The New York Times

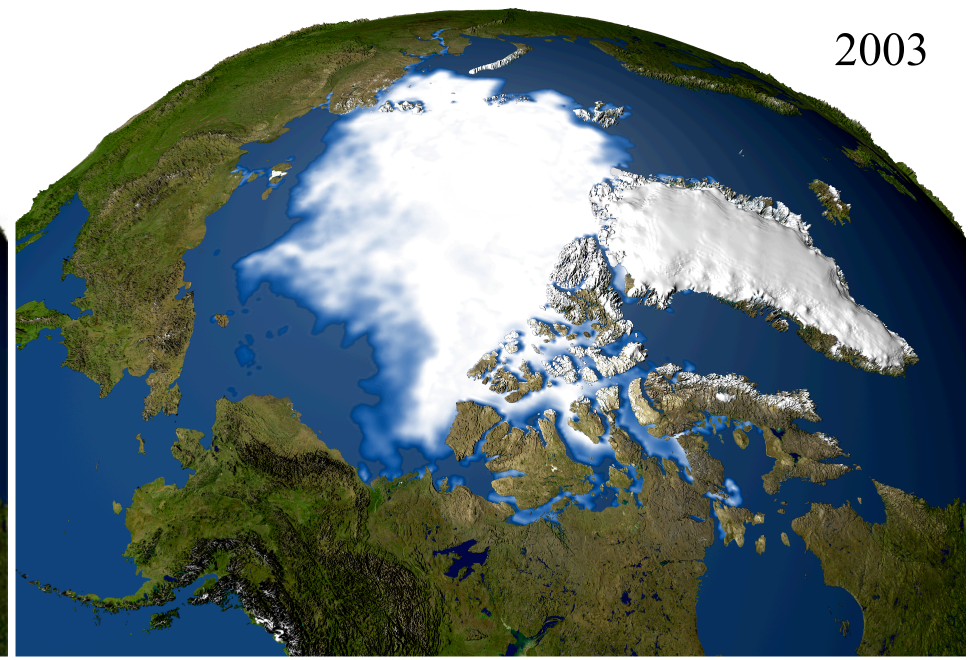
Cold Jumps Arctic 'Fence,' Stoking Winter's Fury

A subway station in Brooklyn. While the Northeast shivers, the Arctic has been freakishly warm.
By JUSTIN GILLIS
Published: January 24, 2011

Increasing River Discharge to the Arctic Ocean

Bruce J. Peterson,[1*] Robert M. Holmes,[1] James W. McClelland,[1]
Charles J. Vörösmarty,[2] Richard B. Lammers,[2]
Alexander I. Shiklomanov,[2] Igor A. Shiklomanov,[3] Stefan Rahmstorf[4]

Synthesis of river-monitoring data reveals that the average annual discharge of fresh water from the six largest Eurasian rivers to the Arctic Ocean increased by 7% from 1936 to 1999. The average annual rate of increase was 2.0±0.7 cubic kilometers per year. Consequently, average annual discharge from the six rivers is now about 128 cubic kilometers per year greater than it was when routine measurements of discharge began. Discharge was correlated with changes in both the North Atlantic Oscillation and global mean surface air temperature. The observed large-scale change in freshwater flux has potentially important implications for ocean circulation and climate.



And rivers are just part of the story………

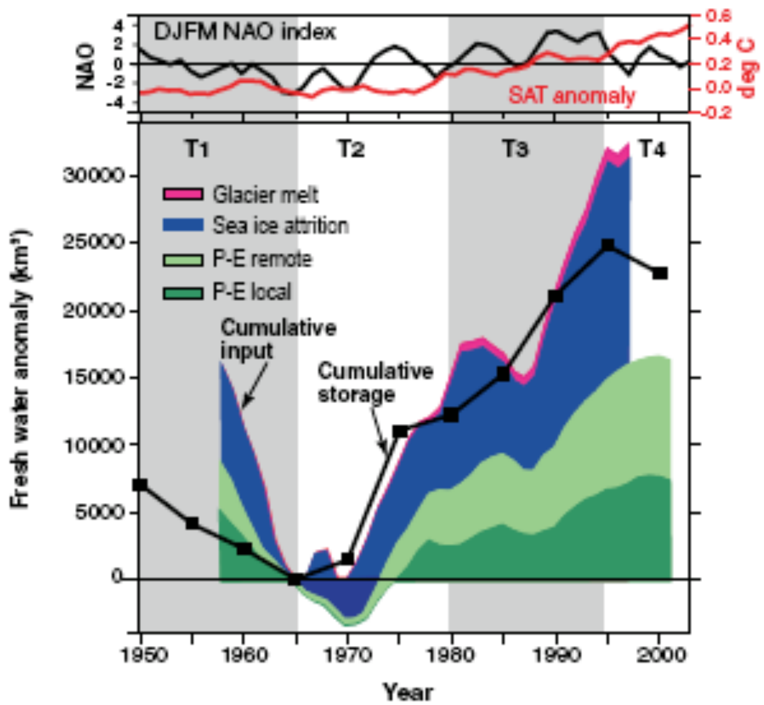


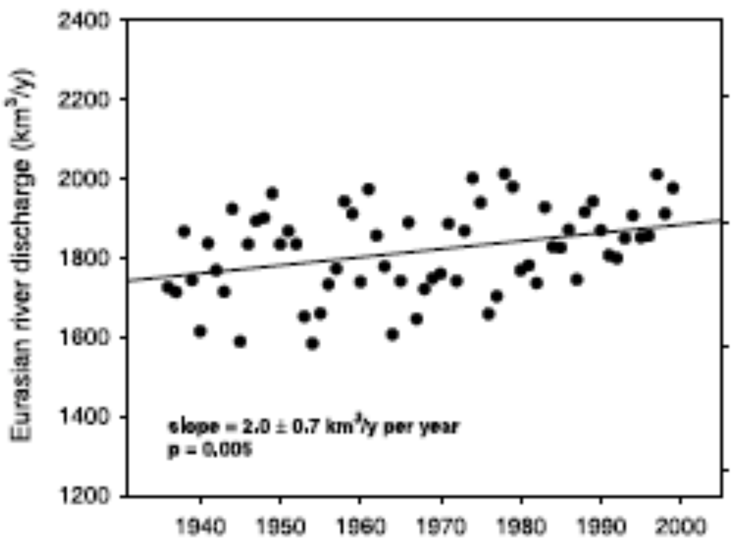
Fig. 4. Comparison of FW source anomalies and FW storage anomalies relative to 1965 (units are km^3). Black curve is cumulative NSSB ocean FW storage. Colored areas represent cumulative FW contributions from P-E local (Subpolar plus Nordic Seas, dark green), P-E remote (Arctic Ocean, HBCA, and river discharge, light green), sea ice attrition (blue), and glacier melt (red). Source contributions are stacked to show total FW source input.

