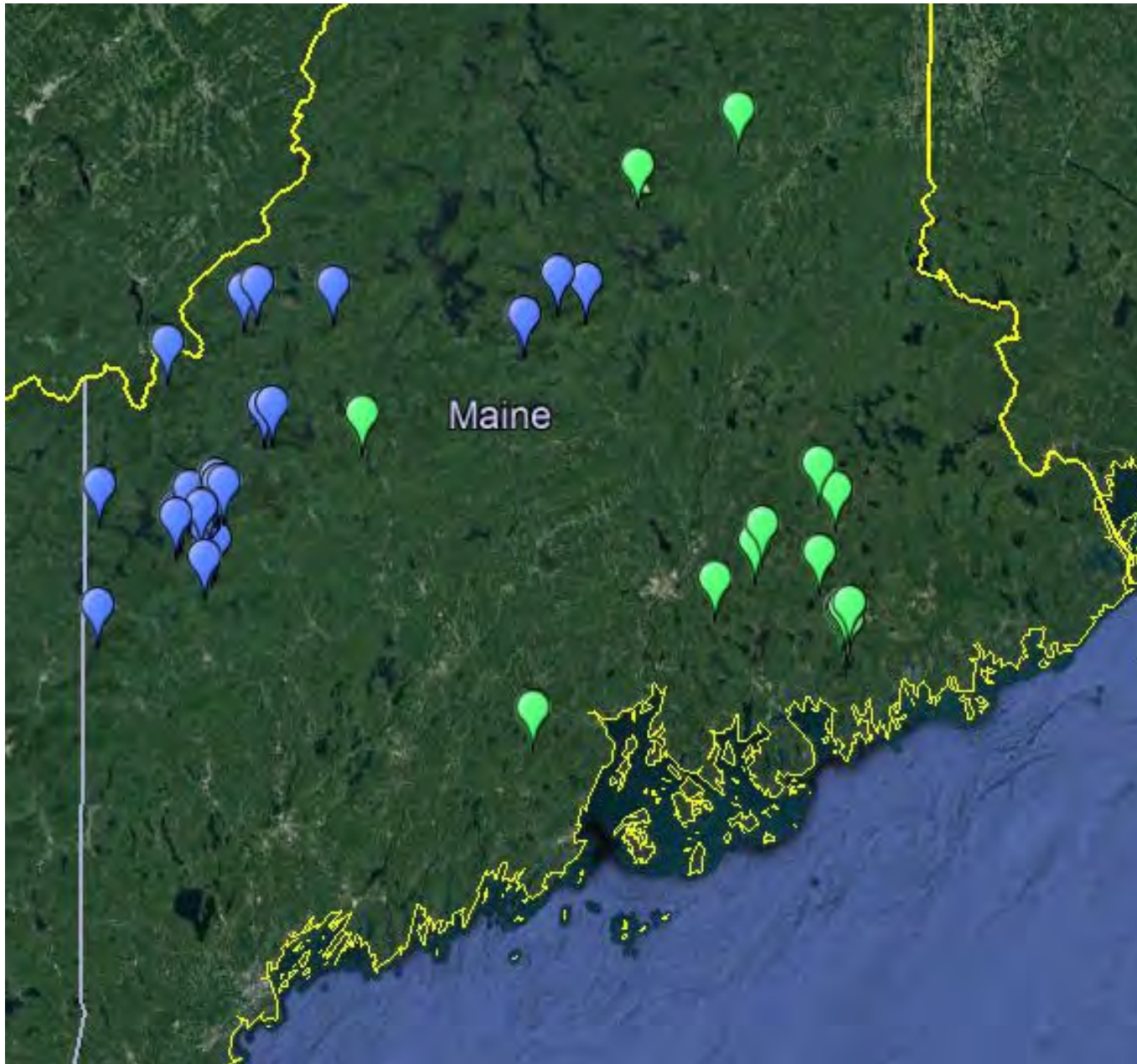


Dissolved organic carbon trends in Maine lakes

Amanda Gavin M.S. Ecology and Environmental Sciences



Committee: Sarah Nelson (SFR), Ivan Fernandez (SFR), Jasmine Saros, (CCI)



16 Regional Long-Term
Monitoring (RLTM) Lakes



29 High Elevation Lake
Monitoring (HELM) Lakes

Chemistry of Maine's High Elevation Lakes: Results from the HELM Project

Jeffrey S. Kahl

*Environmental Science Annex, University of Maine,
Orono, Maine 04469*

Matthew Scott

*Maine Low-Level Radioactive Waste Authority, Augusta,
Maine*



Table 3.—Population descriptions for selected chemical parameters.

PROJECT/ REGION	SECCHI (m)	COLOR Pt/Co	MEAN MEDIAN		ANC μeq/l	SPEC. COND. uS	DOC ppm	CA ^a μeq/l	SO ₄ ^a μeq/l	TOTAL Al ppb
			AIR-EQUIL. pH							
HELM	3.7	33	5.70	6.69	79	22	5.1	108	84	139
ELS-1C	3.0	29	7.07	7.20	180	32	5.6	178	81	94
ELS-1E	3.2	35	6.30	7.26	199	38	6.0	190	68	78
ELS-ME	3.2	34	6.46	7.25	195	37	5.9	189	71	81

Note: (Data are means, except for pH, for which median is also listed. Mean pH is calculated from the mean H⁺ concentration.)

^a marine aerosol corrected

> 600 m

> 1 m deep

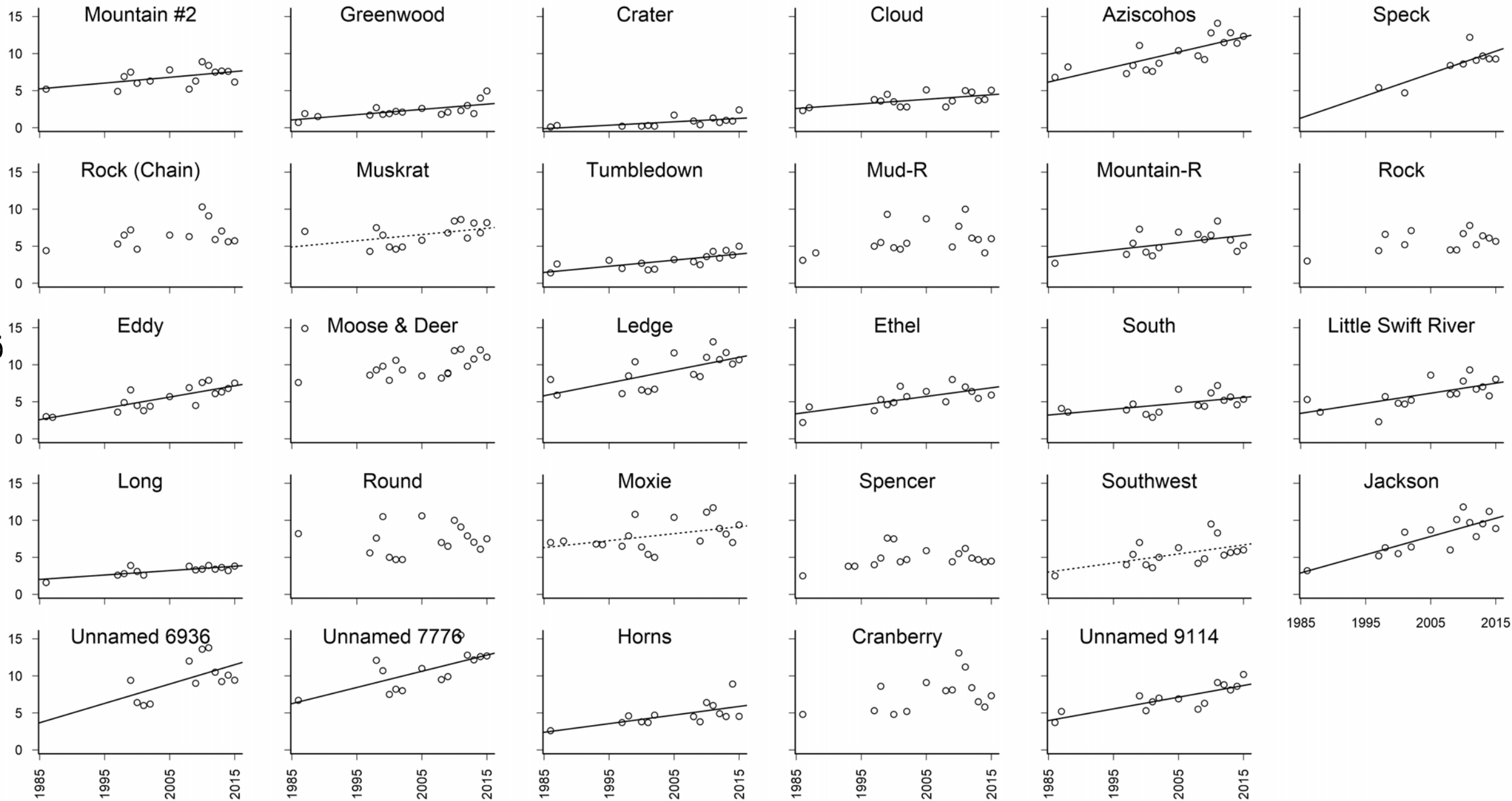
> 0.4 ha surface area

No stream flowages

No beaver impoundments



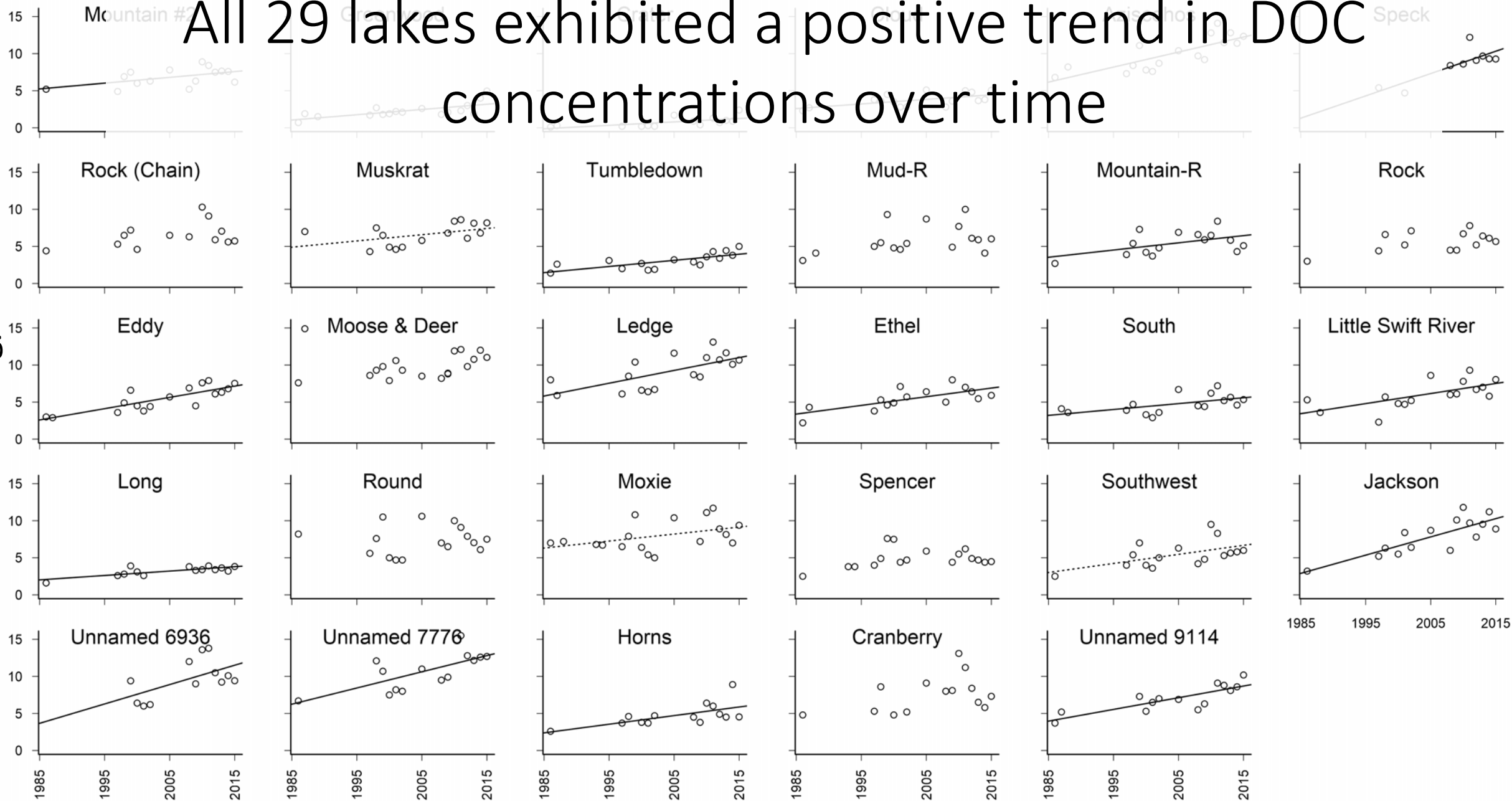
DOC mg/L



Year

All 29 lakes exhibited a positive trend in DOC concentrations over time

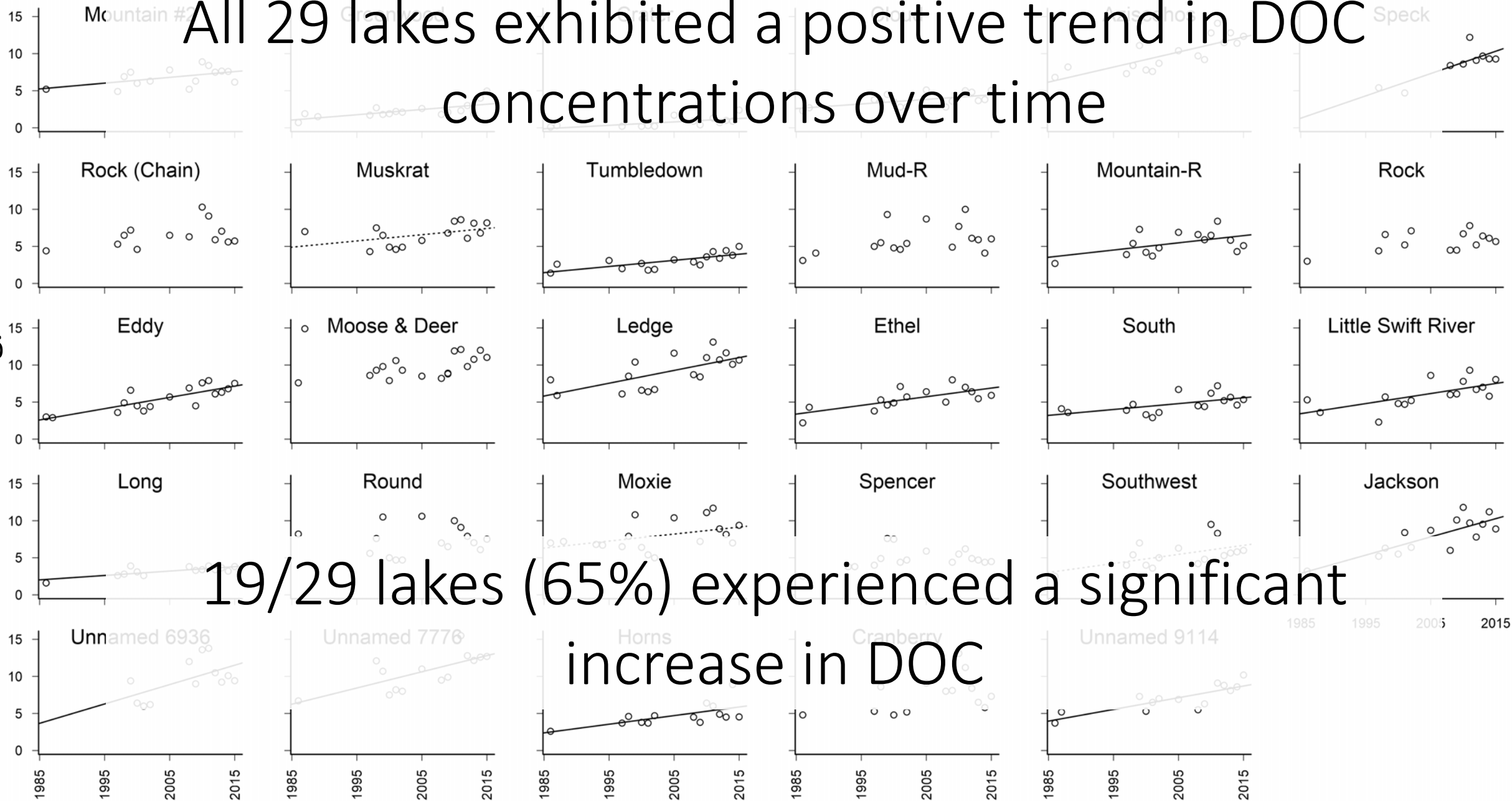
DOC mg/L



Year

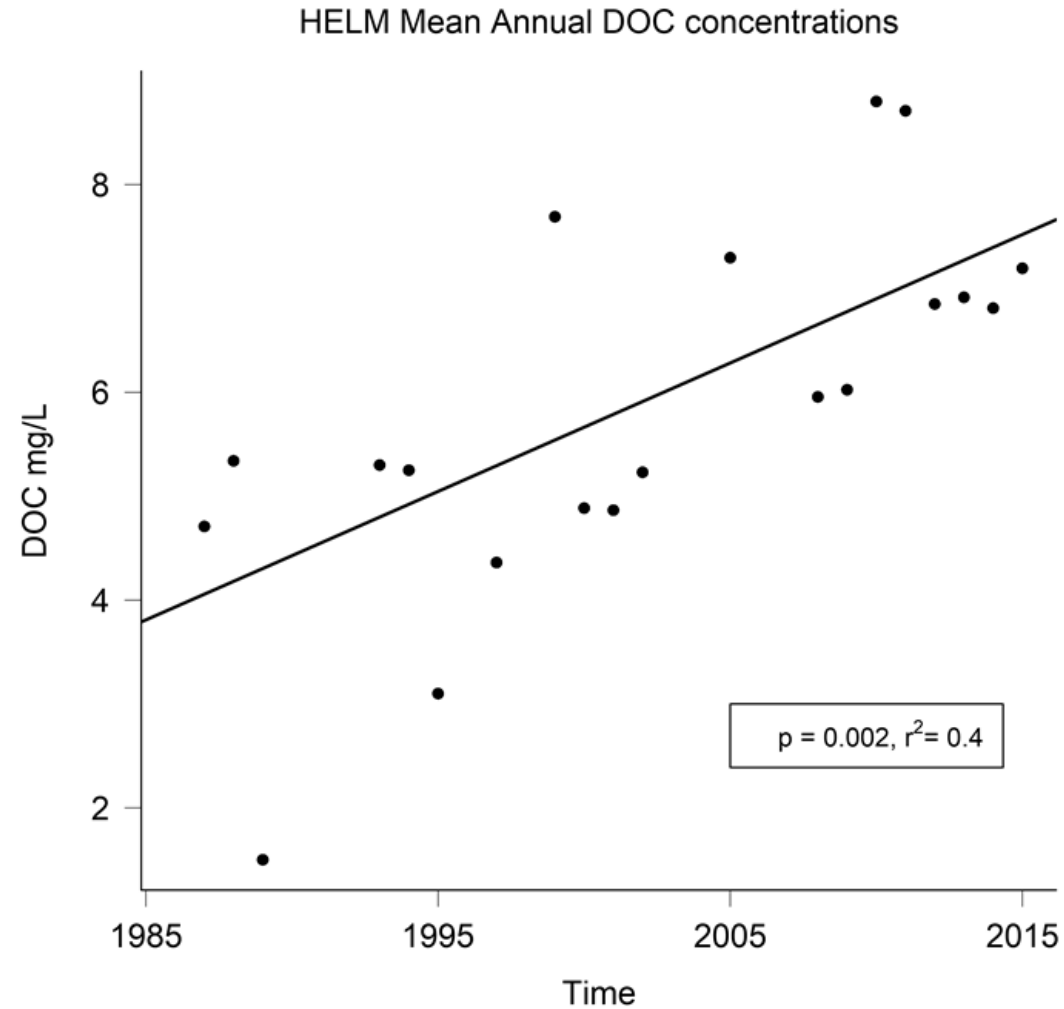
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DOC mg/L



