The Effects of Temperature and Carbon Addition on Arctic Sediment Oxygen and Nutrient Exchanges

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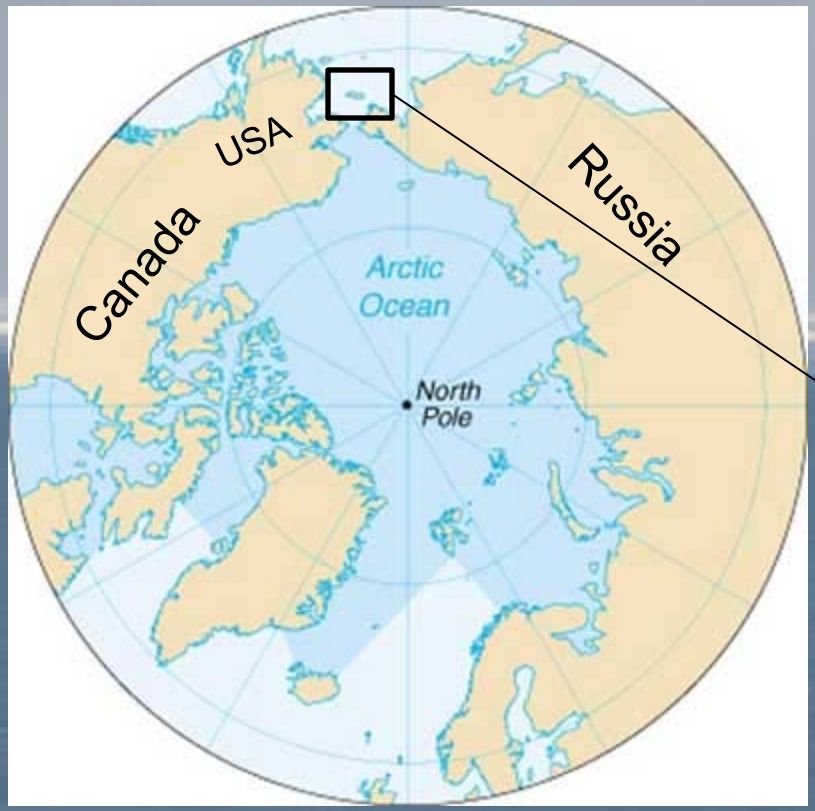
Outline

Background & Study Site:	Why are we interested in sediment exchange rates in the Arctic?
Methods:	What gear and body parts froze first?
Results:	The rates we measured.
Conclusions:	What we learned about Arctic benthic metabolism.
Acknowledgements:	The people that froze their body parts and those that provided the photos.