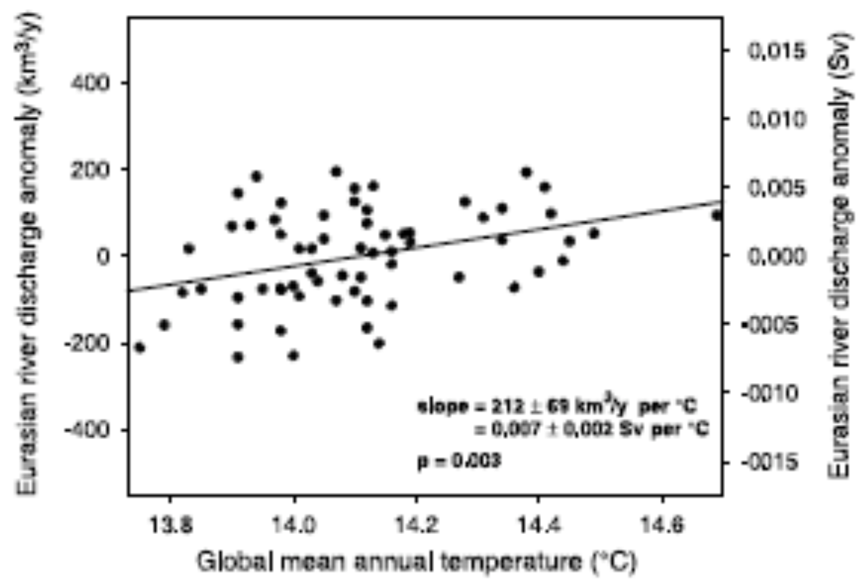
Freshwater sources	References	Years covered in references	Avg. anomaly ± SE for 1990s (km^3 $year^{-1}$)	% relative to 1936–1955 baseline
Rivers flowing into the Arctic Ocean	Peterson *et al.* (4) R-ArcticNET v3.0 (55) Wu *et al.* (14)	1936–1999 2000–2003 1900–2050	163 ± 34	+5.3
Rivers flowing into Hudson Bay	Déry *et al.* (56)	1964–2000	−59 ± 16	−8.0
Small glaciers, ice caps	Dyurgerov and Carter (5)	1961–2001	38 ± 13	—
Greenland Ice Sheet	Box *et al.* (6)	1991–2000	81 ± 38	—
P-E, Arctic Ocean	ERA-40 (57)	1958–2001	124 ± 72	+7.6
P-E, HBCA	ERA-40 (57)	1958–2001	81 ± 33	+15.6
P-E, Nordic Seas	ERA-40 (57)	1958–2001	67 ± 28	+17.8
P-E, Subpolar Basin	ERA-40 (57)	1958–2001	336 ± 73	+16.8
Sea ice	Rothrock *et al.* (7)*	1987–1997	817 ± 339	—
TOTAL			1649	

*Rothrock *et al.* (7) reported observed changes in sea ice thickness annually from 1987–1997 and also modeled changes over a wider time frame (1951–1999). Thickness has been converted to freshwater volume following Wadhams and Munk (58).


180°
135°W
135°E
90°W
90°E
45°W
45°E
0°
Pacific Ocean
Arctic Ocean
Atlantic Ocean
75°N
60°N
45°N
Yukon
Colville
Mackenzie
Kolyma
Lena
Yenisey
Ob'

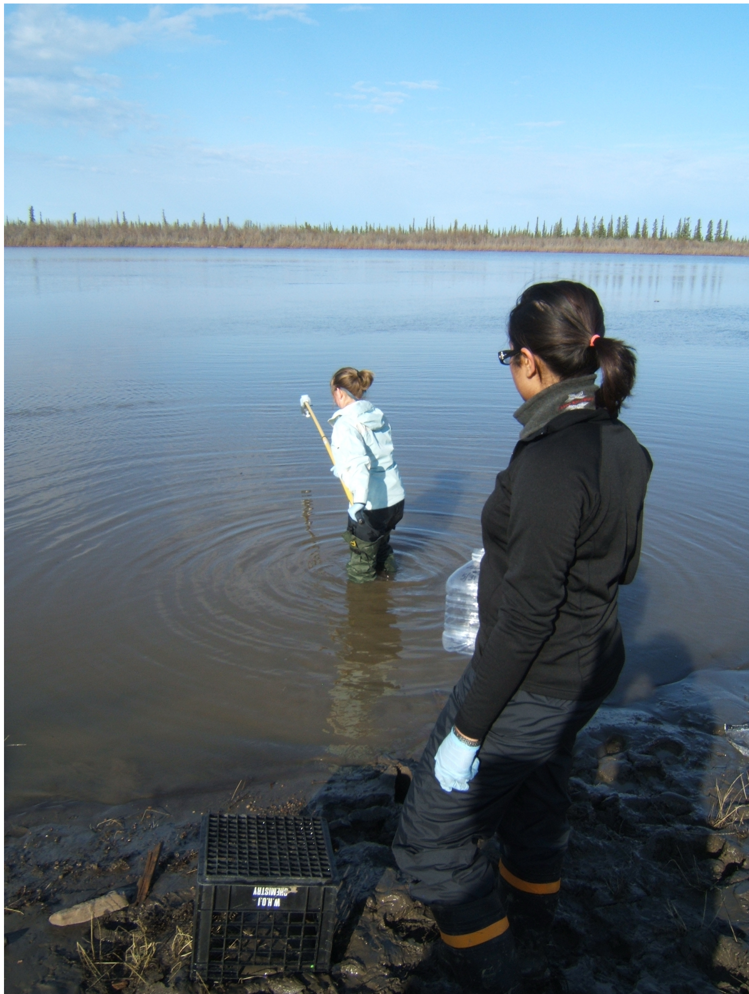
Impact of increasing surface atmosphere temperatures on the delivery of FW to the arctic through Eurasian watersheds






Mackenzie River

Mackenzie River aerial views




6/4/08
STREAM
5/24/08 - #2

The possible consequences of massive carbon transfer from arctic soils to the ocean:

1. **Not much**: the carbon stored in arctic soils represents the end product of carbon cycling on land. The material is inert and cannot be oxidized in the ocean. It is transferred into the ocean and stays there.

2. **Some effect**: It would have been oxidized anyway in soils so the transfer just effects the location of oxidation, not the ultimate fate of the carbon.

3. **Large effect**: The carbon was effectively sequestered in soils and would not have been oxidized if it remained there. Different degradation processes are active in the sea, leading to a different long term fate of the carbon (and N and P).

<u>The three scenarios will have different consequences for atmospheric CO_2 global climate and global carbon cycling</u>!

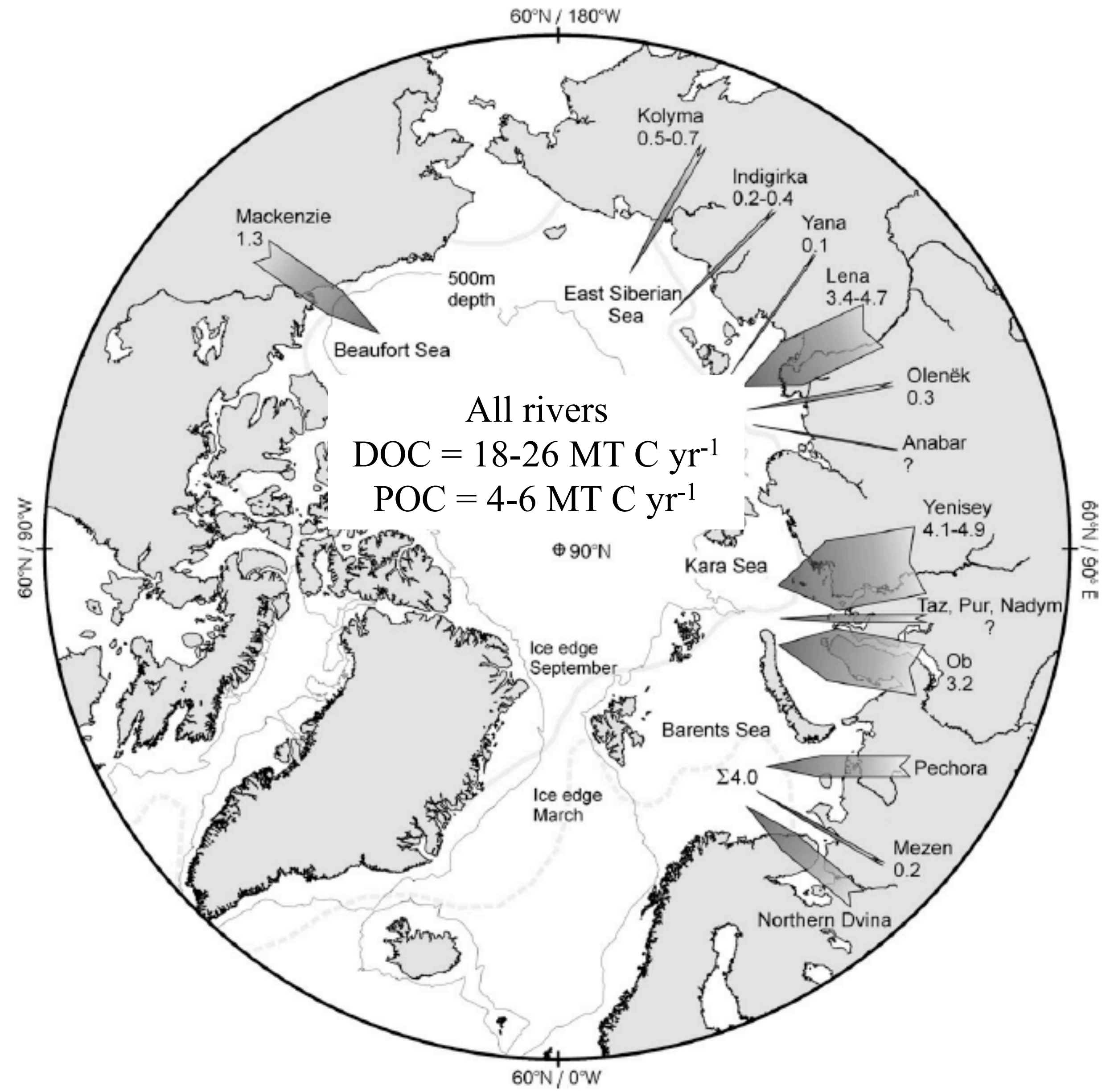
Discharge of dissolved organic and inorganic nutrients from arctic rivers

