=Gulf of Riga, BP=Baltic proper)

	Area	Runoff	Spec. Runoff	DSi	DSi yield	Missing DSi
Sub-basin	(km^2)	($10^6\ m^3\ yr^{-1}$)	($l\ m^{-2}\ yr^{-1}$)	($ton\ yr^{-1}$)	($kg\ km^{-2}\ yr^{-1}$)	($ton\ yr^{-1}$)
BB	235499	97064	412	220855	938	56079
BS	197061	86543	439	151823	770	98786
GF	384853	105779	275	55823	145	105262
GR	122116	29609	242	52820	433	19458
BP	488394	85320	175	230030	471	114197
Unmonitored	196604	69218		143670		26671
	1624527	473533		855021		420453

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Conclusion

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- Damming/channeling of headwaters leads to oligothorophication of entire river systems
- Trapping of particles and algal blooms leads also to lower matter fluxes
- About half of the reduction in Si seen in the Baltic Sea is due to river damming; ecosystem effects needs to be studied more