NOM & Trihalomethanes workshop 2016

NOM in the Northern Irish Aquatic Environment

Sources, fluxes, impacts, and fate

Chris Barry

Agri-Food and Biosciences Institute (AFBI) Belfast

chris.barry@afbini.gov.uk

afbi Agri-Food and Biosciences Institute

The Northern Irish Geo-climate

Land area of 13,550 km^2
75% <150m altitude

<u>76% Agricultural Land</u>
Grassland (58%)
Arable (4%)
Rough grazing (14%)

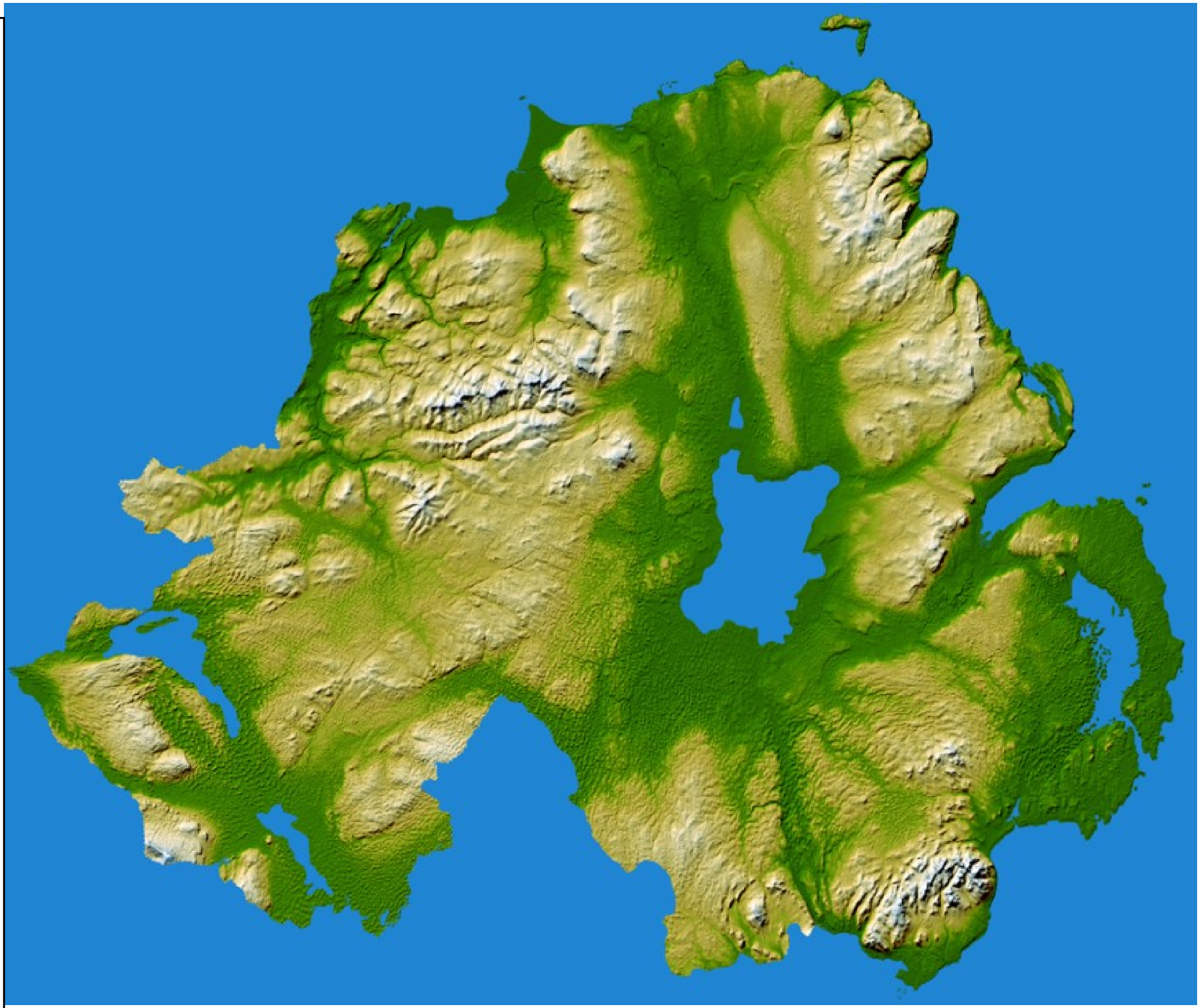
<u>Woodland</u>
880km^2 - ¾ coniferous forestry

<u>Rainfall</u>
Lowlands 800 – 1100 mm yr^{-1}
(c.500 mm pT)

Uplands < 2000 mm yr^{-1}
(<350mm pT)

<u>Soils</u>
brown earths /podzols (18%)
gleyed soils (*Umbric stagnosols*) (60%)
peats (14%)

