Benthic remineralisation rates under contrasting sea-ice conditions in the deep Arctic Ocean

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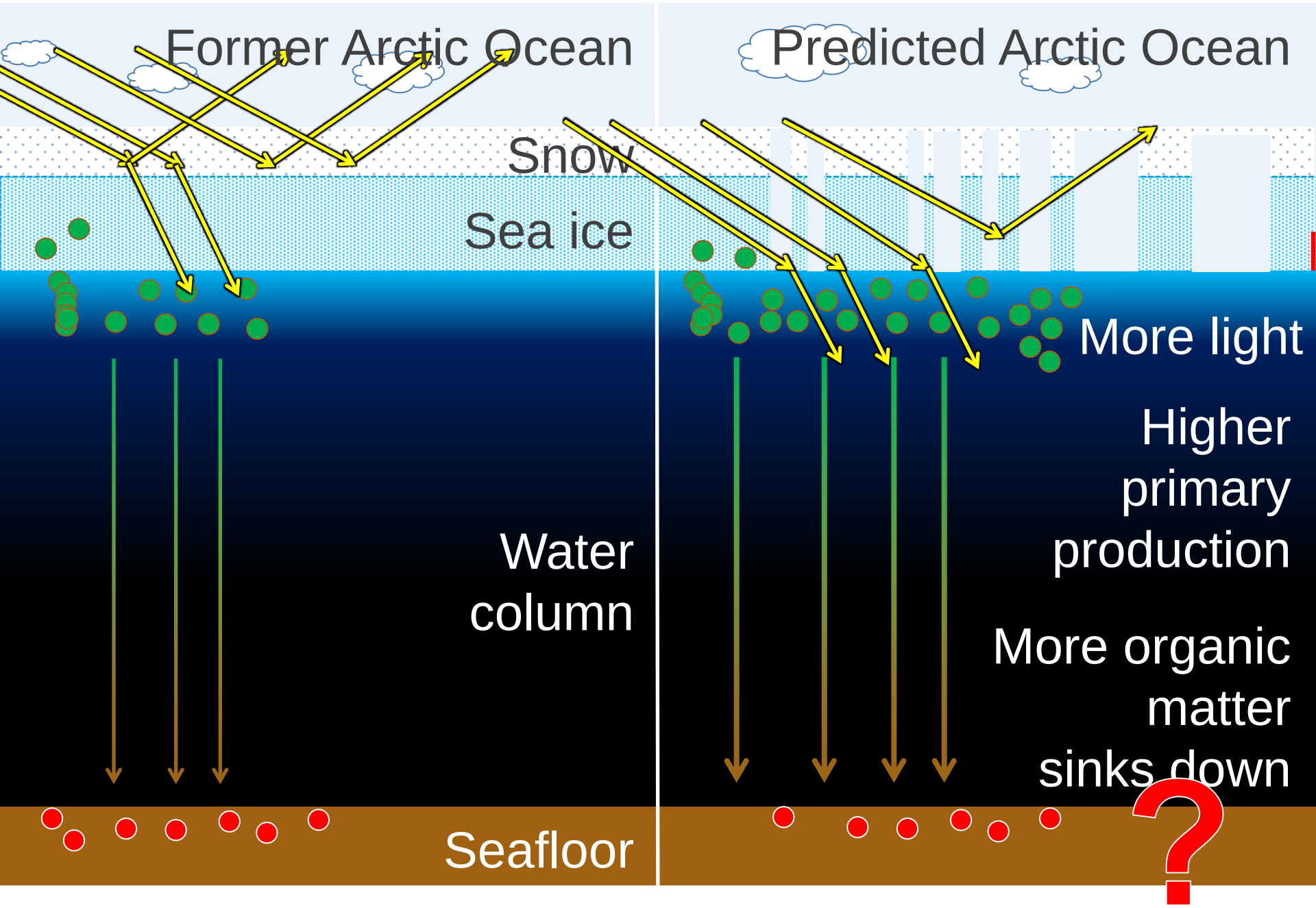
UNIVERSITEIT GENT

Max Planck Institute for Marine Microbiology


Former Arctic Ocean
Predicted Arctic Ocean
Snow
Sea ice
More light
Higher primary production
Water column
More organic matter sinks down
Seafloor
?

Are benthic

remineralisation rates

in the **Arctic deep sea** influenced by

decreasing sea–ice coverage and

increasing primary production?

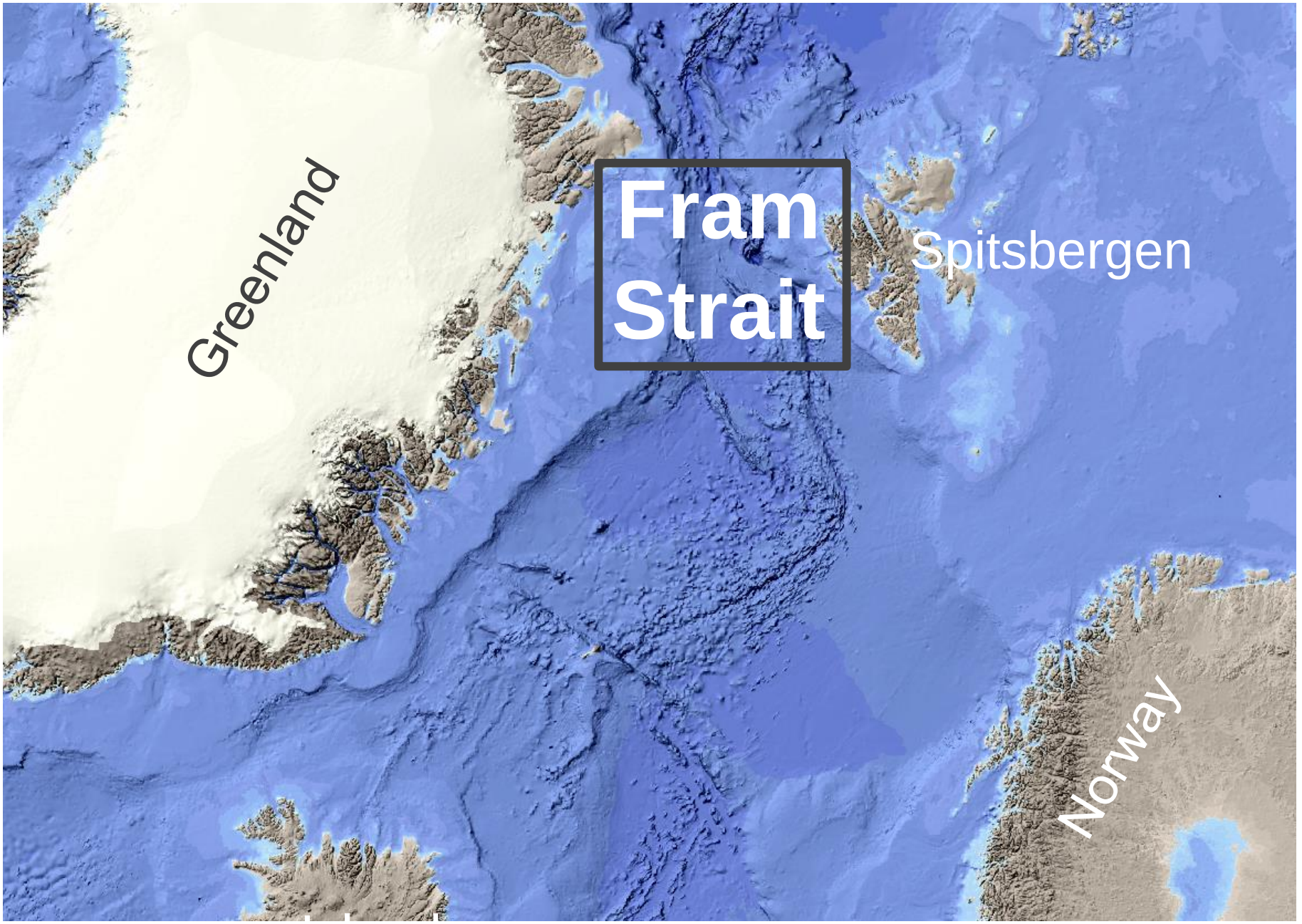
How?