Table 1
Annual discharges of water, dissolved and particulate organic matter (DOC, DON, POC, PON), and inorganic nutrients (dissolved inorganic nitrogen DIN = Nitrate + Nitrite + Ammonium, Silicate, Phosphate) for the rivers entering the Arctic Ocean

River	Watershed area (km^3)	Discharge							
		Water ($km^3 \cdot year^{-1}$)	DOC-C (10^{12} g $\cdot year^{-1}$)	POC-C (10^{12} g $\cdot year^{-1}$)	DON-N (10^9 g $\cdot year^{-1}$)	PON-N (10^9 g $\cdot year^{-1}$)	DIN-N (10^9 g $\cdot year^{-1}$)	Silicate-Si (10^9 g $\cdot year^{-1}$)	Phosphate-P (10^9 g $\cdot year^{-1}$)
Yenisey	2440	562–577	4.1–4.9	0.17	82	17	2.8–70	200–1223	6.0–6.9
Lena	2430	524–533	3.4–4.7	0.47	80–245	54	3.4–46	890–1640	3.5–6.5
Ob	2950	404–419	3.1–3.2	0.31–0.6*	66*	28*–54*	20–40	311	7.9–23.5
Mackenzie	1680	249–333	1.3	1.8–2.1	27*	160*–190*	23.6*	470*	1.5
Pechora	312	135	2.1*	–	44*	–	7.1*	–	4.2
Northern Dvina	348	106	1.7*	–	35*	–	6.7*	–	2.0
Kolyma	526	71–98	0.46–0.7*	0.31	16	34	2.5*	–	0.76
Indigirka	305	50	0.24–0.4*	0.17	8.4	24	0.18–2.3*	0.7	0.11–0.35
Taz	100	33	–	–	–	–	0.75*	–	2.8
Olenĕk	198	32	0.32	0.03	7.9	2.5	0.20–0.78*	21	0.03–0.23
Yana	224	31–32	0.09	0.05	2.9	4.8	1.2*–1.7	61	0.08–0.36
Pur	95	28	–	–	–	–	0.74	–	3.0
Mezen	56	20	0.25	0.04	4.5	3.2	0.71*–1.3	10	0.27–0.44
Onega	56	16	–	–	–	–	0.99*	–	0.15
Nadym	48	15	–	–	–	–	0.55*	–	2.0
Anabar	79	13	–	–	–	–	0.09*	–	0.03

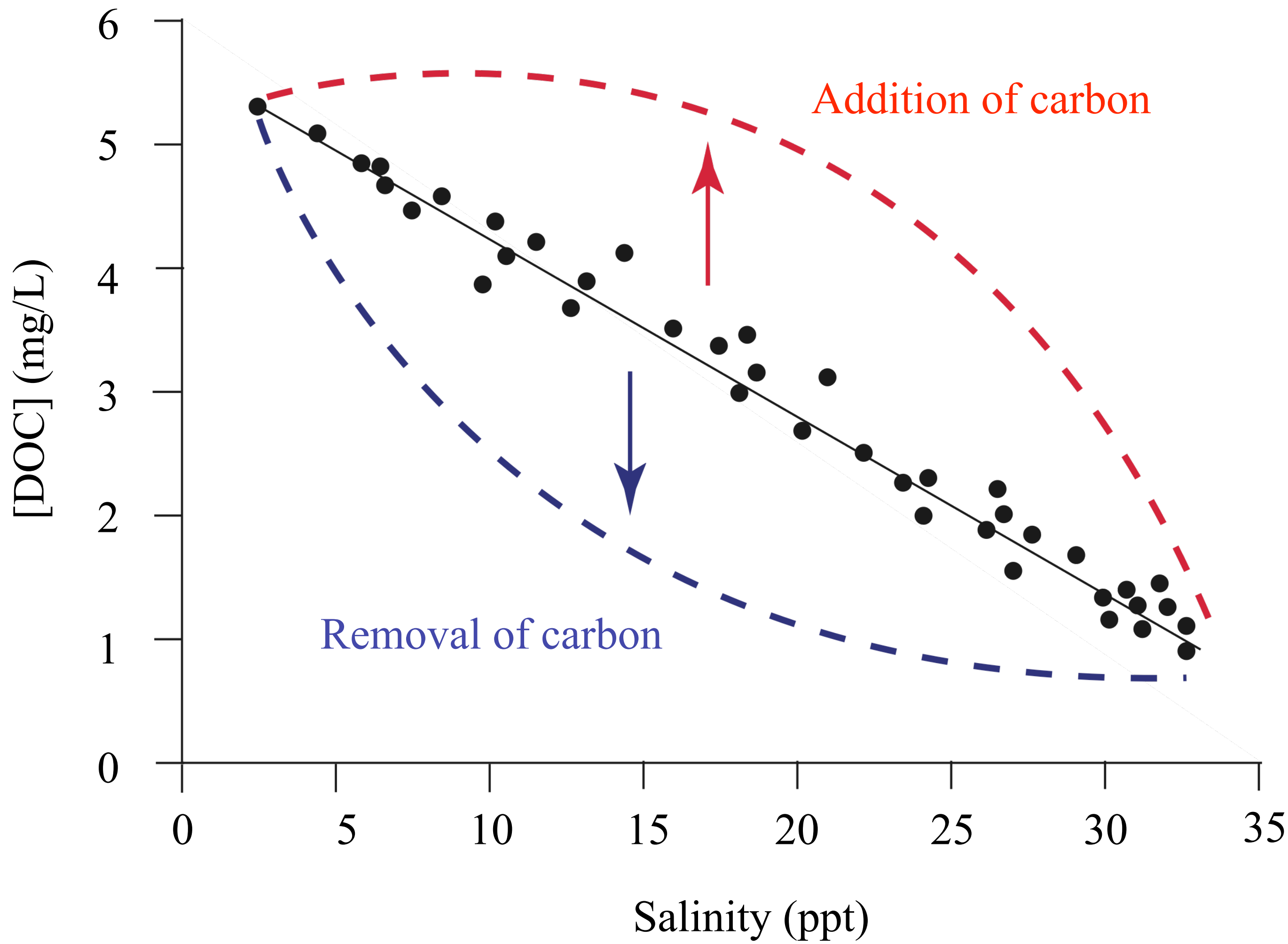
DOC = **D**issolved **O**rganic **C**arbon   **POC** = **P**articulate **O**rganic **C**arbon