Background & Study Site



http://www.kidsgeo.com/images/arctic-ocean.jpg

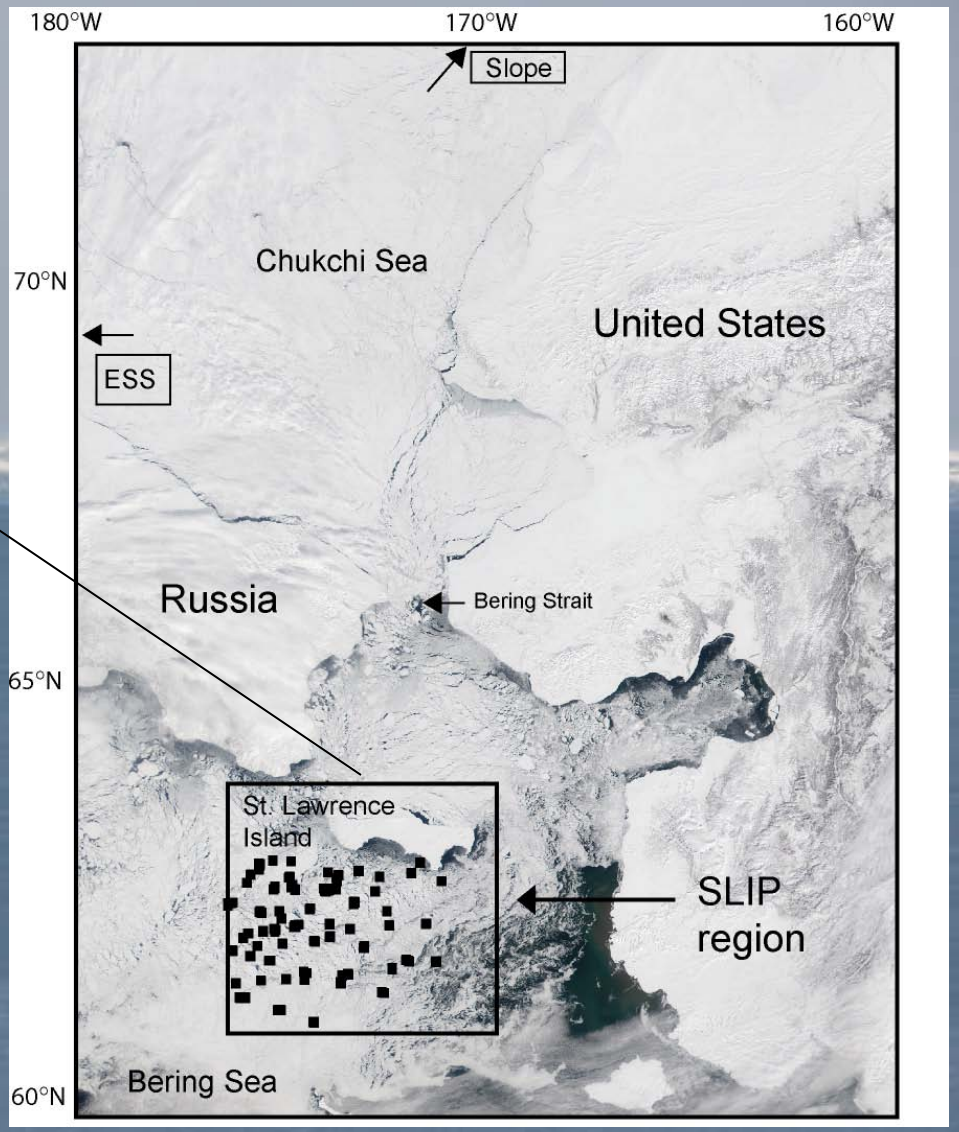