Mean annual temp c.9 ° C
Winter temps seldom < 0 ° C



Agri-Food and Biosciences Institute

Concentrations and Fluxes of Dissolved Organic Carbon

70 catchments monitored

44%	<10 km^2
34%	10-100 km^2
20%	100-1000 km^2
3%	>1000km^2

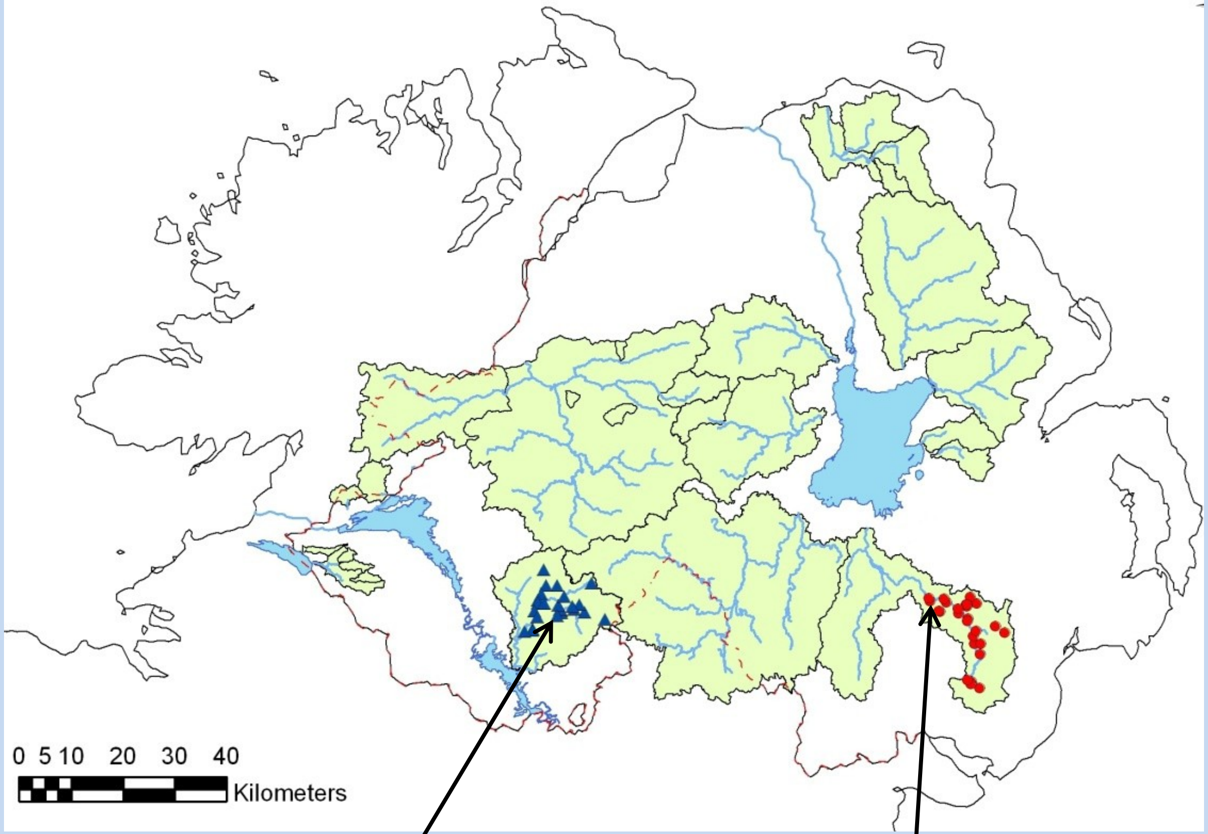
12-52 samples yr^1

46% NI land area monitored

DOC sample concentration
range: 2.7 – 58.9 mg L-1

DOC annual flow-weighted mean
range: 7 – 30 mg L^{-1}

Export rates
range: 4.1 – 31.0 g m^{-2} yr^{1} *



Greatest export
31 g m^{-2} yr^1

humic soils	(55%)
Peat soils	(43%)
coniferous forestry	(47%)
pastures	(34%)

Lowest export
4.1 g m^{-2} yr^1

mineral soils	(86%)
humic soils	(14%)
Peat soils	–
Pastures	(80%)

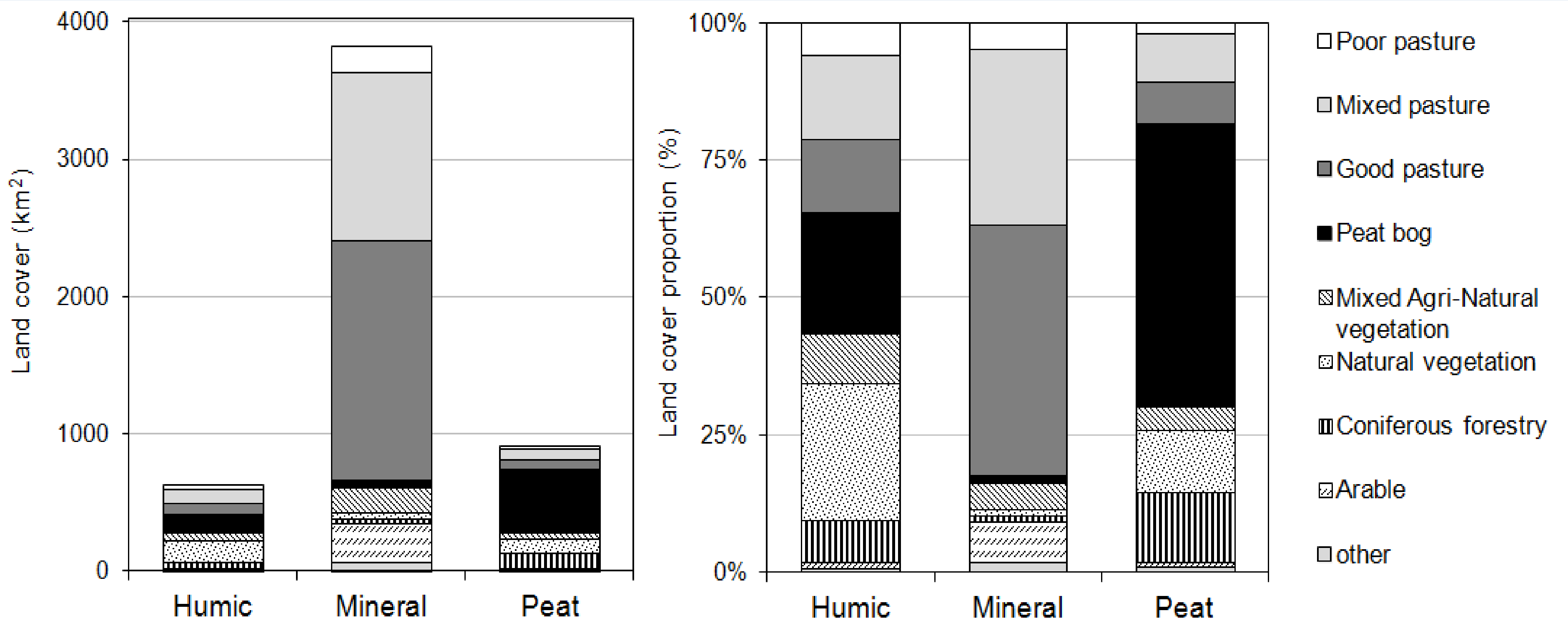
*(t km^{-2} ; x10 = kg ha^{-1})

Modelling DOC exports

Soil - Land Use associations

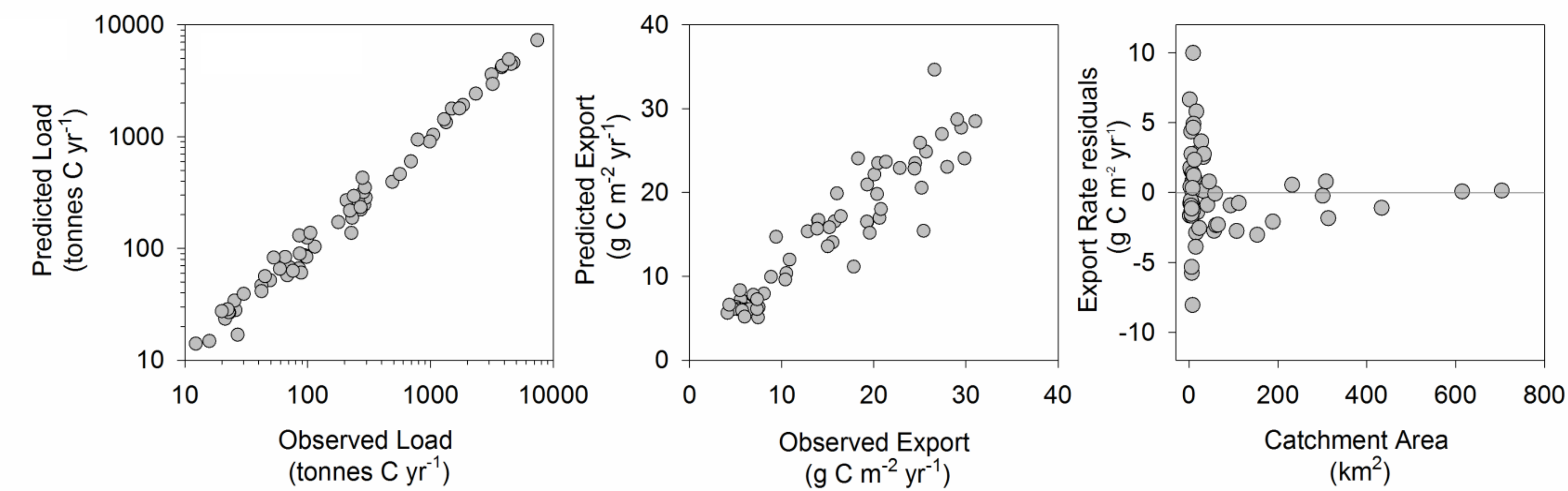
15 principal soil types aggregated based on A_0 C content

- Peat: > 20% organic C > 50cm deep
- Humic: > 10% organic C topsoil
- Mineral: < 10% organic C topsoil