Dittmar and Kattner, MC 2003

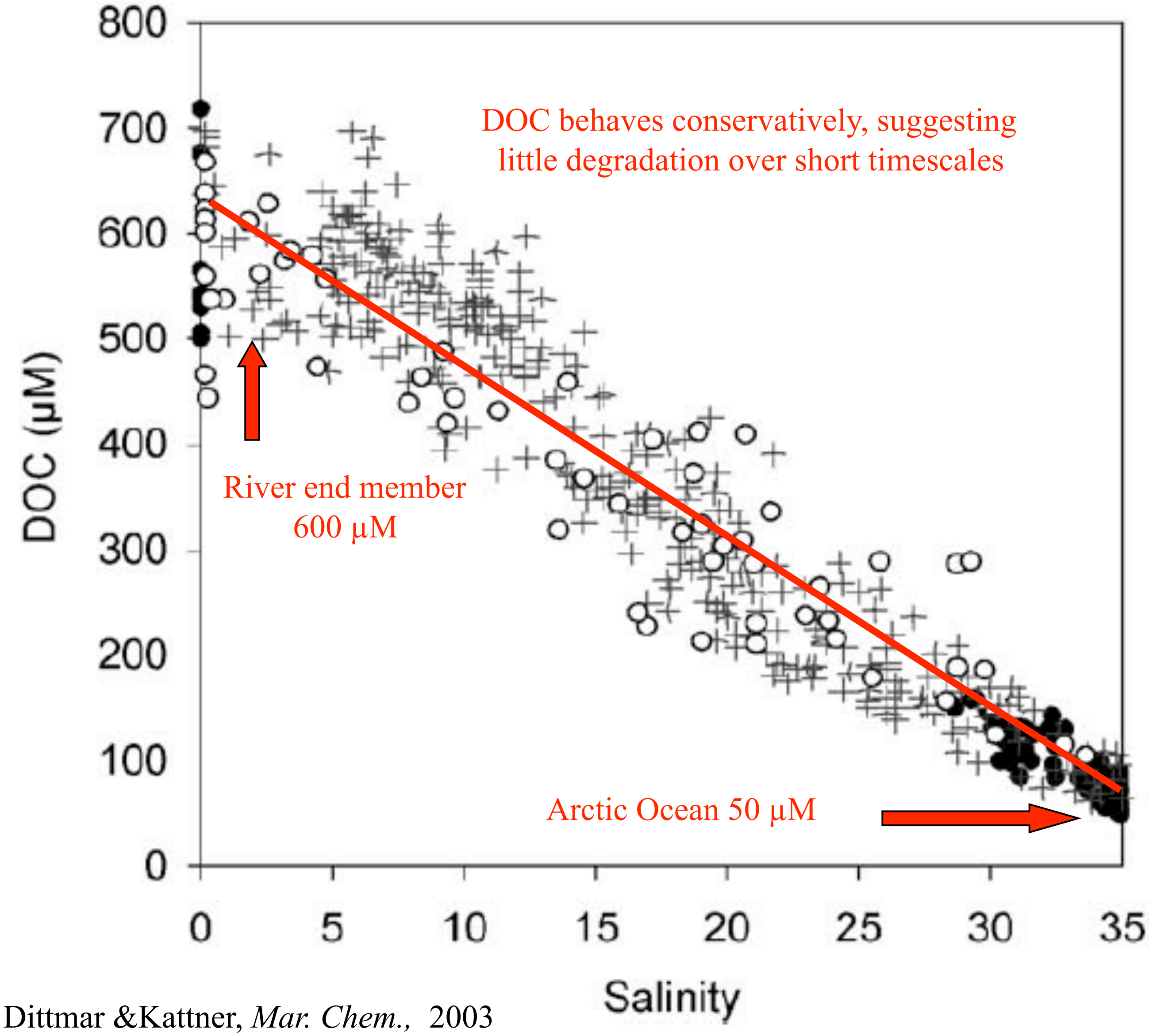


60°N / 180°W
Kolyma
0.5-0.7
Indigirka
0.2-0.4
Yana
0.1
Lena
3.4-4.7
Mackenzie
1.3
500m
depth
East Siberian
Sea
Beaufort Sea
Olenëk
0.3
All rivers
DOC = 18-26 MT C yr-1
POC = 4-6 MT C yr-1
Anabar
?
Yenisey
4.1-4.9
60°N / 90°W
90°N
Kara Sea
60°N / 90°E
Taz, Pur, Nadym
?
Ice edge
September
Ob
3.2
Barents Sea
Pechora
Σ4.0
Ice edge
March
Mezen
0.2
Northern Dvina
60°N / 0°W