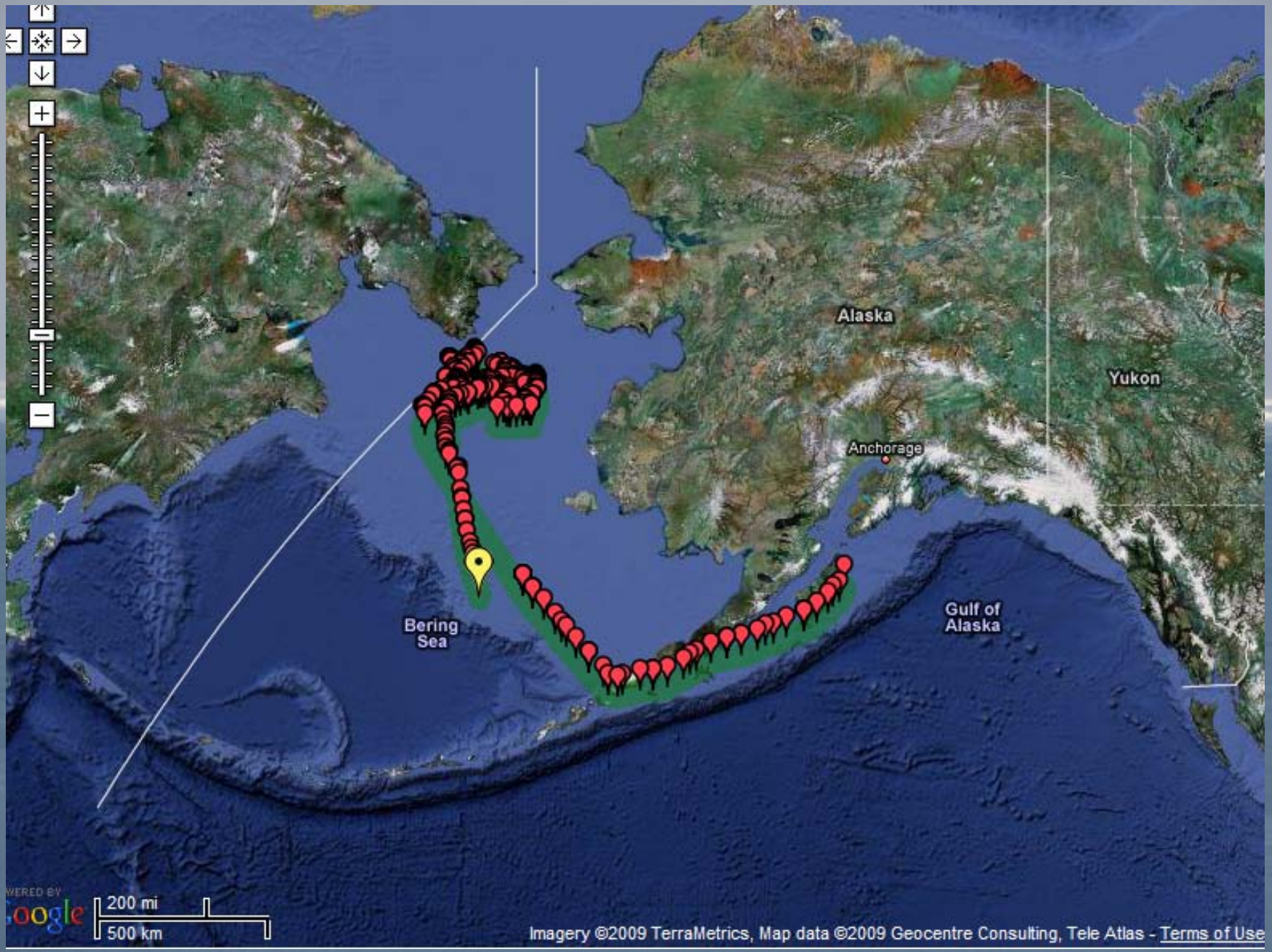
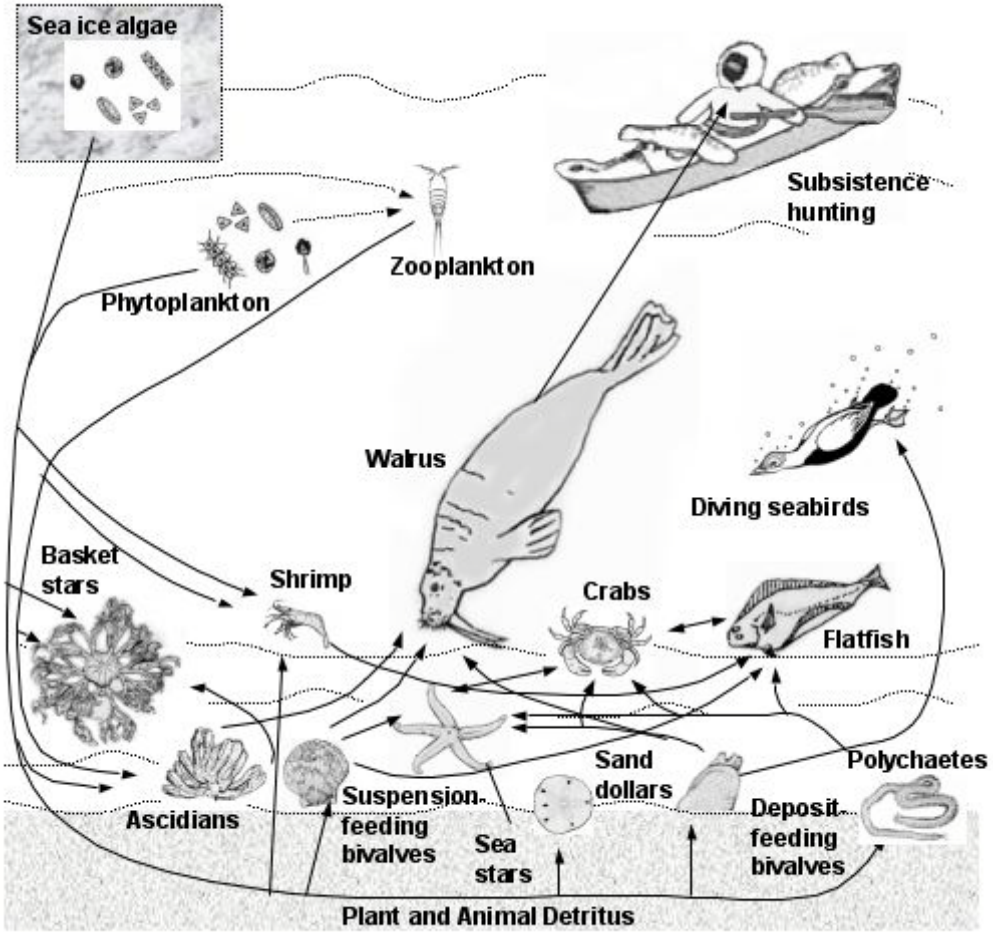