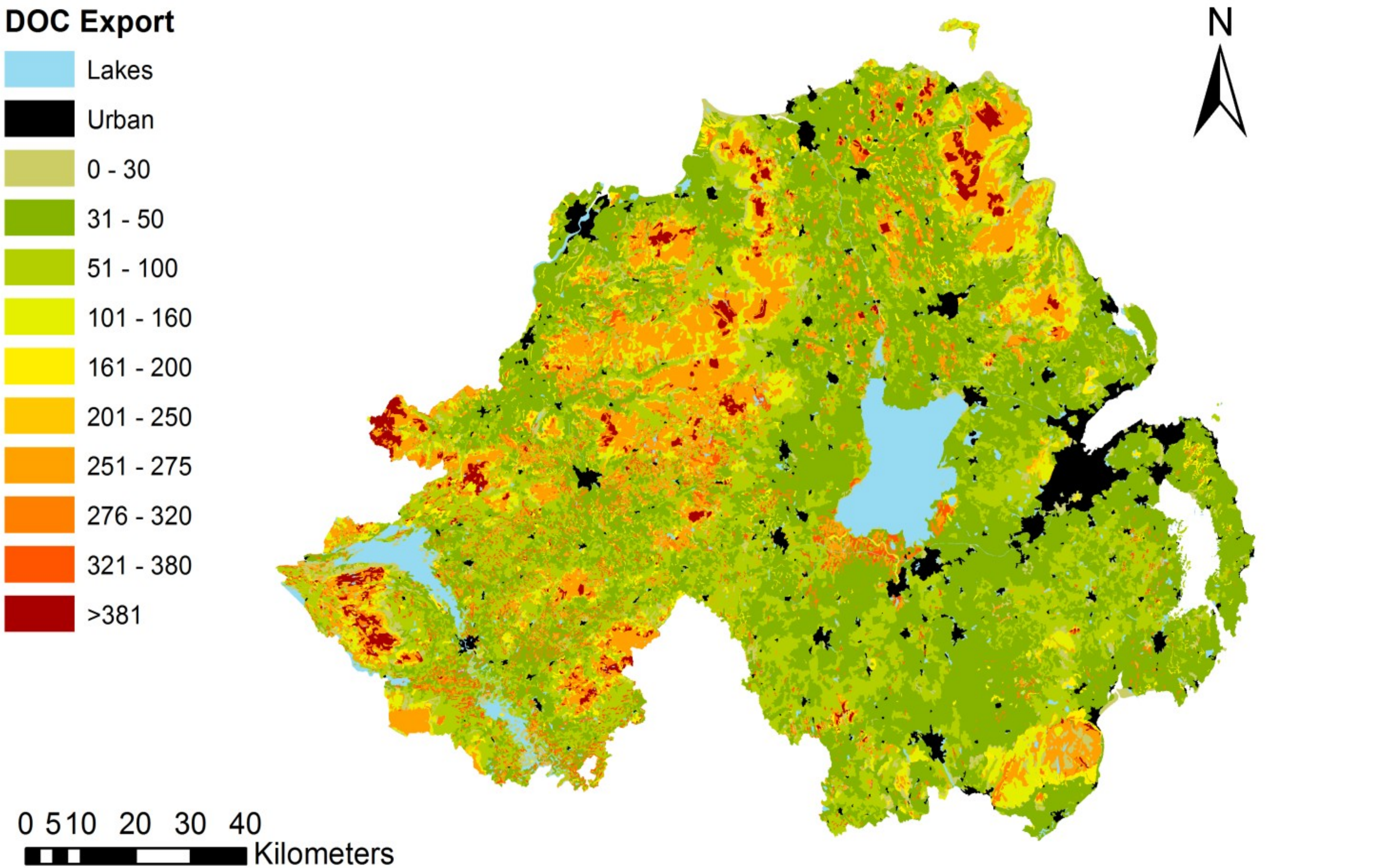


Soil – Land use export coefficients

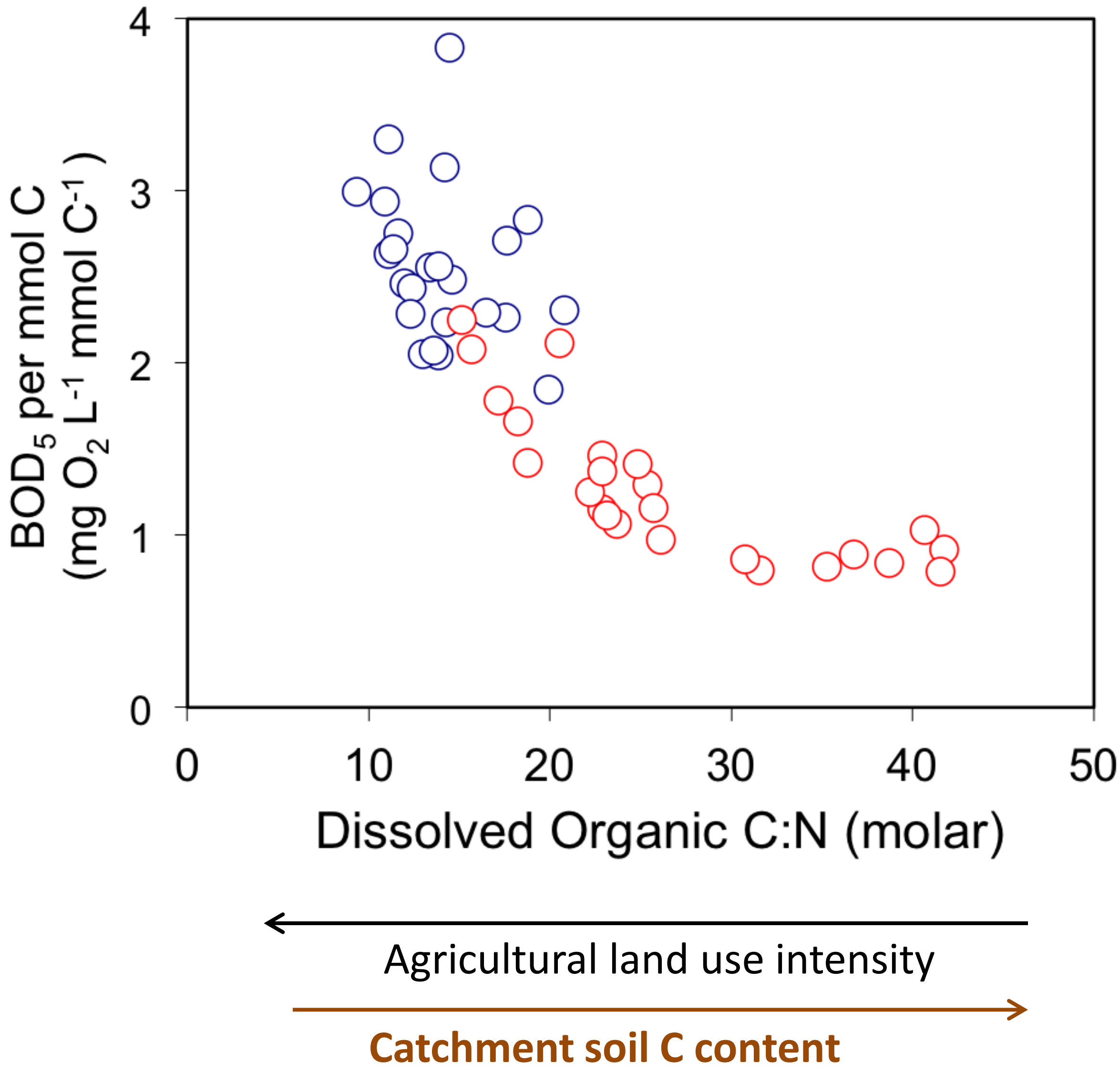
$g\ C\ m^{-2}\ yr^{-1}$	Mineral	Humic	Peat
Natural Vegetation	2.7	14.7	26.5
Arable	5.2	18.7	30.7
Good Pasture	5.0	19.1	30.9
Mixed Pasture	8.8	25.1	35.8
Poor Pasture	9.8	23.9	35.8
All Pasture	7.3	21.1	31.0
Coniferous Forestry	19.4	31.7	42.7