Conservative and nonconservative behavior of DOC in estuaries



Conservative behavior of DOC on the Eurasian Shelf



Dittmar &Kattner, *Mar. Chem.*, 2003

May 28, 11:43 am

Photo from Max Holmes WHRC

May 30, 7:25 pm

Photo from Max Holmes WHRC

Changes in DOC concentration with changes in river discharge for the Lena River

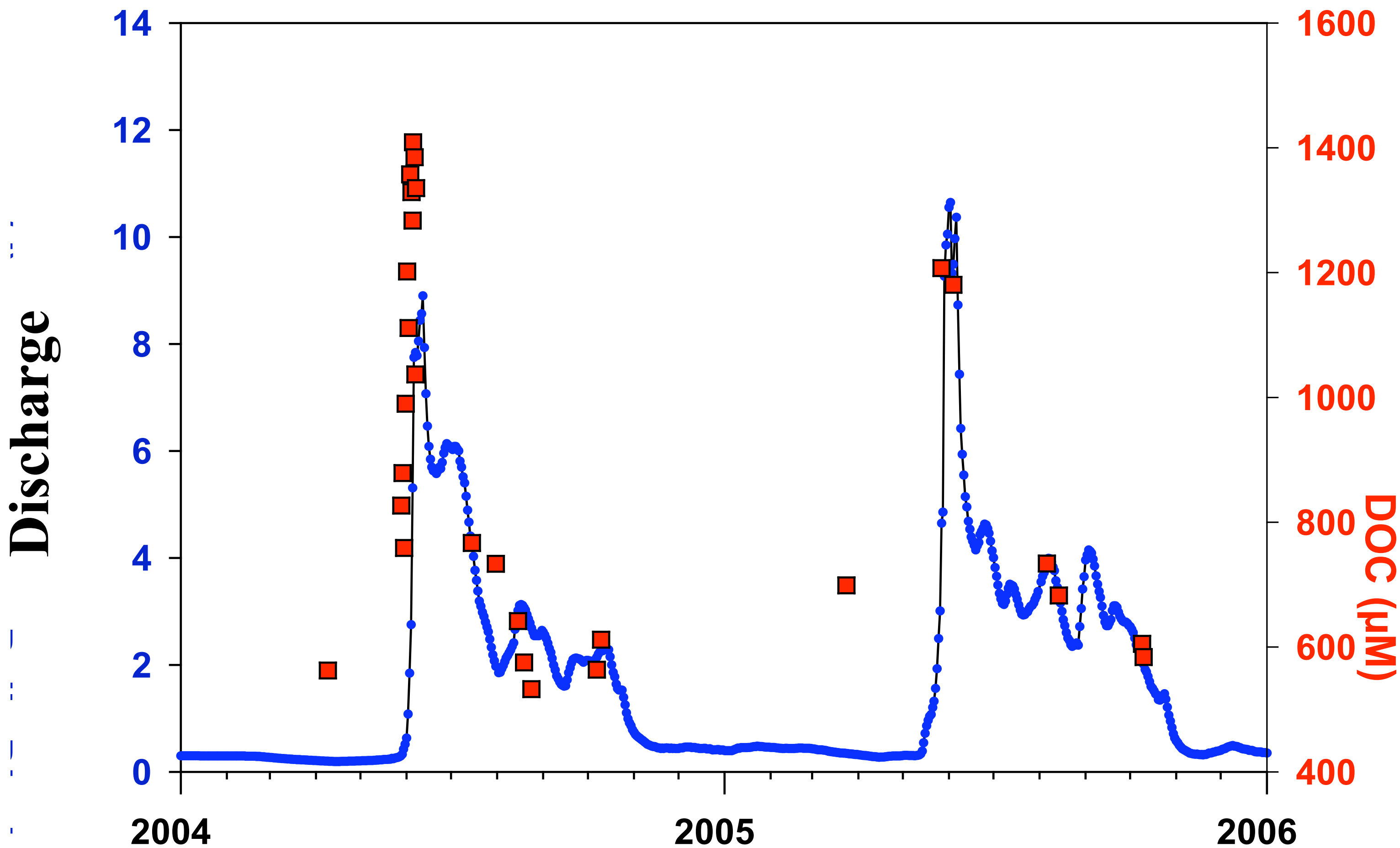
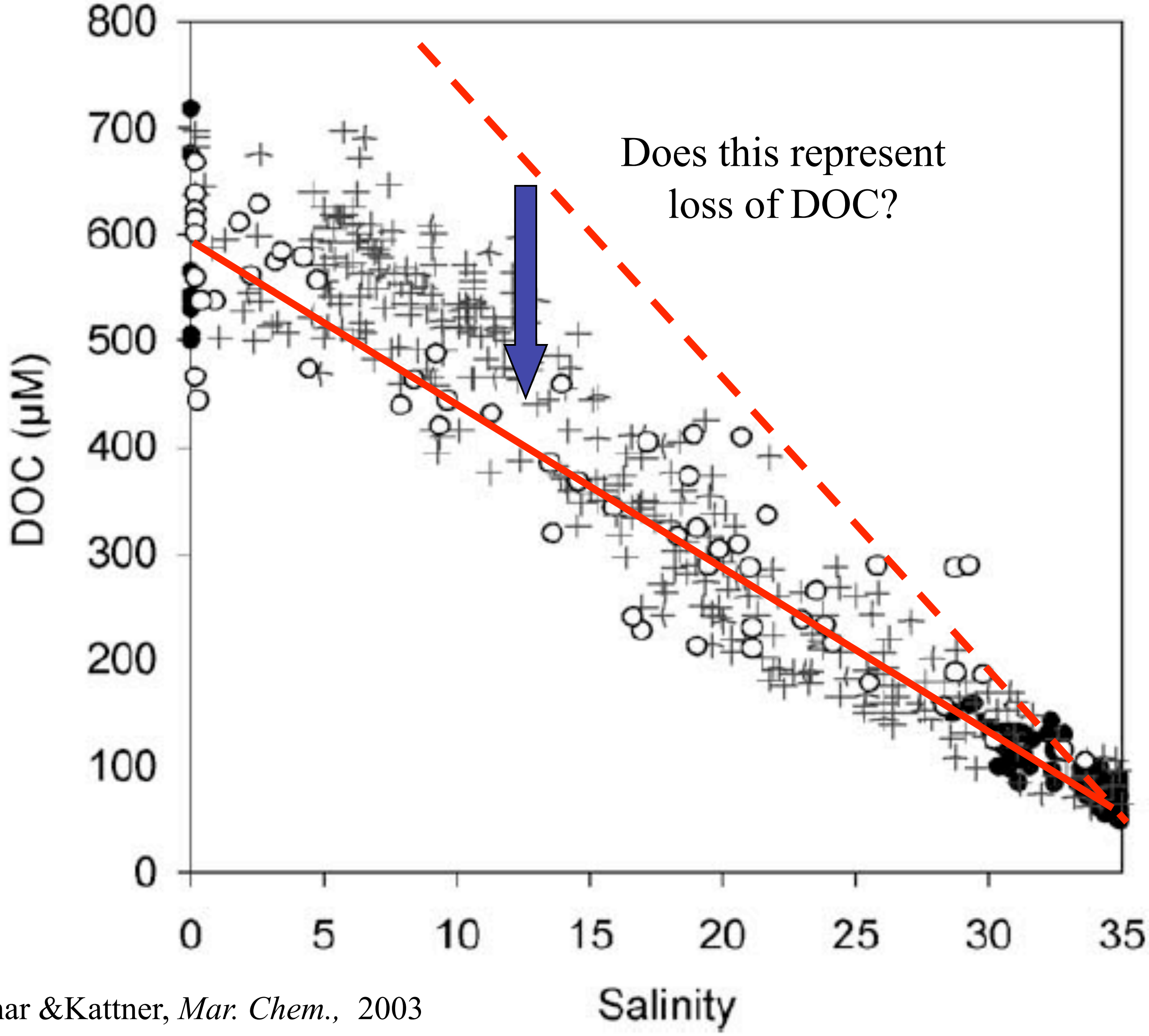