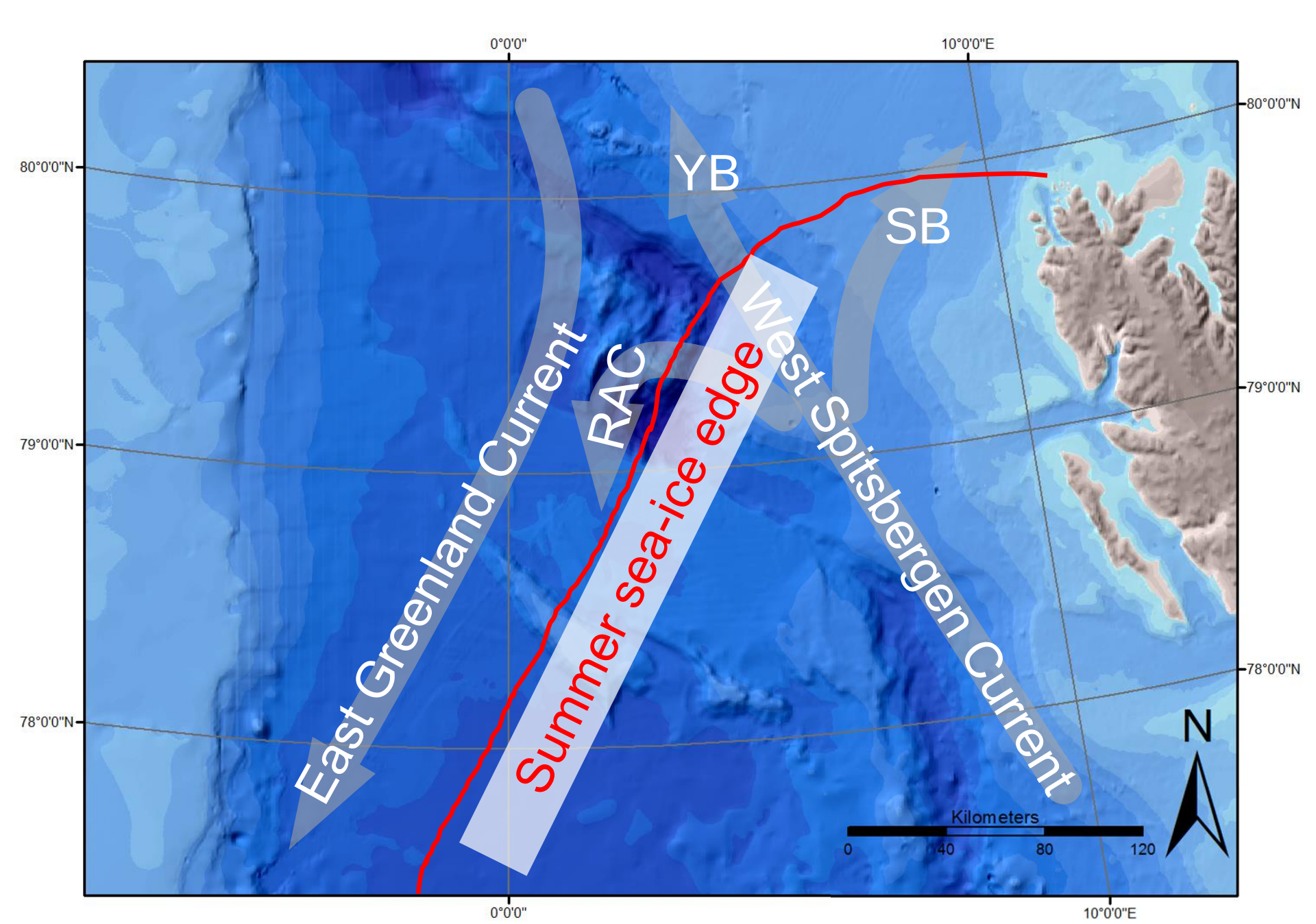
Hypothesis

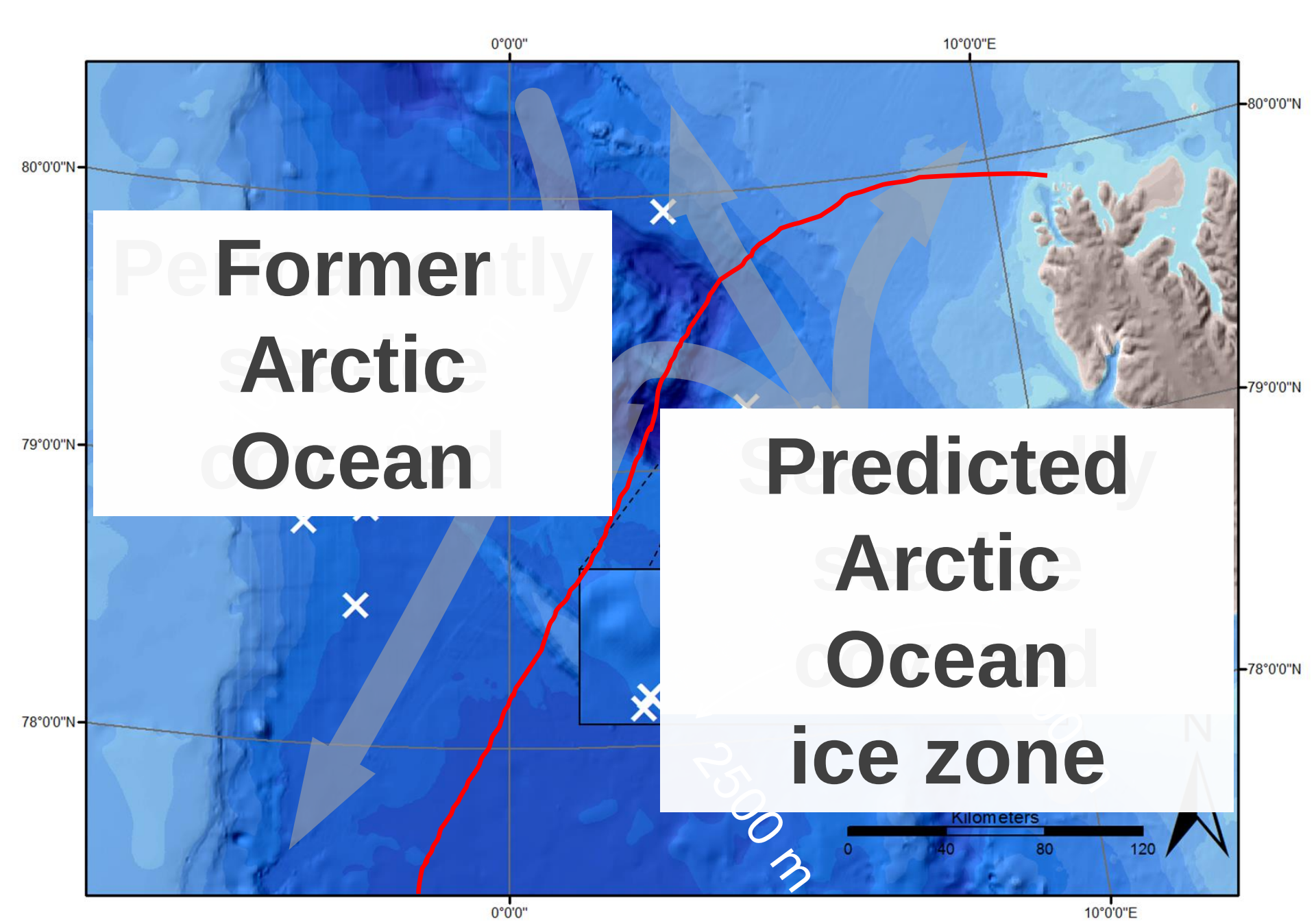
Arrigo et al., Geophysical Resrach Letters, Vol. 35, 2008
Boetius et al., Science, Vol. 339, 2013

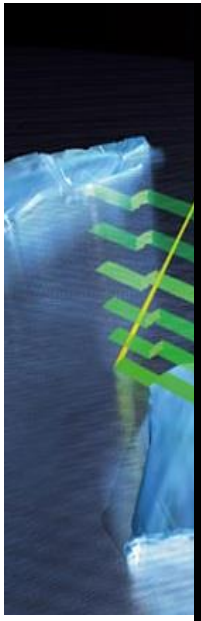
Decreasing sea–ice coverage
Increasing primary production