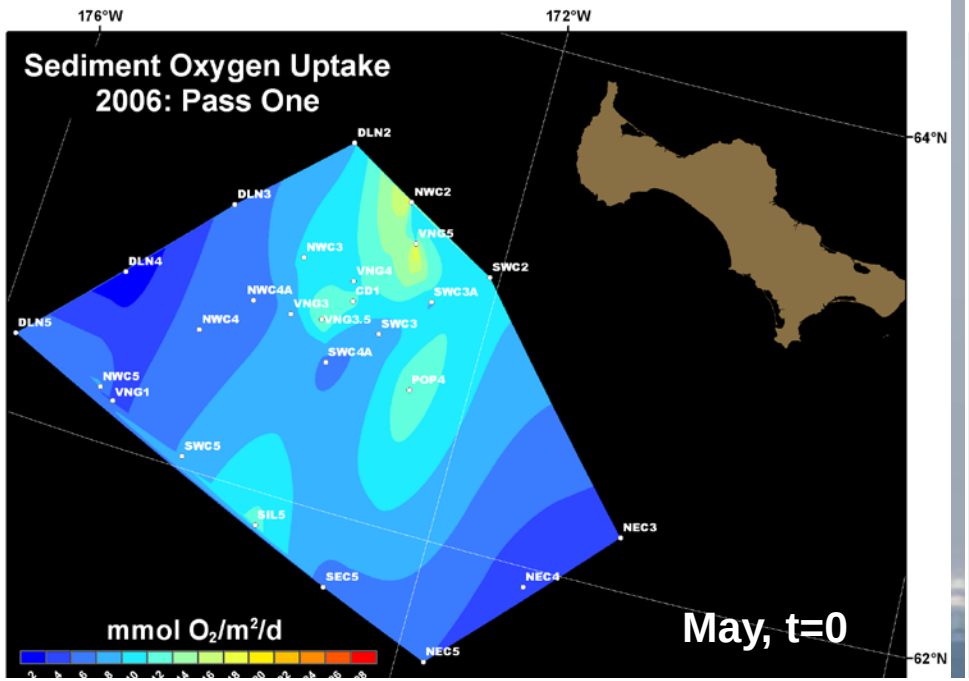
Image courtesy of NASA/Visible Earth
(http://visibleearth.nasa.gov)
May 2006