Soil – Land use export coefficients

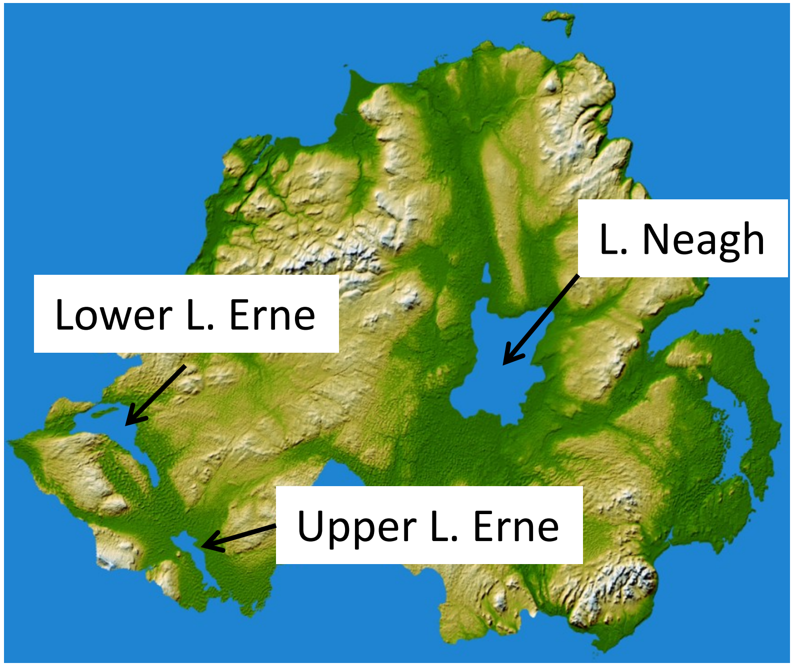


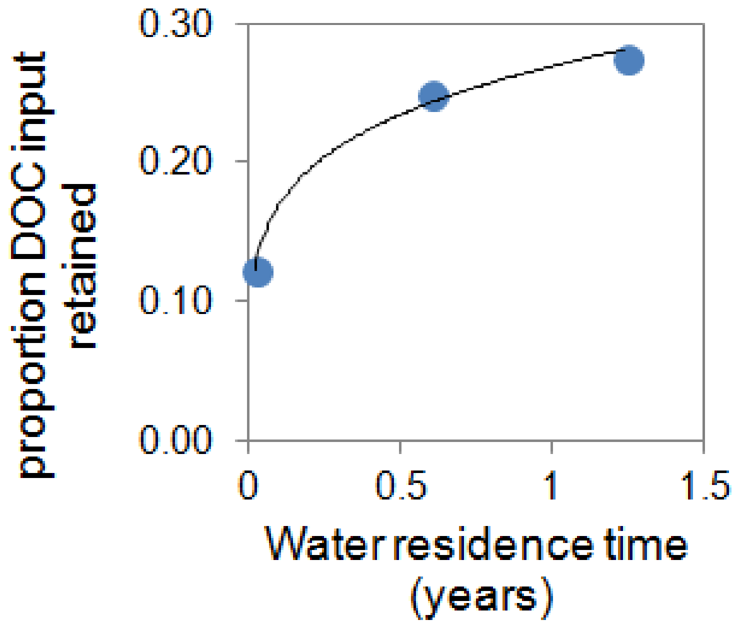
Land use impacts on DOC quality



Role of lakes for Carbon processing

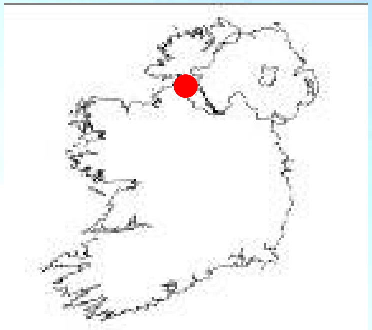
downstream processing? 44% land area drains to regions 3 largest lakes



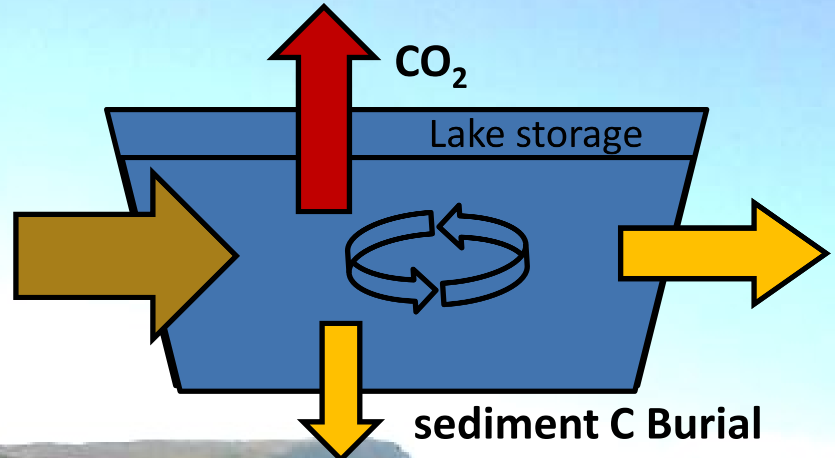


	DOC In ($t\ yr^{-1}$)	DOC Out ($t\ yr^{-1}$)	% retained*
Lough Neagh	39875	28903	28
Upper Lough Erne	48832	42847	12
Lower Lough Erne	50627	37991	25

Role of lakes for Carbon processing: Lough Melvin



Lake C budget case study



Top: Gillaroo trout, *Salmo stomachius* : littoral feeder

Bottom: Sonaghen trout, *Salmo nigripennis* : planktivore

Lake /Catchment Area	**22.8 km^2 / 224.6 km^2**
Mesotrophic –TP / chl *a*	**30µg l^{-1} / 2.5 µg l^{-1}**
DOC	**10.5 mg l^{-1}**
Alkalinity	**1 meq l^{-1} (pH 8)**
Water residence	**0.9 years**
Mean/Max Depth	**10 m / 45 m**
Precipitation	**~1600 mm a^{-1}**

Role of lakes for Carbon processing: Lough Melvin

tonnes C yr^{1}	In	Out	Lake Storage	In-Out (-storage)	% of input
Dissolved Organic C	3768	2834	933	1	99.9%
Dissolved Inorganic C	3729	3646	84	-1	100.0%
Particulate Organic C	1490	315		+1175	21.0%
C sediment burial		303		-303	
CO_2 evasion		1580		-1580	
Cl^- budget	4735	4791	-61	5	99.9%
Total	**8987**	**8678**	**1017**	**-708**	**107.9%**

Loss terms are appear balanced by POC input

- Particulate matter may be degraded to DOC – offset remineralisation of DOC
- Underestimation of DOC / POC input
- lake DOC storage….. What happens to this pool?

c. **34% of the Total Organic Input retained**
Lake is important site for C processing at the landscape scale
Implies terrestrial C is important to lake ecology……