Increasing benthic remineralisation rates


Greenland
Fram Strait
Spitsbergen
Norway

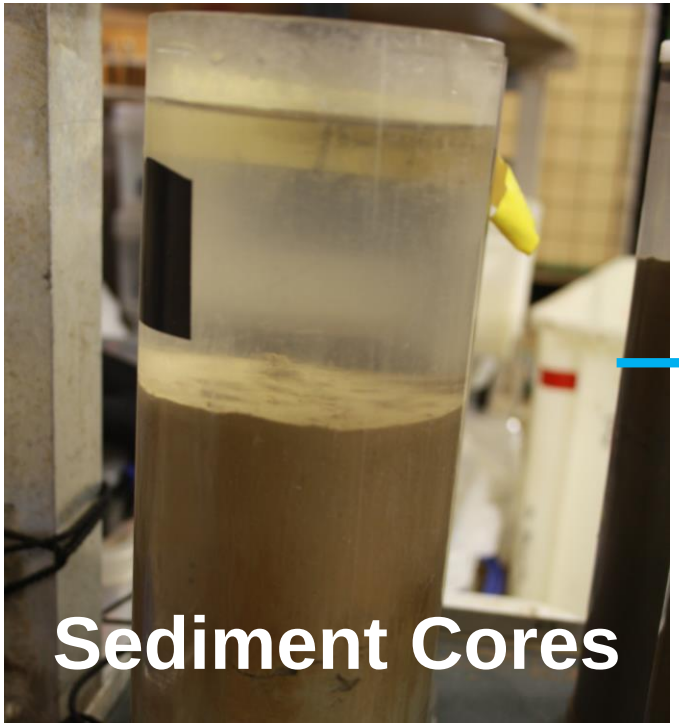

0°0'0"
10°0'0"E
80°0'0"N
79°0'0"N
78°0'0"N
YB
SB
RAC
East Greenland Current
Summer sea-ice edge
West Spitsbergen Current
N
Kilometers
0
40
80
120

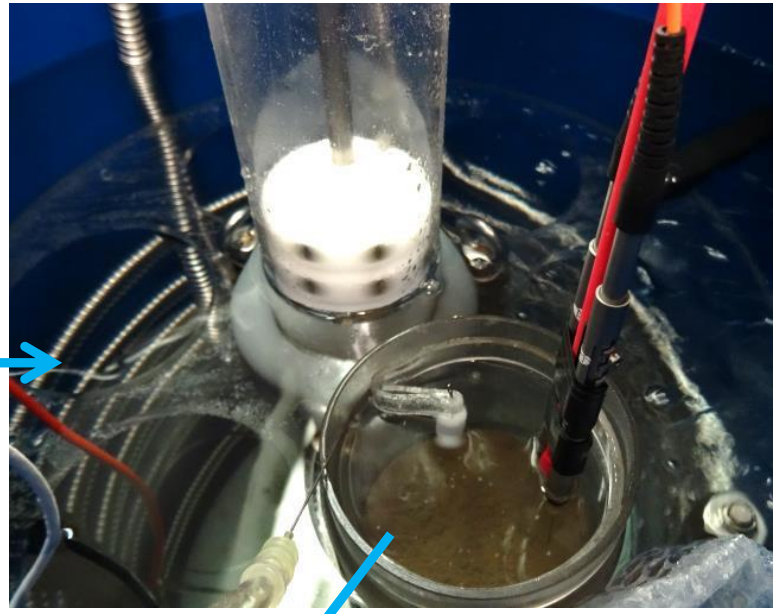

Former Arctic Ocean
Predicted Arctic Ocean ice zone
0°0'0"
10°0'0"E
80°0'0"N
79°0'0"N
78°0'0"N
2500 m
Kilometers
0
40
80
120