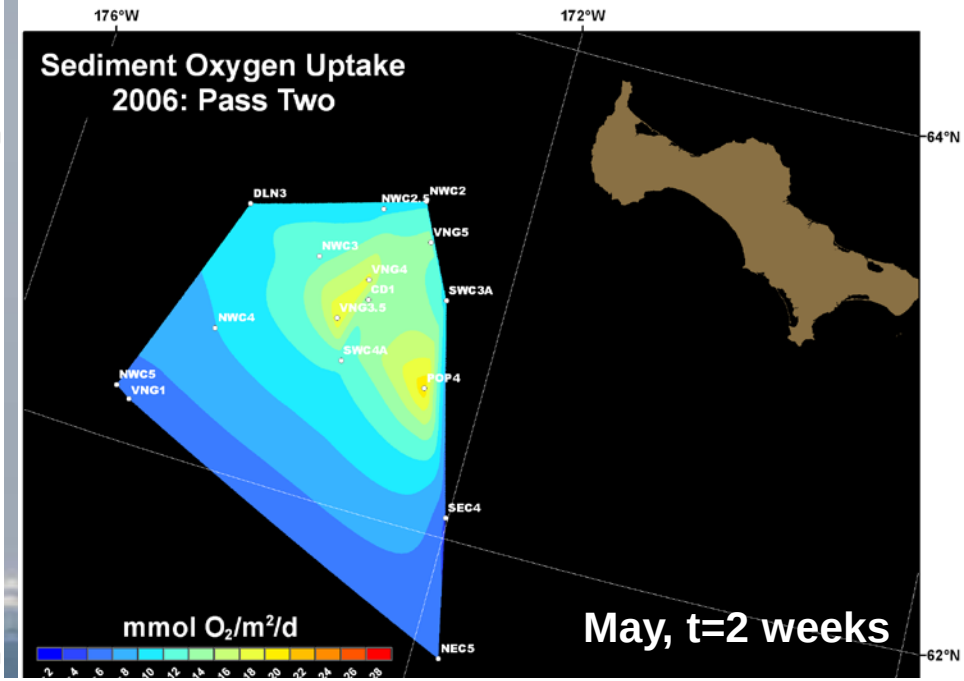

Alaska
Yukon
Anchorage
Bering Sea
Gulf of Alaska
200 mi
500 km
Imagery ©2009 TerraMetrics, Map data ©2009 Geocentre Consulting, Tele Atlas - Terms of Use

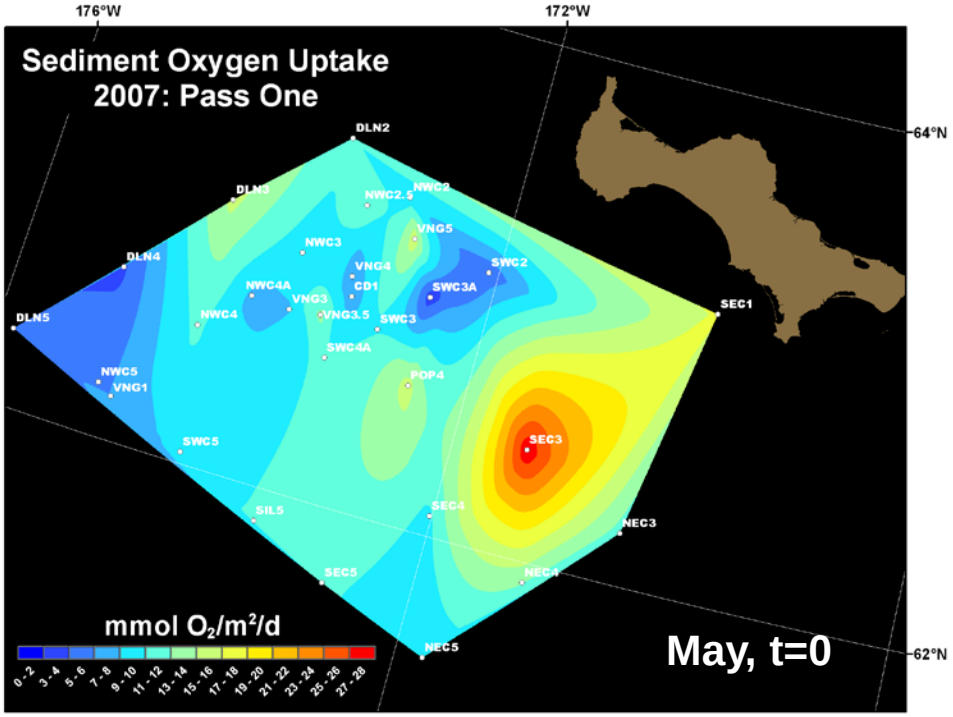


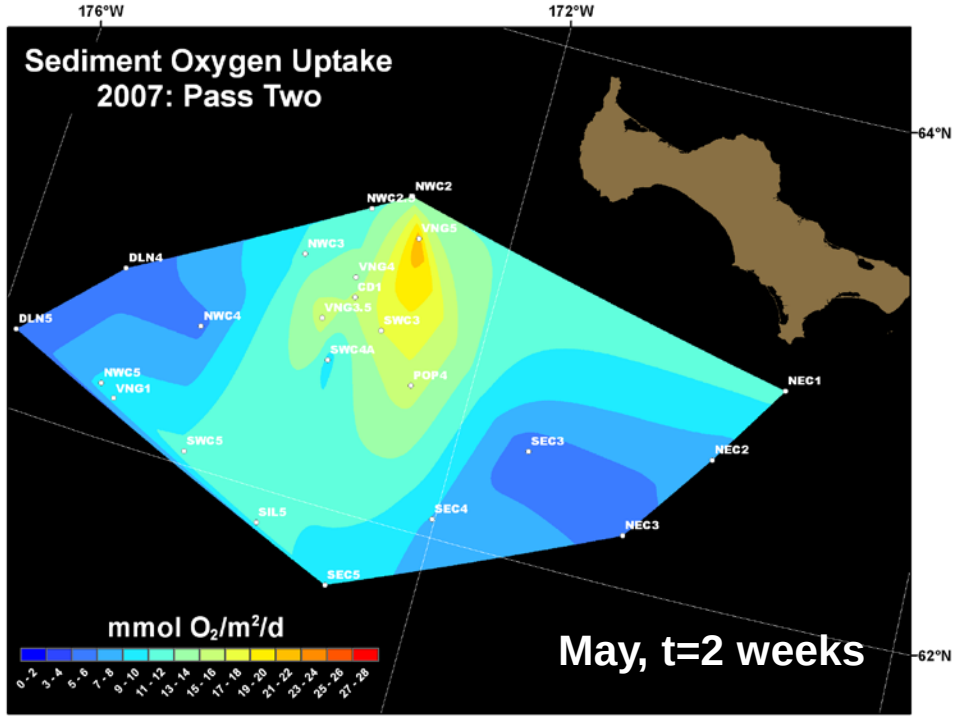
[modified from Grebmeier and Dunton 2000]