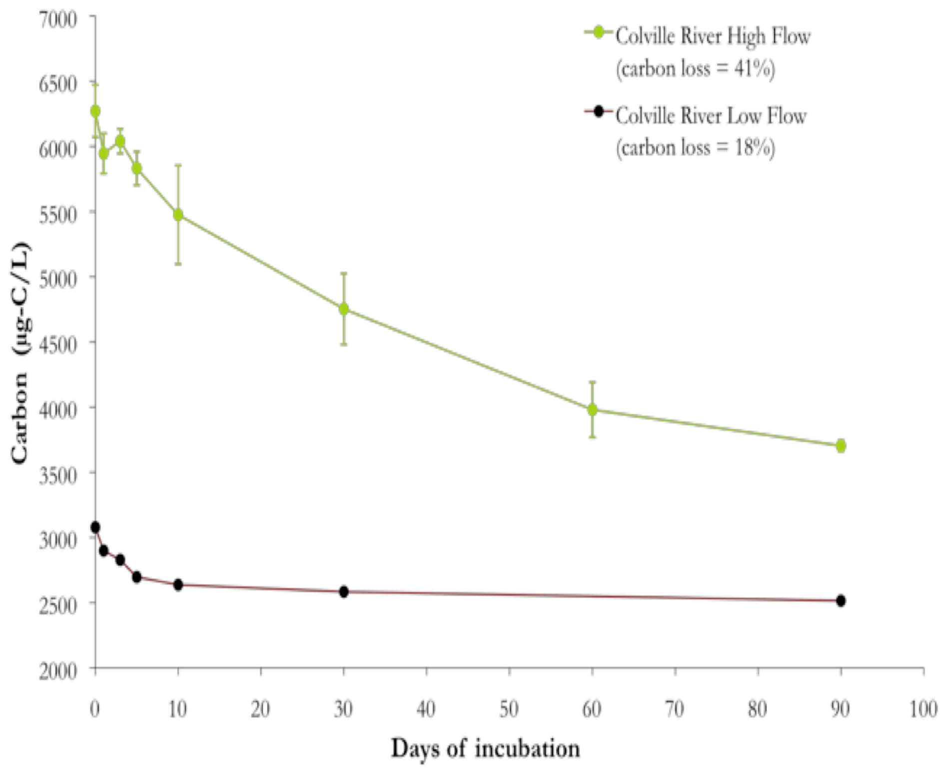
Figure from Max Holmes, WHRC

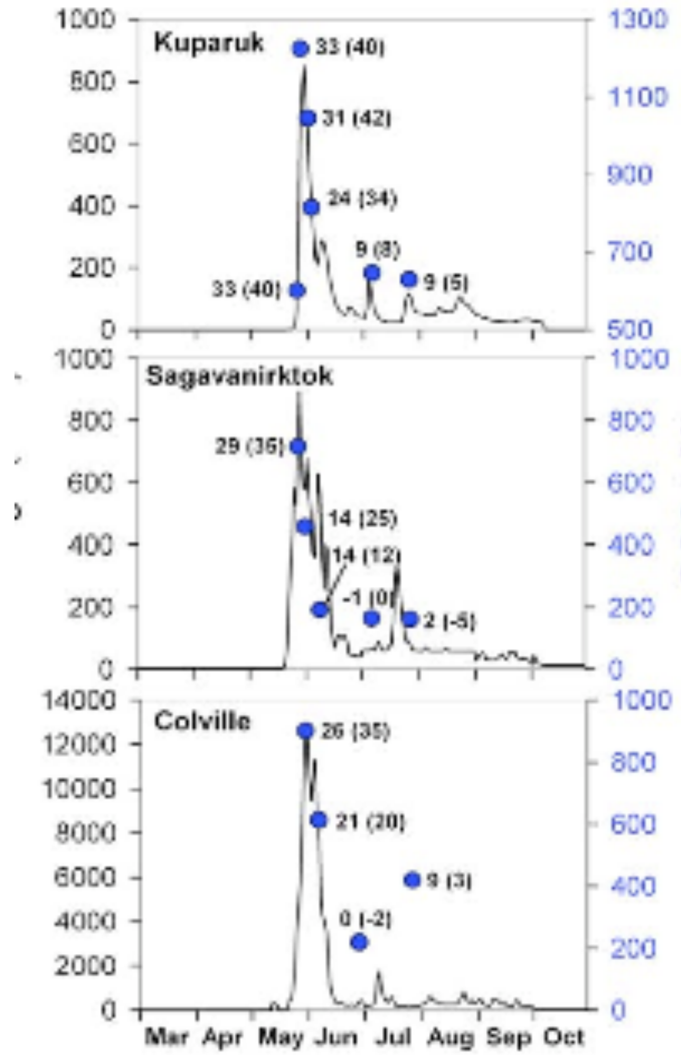
DOC behaves conservatively on the Eurasian Shelf, but is this masking A major cycling and loss of carbon in arctic rivers and on the shelf?

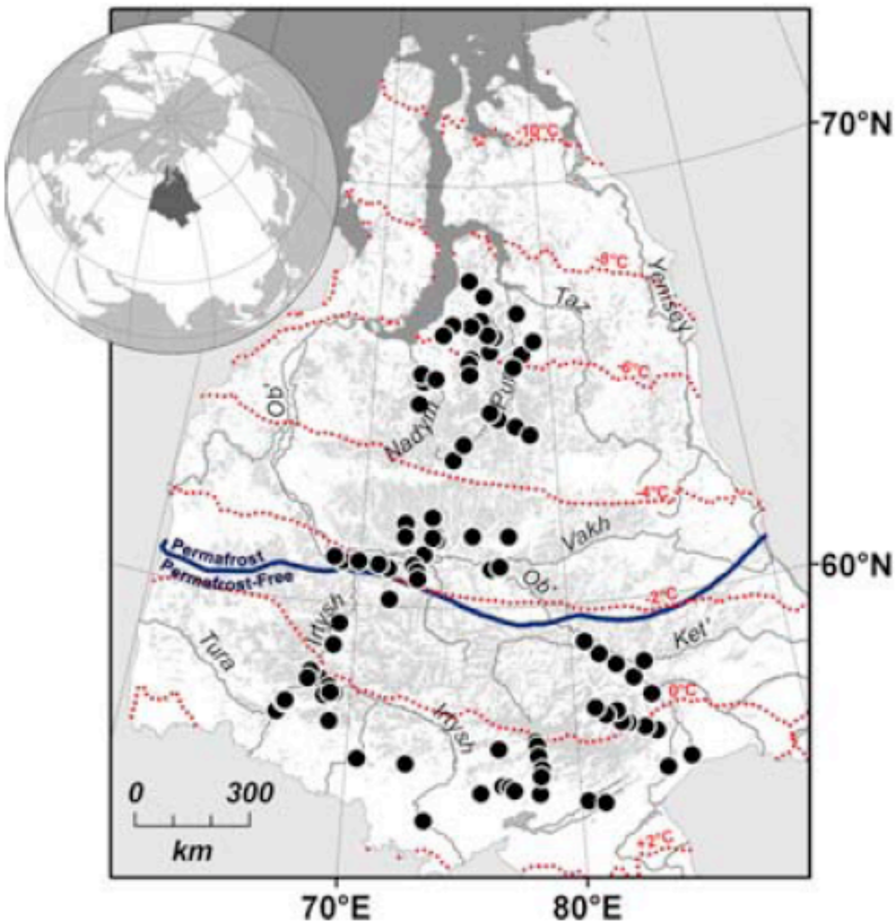


Dittmar &Kattner, *Mar. Chem.,* 2003

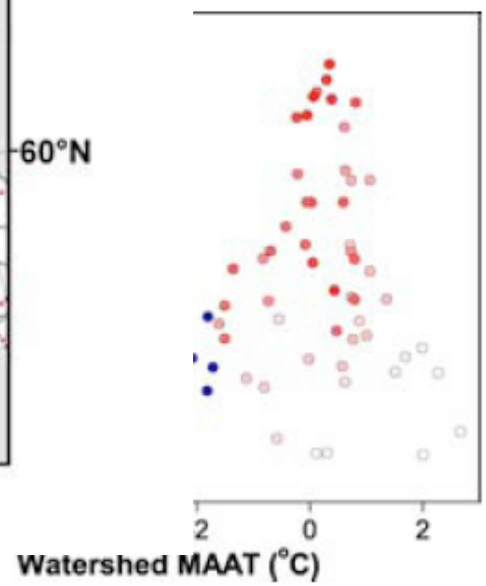
How do we determine the "reactivity" of dissolved organic carbon in arctic rivers? Laboratory microbial degradation experiments.