Sediment Cores

Lander

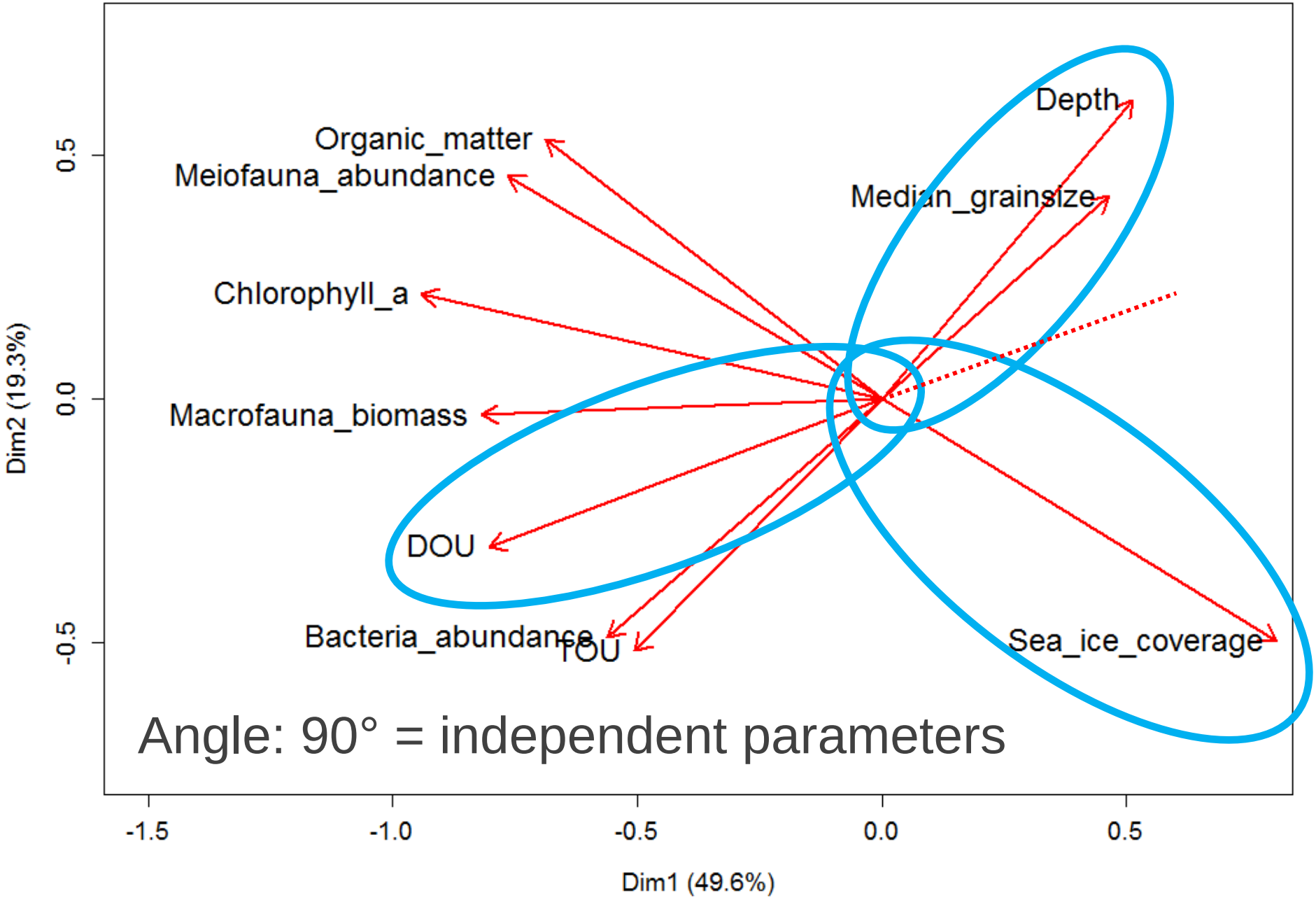




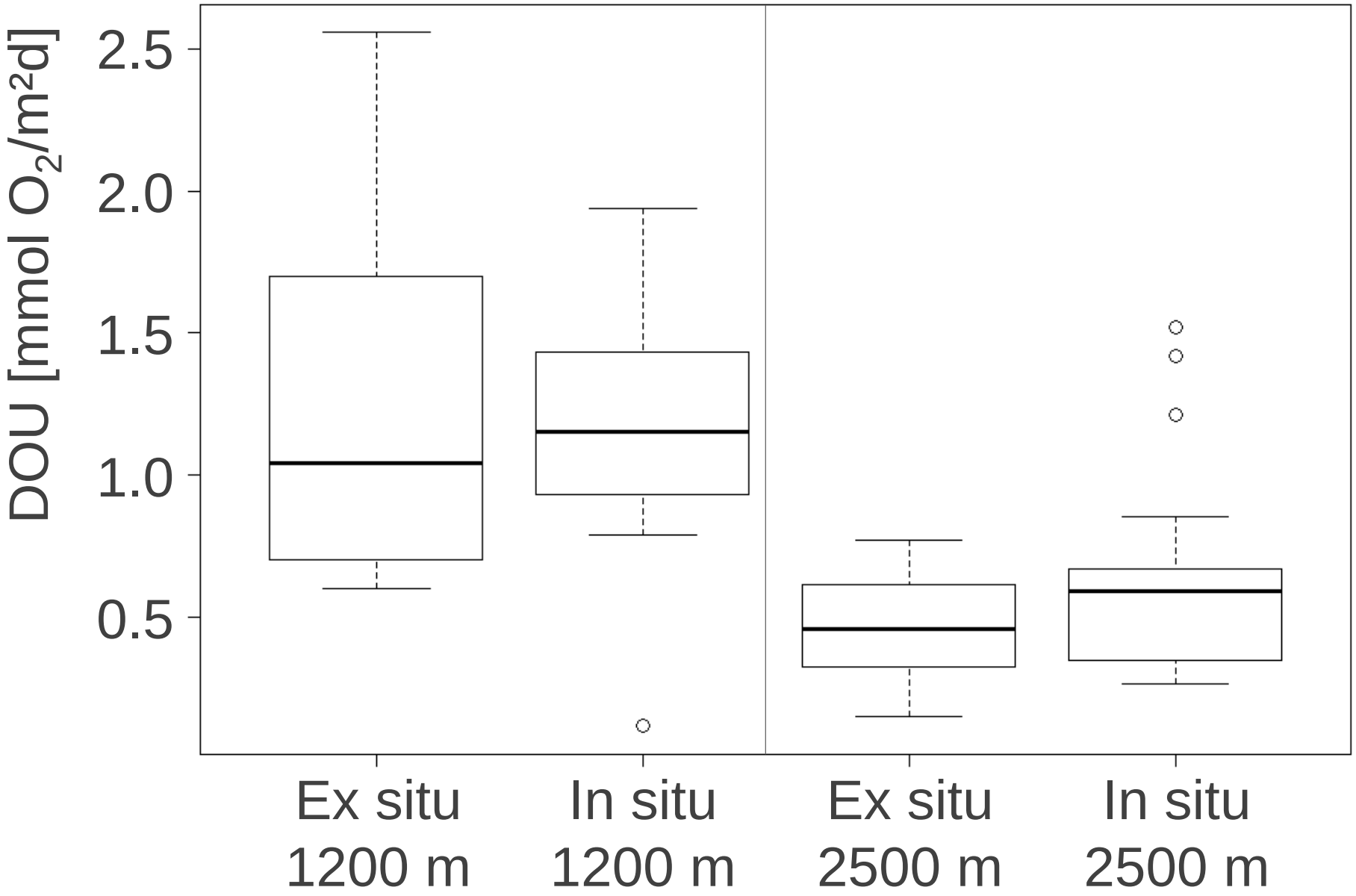
Oxygen fluxes: ex situ & in situ

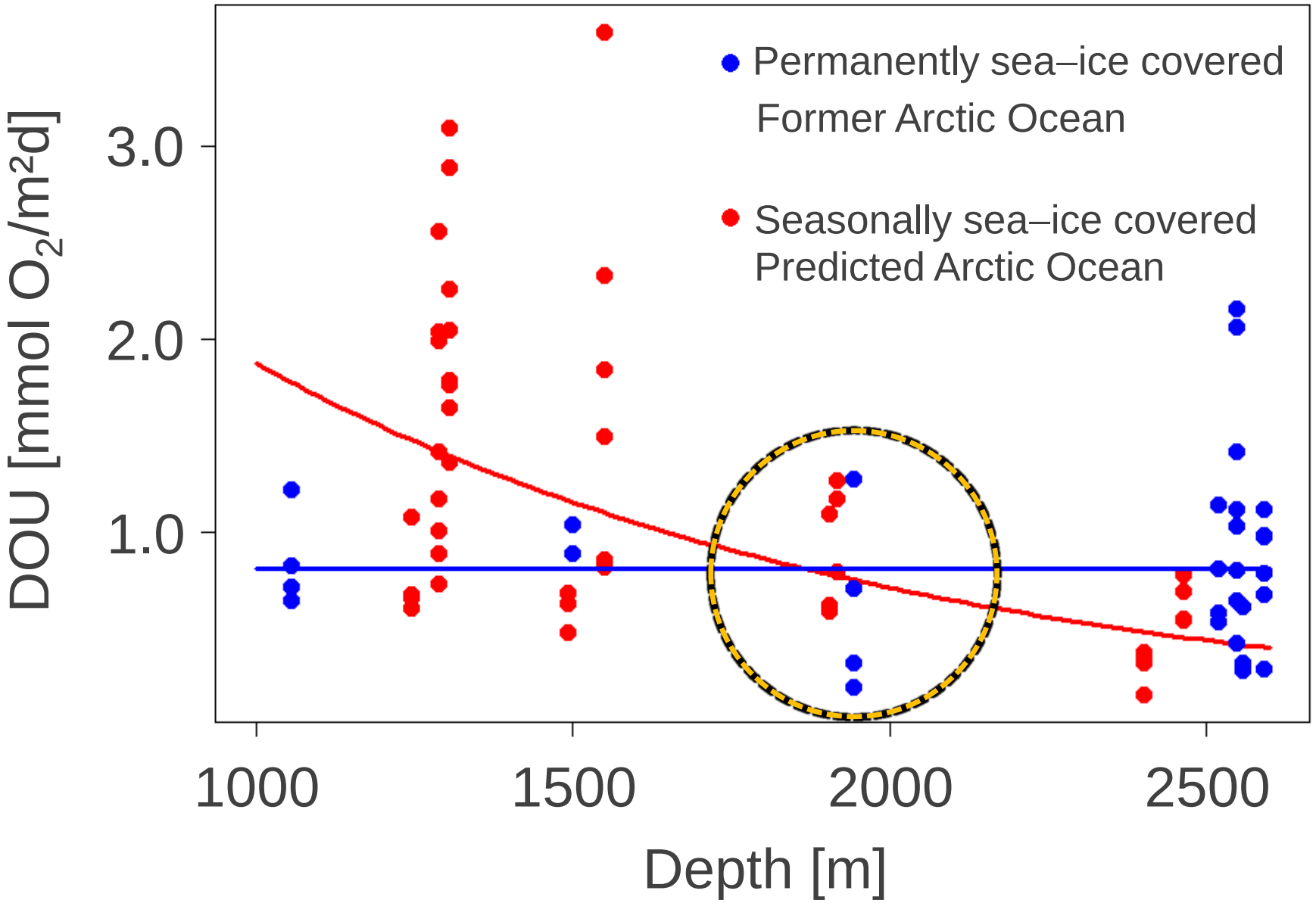
Diffusive oxygen uptake (DOU)
= Bacterial remineralisation
Method: Micro-profiling

Total oxygen uptake (TOU)
= Entire benthos remineralisation
Method: Incubation


Depth
Organic_matter
Meiofauna_abundance
Median_grainsize
Chlorophyll_a
Macrofauna_biomass
DOU
Bacteria_abundance
TOU
Sea_ice_coverage
Angle: 90° = independent parameters
0.5
0.0
-0.5
Dim2 (19.3%)
-1.5
-1.0
-0.5
0.0
0.5
Dim1 (49.6%)

Stations from seasonally sea–ice covered area




Permanently sea–ice covered
Former Arctic Ocean
Seasonally sea–ice covered
Predicted Arctic Ocean
DOU [mmol O2/m2d]
3.0
2.0
1.0
1000
1500
2000
2500
Depth [m]

Are benthic

remineralisation rates

in the **Arctic deep sea** influenced by decreasing sea–ice coverage and increasing primary production?

How?

Answer:

Remineralisation rates will shift towards depth dependency

Increasing rates are expectable for depth < 2000 m

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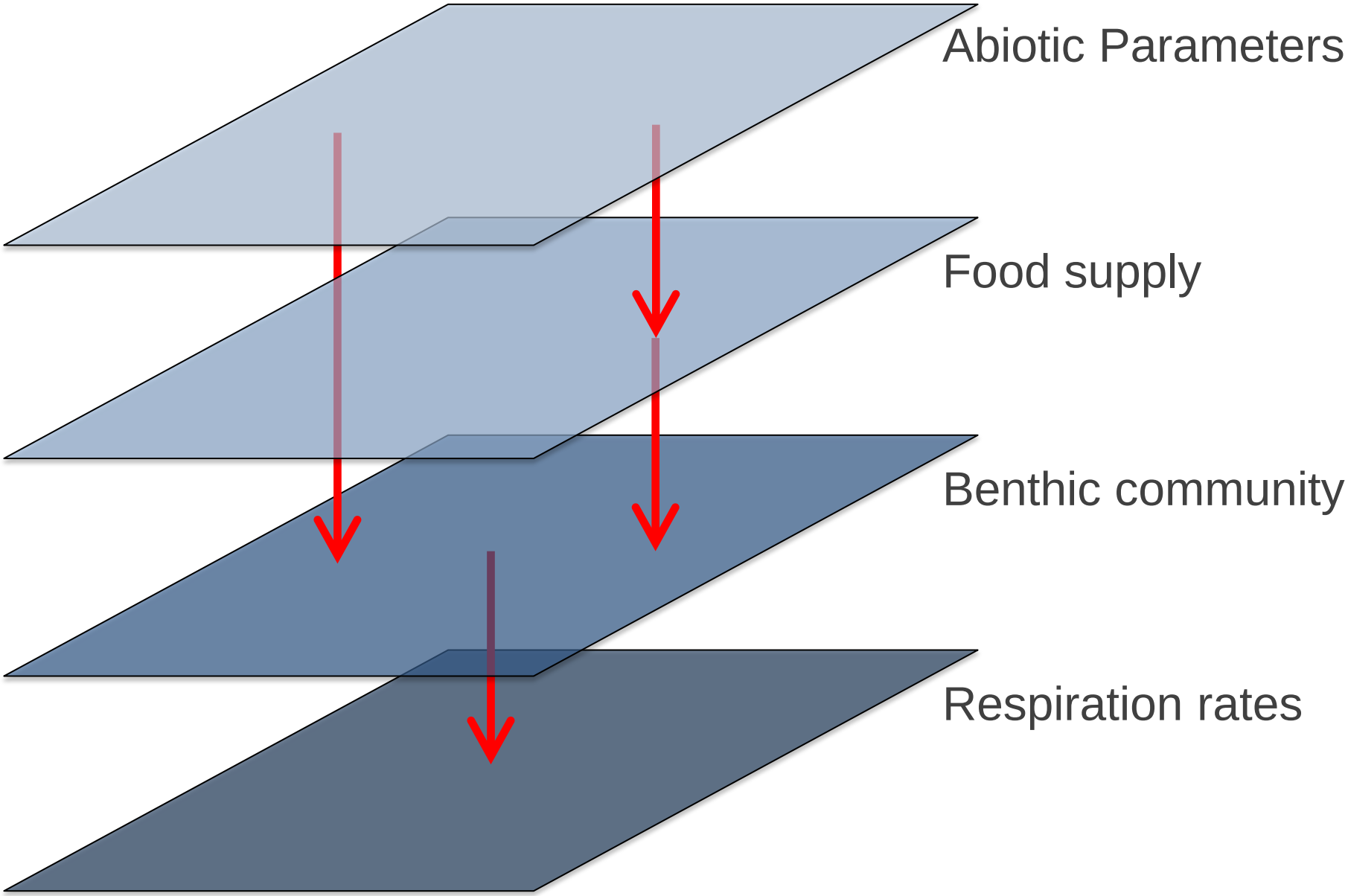
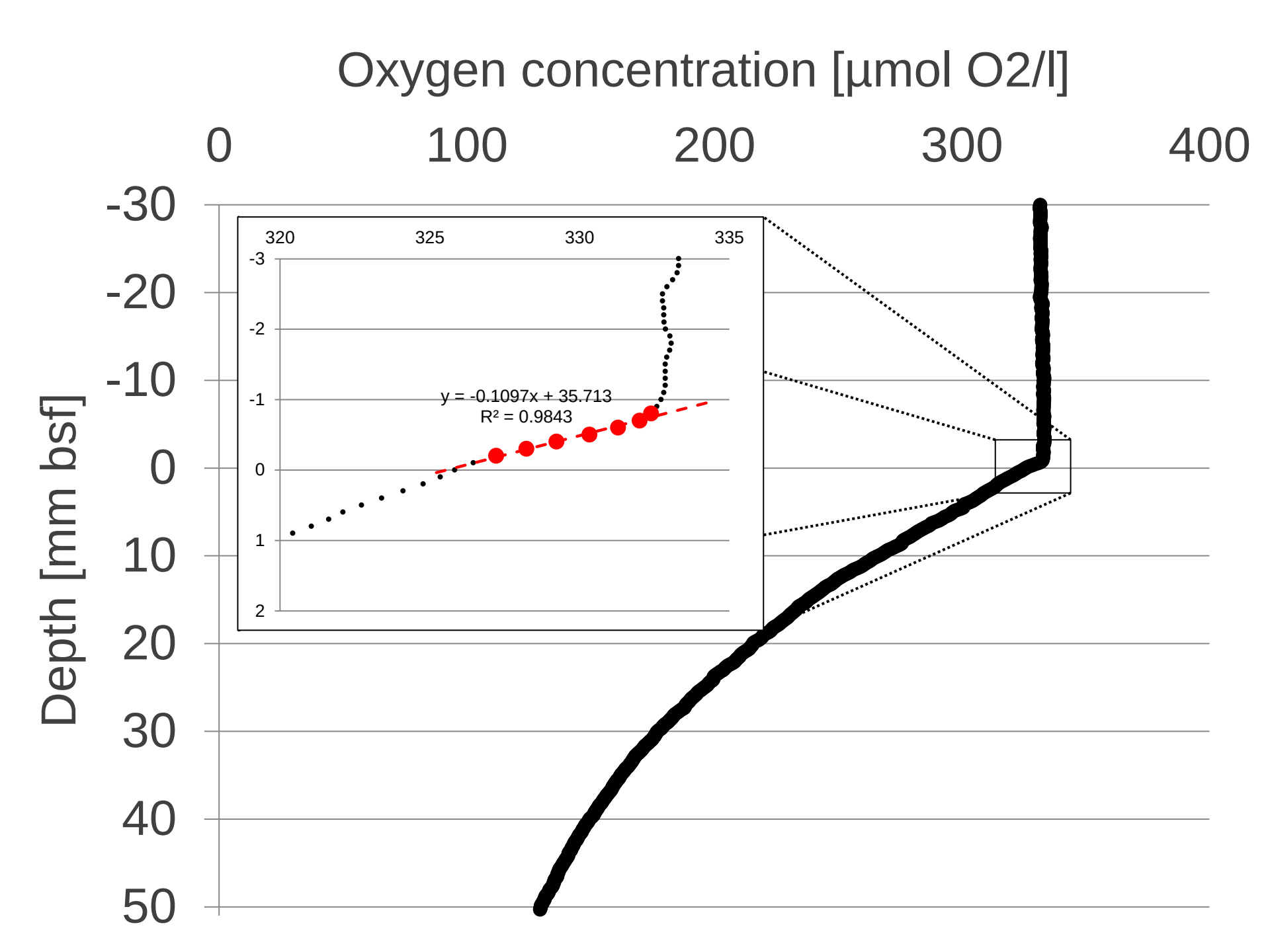
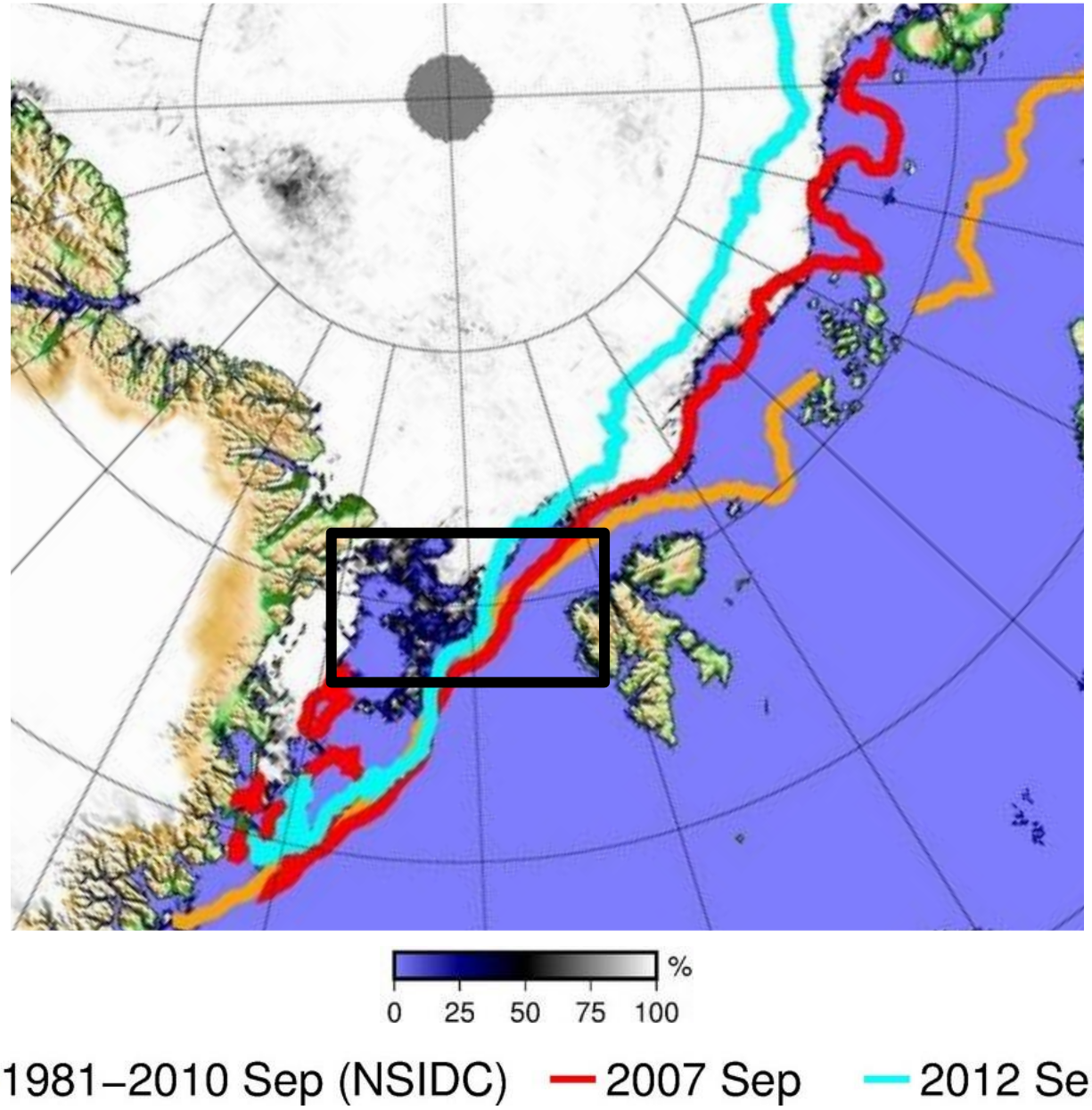
FRAM