Common infaunal animals in northern Bering Sea


Sediment Oxygen Uptake
2006: Pass One
176°W
172°W
64°N
62°N
DLN2
DLN3
DLN4
DLN5
NWC2
NWC3
NWC4
NWC4A
NWC5
VNG1
VNG3
VNG3.5
VNG4
VNG5
CD1
SWC2
SWC3
SWC3A
SWC4A
SWC5
POP4
SIL5
SEC5
NEC3
NEC4
NEC5
mmol O2/m2/d
May, t=0


Sediment Oxygen Uptake
2006: Pass Two
176°W
172°W
64°N
62°N
DLN3
NWC2.5
NWC2
VNG5
NWC3
VNG4
CD1
SWC3A
VNG3.5
NWC4
SWC4A
NWC5
VNG1
POP4
SEC4
NEC5
mmol O2/m2/d
May, t=2 weeks


Sediment Oxygen Uptake
2007: Pass One
176°W
172°W
64°N
62°N
DLN2
DLN3
NWC2.5
NWC2
VNG5
NWC3
DLN4
VNG4
SWC2
NWC4A
CD1
SWC3A
VNG3
SEC1
DLN5
NWC4
VNG3.5
SWC3
SWC4A
NWC5
VNG1
POP4
SEC3
SWC5
SIL5
SEC4
NEC3
SEC5
NEC4
NEC5
mmol O2/m2/d
0 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24
25 - 26
27 - 28
May, t=0


Sediment Oxygen Uptake
2007: Pass Two
176°W
172°W
64°N
62°N
NWC2
NWC2.5
VNG5
NWC3
DLN4
VNG4
CD1
DLN5
NWC4
VNG3.5
SWC3
SWC4A
NWC5
VNG1
POP4
NEC1
SWC5
SEC3
NEC2
SIL5
SEC4
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SEC5
mmol O2/m2/d
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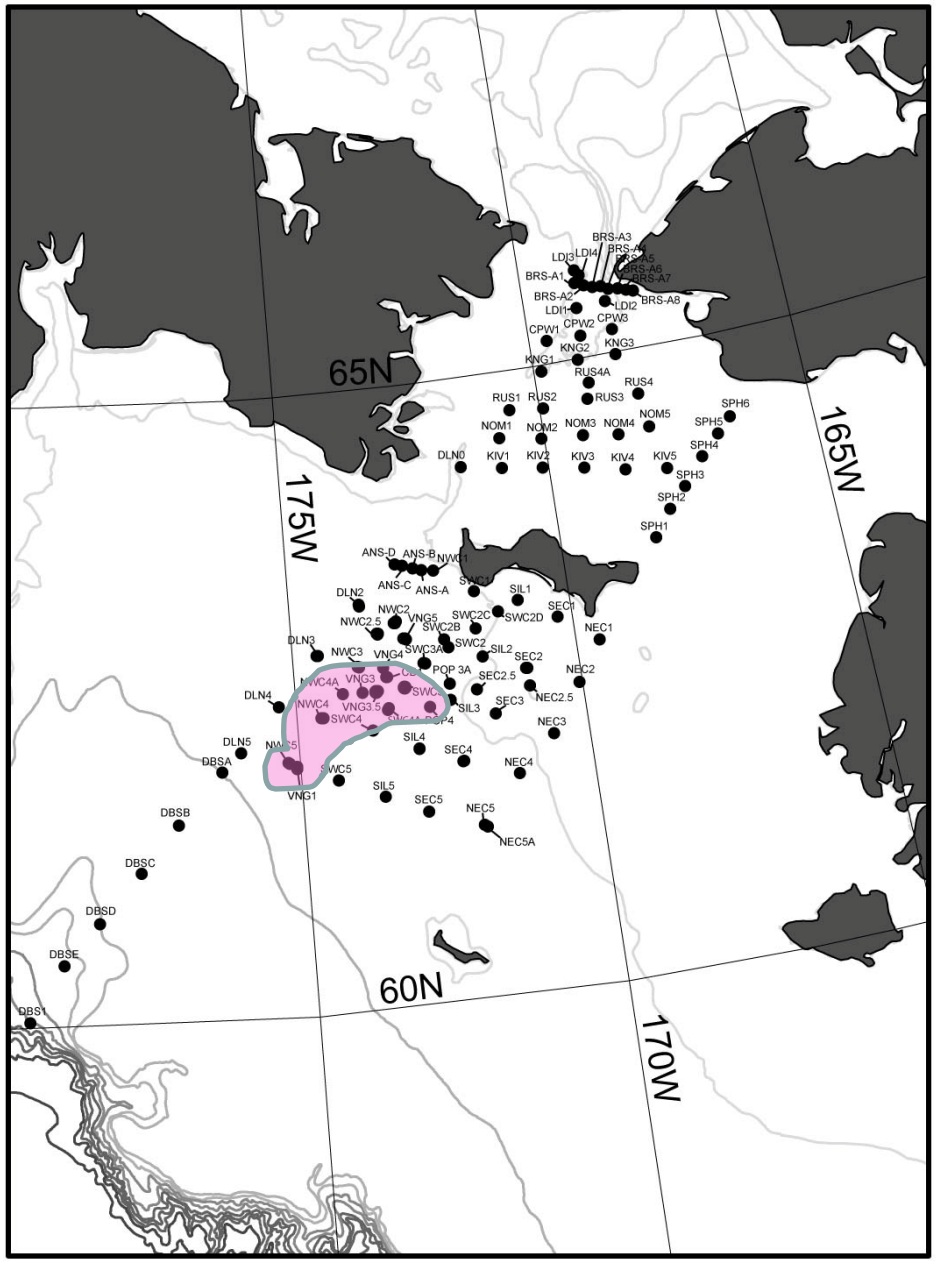
21 - 22
23 - 24
25 - 26
27 - 28
May, t=2 weeks