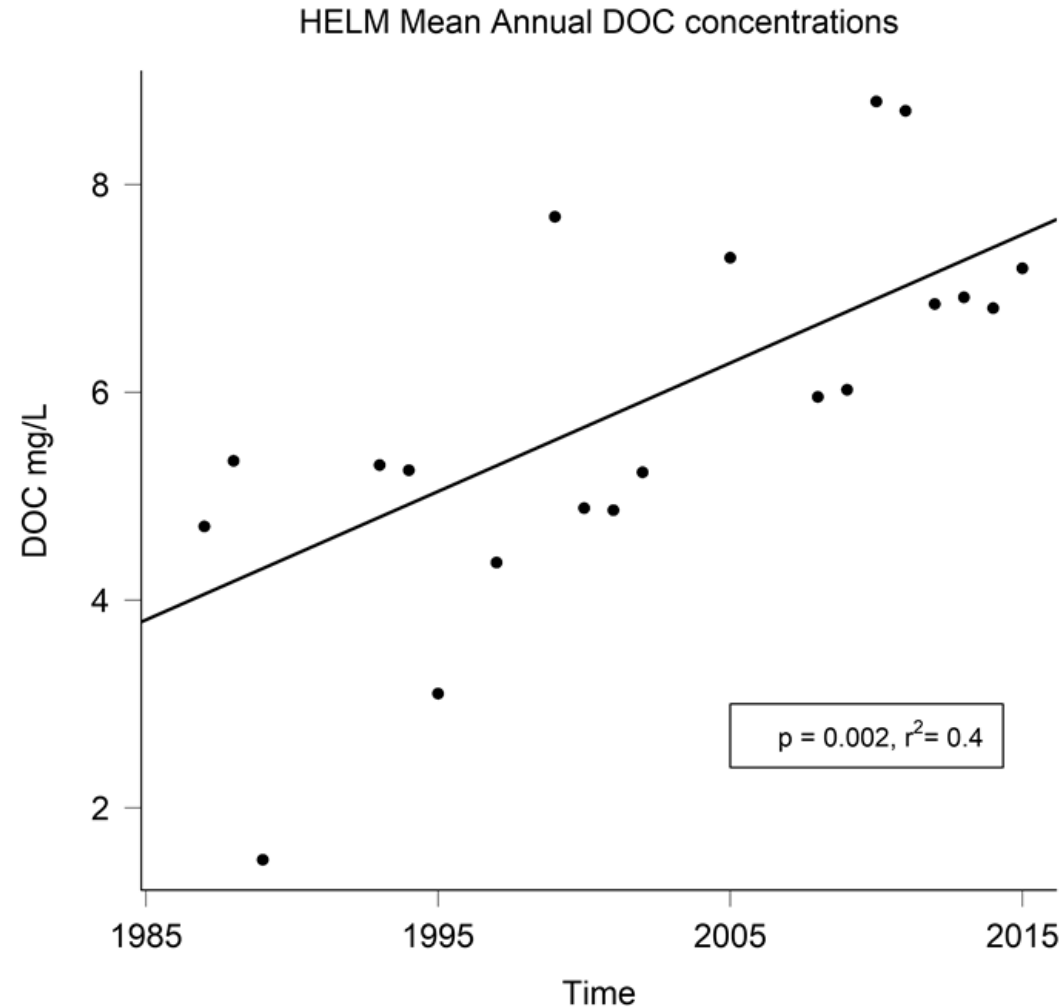
Year

Region-wide increase in DOC shifts the HELM lakes from *low* DOC lakes to *intermediate* DOC lakes



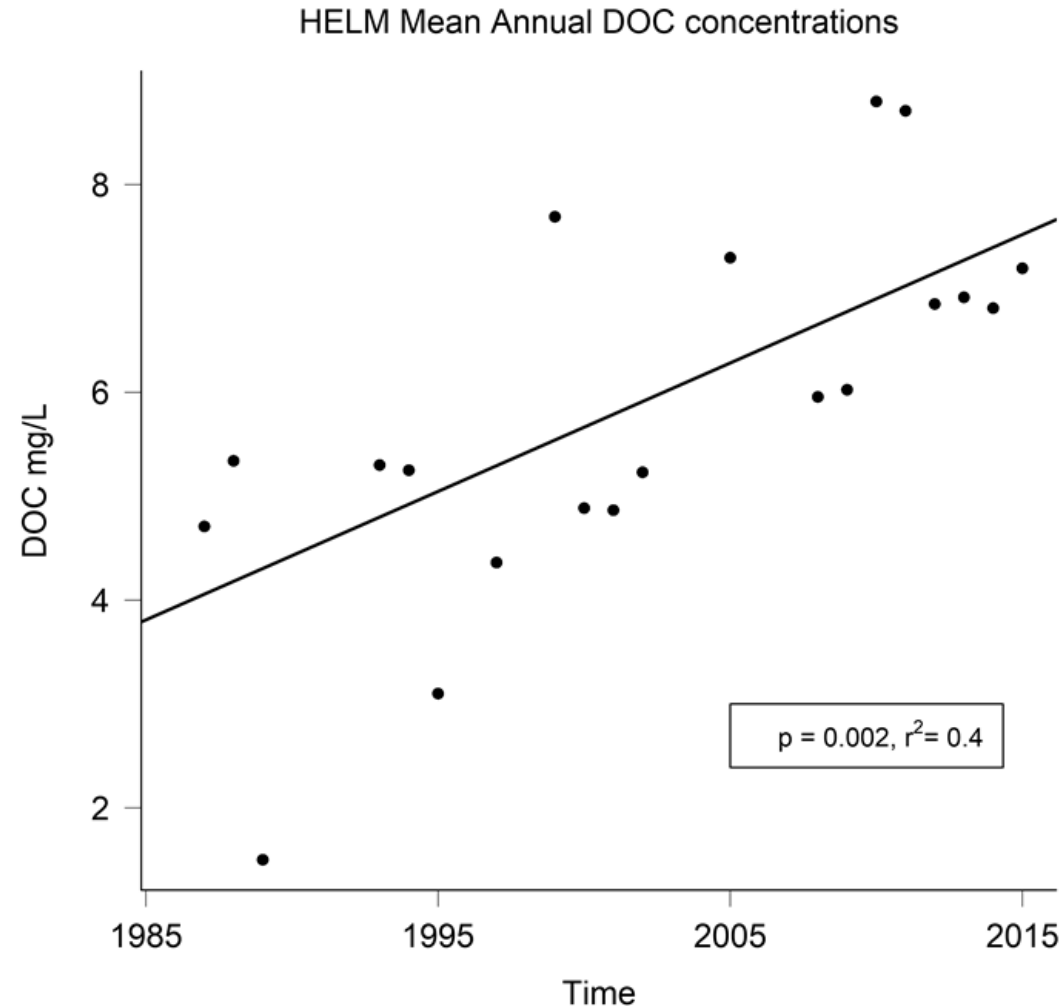
Region-wide increase in DOC shifts the HELM lake set from *low* DOC lakes to *intermediate* DOC lakes

1986
DOC < 5mg/L
17/29 lakes



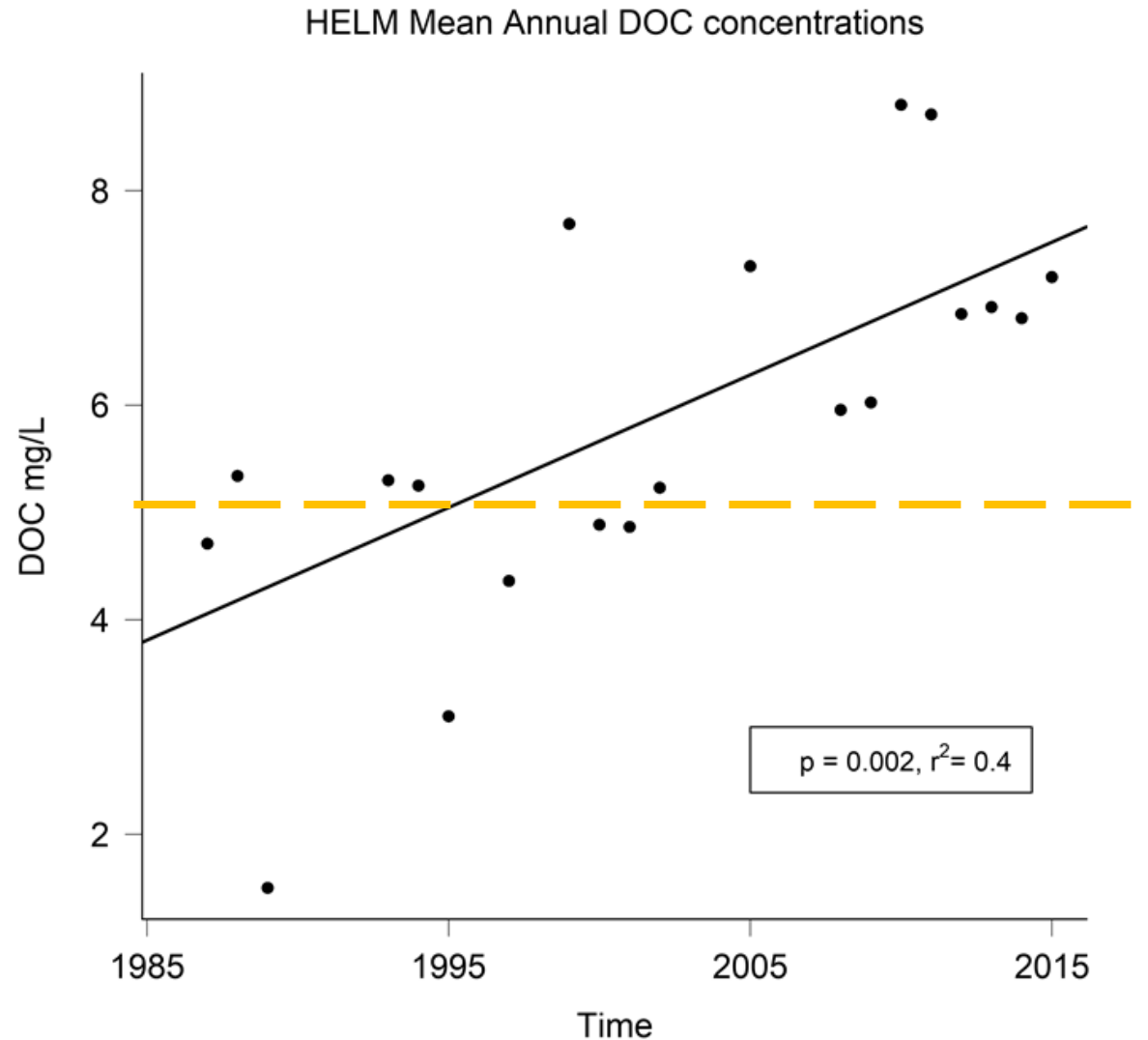
Region-wide increase in DOC shifts the HELM lake set from *low* DOC lakes to *intermediate* DOC lakes

1986
DOC < 5mg/L
17/29 lakes



2015
DOC < 5mg/L
5/29 lakes
*3 of these had DOC > 4.5 mg/L

Region-wide increase in DOC shifts the HELM lakes from *low* DOC lakes to *intermediate* DOC lakes

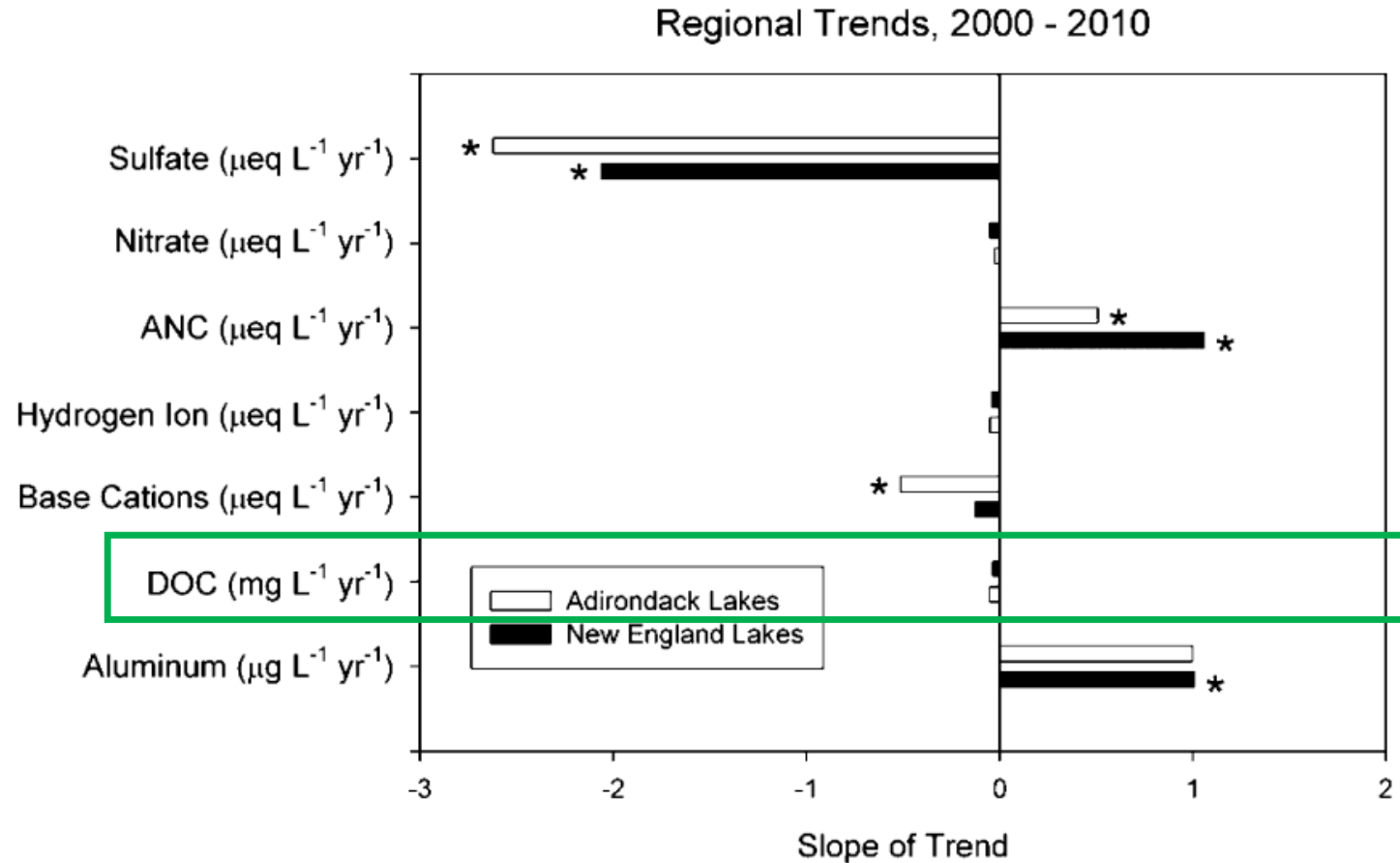


Decadal Trends Reveal Recent Acceleration in the Rate of Recovery from Acidification in the Northeastern U.S.

Kristin E. Strock,^{*,†,‡} Sarah J. Nelson,[‡] Jeffrey S. Kahl,[§] Jasmine E. Saros,[†] and William H. McDowell^{||}

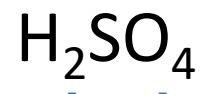
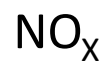
Between 2000 and 2010:

7/74 (9%) lakes in this study demonstrated significant increasing trends in DOC

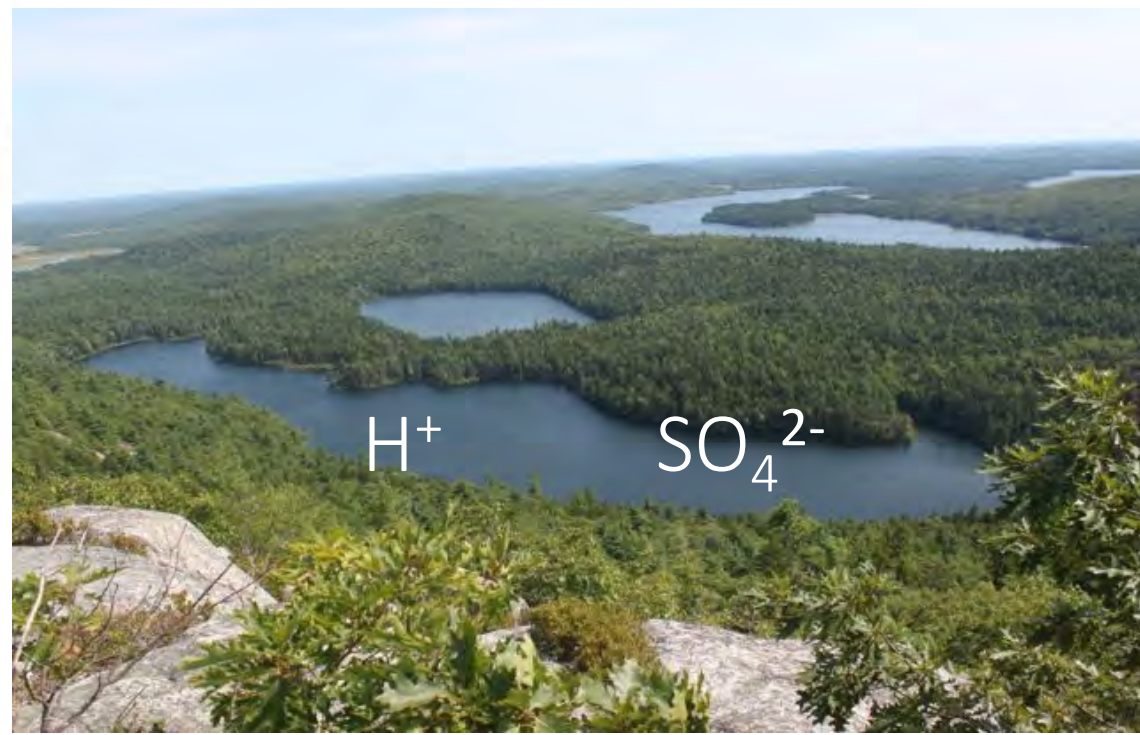
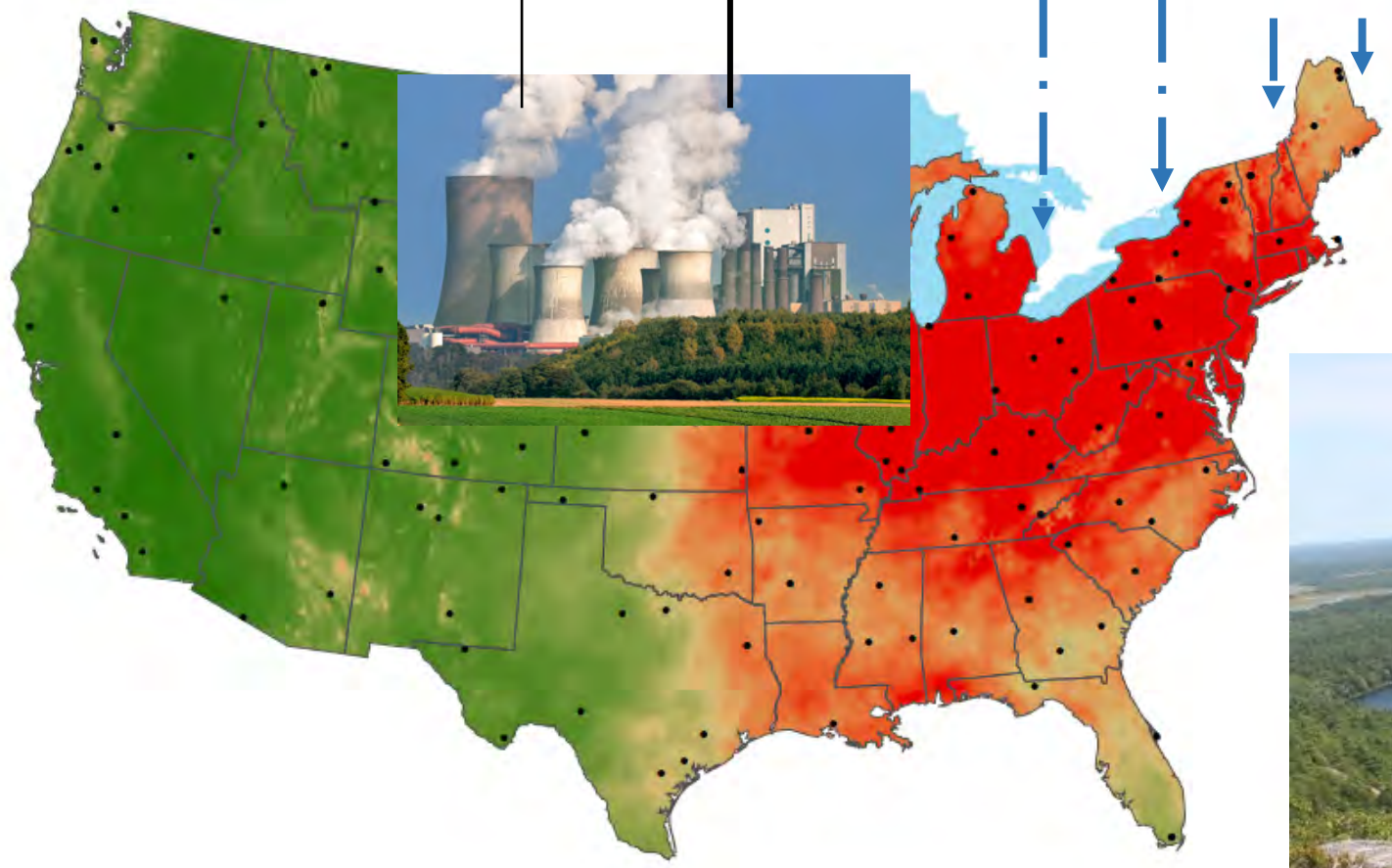