Role of terrestrial Carbon for lake processes: Lough Melvin

Pelagic food web utilisation of terrestrial C

C & N stable isotope analysis

Abundance weighted zooplankton reliance upon terrestrial organic carbon

61 %

Daphnia hyalina

45 %

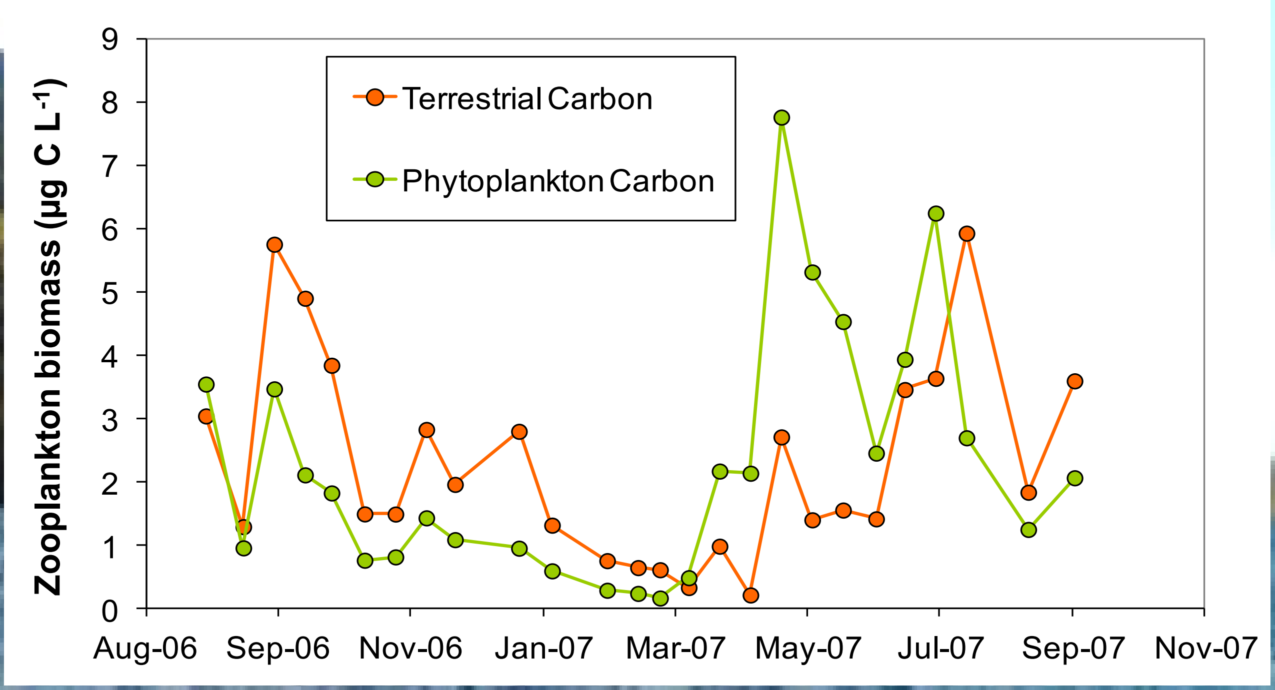
Cyclops abyssorum

34 %

Arctodiaptomus laticeps

53 %

Eudiaptomus gracilis



Role of terrestrial Carbon for lake processes: Lough Melvin

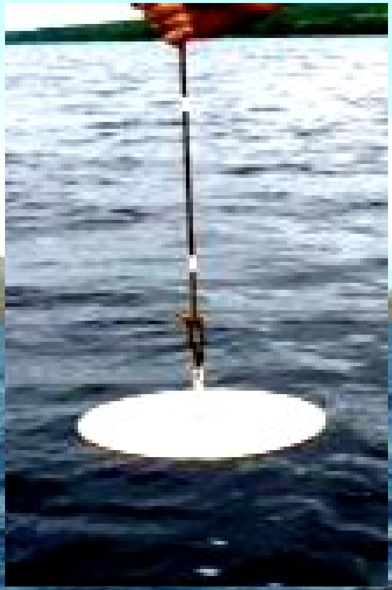
1990 ▸ 2007: ~50% decline in Chl ***a***

Oligo-trophication despite P enrichment from 20 to 30 μg TP L^{-1}

1990 mean, max Chl a: 4.8 , 13.5 μg L^{-1}
2007 mean, max Chl a: 2.7 , 6.8 μg L^{-1}

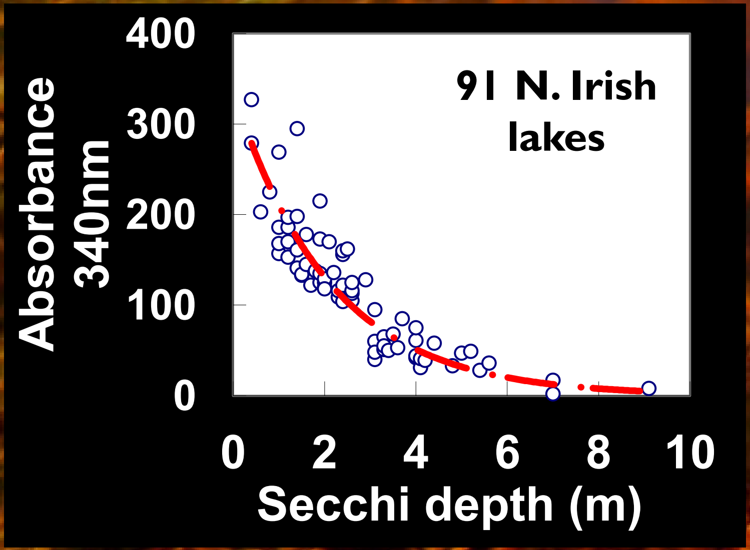
Light attenuation

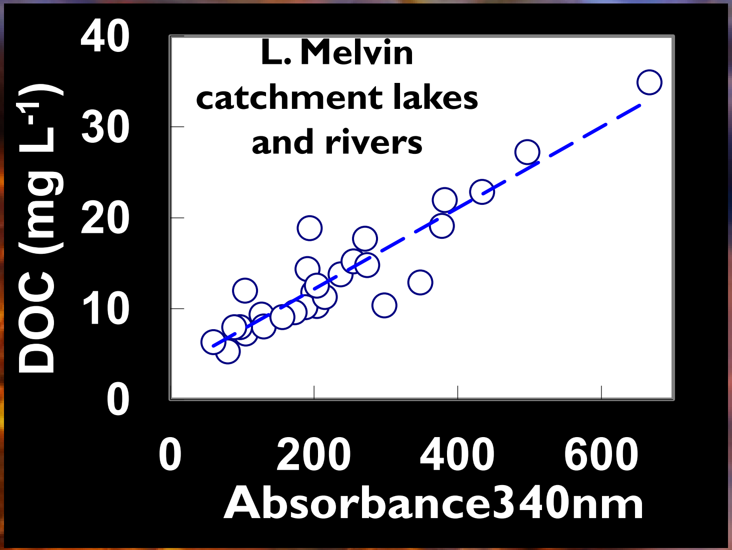
Secchi Depths	1990	2007
	2.6m	1.8m



We can make estimates of changing DOC loading from colour-carbon relationships with light attenuation