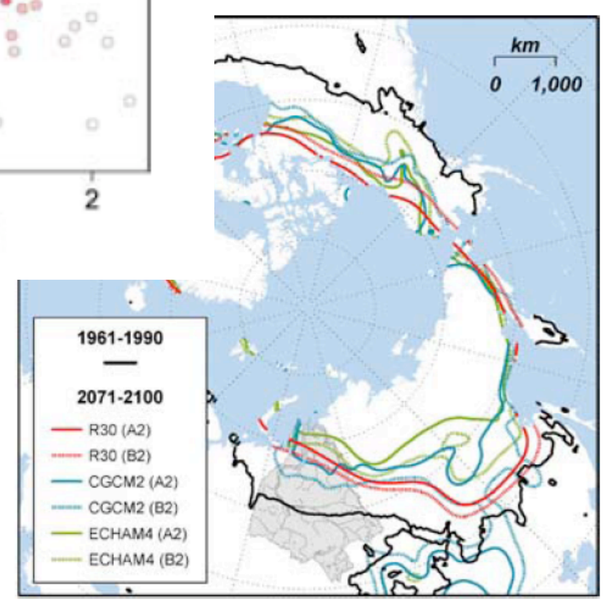




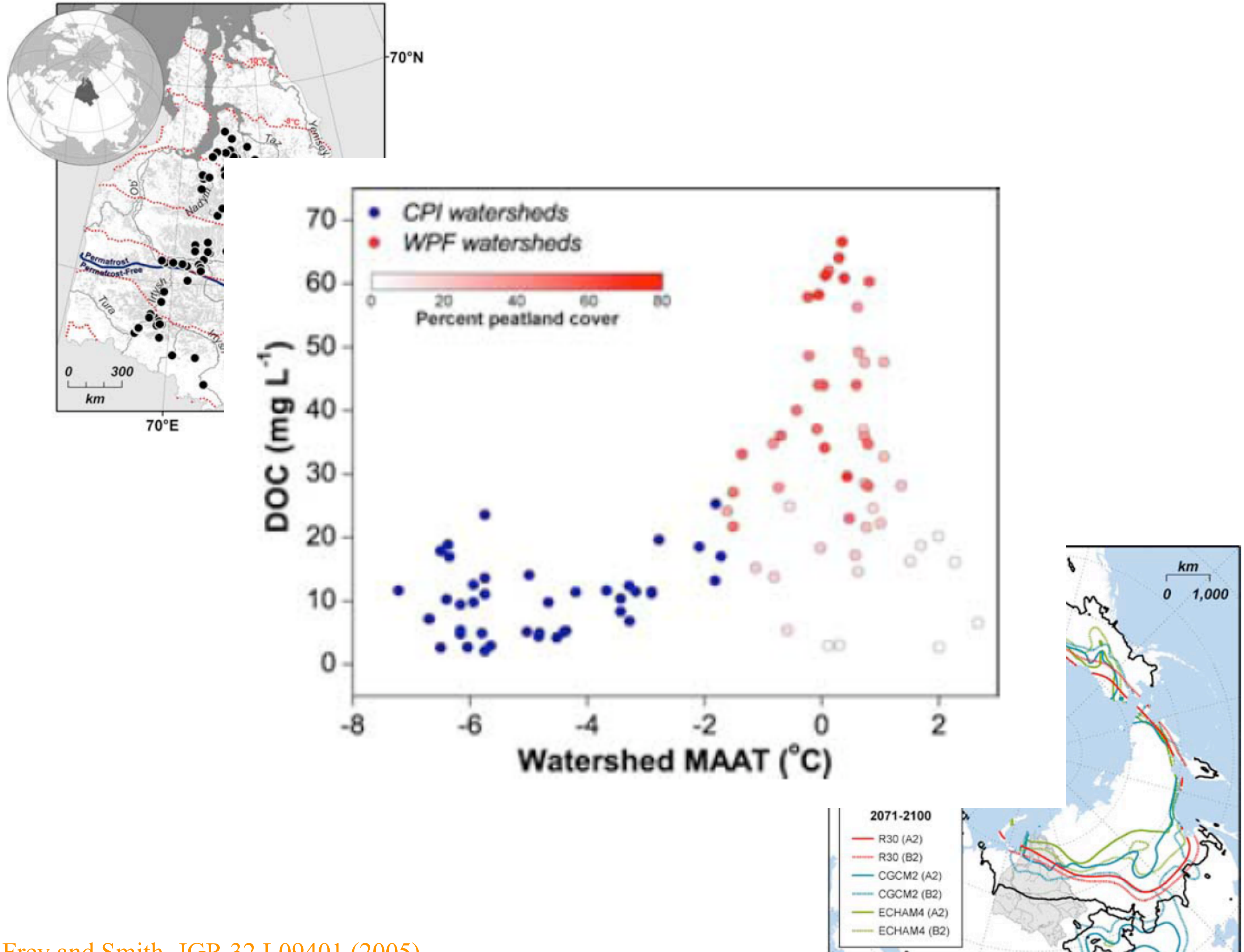


Possible impact of climate change driven arctic warming on DOC flux and fate





Frey and Smith, JGR 32 L09401 (2005)



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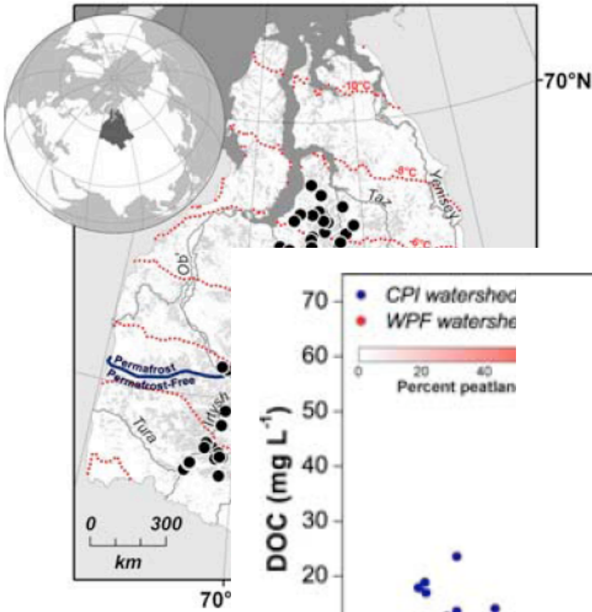

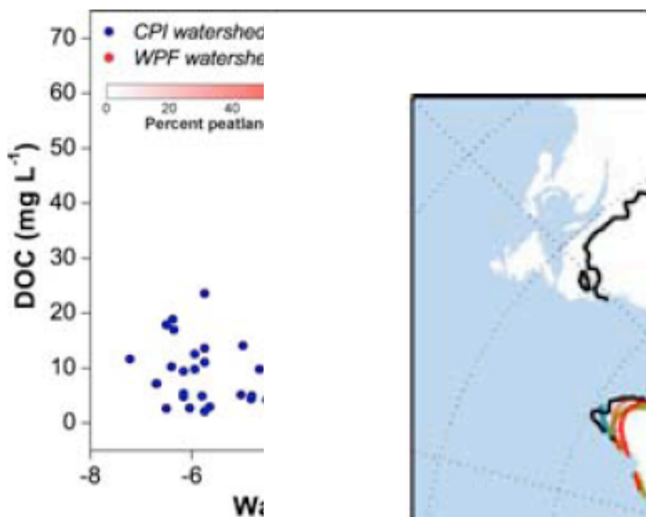

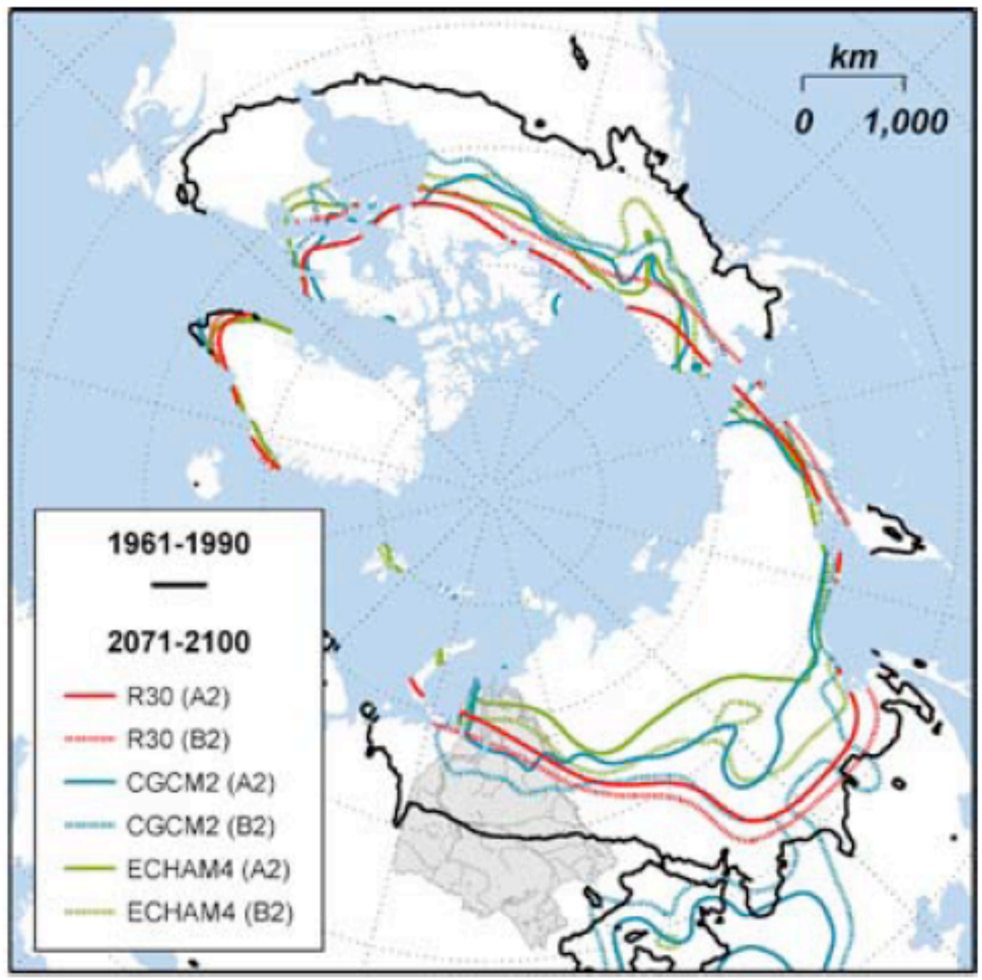

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C/N of terrigenous DOM is about 50, compared to Redfield (6-7)

How can we assess the influence of a warmer polar region on global carbon cycling and atmospheric carbon dioxide levels?