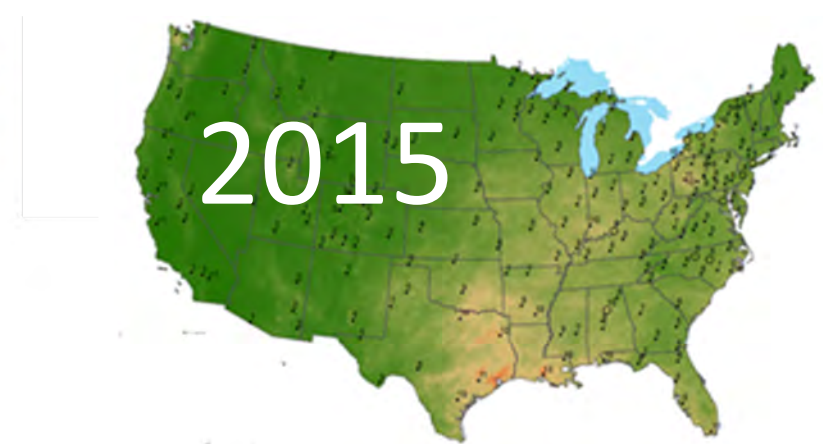
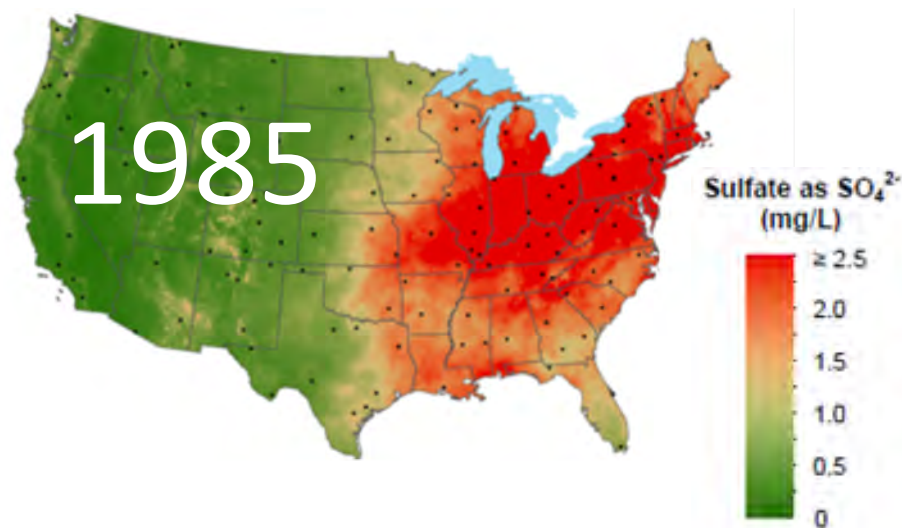
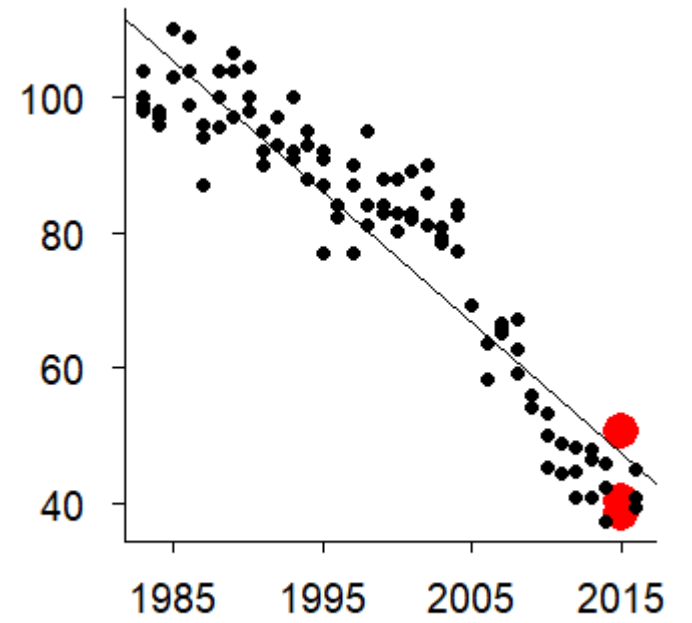
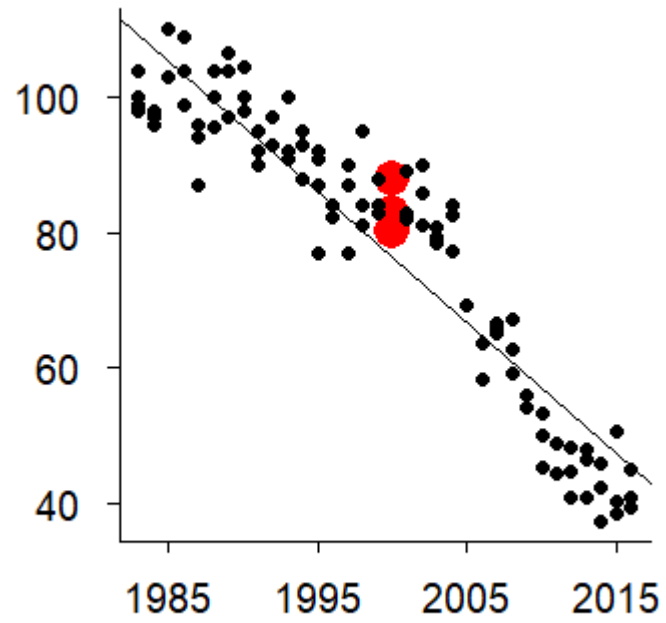
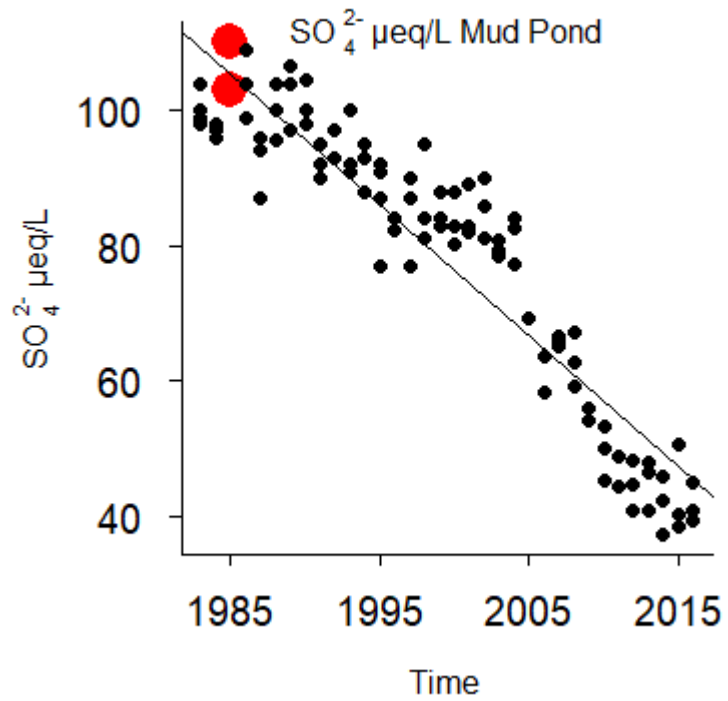
Why is DOC increasing?



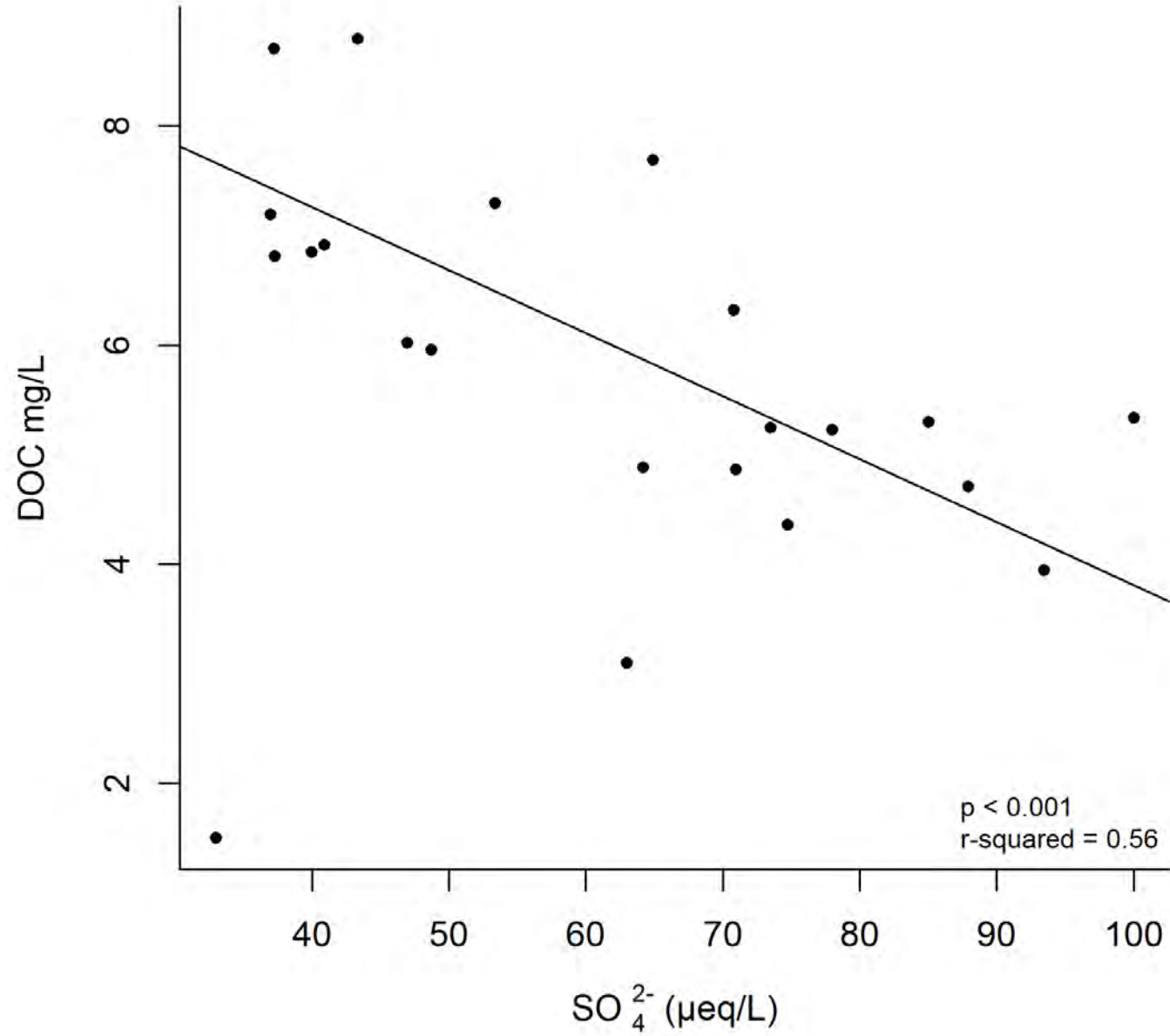


ACID RAIN





HELM Lakes



Chemistry of Maine's High Elevation Lakes: Results from the HELM Project

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Note: (Data are means, except for pH, for which median is also listed. Mean pH is calculated from the mean H⁺ concentration.)

^a marine aerosol corrected

SOLAR RADIATION
Temperature Increase

PRECIPITATION
Increased variability
More frequent, intense storms

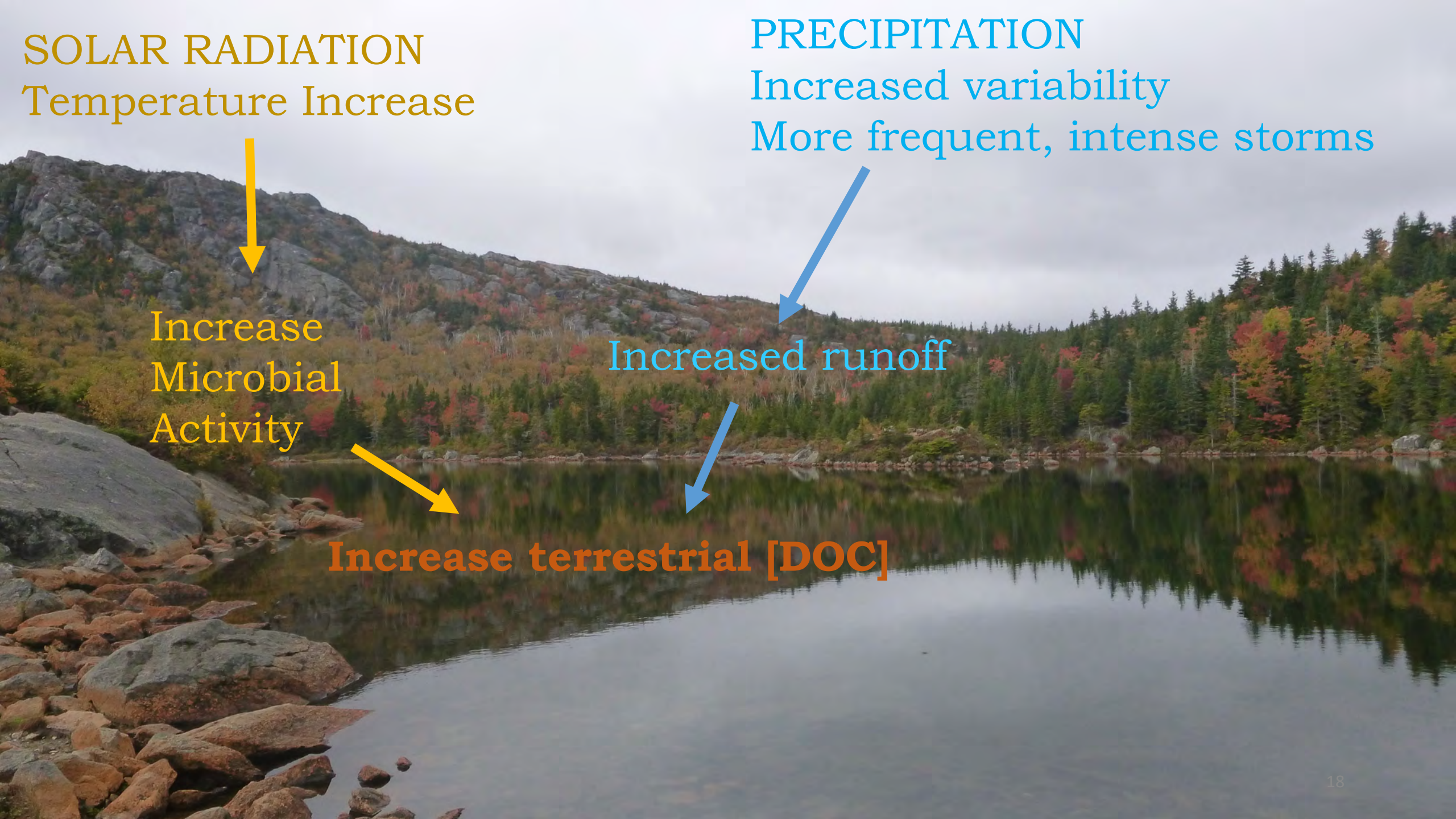


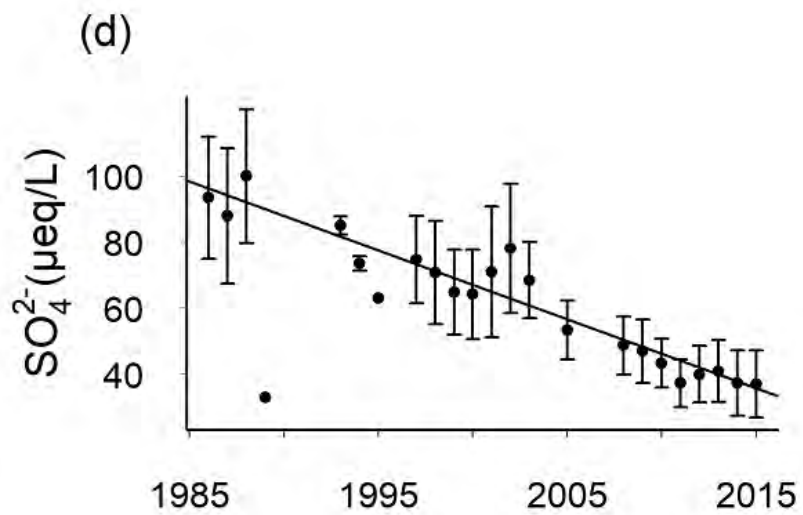
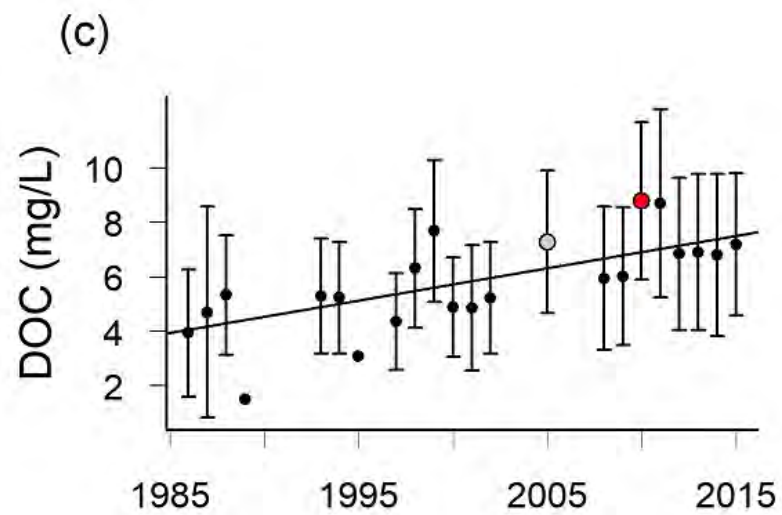
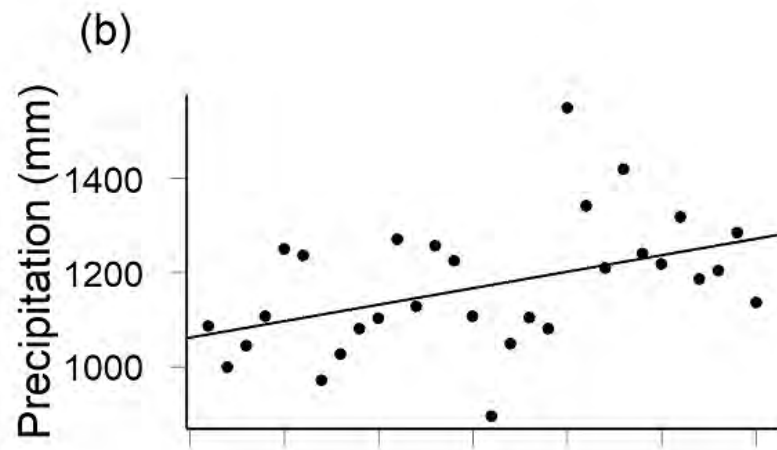
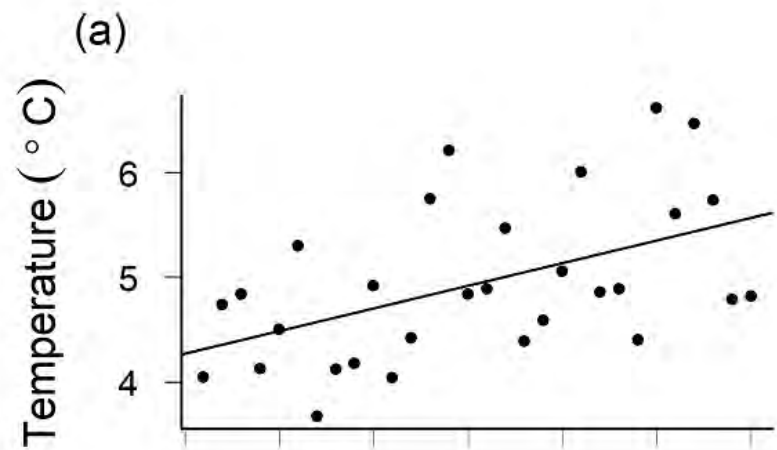
**Increase
Microbial
Activity**