NOM impacts: light attenuation





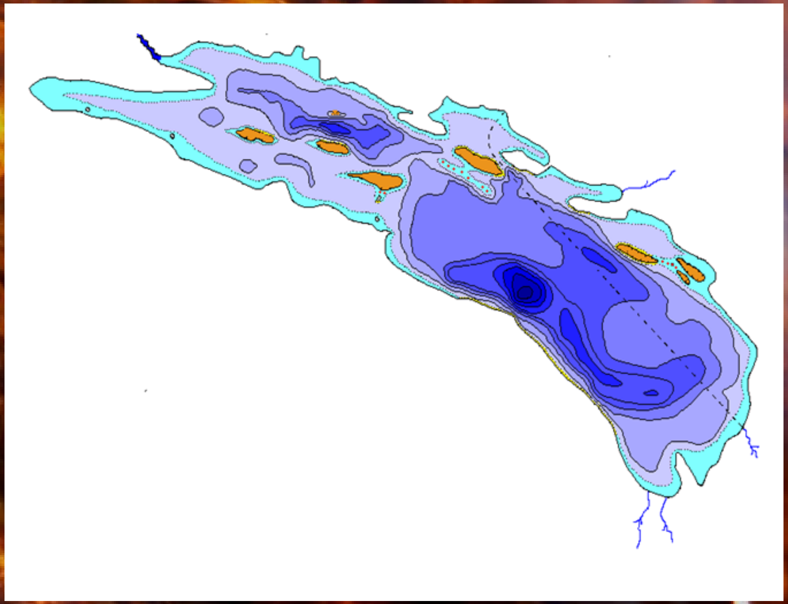
	1990	2007
Secchi depth (m)	2.6	1.8
colour (abs_{340nm}*10^3)	98.8	141.4
Lake DOC (mg L^{-1})	7.6	9.5
Mean Inflow DOC (mg L^{-1})	9.9	12.4
runoff (mm)	1402	1314
predicted export (kg ha^{-1} yr^{-1})	**139**	**162**
Measured Export in 2007 (kg ha^{-1} yr^{-1})		**173**

What is the impact of changing DOC loading?

NOM impacts: light attenuation

Light limitation of pelagic trophic status (chl a) – pelagic insensitivity to P enrichment
...... What about the littoral zone?

		Change	
DOC export (kg ha^{-1} yr^{-1})	139	+17%	162
Euphotic Depth (m)	5.2	-31%	3.6
Littoral Zone Area (km^2)	5.17	-39%	3.15

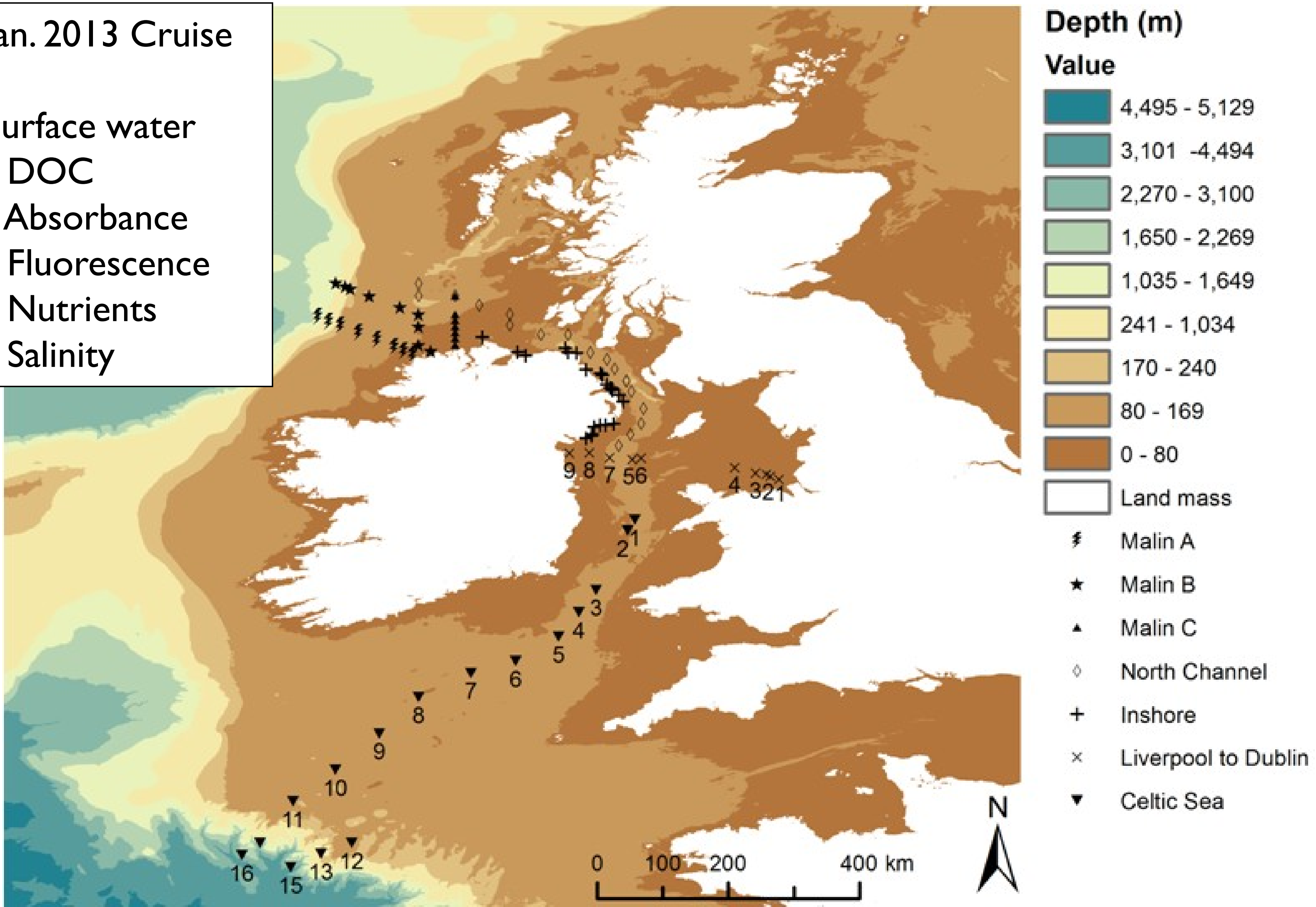


Reversion towards pre-acidification conditions
BUT, nutrient impairment of the Littoral zone
-impacts on Arctic charr spawning
-impacts on endemic littoral trout +other stressors- invasive species