- Conducted experiments on board the USCG Healy as part of the BEST and BSIERP projects.

Stations:

NWC5 ~ 80 m

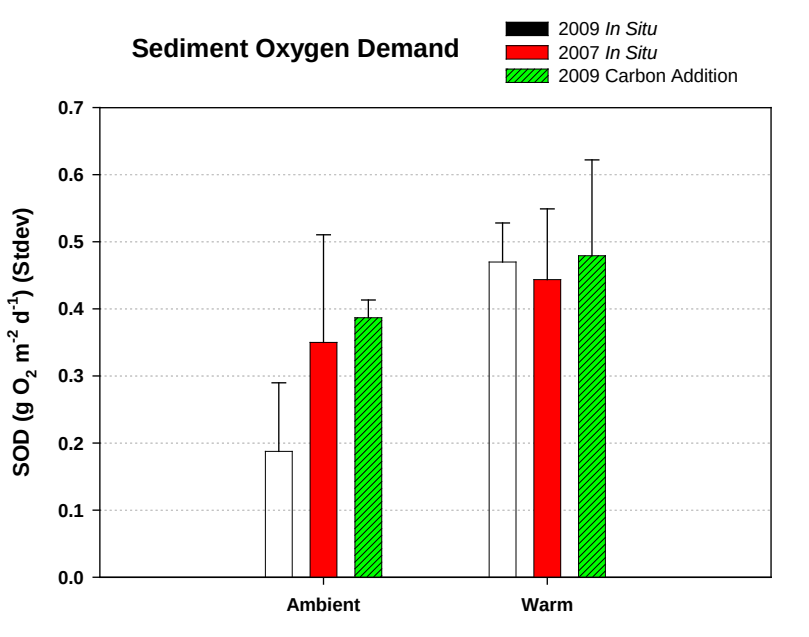
SWC3 ~ 62 m

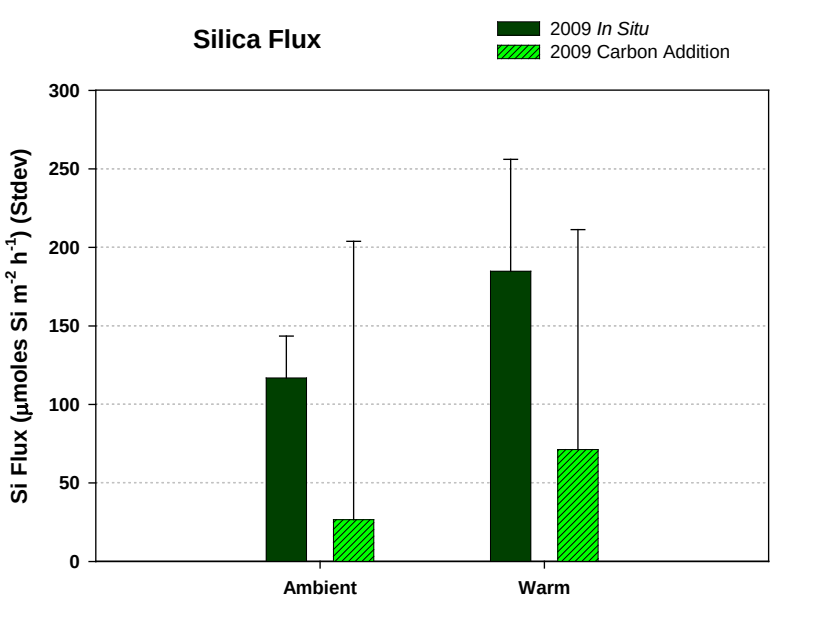
VNG3.5 ~ 67 m

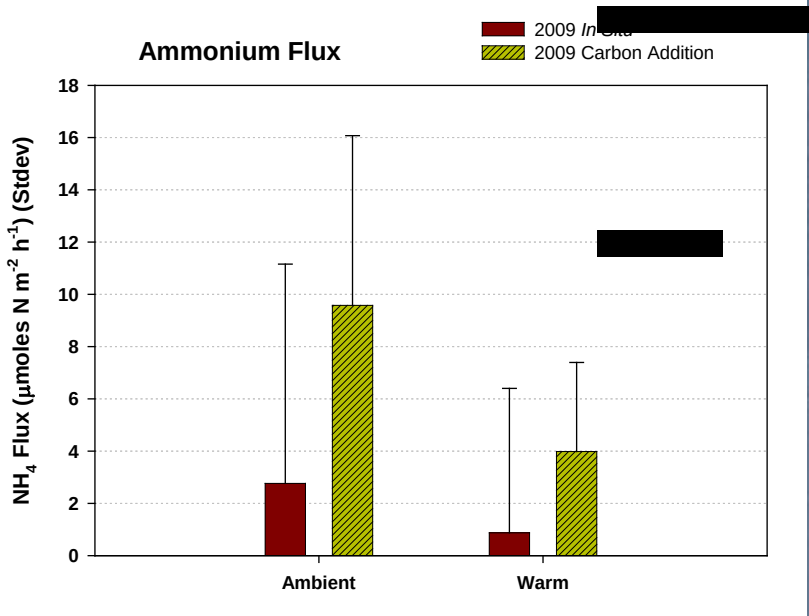
Methods

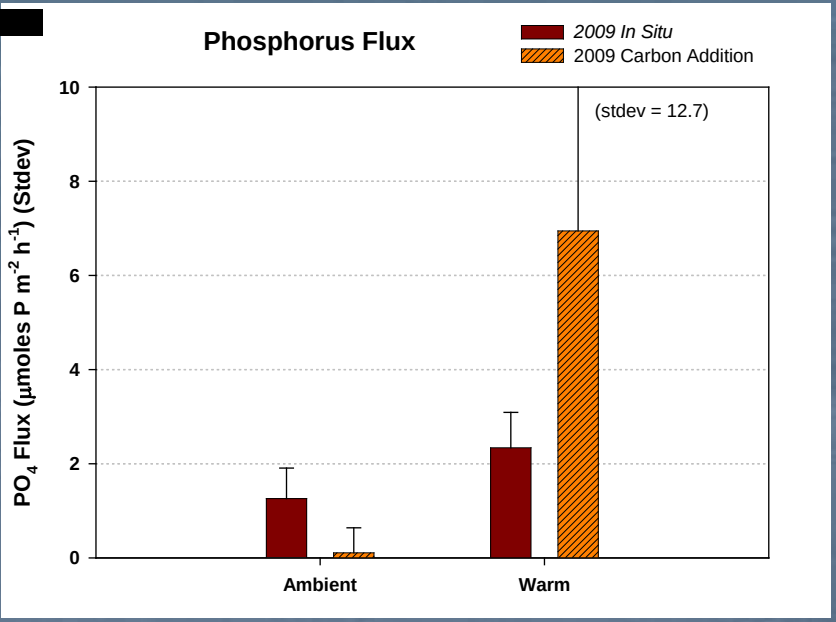
- Measured rates of sediment remineralization using sediment core incubations.
- Rates of: SOD, DIN, DIP and Silica exchange between sediments and overlying water.
- Two experiments:
  - Ambient (-1 °C) vs Warm (3 °C) incubations
  - Carbon addition : adding labile organic matter and measuring remineralization rates over the course of 5 days

Results


Sediment Oxygen Demand
2009 In Situ
2007 In Situ
2009 Carbon Addition
SOD (g O2 m-2 d-1) (Stdev)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Ambient
Warm


Silica Flux
2009 In Situ
2009 Carbon Addition
Si Flux (µmoles Si m-2 h-1) (Stdev)
0
50
100
150
200
250
300
Ambient
Warm


Ammonium Flux
2009 In Situ
2009 Carbon Addition
NH4 Flux (µmoles N m-2 h-1) (Stdev)
0
2
4
6
8
10
12
14
16
18
Ambient
Warm


Phosphorus Flux
2009 In Situ
2009 Carbon Addition
(stdev = 12.7)
PO4 Flux (µmoles P m-2 h-1) (Stdev)
0
2
4
6
8
10
Ambient
Warm

Temperature Change

	SOD ($g\ O_2\ m^{-2}\ d^{-1}$)	DIN ($\mu moles\ N\ m^{-2}\ h^{-1}$)	DIP ($\mu moles\ P\ m^{-2}\ h^{-1}$)	Si ($\mu moles\ Si\ m^{-2}\ h^{-1}$)
Ambient	0.22	5.66	1.58	99
Warm	0.45	1.15	2.34	185
Change	↑	↓	↑	↑
%	105	80	48	86

Carbon Addition

	SOD ($g\ O_2\ m^{-2}\ d^{-1}$)	DIN ($\mu moles\ N\ m^{-2}\ h^{-1}$)	DIP ($\mu moles\ P\ m^{-2}\ h^{-1}$)	Si ($\mu moles\ Si\ m^{-2}\ h^{-1}$)
Ambient	0.39	10.31	0.11	177
Warm	0.48	4.40	6.95	140
Change	↑	↓	↑	↑
%	23	57	6218	21