Increased runoff

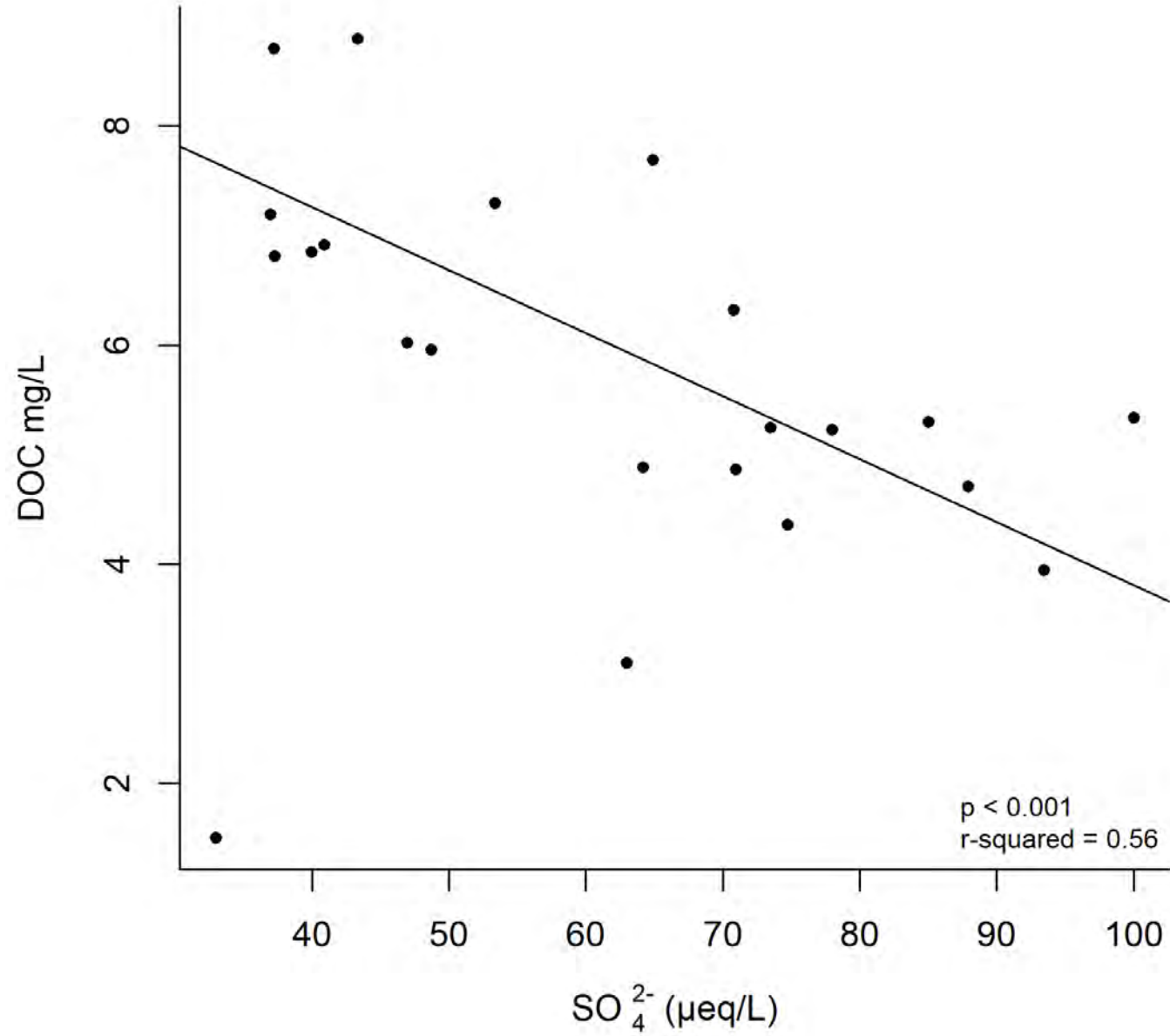


Increase terrestrial [DOC]

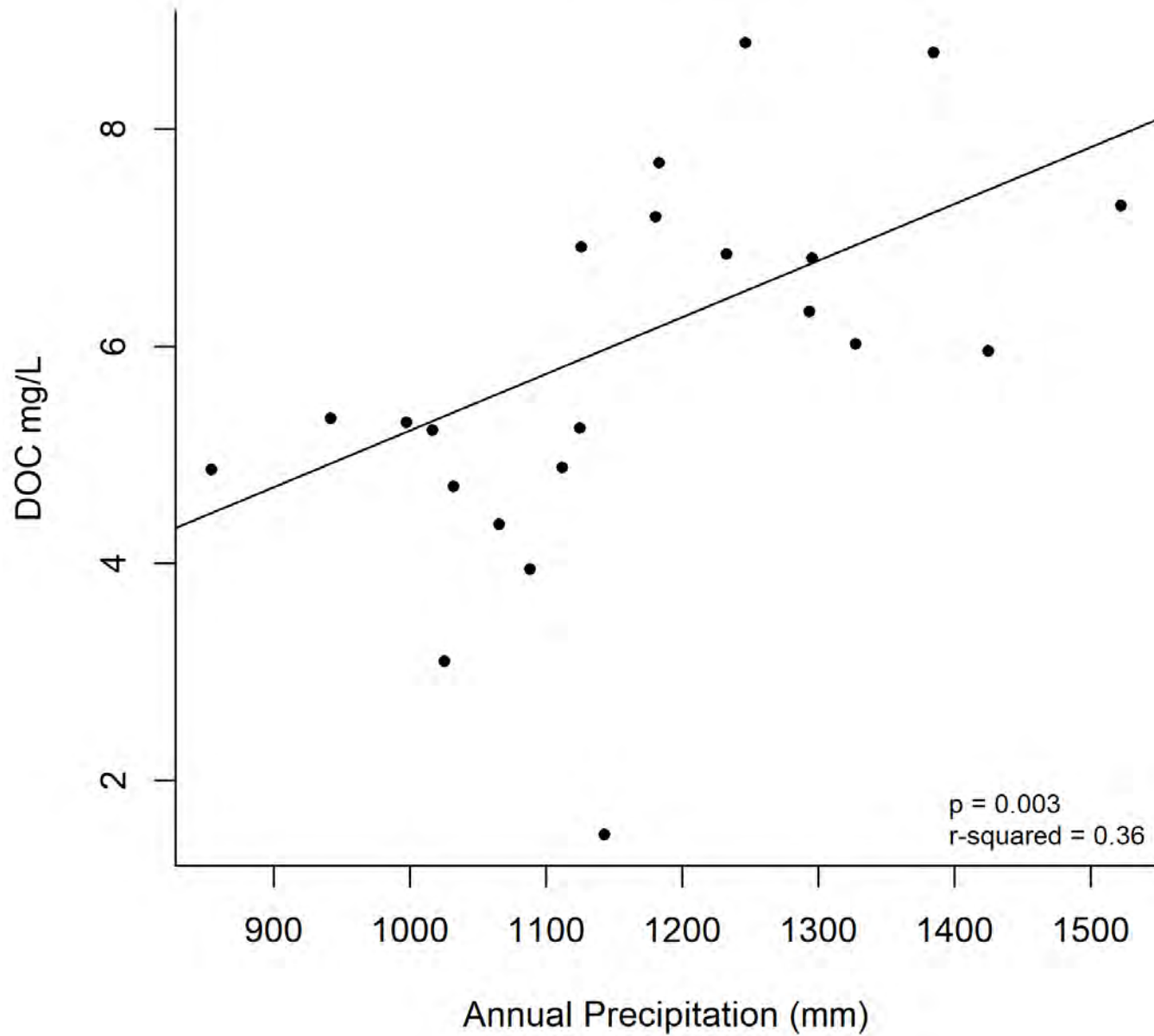




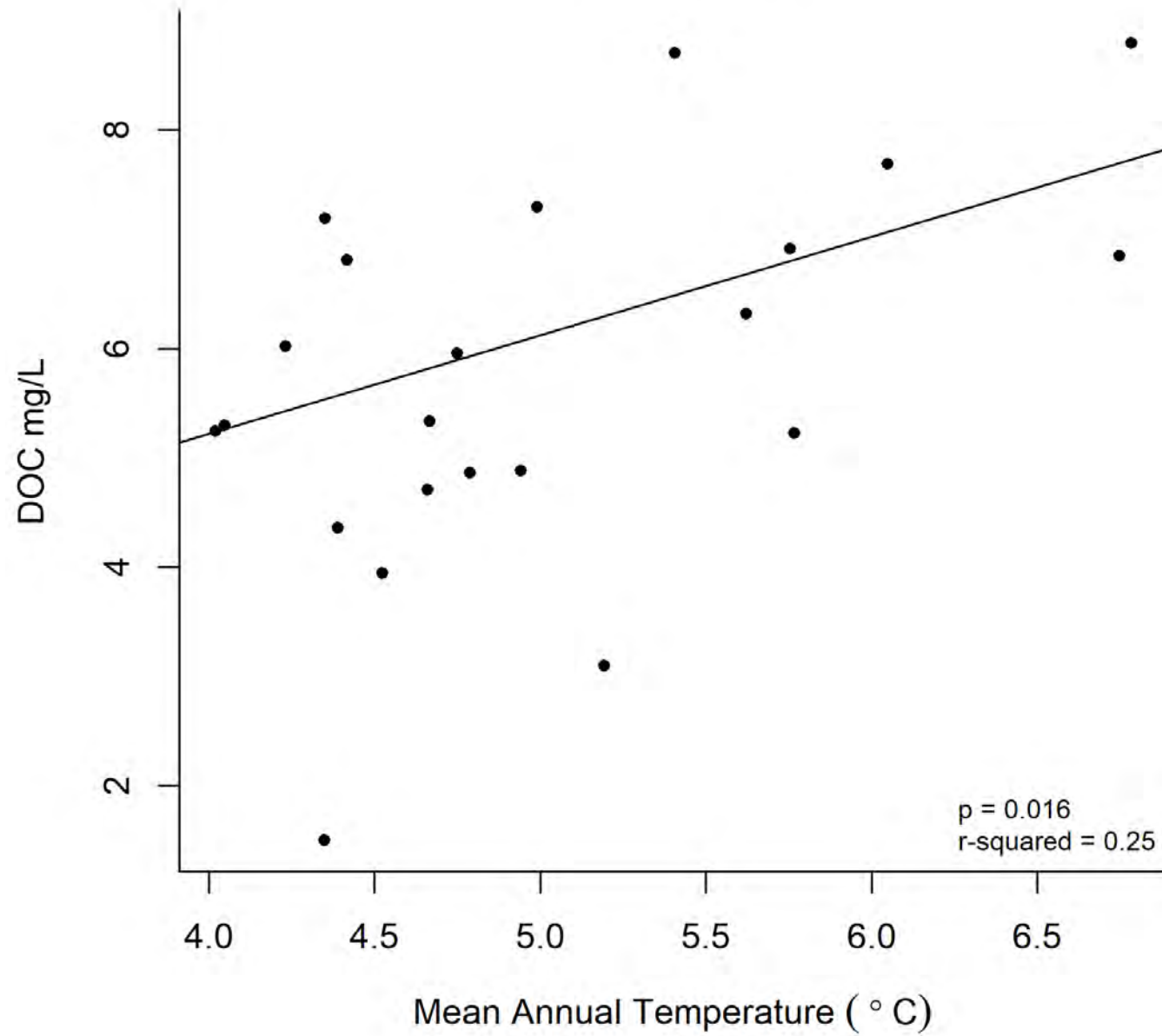
HELM Lakes



HELM Lakes



HELM Lakes



Linear Mixed Effect Model

	Scaled		r^2
	Estimates	p - value	
log SO ₄ ²⁻	-0.361368	0.000000	
Fall Precipitation	0.135331	0.000003	
Fall Temperature	0.112383	0.001828	
Summer Precipitation	-0.064650	0.012057	
Summer Temperature	-0.008524	0.840793	
Winter Precipitation	0.048151	0.072882	
Winter Temperature	0.032248	0.292531	
Spring Precipitation	-0.004392	0.866057	
Spring Temperature	0.073512	0.003223	

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SO₄²⁻ and seasonal climate variables explain 78% of DOC variability

0.78

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Strong control of SO₄²⁻ when compared to other individual drivers

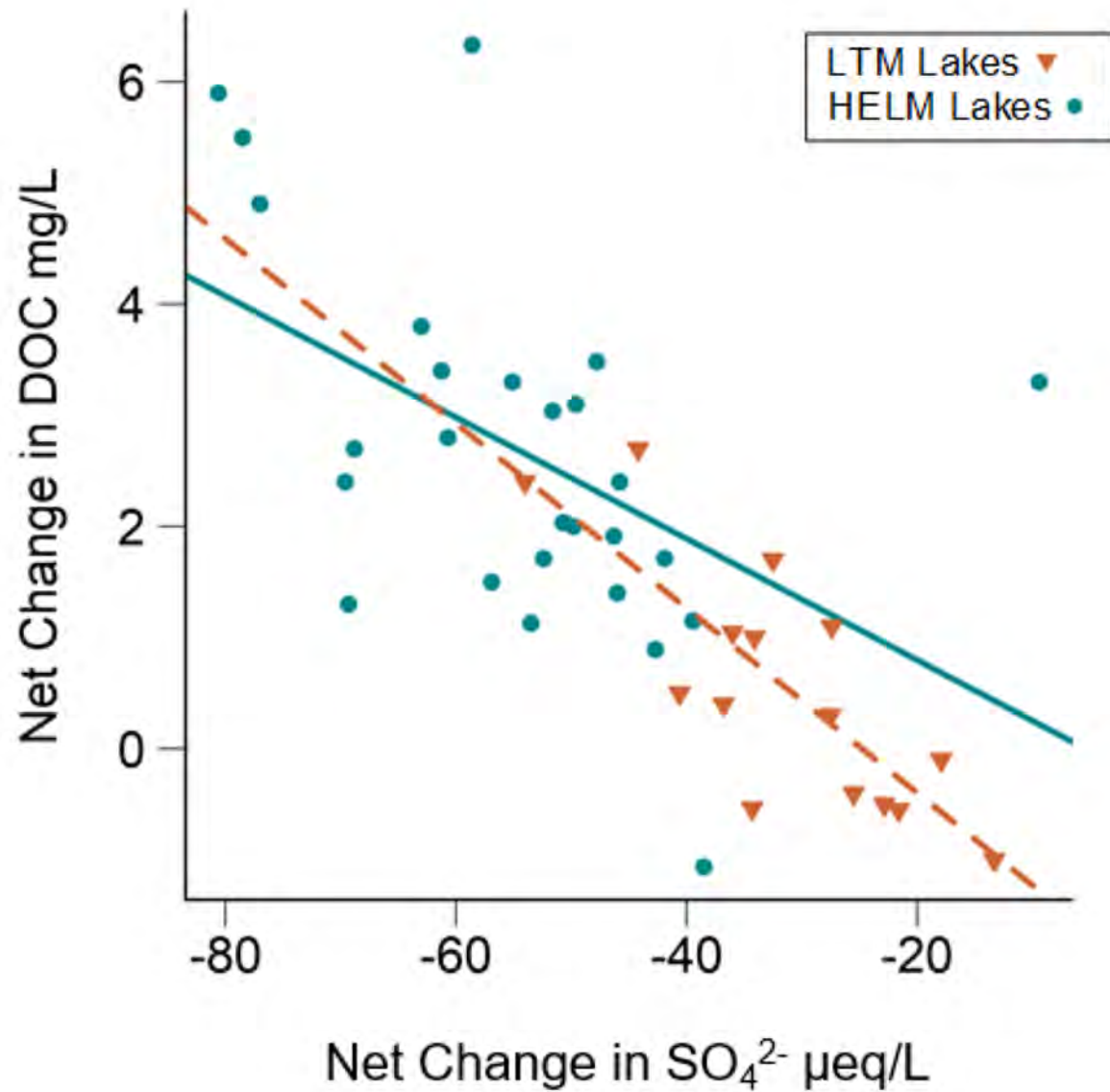
0.78

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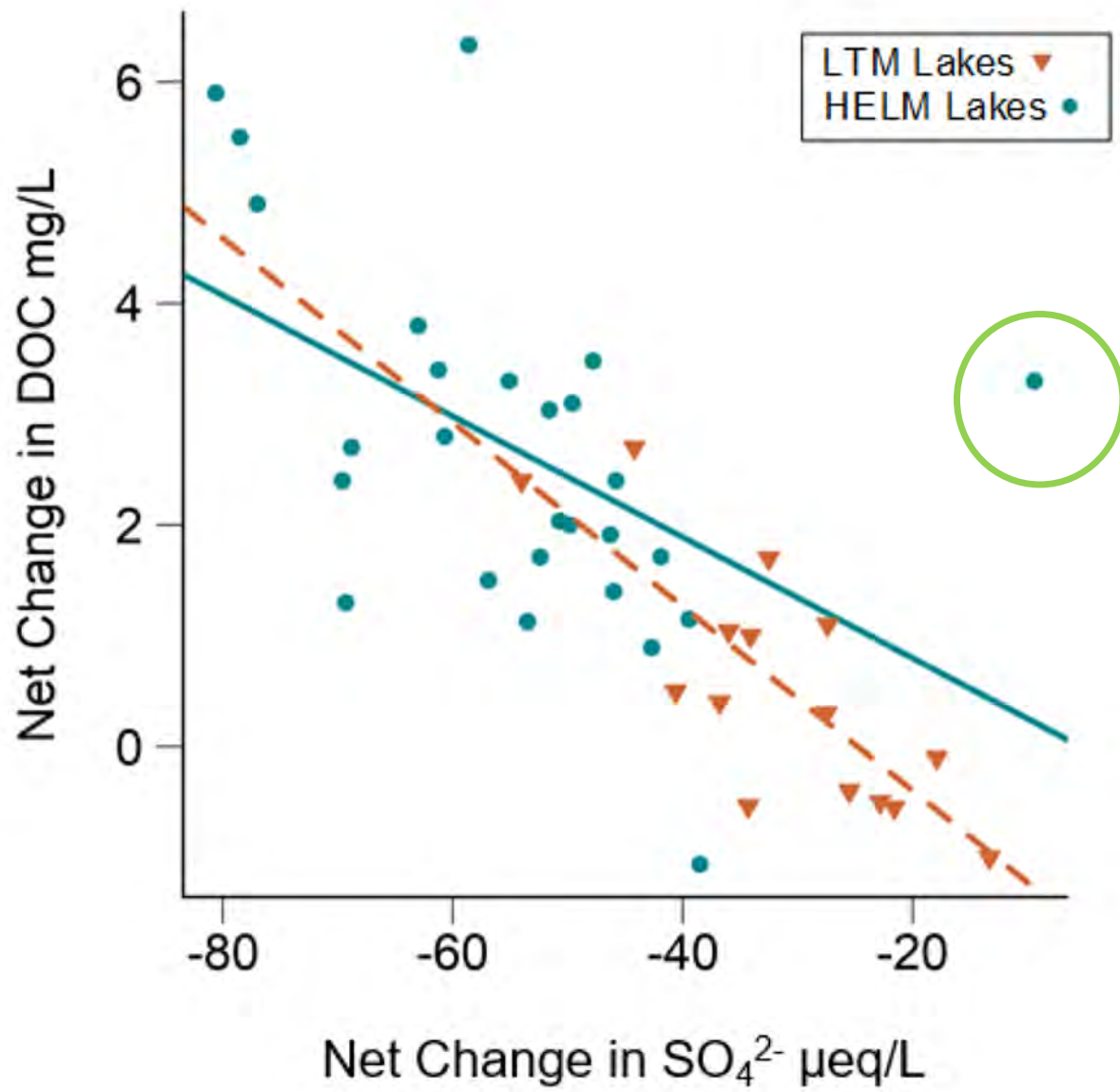
When climate variables are combined, have a similar effect size to SO₄²⁻