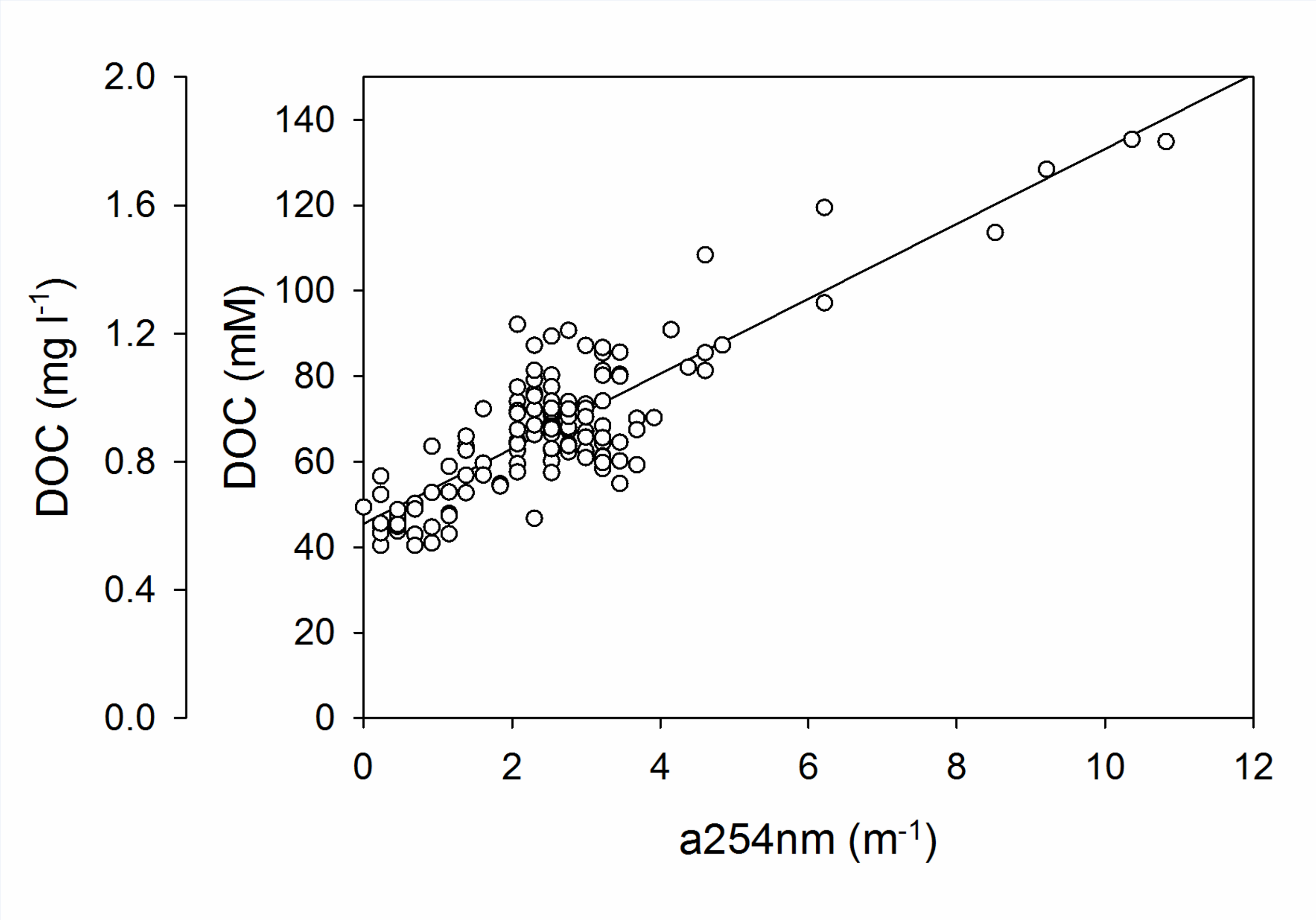
DOM provenance in Irish coastal waters

Jan. 2013 Cruise

Surface water
- DOC
- Absorbance
- Fluorescence
- Nutrients
- Salinity

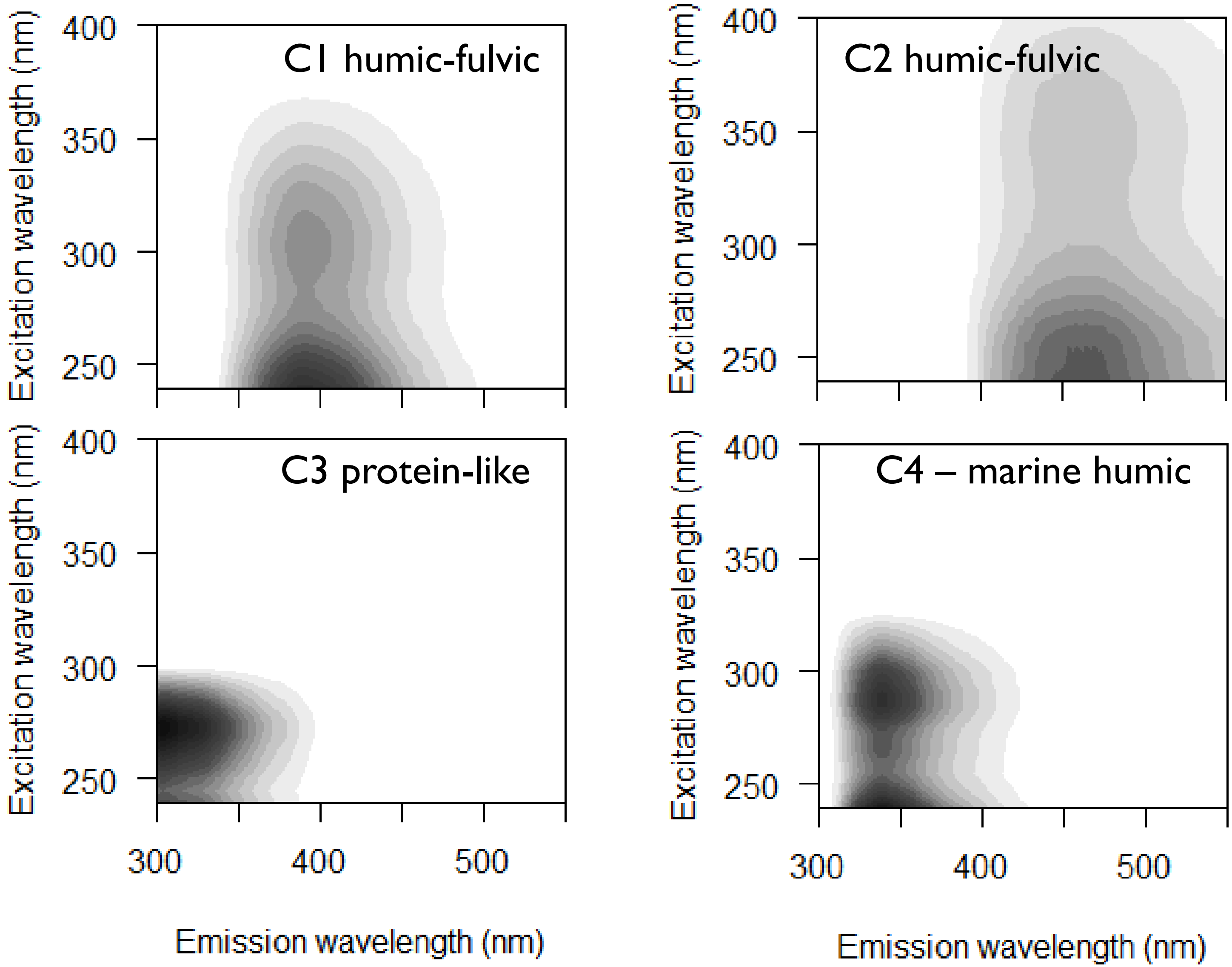


DOM provenance in Irish coastal waters

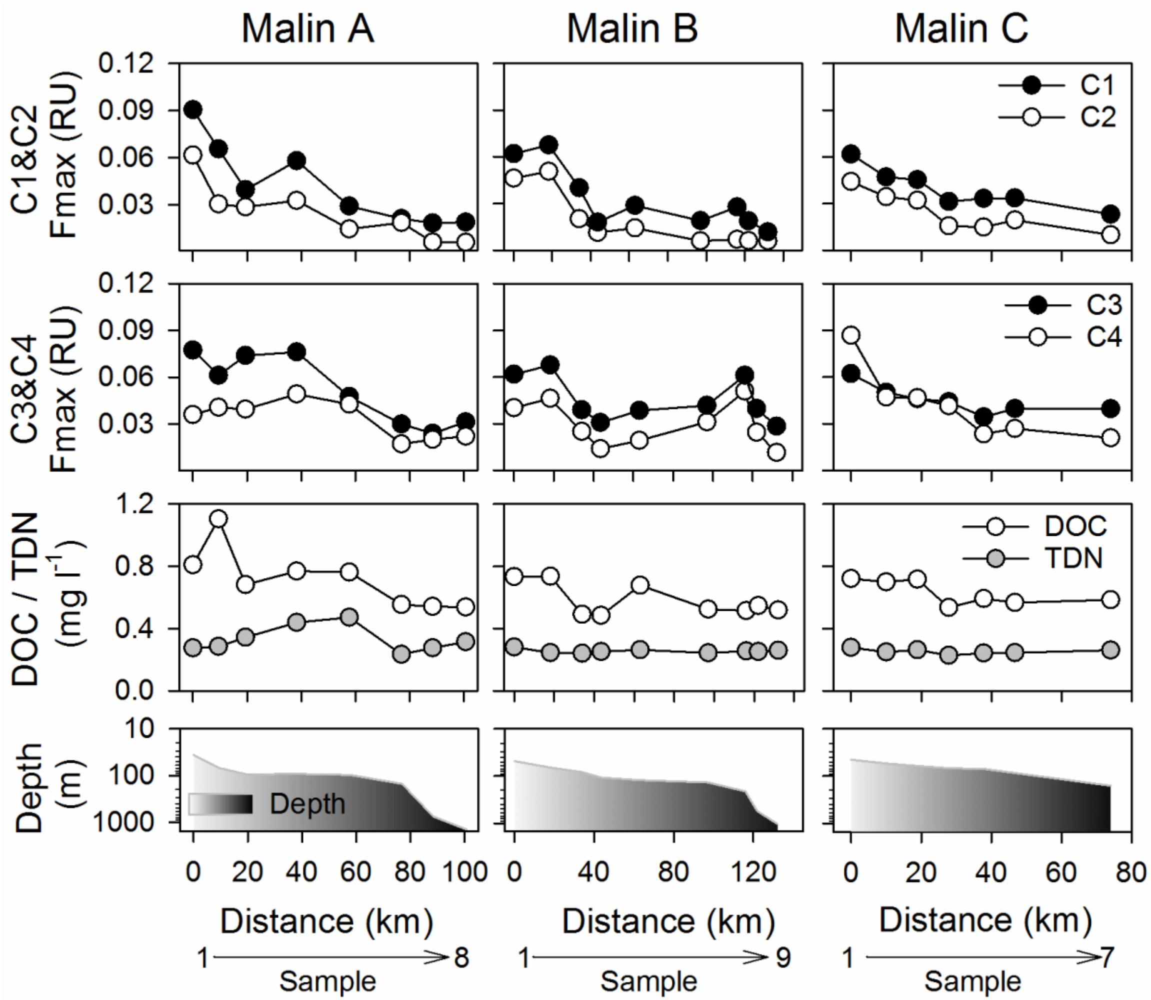


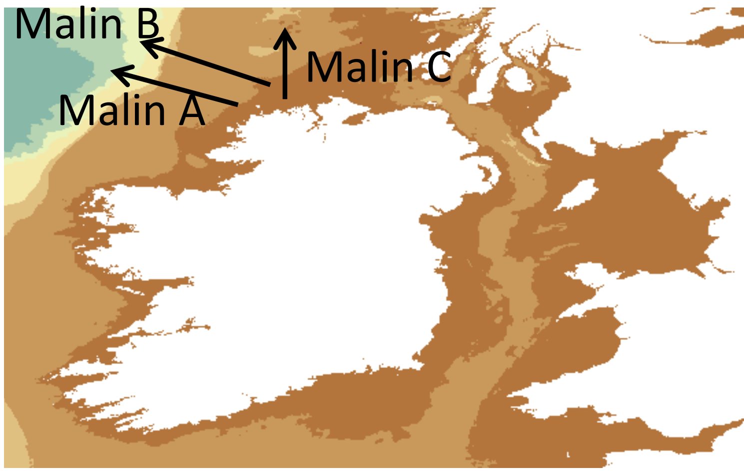
DOM provenance in Irish coastal waters