How much carbon is being introduced to the system?

One broad goal of marine organic chemistry is to inventory the reservoirs of carbon in the sea and determine the magnitude and direction of fluxes between reservoirs (ocean, land and atmosphere).

How can we measure organic carbon? What is the speciation of organic carbon (particulate, dissolved…specific compounds) and what species are important to how carbon is moved or stored?

What are the sources of organic matter in the environment?

A second broad goal of marine organic geochemistry is to identify the major sources of organic matter, determine their speciation, and asses how source and speciation interact with physical, chemical and biological factors to drive organic matter cycling and fate.

Can we use molecular organic tracers to assess the sources of organic matter in environmental samples?

What is the fate or organic matter in the environment?

Another broad goal of organic geochemistry is to understand the long term fate of organic matter in the environment and how this impacts the global carbon cycle.

How much carbon is sequestered in seawater, sediments, and sedimentary rocks?

What are the major factors (source? speciation? temperature?, etc.) that result in carbon degradation or preservation? How is petroleum formed? How is coal formed?

Why is carbon sequestered at all?

How does organic matter interact with matter and energy to impact marine ecosystem functioning?

Finally, we wish to understand how organic matter impacts the system as a whole, and what are The consequences of organic matter more broadly to elemental cycling and the geo- and biosphere

Impacts of organic matter on nutrient cycling

Impacts on metal speciation

Impacts on gas transfer

Impacts on light penetration into seawater

Marine Organic Geochemistry (12.746)

MRF conference room
2:30-4 Tuesday and Thursday

Instructor
Dan Repeta (drepeta@whoi.edu)
Office: Watson 119, 508-289-2635

Teaching Assistant
Jamie Becker (jbecker@whoi.edu)
Office: Watson 115, 508-289-2835

Grades will be based on:

Mid Term (15%)

Written & Oral presentation of NSF style proposal (40%)
-Outline (5%)
-Draft (5%)
-Final (30%)

Final exam (30%)

Participation in class discussions (15%)

MOG 12.746

2011

Month	Day	Week Day	Instructor	Topic
February	1	Tuesday	DJR	OC cycling-forms, inventory, fluxes, residence times
	3	Thursday	DJR	DOM-measurement, global dist., res. times, sources/sinks
	8	Tuesday	DJR	Dissolved organic matter composition
	10	Thursday	DJR	Dissolved organic nutrients
	15	Tuesday	Becker	Dissolved organic matter and the microbial loop
	17	Thursday	DJR/Becker	Discussion: Dissolved organic matter cycling
	22	Tuesday		No Class
	24	Thursday	Bob Chen	CDOM/FDOM

March	1	Tuesday	DJR	OM on particles and sediments- overview, POC and C-flux
	3	Thursday	DJR	Biomarkers- analytical chemistry and distribution
	8	Tuesday	DJR	carbon preservation in marine sediments
	10	Thursday	Galy	terrestrial organic carbon in the marine environment **PROPOSAL OUTLINES DUE**
	15	Tuesday	DJR/Becker	Discussion: Organic carbon cycling and marine POM
	17	Thursday	DJR/Becker	**mid term**
	22	Tuesday		No Class
	24	Thursday		No Class
	29	Tuesday	DJR	Application of Biomarkers I: alkenones
	31	Thursday	Hughen	Application of biomarkers to paleoclimate studies
April	5	Tuesday	DJR	Light isotopes (C, N,H) in organic geochemistry
	7	Thursday	Pierson	Application of Biomarkers II: Archea and chemosynthesis **FIRST DRAFT OF PROPOSAL DUE**
	12	Tuesday	DJR	microbial BGC in anoxic marine sediments
	14	Thursday	DJR/Becker	Discussion: application of biomarkers to paleo & present
	19	Tuesday		No Class
	21	Thursday	DJR	DOC cycling and climate change
	25	Tuesday	Becker	Microbial BGC and DOM cycling
	28	Thursday	TBA	

May	3	Tuesday	Mincer	Natural Products
	5	Thursday	DJR	Class Presentation **Final proposal due**
	10	Tuesday	DJR	Class Presentation
	12	Thursday	DJR	Review

MOG research Proposal

The proposal format is flexible. We are more interested in content and ideas than format and number of pages. The “NSF style” proposal format was selected to give you a benchmark from which to work. For NSF, we are allowed 15 pages (including figures but not references) to describe the research project. Major sections are:

Abstract (~1/2 page)
Much like a research paper abstract it summarizes the central idea/question the proposal addresses, objective(s), proposed research or approach, and expected impacts.

Introduction/background (5-7 pages)
Give an overview of the current state of knowledge on the particular topics. Include competing ideas and hypotheses as well as the major lines of evidence supporting or not supporting the different hypotheses. Try to be critical in your evaluation of the literature. Because a paper says something is true only means that 2-3 reviewers signed off on the interpretation. You need to make your own assessment based on the strength of the data and the likelihood of alternative explanations. Highlight and place in context the major questions you address in the proposed research. Your goal is to present a strong case for why the research is important, what the next steps should be, and how the expected results will modify or strengthen our concepts of how systems work.

Objectives/hypotheses (1-2 pages)
This is often the most important part of the proposal. Try to clearly and concisely state what hypotheses will be tested, what the larger objectives of the proposal are, and briefly, how the proposed set of measurements will address the hypotheses.

Proposed Research (balance of the proposal).
This is a description of the research plan including sampling (we are more interested in the rationale behind your choice of sampling locations and types of samples than the mechanics of how they will be collected) analytical methods, (again we are more interested in why you chose that particular set of measurements rather than the details of the methodology), blanks and controls, and the numerical treatment/interpretation of the data.

Summary
Provide a brief statement of what you think the impact of your research will be. Be as specific as possible.

Figures and tables
If possible, imbed these into the text. Choose figures and tables that support and lend credence to your arguments. Feel free to redraft, reinterpret, etc. other data but be sure to cite original sources.

References

Possible research proposal topics

Microbial degradation of DOC; why is DOC so old in the deep ocean?

Dissolved organic nutrients

What fuels microbial diversity in seawater?

C cycling in the Arctic & the consequences of climate change

Controls on carbon preservation in marine sediments

Reconstructing paleo pCO2 variations from biomarker 13C records: potential and pitfalls

Evaluation and utility of molecular markers of anaerobic ammonium oxidation (anammox)

Assessing the importance of sediments as sources of DOM to the oceanic water column

Importance of hydrothermal systems to DOC in the ocean

Biogeochemical utility of nitrogen isotopic analysis of chlorophyll and other tetrapyrroles

Are marine algae a viable source of biofuels?

Early diagenesis and light isotope (CHN) fractionation on paleoenvironmental studies using biomarkers

The deep biosphere: molecular evidence and consequences for interpretation of the sedimentary record

Anaerobic methane oxidation and the formation of gas hydrates

Carbon cycling and burial on continental margins and climate: molecular evidence

Allelopathic organic compounds (toxins, grazing inhibitors, etc.)

Organic ligand-trace metal biogeochemistry

Molecular evidence for variations in SST, pCO_2 and photic zone anoxia during Cretaceous oceanic anoxic events (OAEs)

The biogeochemical role and molecular manifestation of viruses in the ocean