0.78



HELM lake trend
($p = 0.009$, $r^2 = 0.24$)

LTM trend
($p = 0.0004$, $r^2 = 0.62$)



Gavin et al., 2018, in press

Weather Case Study

October 1997

November 1997

34% mean October rainfall
since 1895

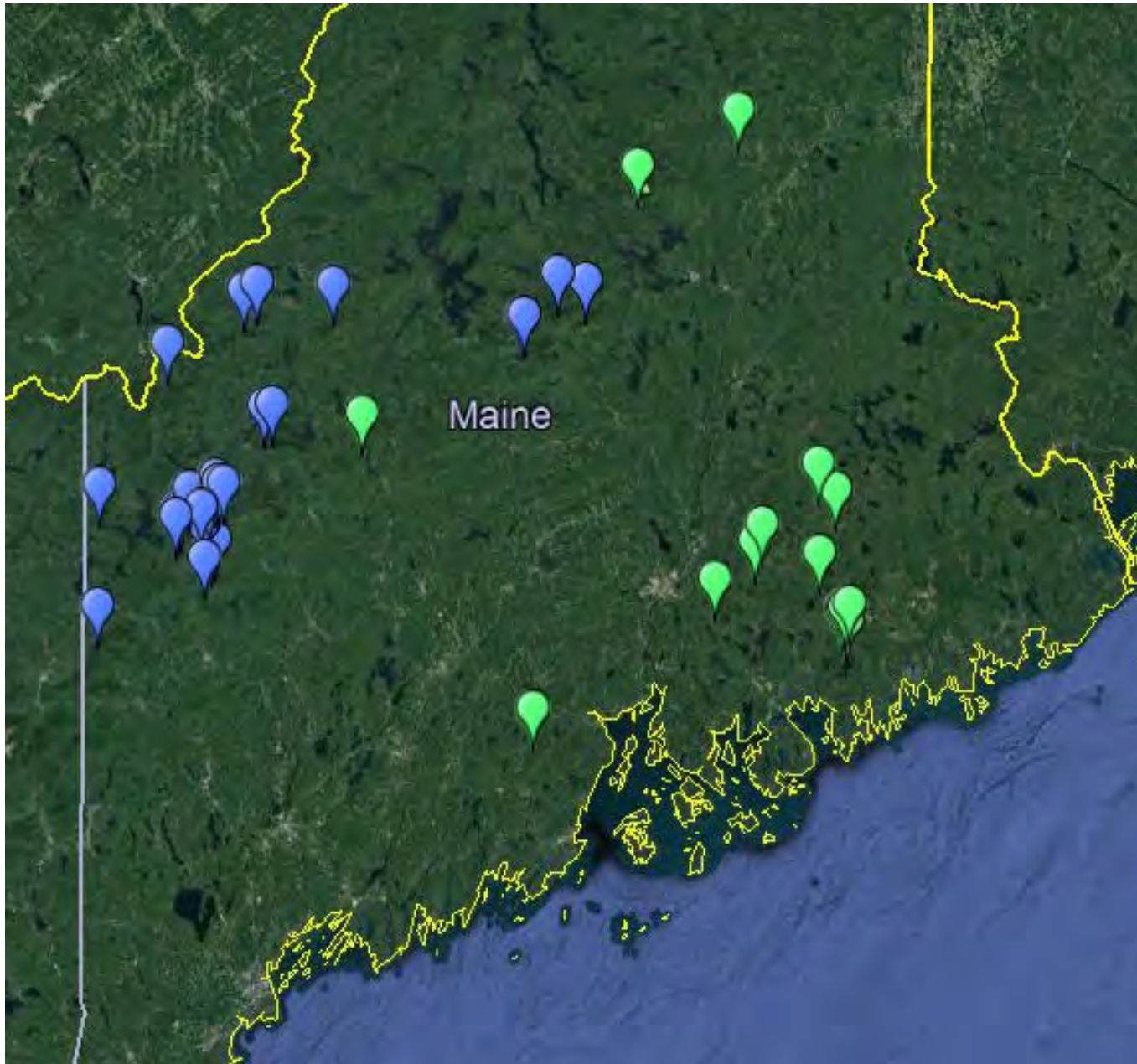


116 mm of rain, wettest
month of the year

Mean [DOC] 4.4 mg/L



Mean [DOC] 7.7 mg/L



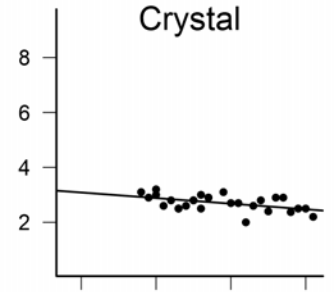
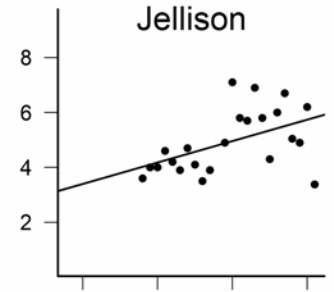
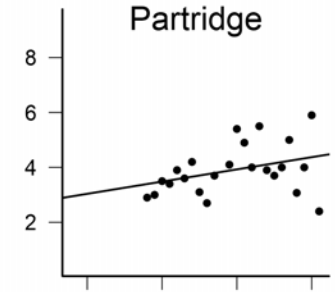
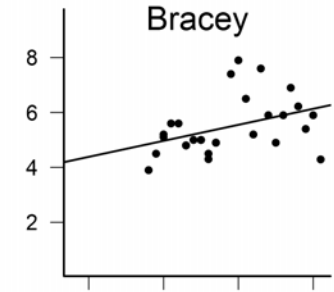
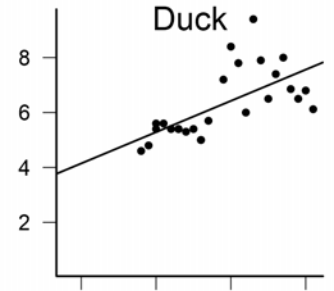
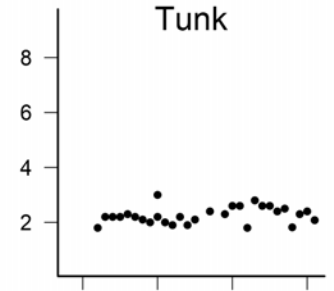
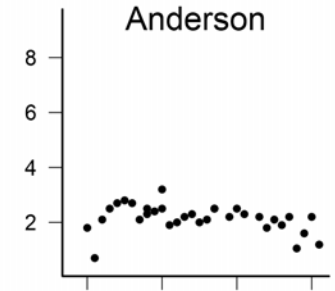
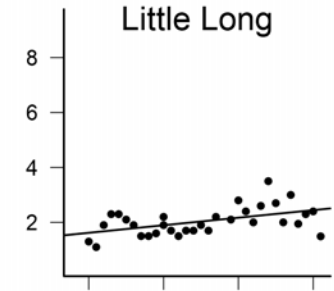
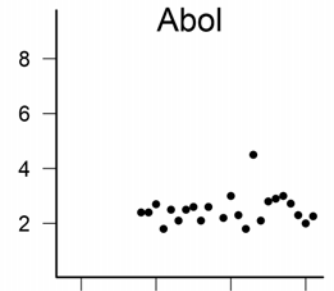
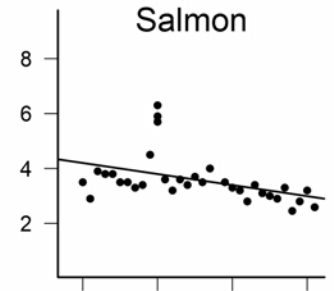
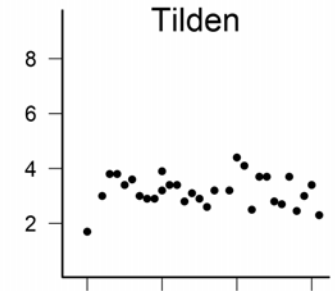
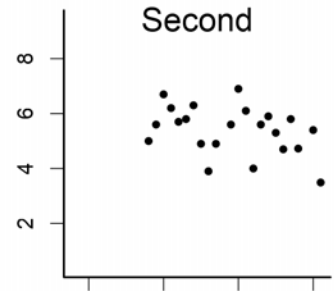
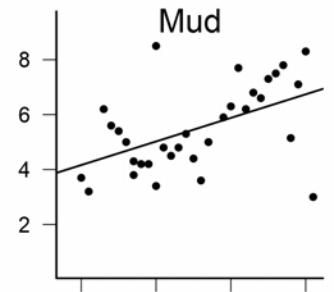
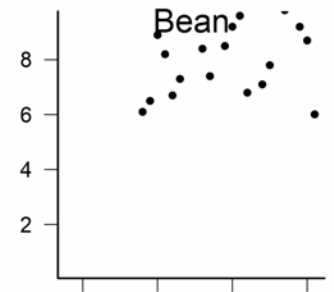
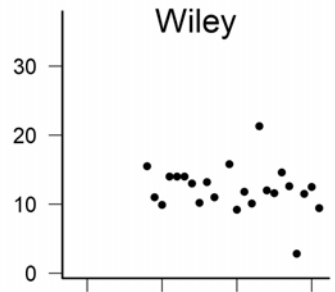
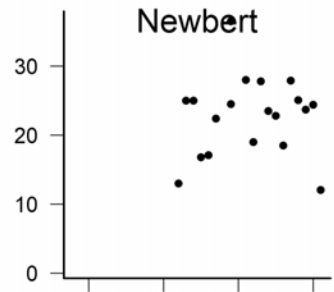
16 Regional Long-Term Monitoring (RLTM) Lakes



29 High Elevation Lake Monitoring (HELM) Lakes

RLTM Fall DOC Trends

DOC mg/L



1985 1995 2005 2015

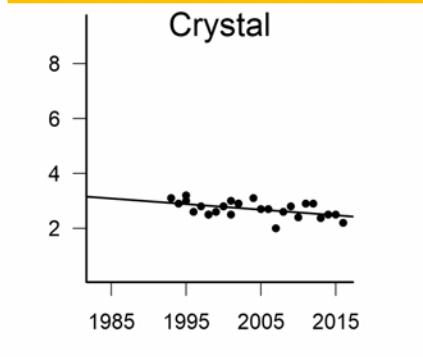
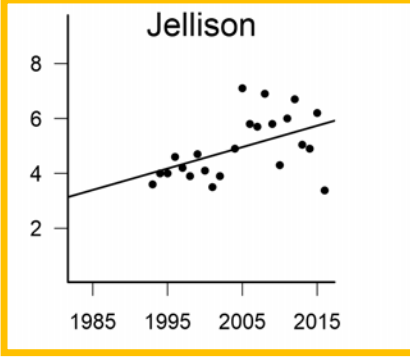
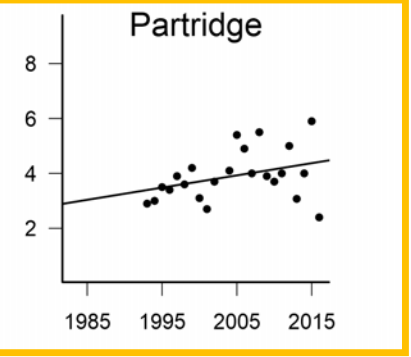
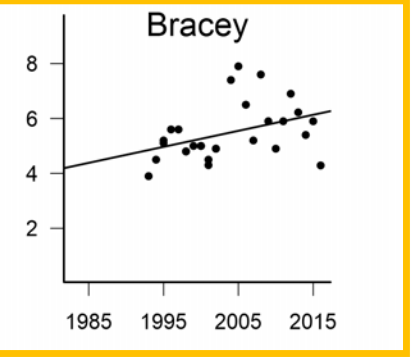
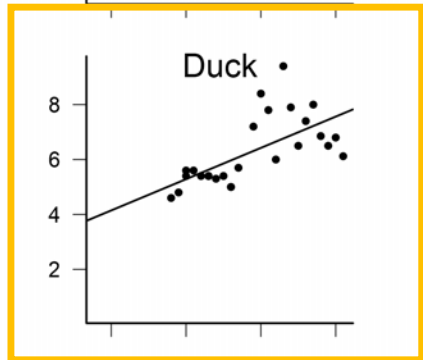
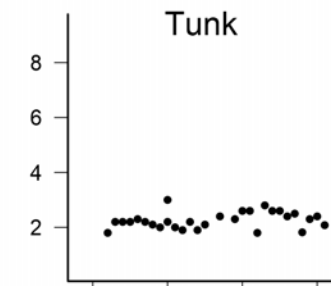
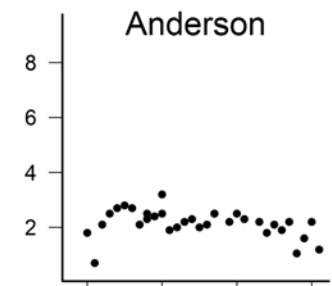
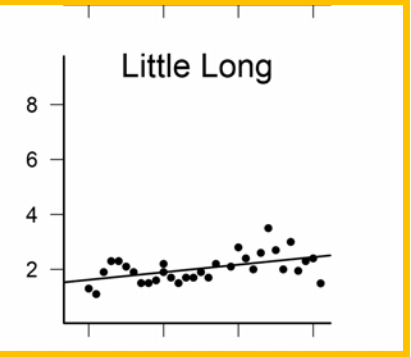
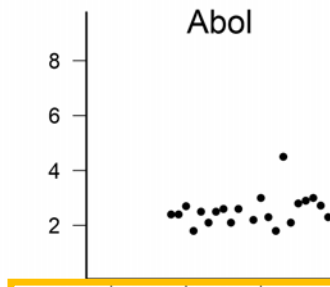
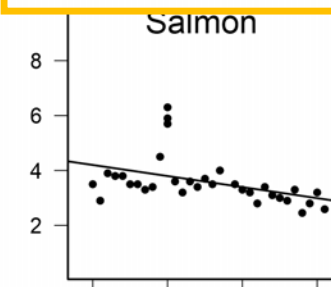
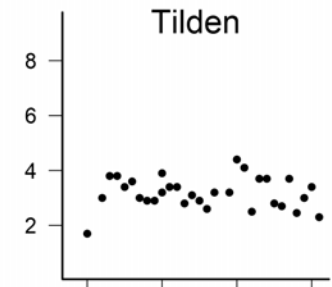
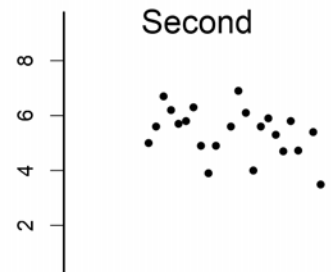
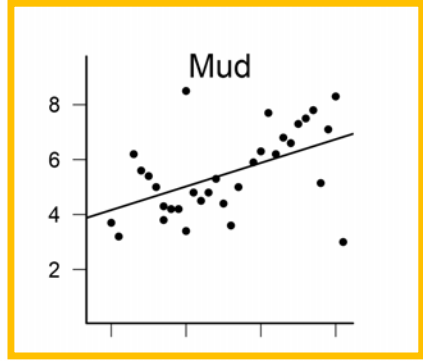
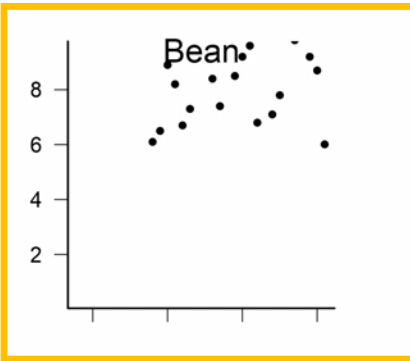
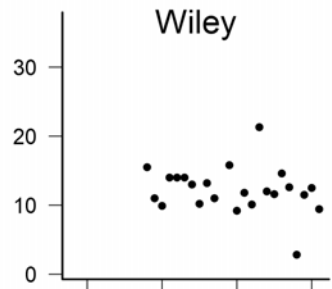
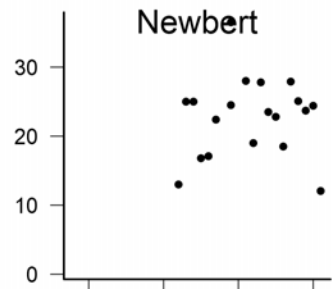
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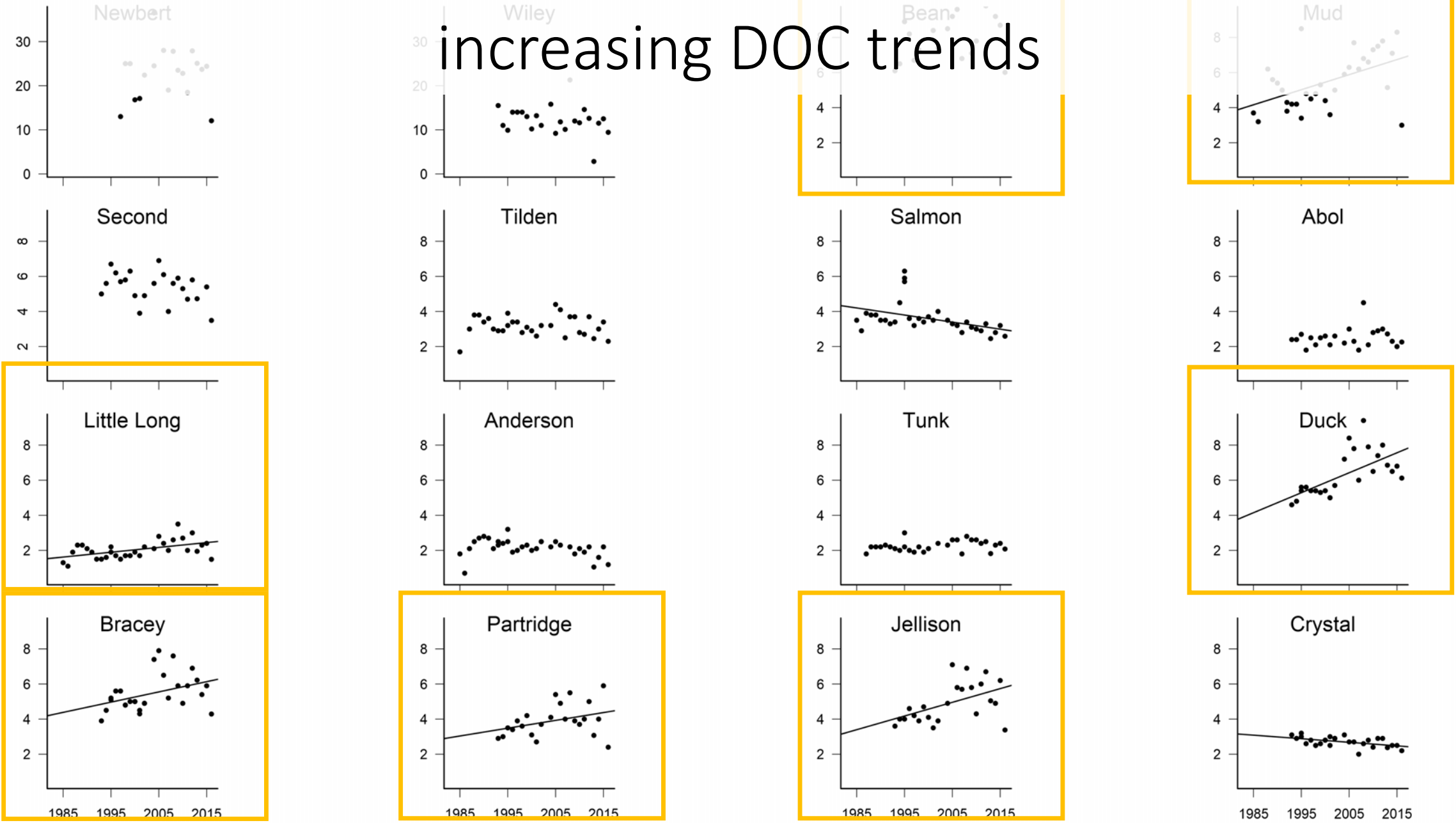
RLTM Fall DOC Trends