4 component PARAFAC model validated



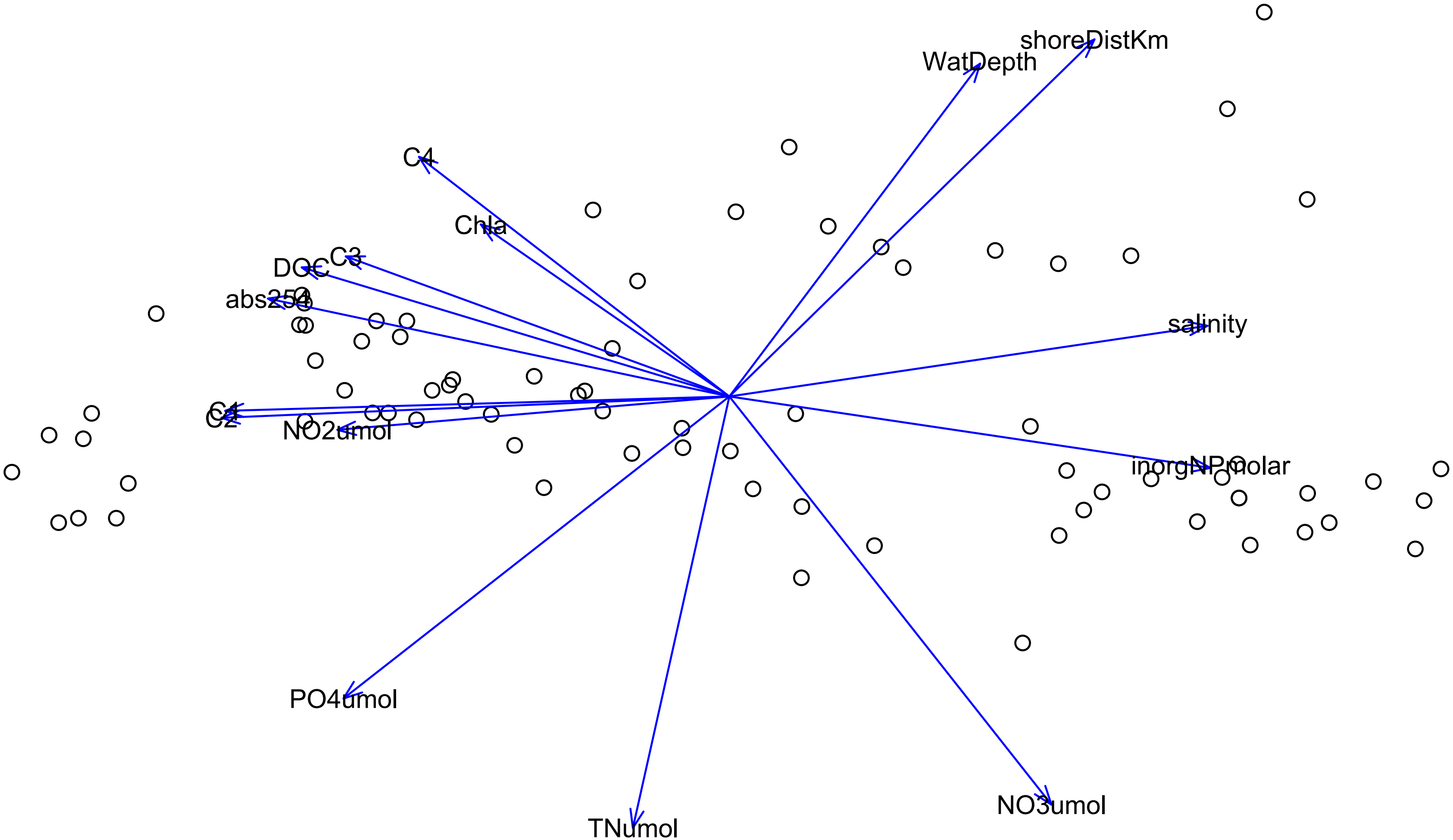
DOM provenance in Irish coastal waters





DOM provenance in Irish coastal waters

PCA 1st 2 axes



Acknowledgements

Co-authors
Bob Foy
John Anderson (Loughborough Uni.)
Alex Higgins (AFBI)
Cordula Scherer (TCD)
Brian Stewart (AFBI)

Funding INTERREG IIIA and DAERA (NI)

Agri-Food and Biosciences Institute