Contact: ralf.hoffmann@awi.de


Abiotic Parameters
Food supply
Benthic community
Respiration rates


Oxygen concentration [µmol O2/l]
0
100
200
300
400
Depth [mm bsf]
-30
-20
-10
0
10
20
30
40
50
320
325
330
335
-3
-2
-1
0
1
2
y = -0.1097x + 35.713
R² = 0.9843

Sea Ice concentration 06.09.2015



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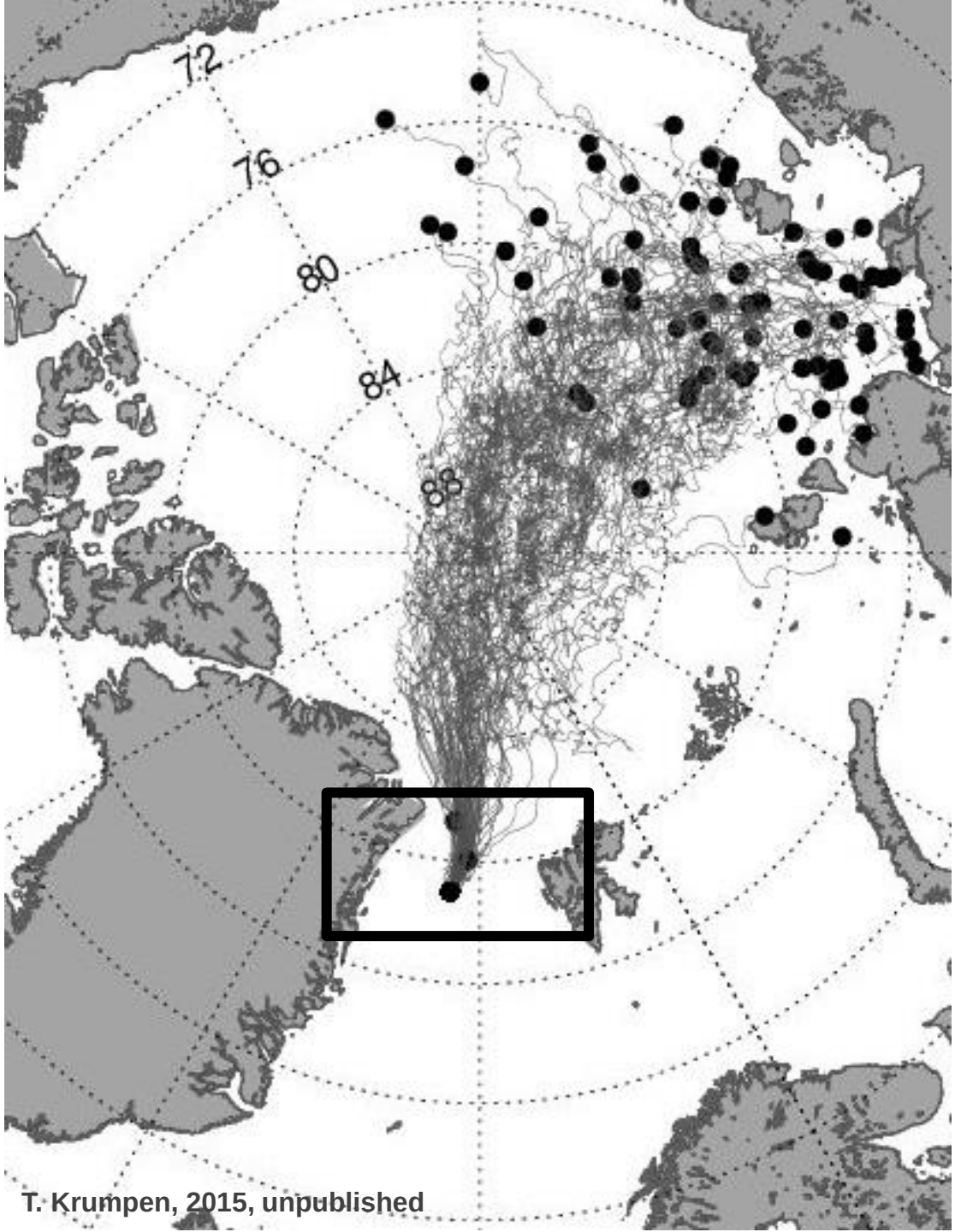