DOC mg/L



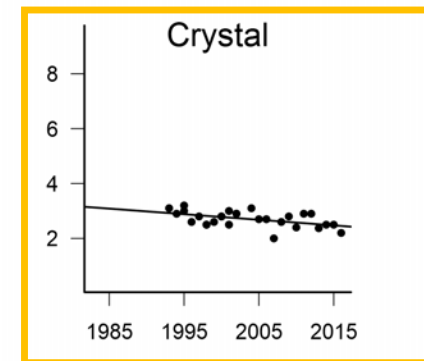
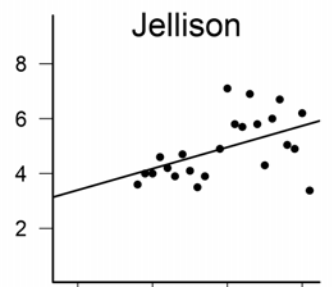
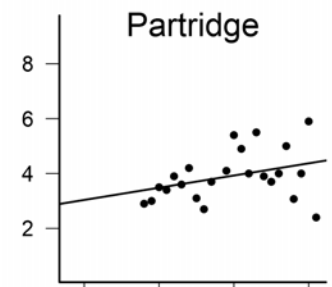
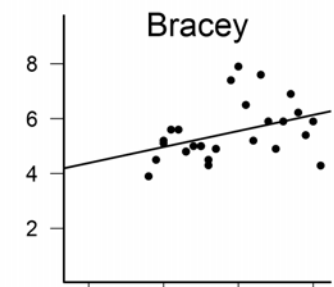
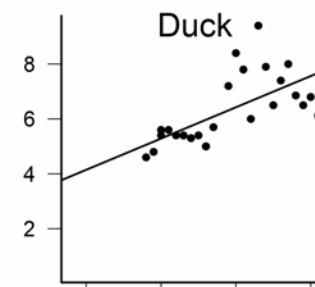
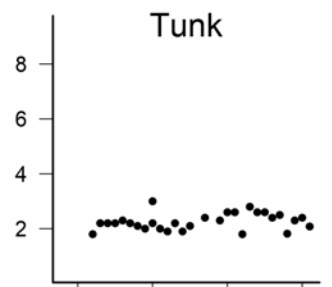
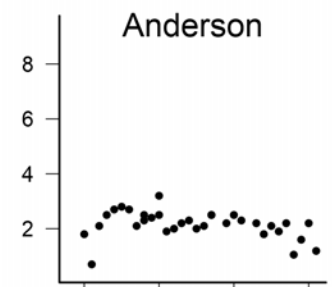
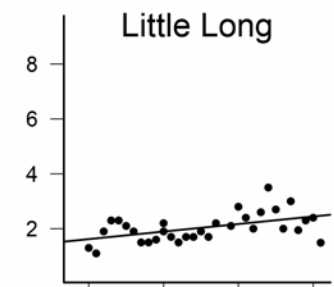
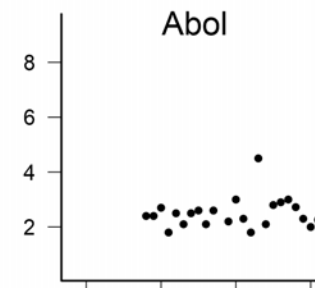
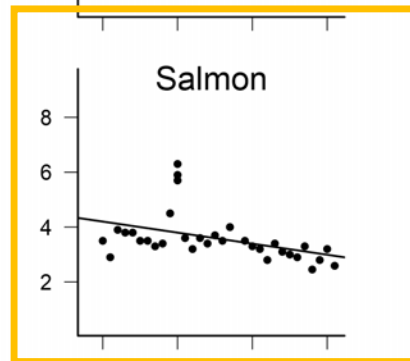
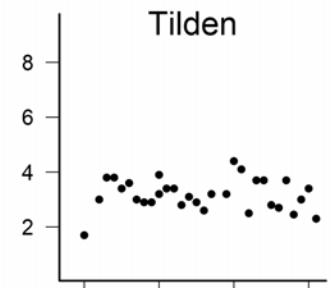
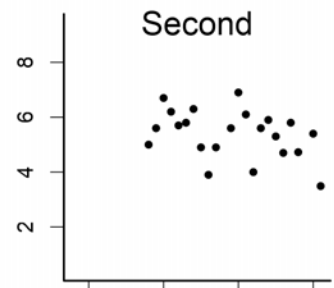
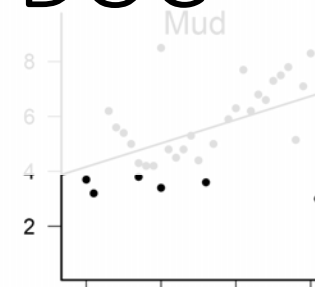
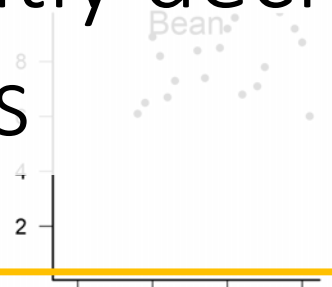
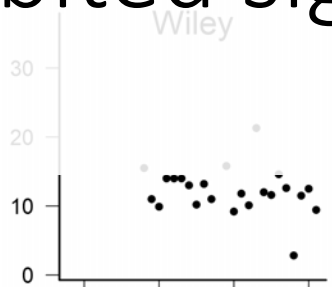
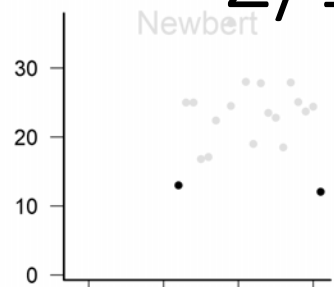
7/16 (43%) lakes exhibited significantly increasing DOC trends

DOC mg/L



2/16 exhibited significantly decreasing DOC trends

DOC mg/L



1985 1995 2005 2015

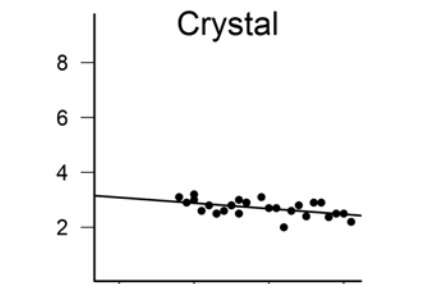
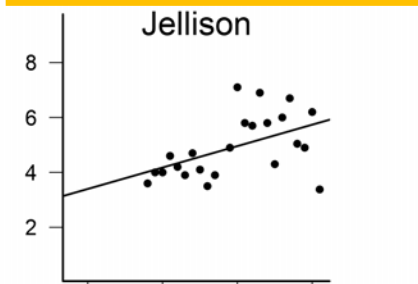
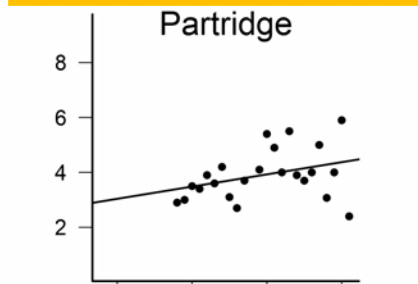
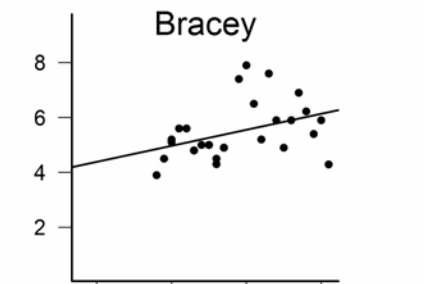
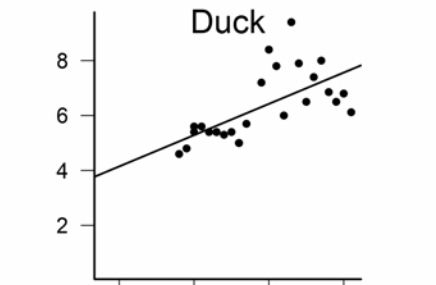
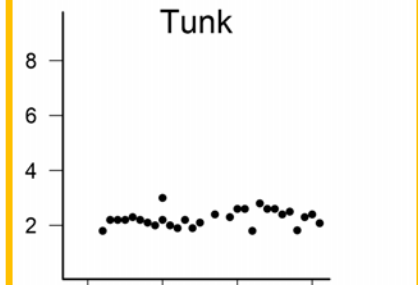
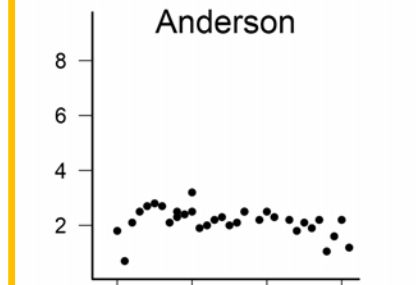
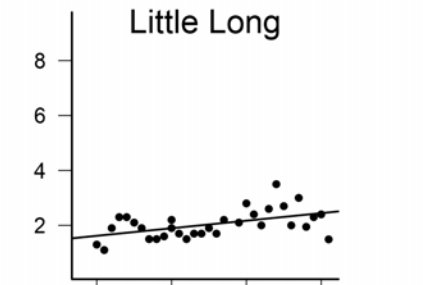
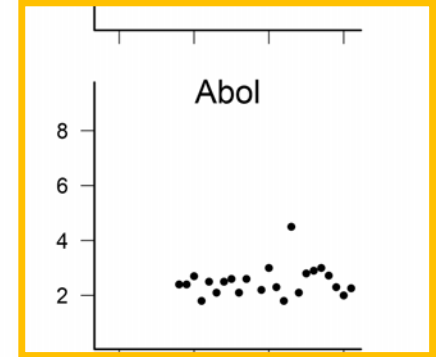
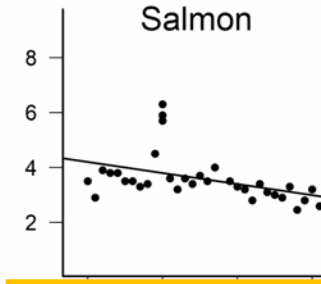
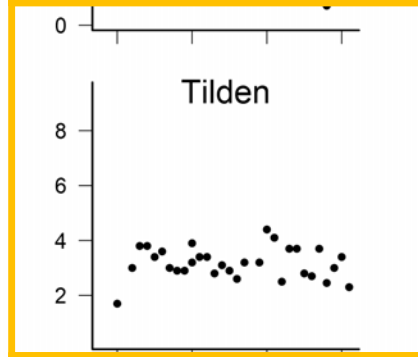
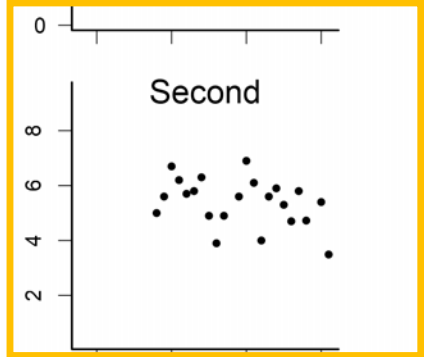
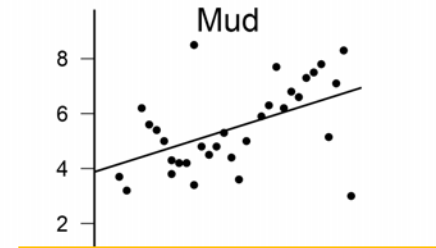
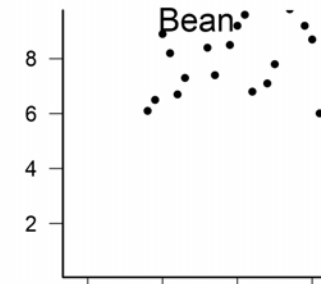
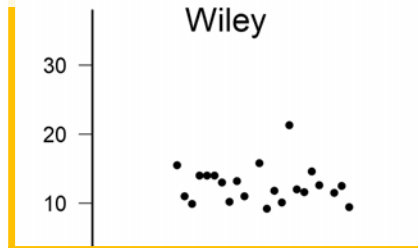
1985 1995 2005 2015