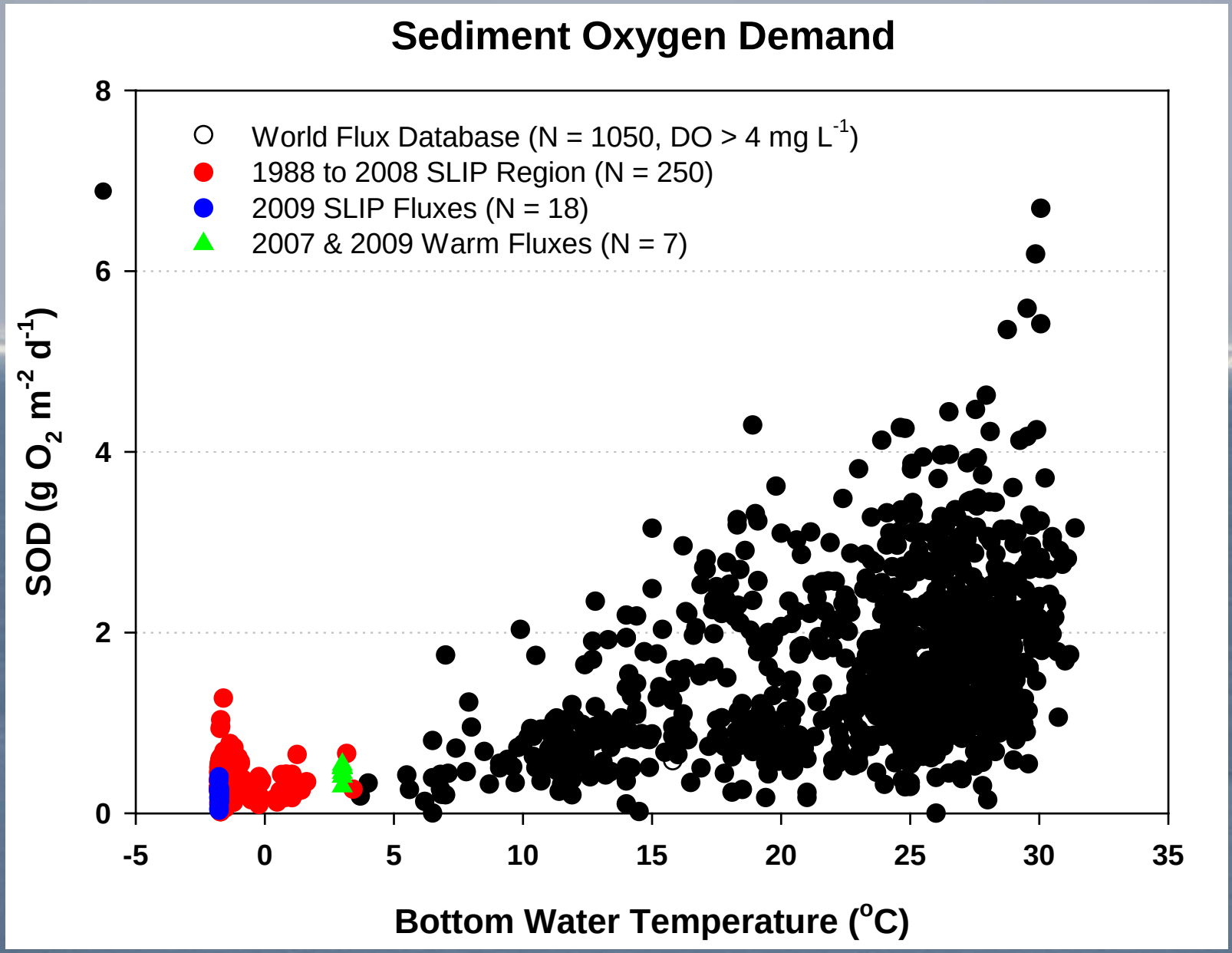
Results

SOD

($g\ O_2\ m^{-2}\ d^{-1}$)

	In Situ	C-Addition	Change	%
Ambient	0.22	0.39		77
Warm	0.45	0.48		7
Change				
%	105	23		

Results


Sediment Oxygen Demand
World Flux Database (N = 1050, DO > 4 mg L-1)
1988 to 2008 SLIP Region (N = 250)
2009 SLIP Fluxes (N = 18)
2007 & 2009 Warm Fluxes (N = 7)
SOD (g O2 m-2 d-1)
Bottom Water Temperature (oC)
0
2
4
6
8
-5
0
5
10
15
20
25
30
35

Conclusions

- Sediment oxygen demand (SOD) rates increased with both temperature and carbon supply.

- Nutrient responses were varied and suggested interactions with benthic fauna effecting rates of exchange.

- Preliminary experiments worked well and provided measurements where data is sparse.

- We would like to expand these experiments to include more of the SLIP stations, use local carbon source (Arctic diatoms) and measure the carbon addition fluxes for 3+ weeks.

Acknowledgements

Maria Ceballos

Jackie Grebmeier

Walter Boynton

Lee Cooper

Crew of USGC Healey

CBL NASL

NSF

Photo Credits: M.Ceballos, L. Cooper, N. Morata, D. Wheeler, M. Guarinello, E. Bailey

Results

SOD

	In Situ	C-Addition	Change	%
Ambient	0.22	0.39	↑	77
Warm	0.45	0.48	↑	7
Change	↑	↑		
%	105	23		

Silica

	In Situ	C-Addition	Change	%
Ambient	99	177	↑	78
Warm	185	140	↓	24
Change	↑	↓		
%	86	21		

DIN

	In Situ	C-Addition	Change	%
Ambient	5.66	10.31	↑	82
Warm	1.15	4.40	↑	283
Change	↓	↓		
%	80	57		

Phosphorus

	In Situ	C-Addition	Change	%
Ambient	1.58	0.11	↓	93
Warm	2.34	6.95	↑	197
Change	↑	↑		
%	48	6218		