T. Krumpen, 2015, unpublished

Sampling

2014: 8 MUC + 2 Lander stations
Mid – End of June
Depth: 1000 – 2500m

2015: 8 MUC + 2 Lander stations
End of July – Mid of August
Depth: 275 – 2600m

Four stations in both years
Two bathymetric transects

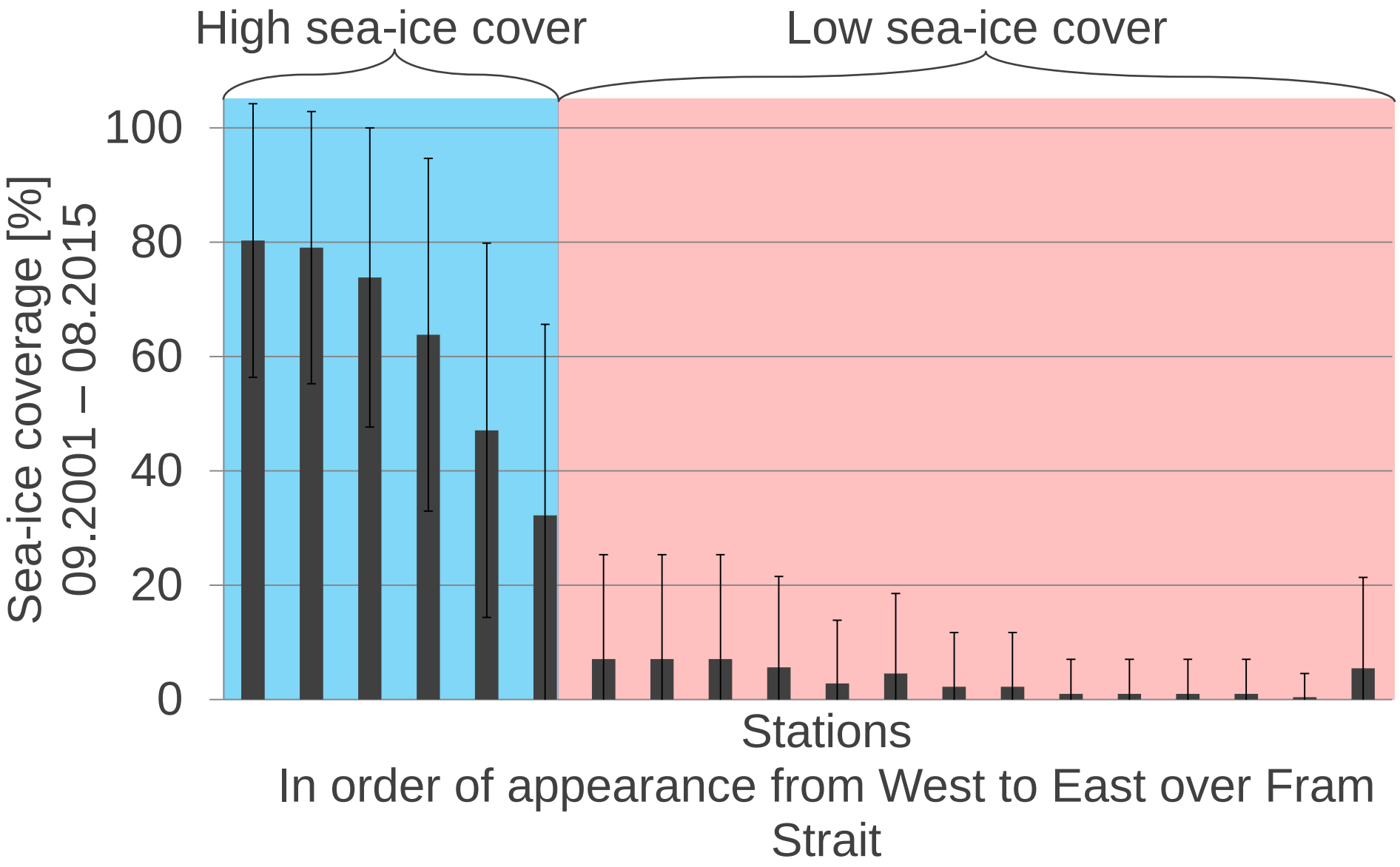
Test of compatibility of data

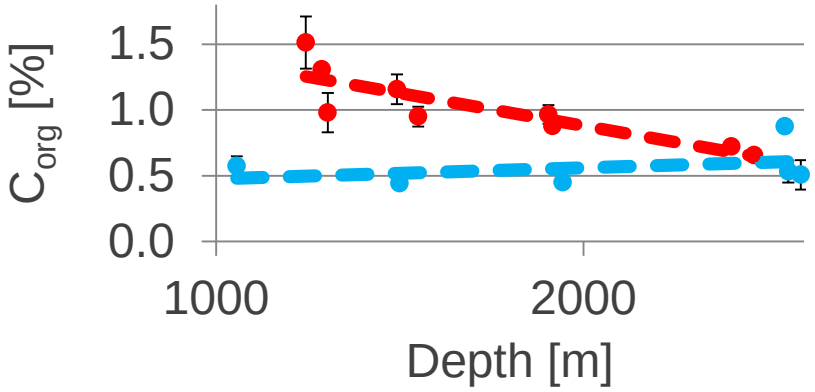
PCA on data biogenic data = not compatible

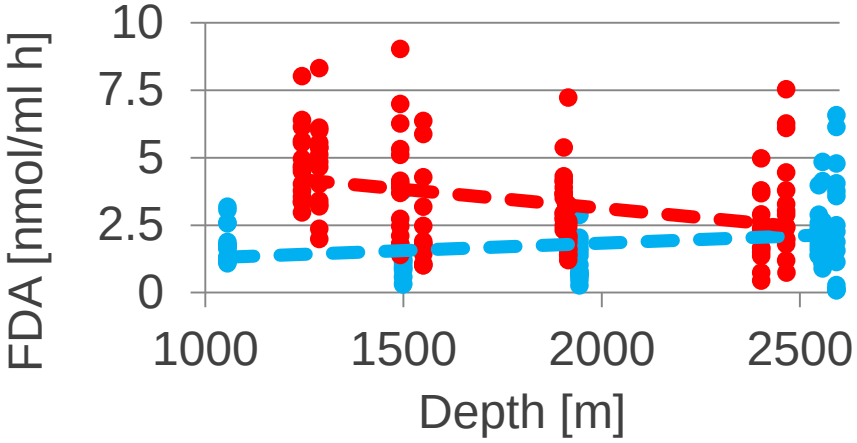
Wilcoxon: $p > 0.05$ = compatible
(Cathalot et al., Plos ONE, 2015)

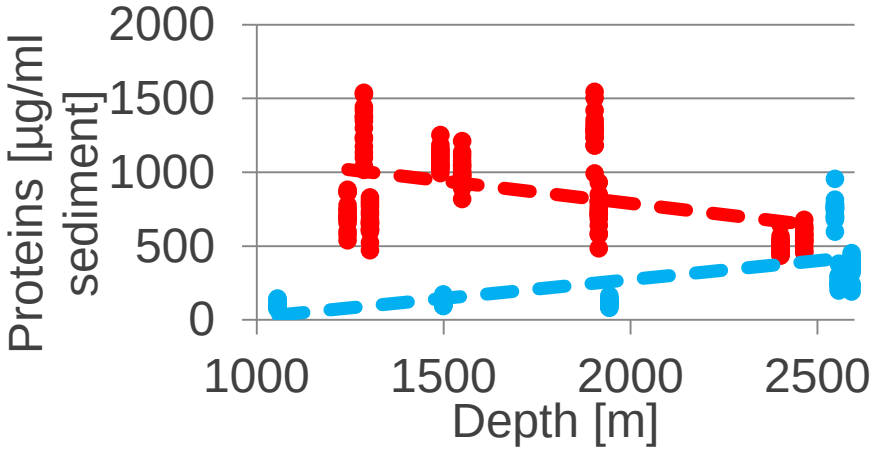
Timewise differences → data over 15 years needed (Henson et al., Global Change Biology, 2016)

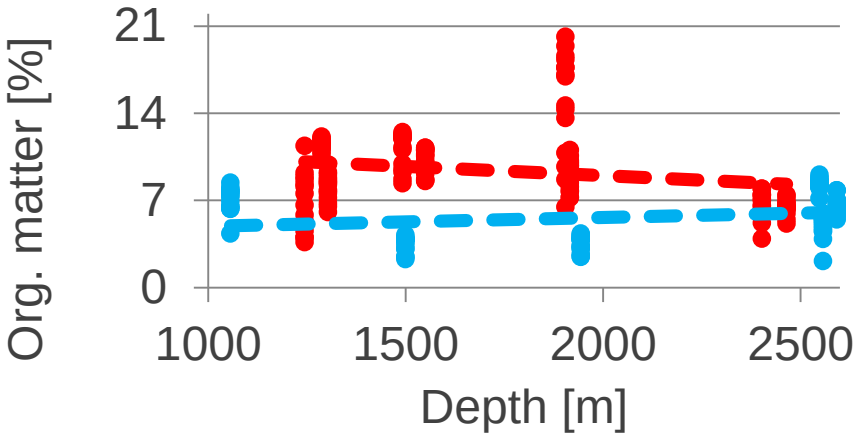
Sea-ice coverage

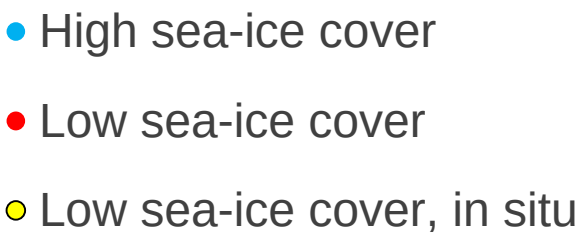


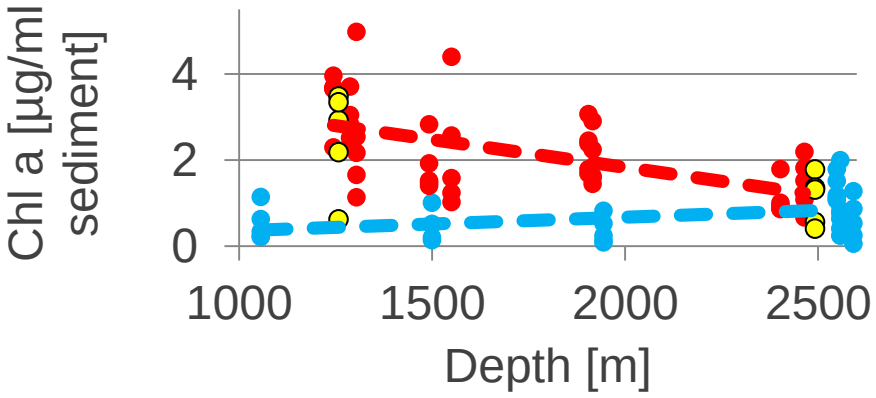

C_{org} [%]
1.5
1.0
0.5
0.0
1000
2000
Depth [m]