1985 1995 2005 2015

1985 1995 2005 2015

7/16 (43%) lakes exhibited no change in DOC

DOC mg/L



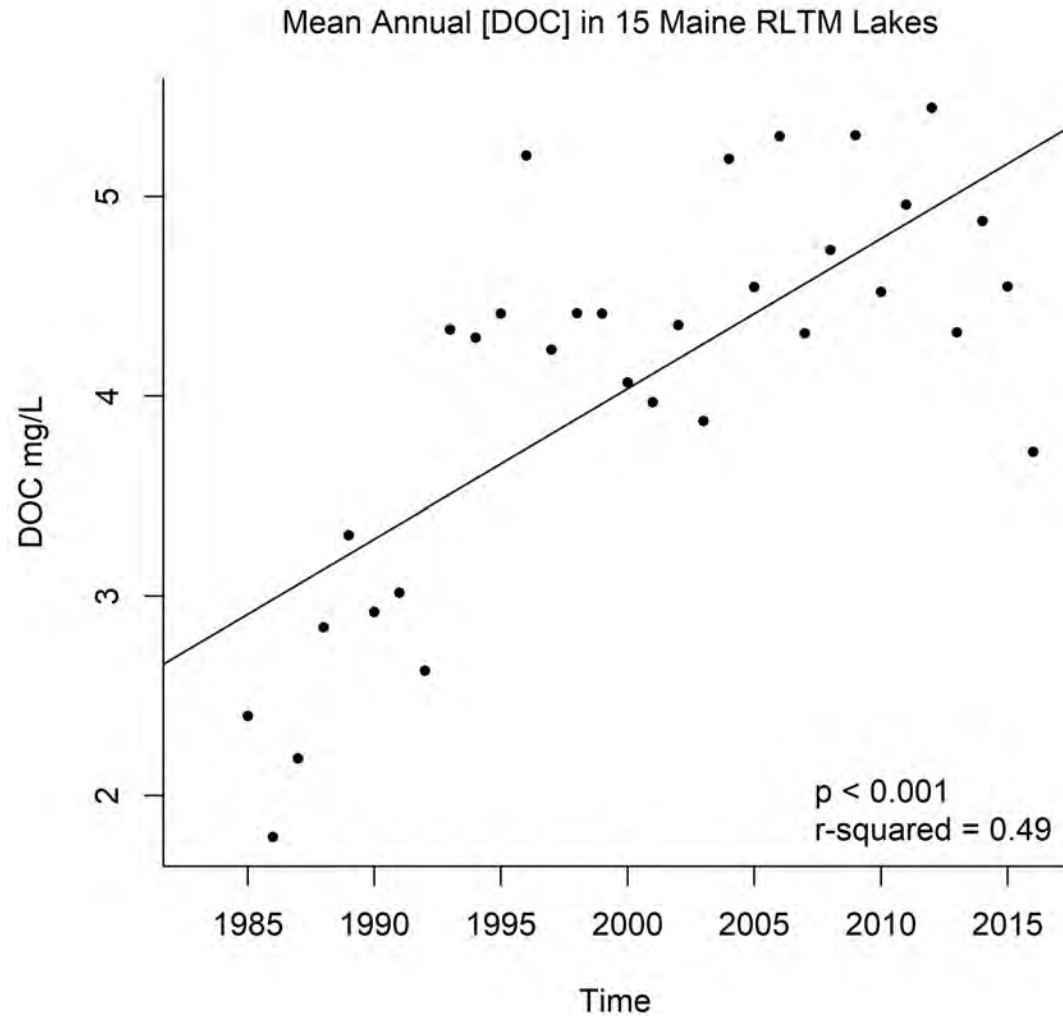
1985 1995 2005 2015

1985 1995 2005 2015

1985 1995 2005 2015

1985 1995 2005 2015

Physical Response: Implications for Increasing DOC



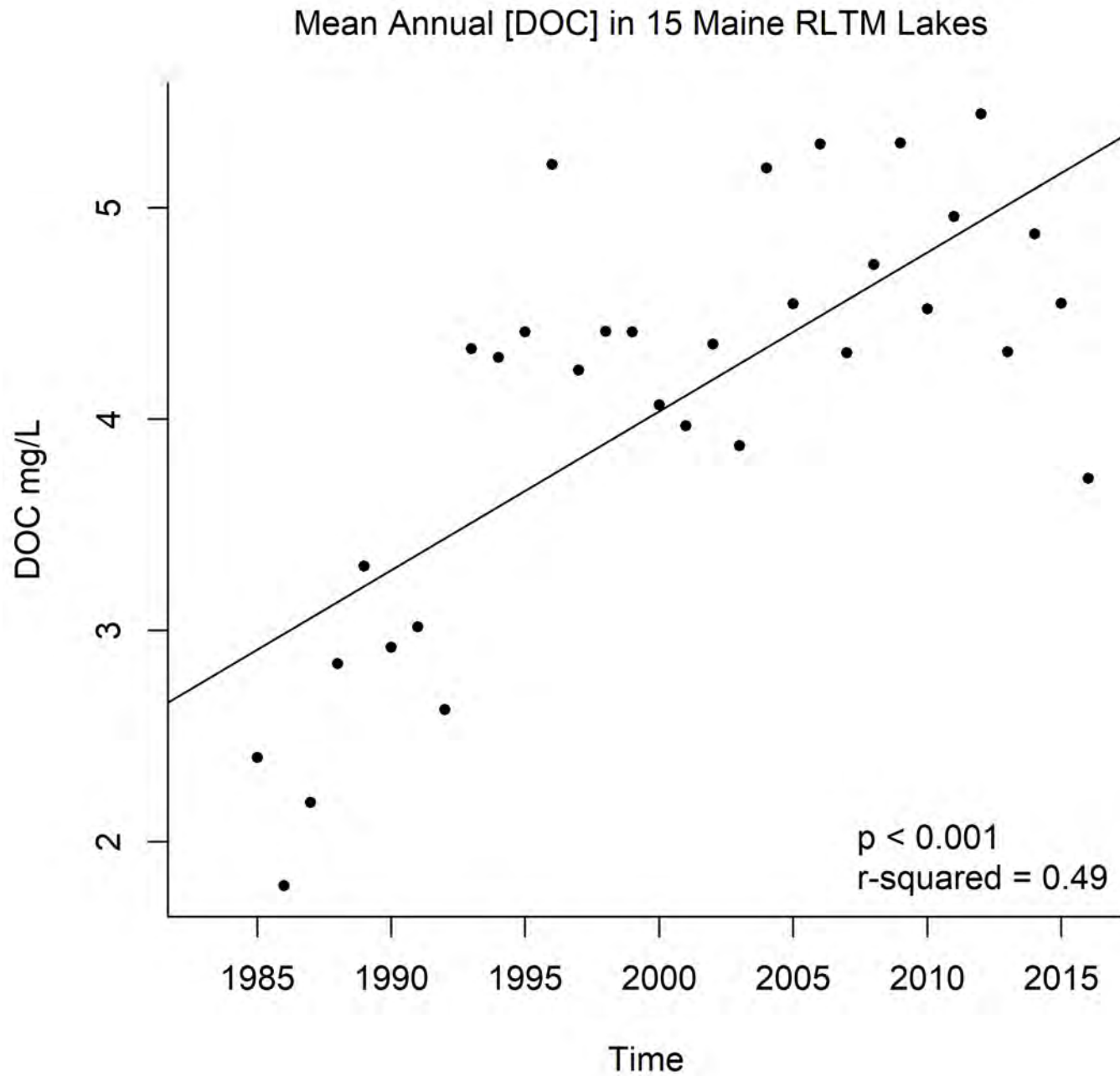
University of Notre Dame

Lower DOC

Clearer Water

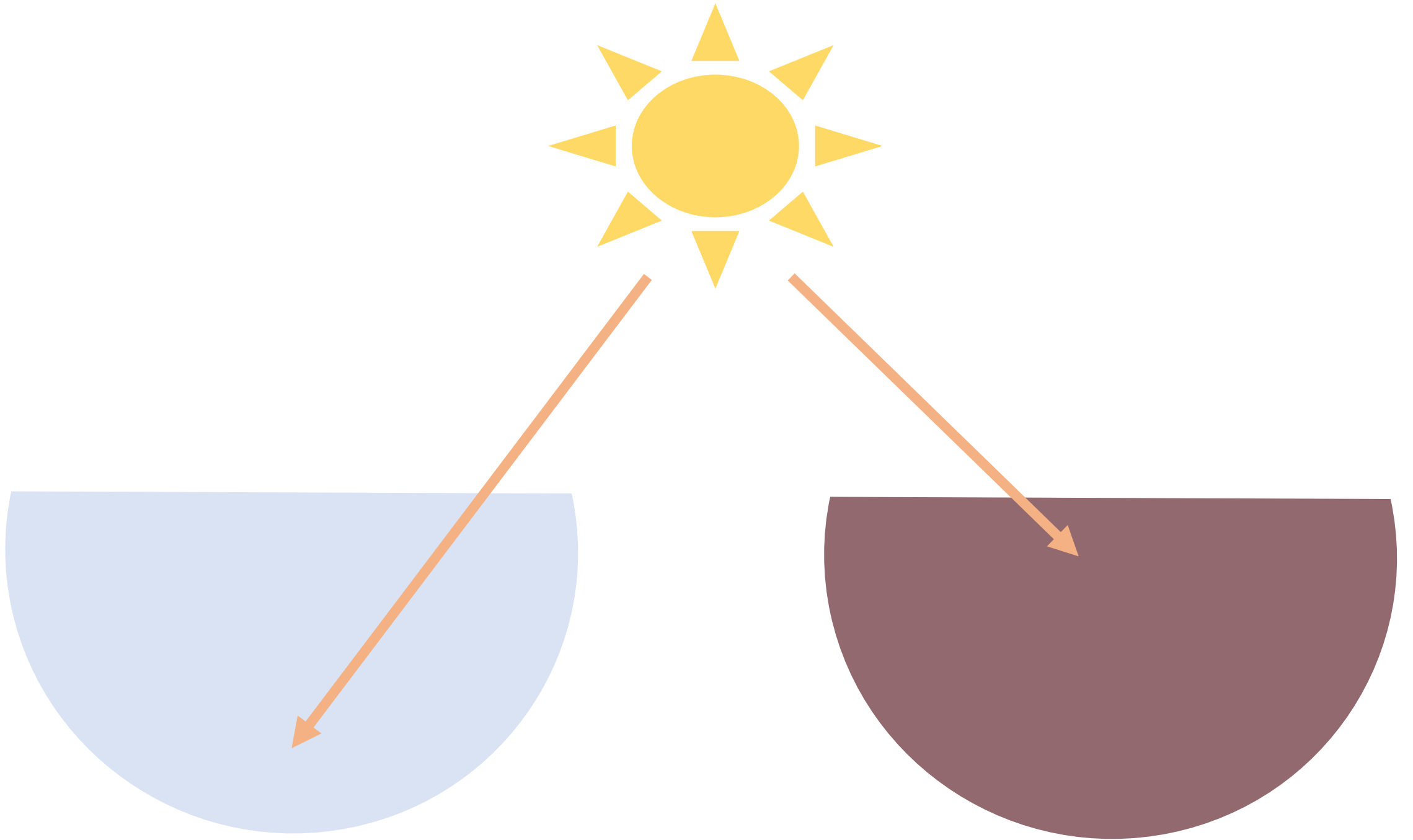


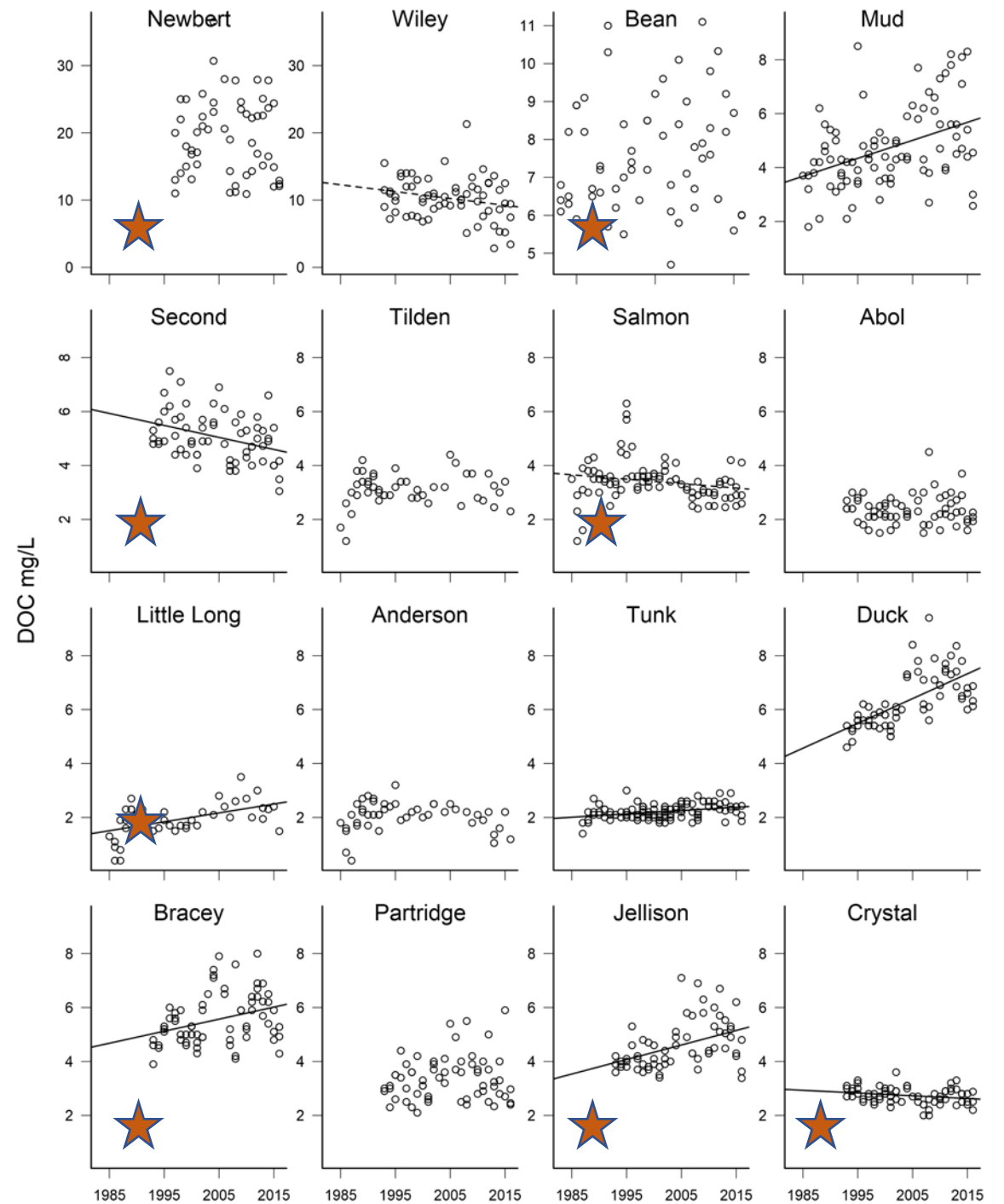
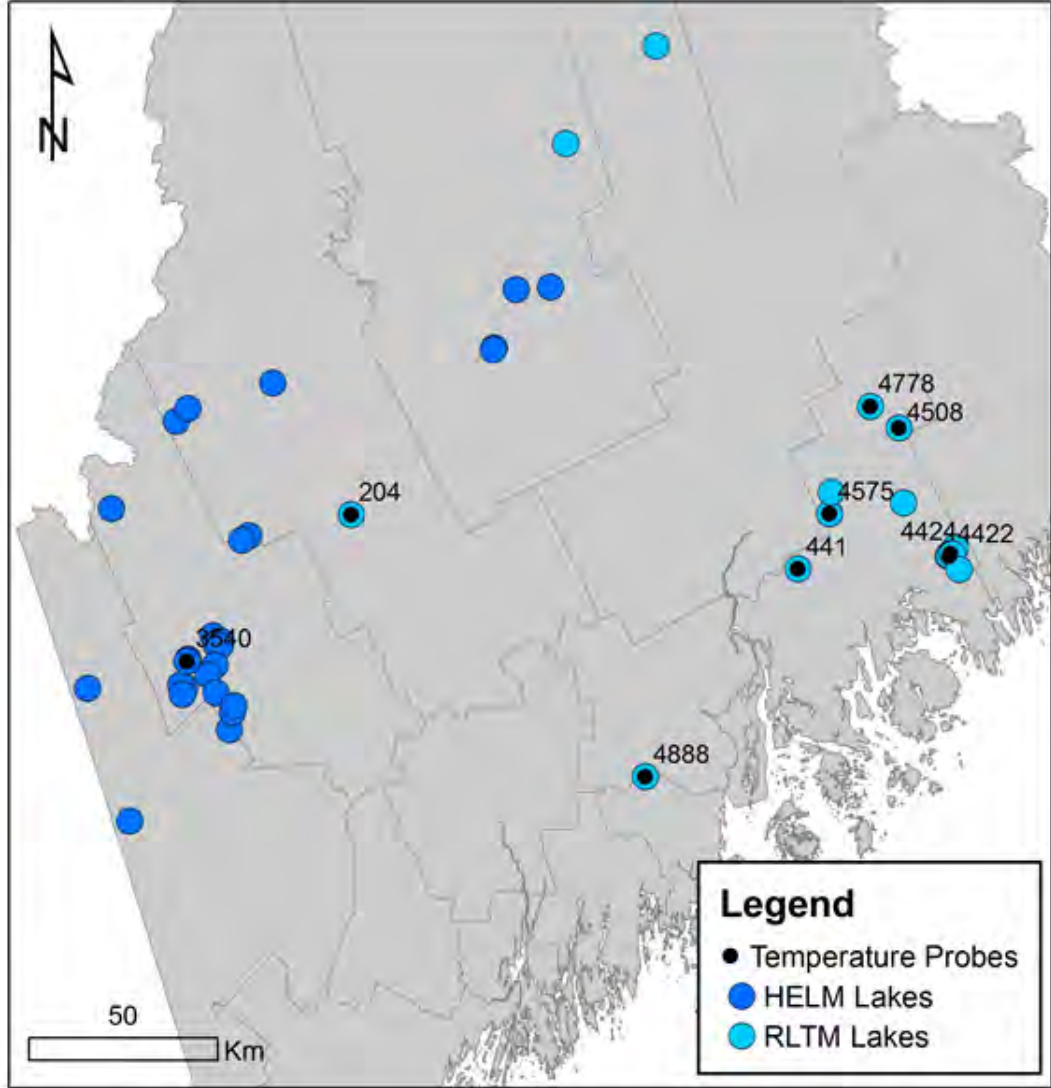
University of Notre Dame



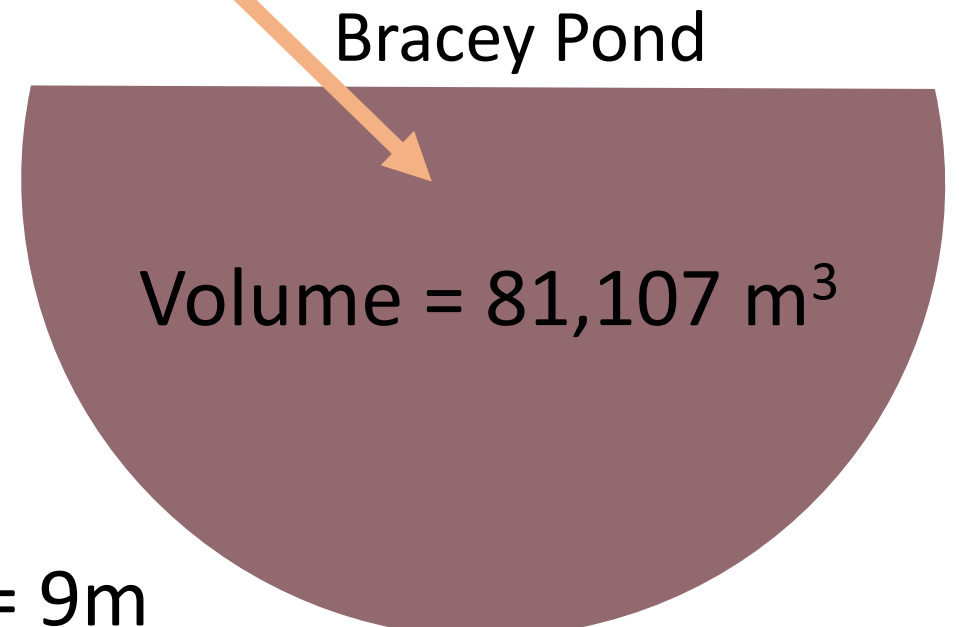
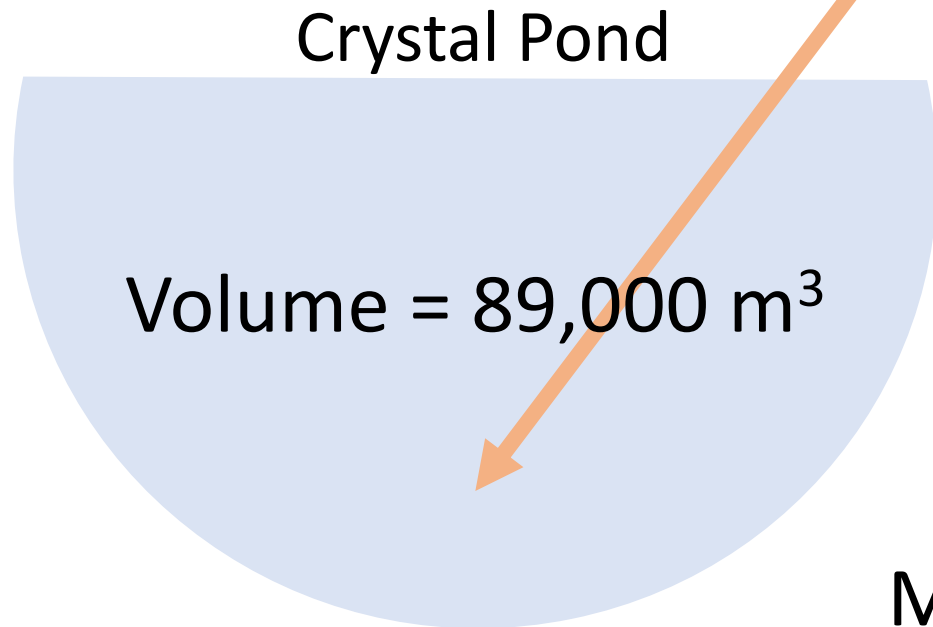
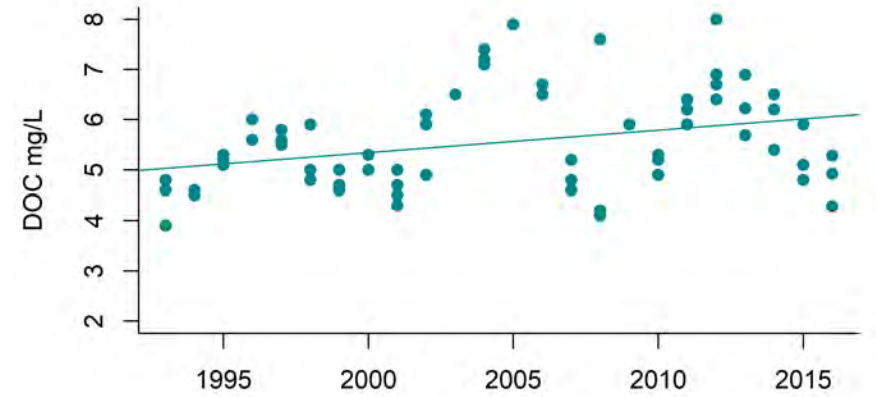
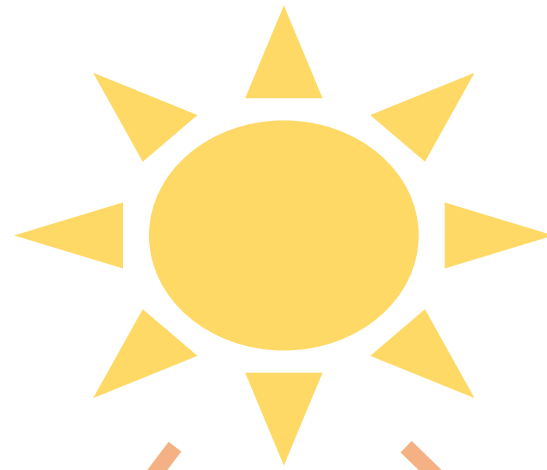
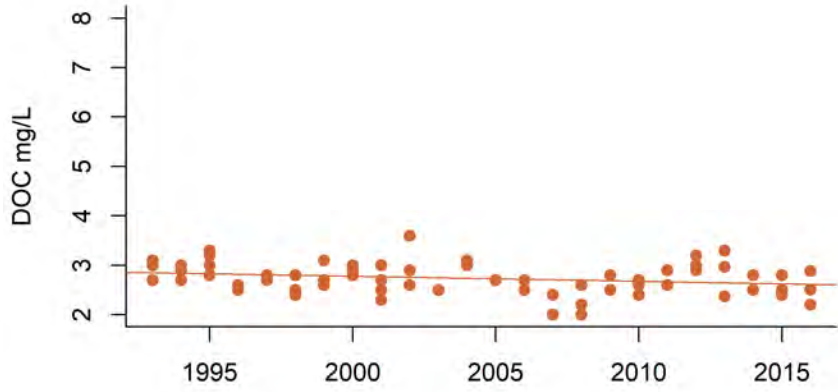
Higher DOC

Darker Water



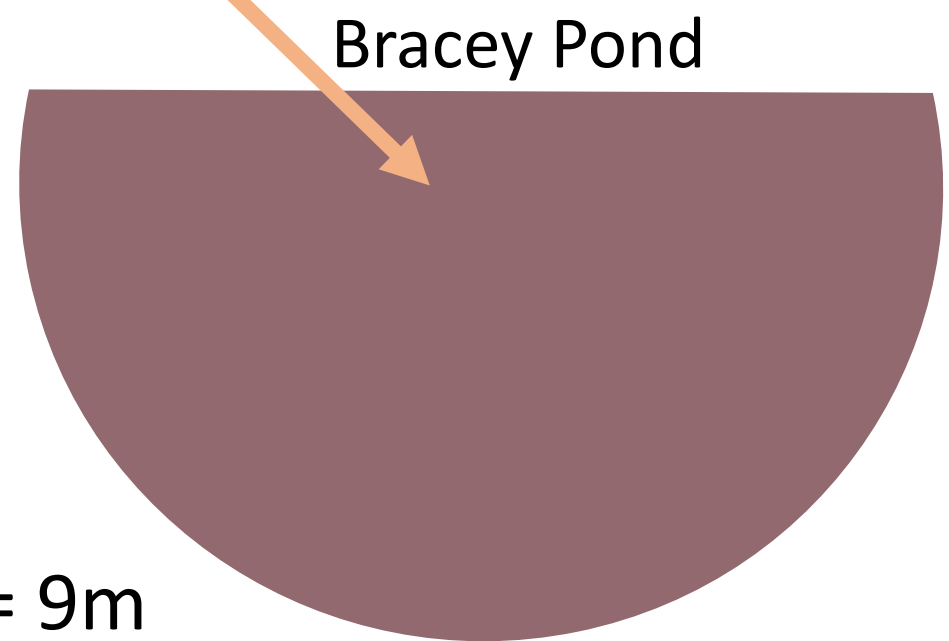
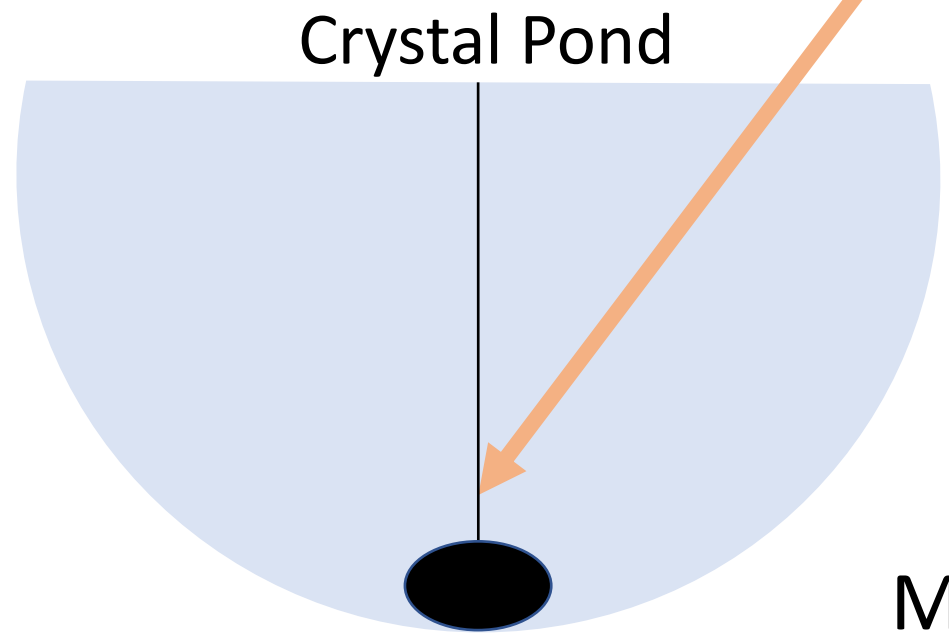
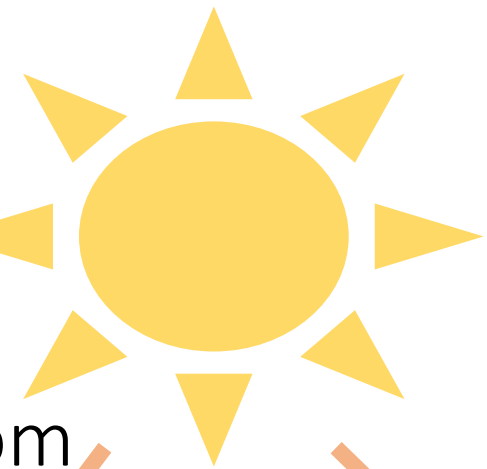