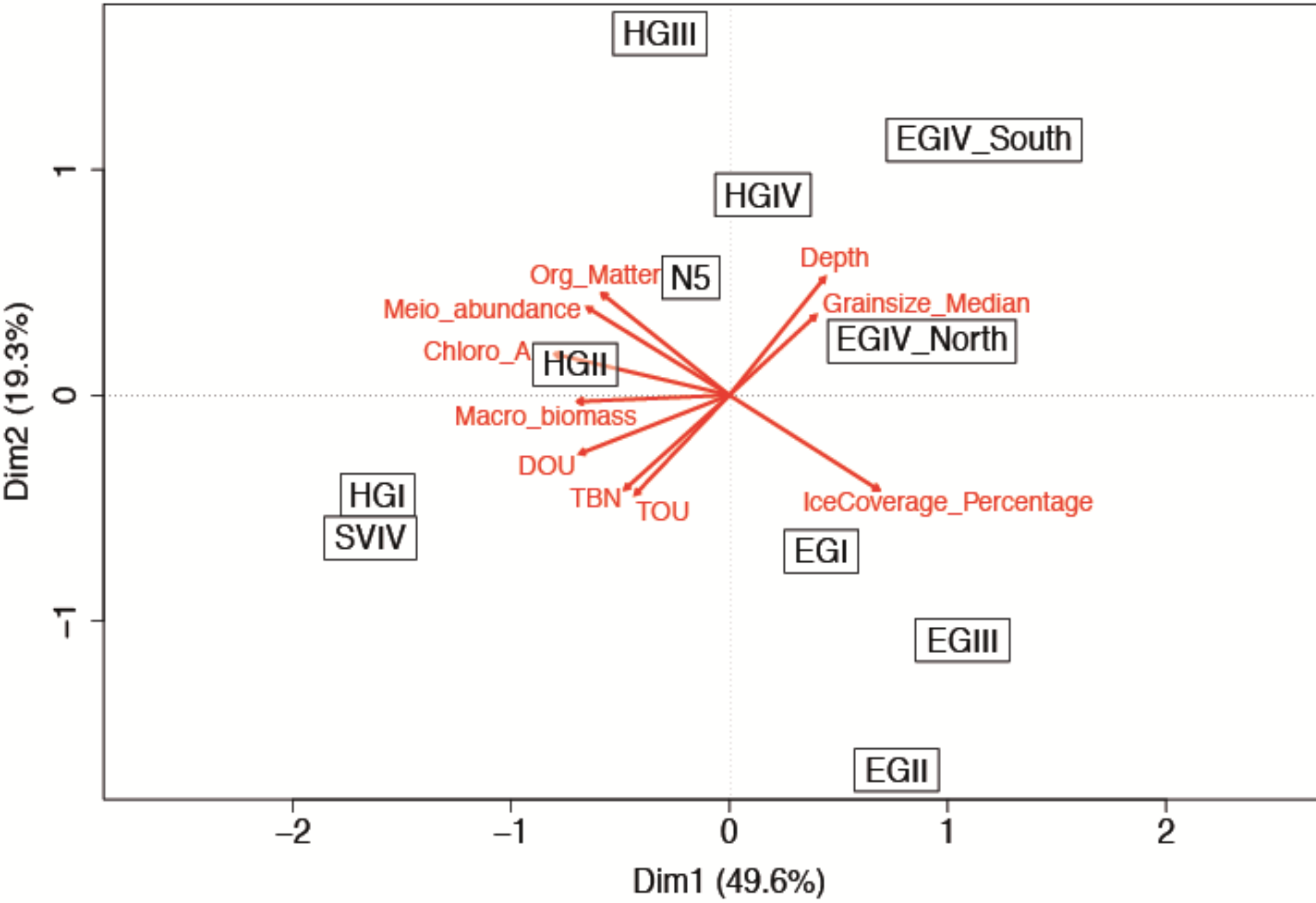

FDA [nmol/ml h]
10
7.5
5
2.5
0
1000
1500
2000
2500
Depth [m]


Proteins [µg/ml sediment]
2000
1500
1000
500
0
1000
1500
2000
2500
Depth [m]

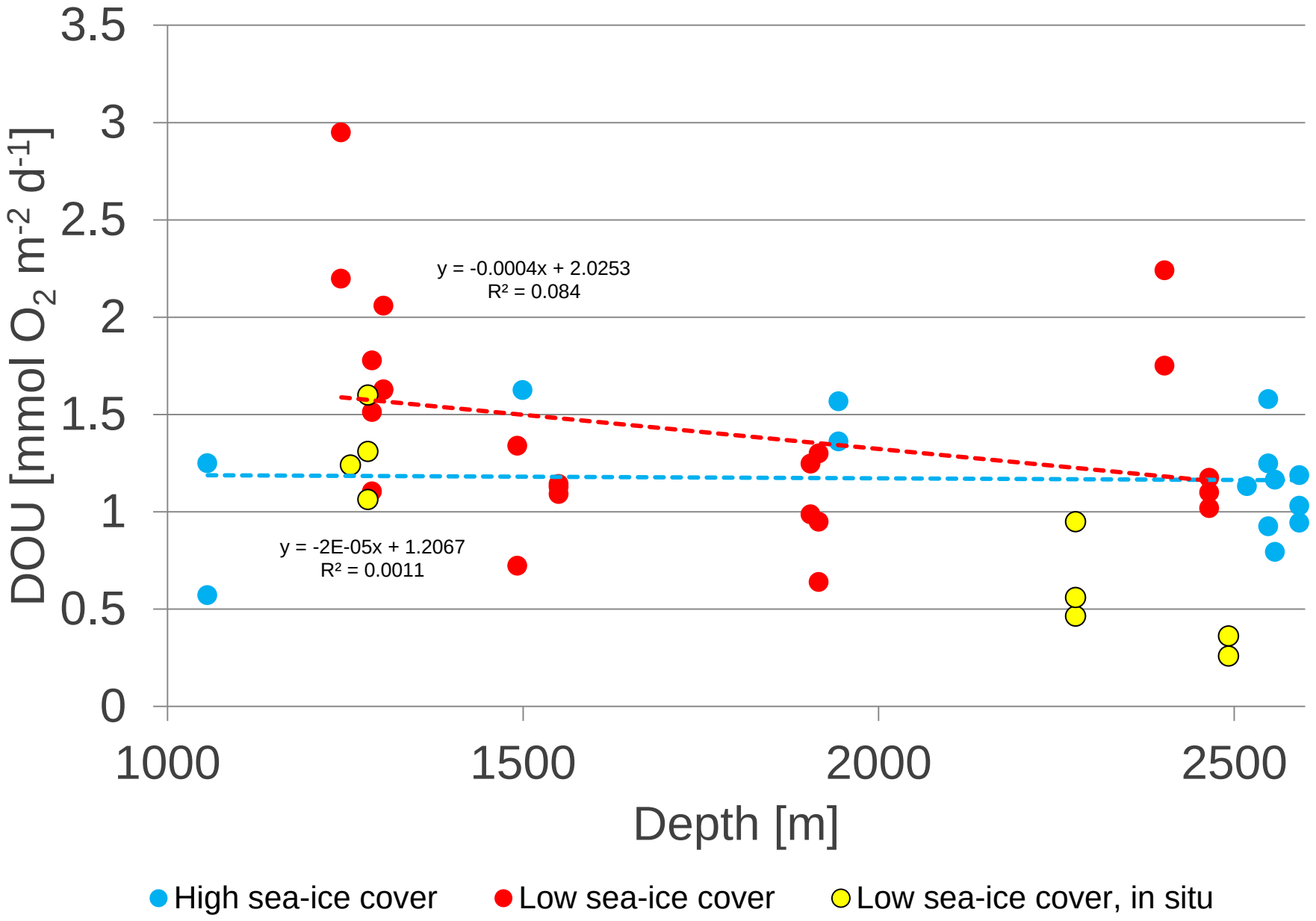

Org. matter [%]
21
14
7
0
1000
1500
2000
2500
Depth [m]


High sea-ice cover
Low sea-ice cover
Low sea-ice cover, in situ


Chl a [µg/ml sediment]
4
2
0
1000
1500
2000
2500
Depth [m]


HGIII
EGIV_South
HGIV
N5
Org_Matter
Meio_abundance
Chloro_A
HGII
Depth
Grainsize_Median
EGIV_North
Macro_biomass
DOU
TBN
TOU
IceCoverage_Percentage
HGI
SVIV
EGI
EGIII
EGII
Dim2 (19.3%)
Dim1 (49.6%)
1
0
−1
−2
−1
0
1
2

TOU


DOU [mmol O2 m-2 d-1]
3.5
3
2.5
2
1.5
1
0.5
0
y = -0.0004x + 2.0253
R² = 0.084
y = -2E-05x + 1.2067
R² = 0.0011
1000
1500
2000
2500
Depth [m]
High sea-ice cover
Low sea-ice cover
Low sea-ice cover, in situ