2017 summer DOC = 2.3 mg/L

Water Clarity = Visible @ Bottom



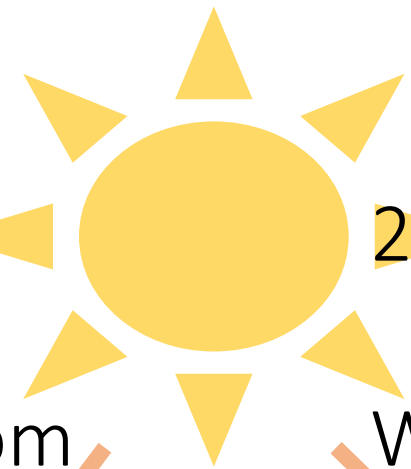
Max Depth = 9m

2017 summer DOC = 2.3 mg/L

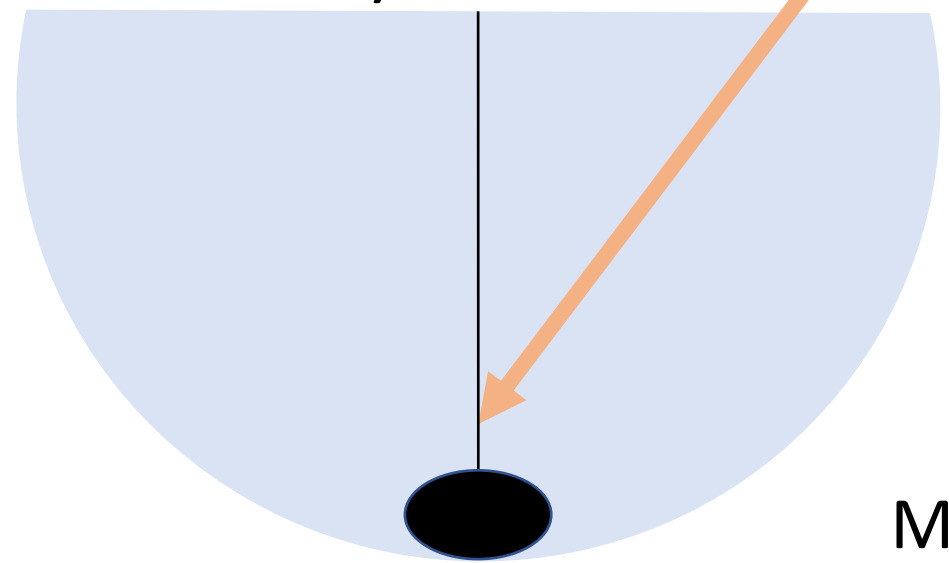
2017 summer DOC = 5.4 mg/L

Water Clarity = Visible @ Bottom

Water Clarity = 4 m

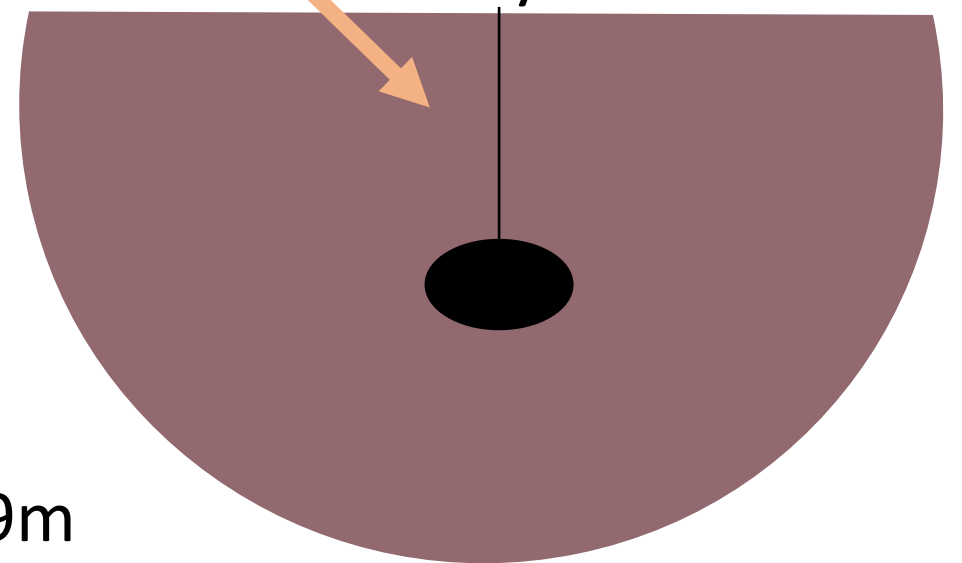


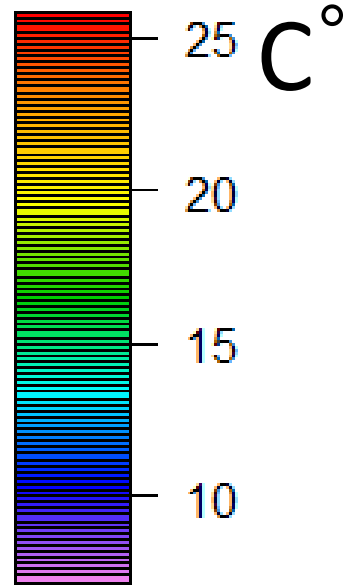
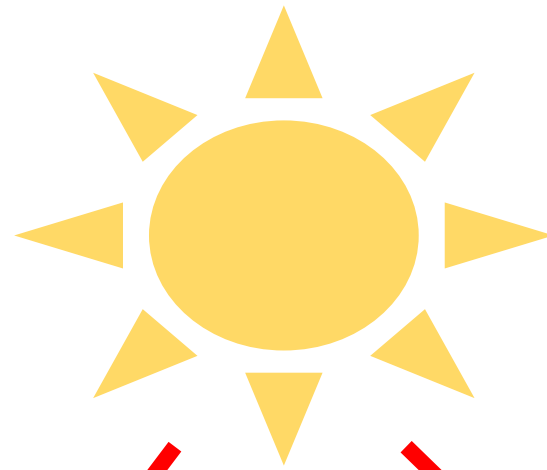
Crystal Pond



Max Depth = 9m

Bracey Pond





Crystal Pond

Bracey Pond

0m

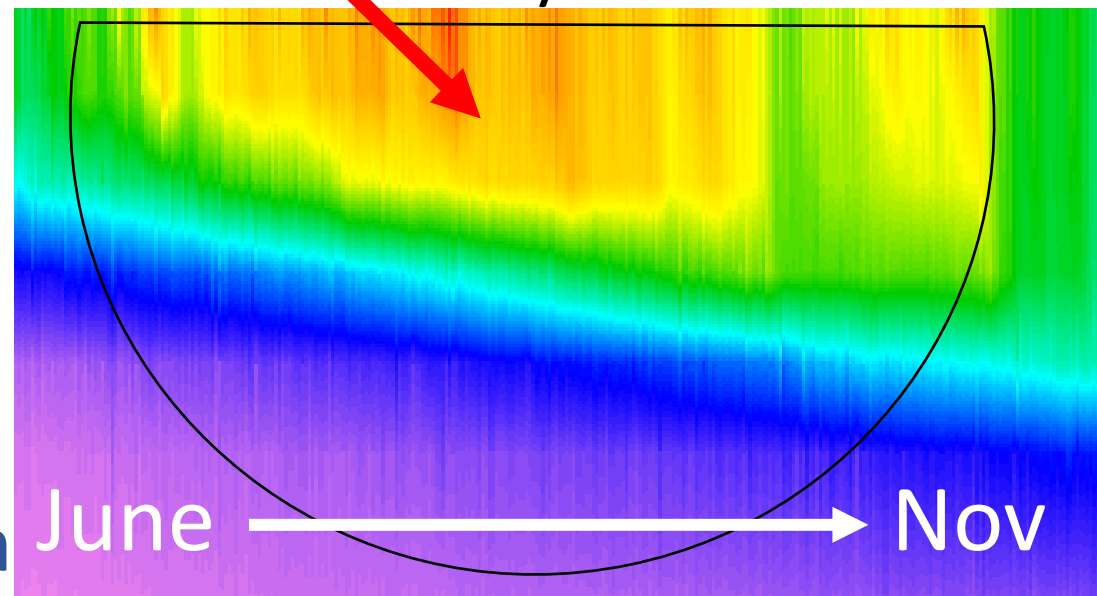
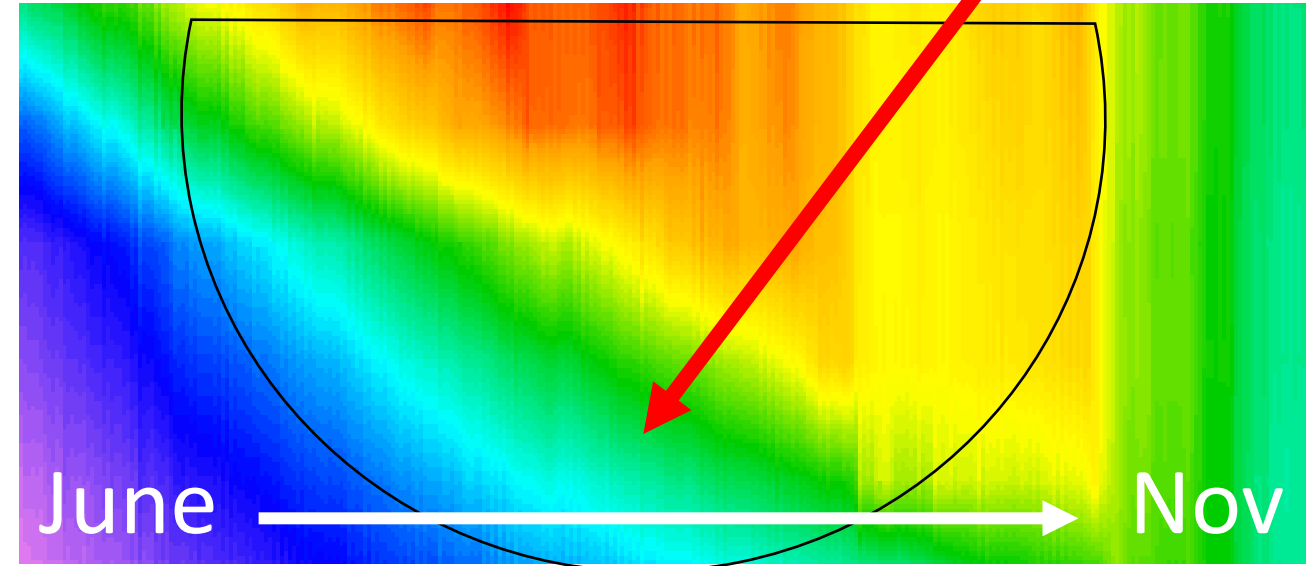
9 m

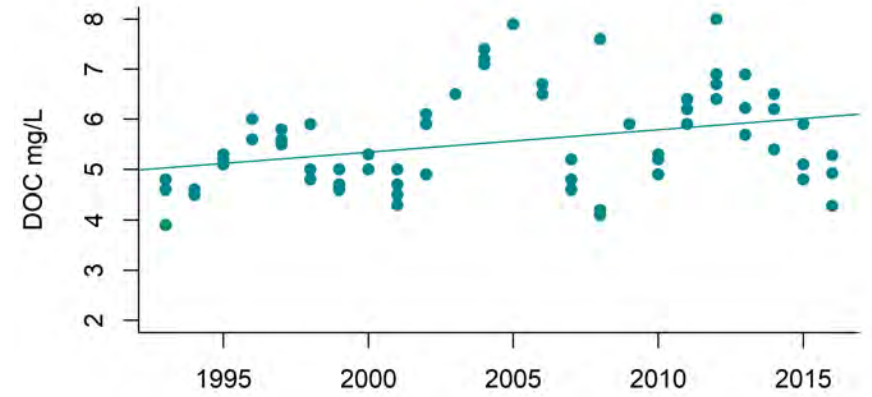
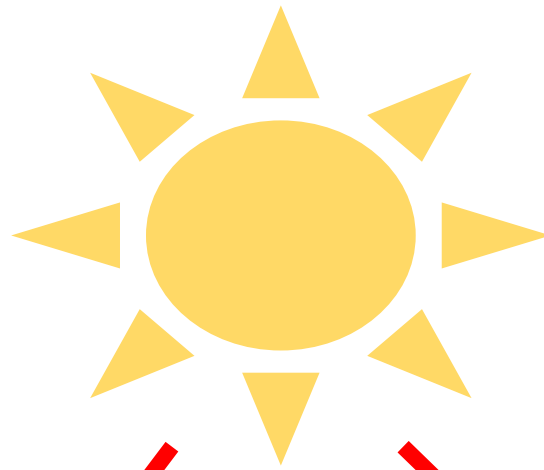
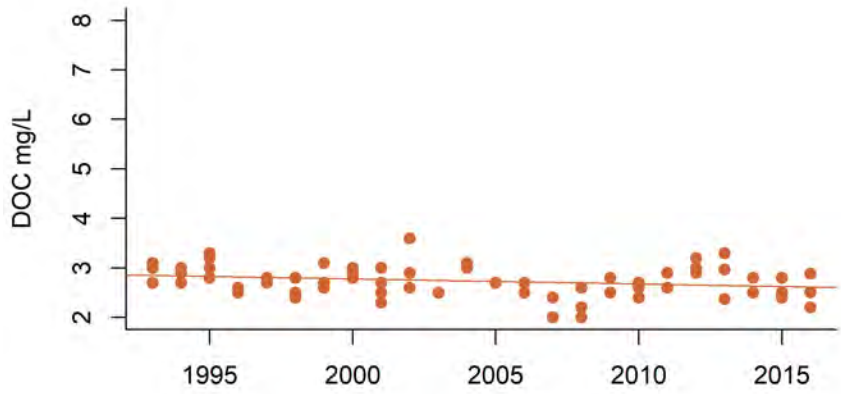
June

Nov

June

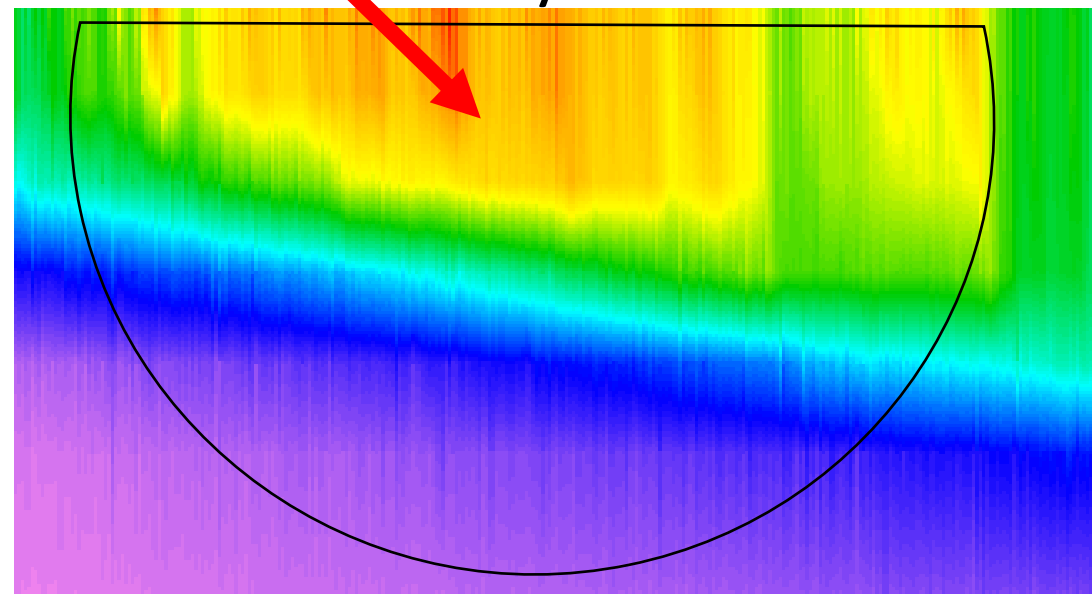
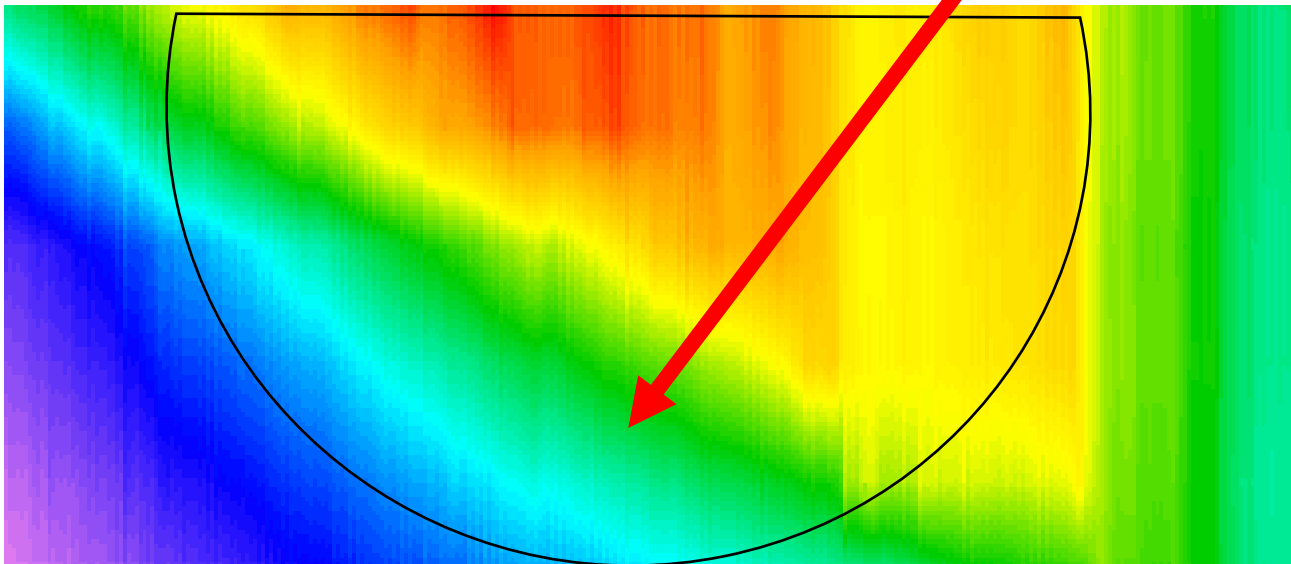
Nov





Crystal Pond

Bracey Pond



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