# Effects of climate change on sedimentary nitrogen cycling in the Bering Sea

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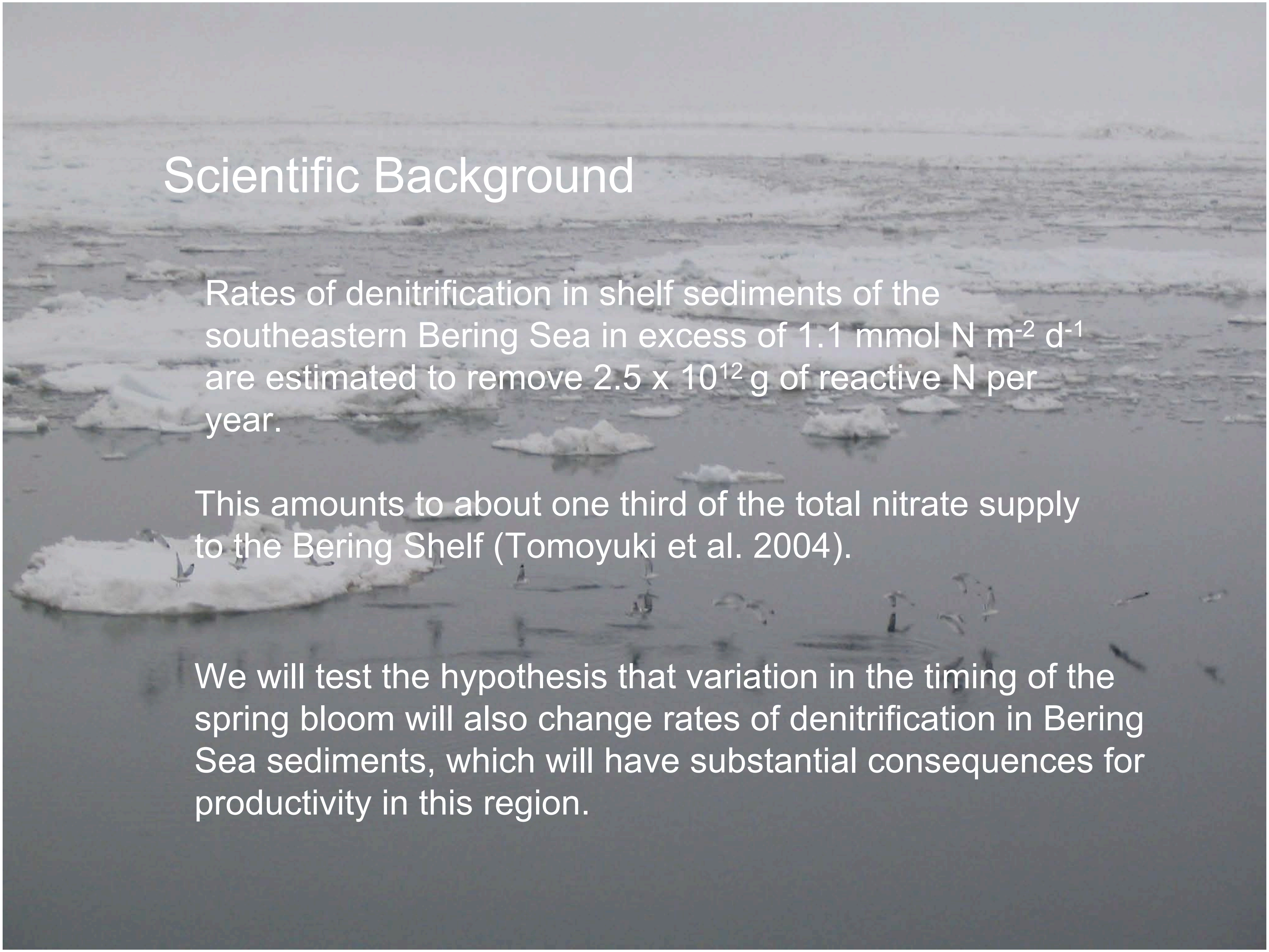


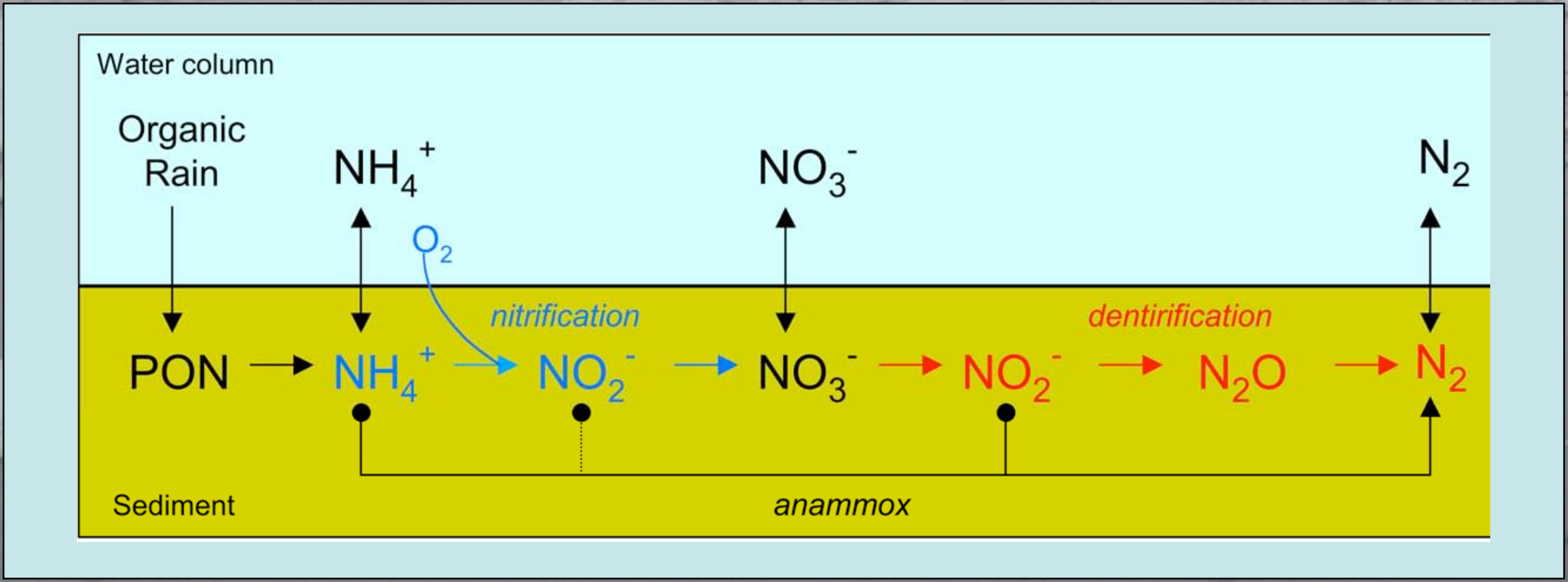
# Scientific Background

Rates of denitrification in shelf sediments of the southeastern Bering Sea in excess of 1.1 mmol N $m^{-2}$ $d^{-1}$ are estimated to remove 2.5 x $10^{12}$ g of reactive N per year.

This amounts to about one third of the total nitrate supply to the Bering Shelf (Tomoyuki et al. 2004).

We will test the hypothesis that variation in the timing of the spring bloom will also change rates of denitrification in Bering Sea sediments, which will have substantial consequences for productivity in this region.

# Scientific Background – Sedimentary N-cycling



Water column

Organic Rain

$NH_4^+$

$NO_3^-$

$N_2$

$O_2$

*nitrification*

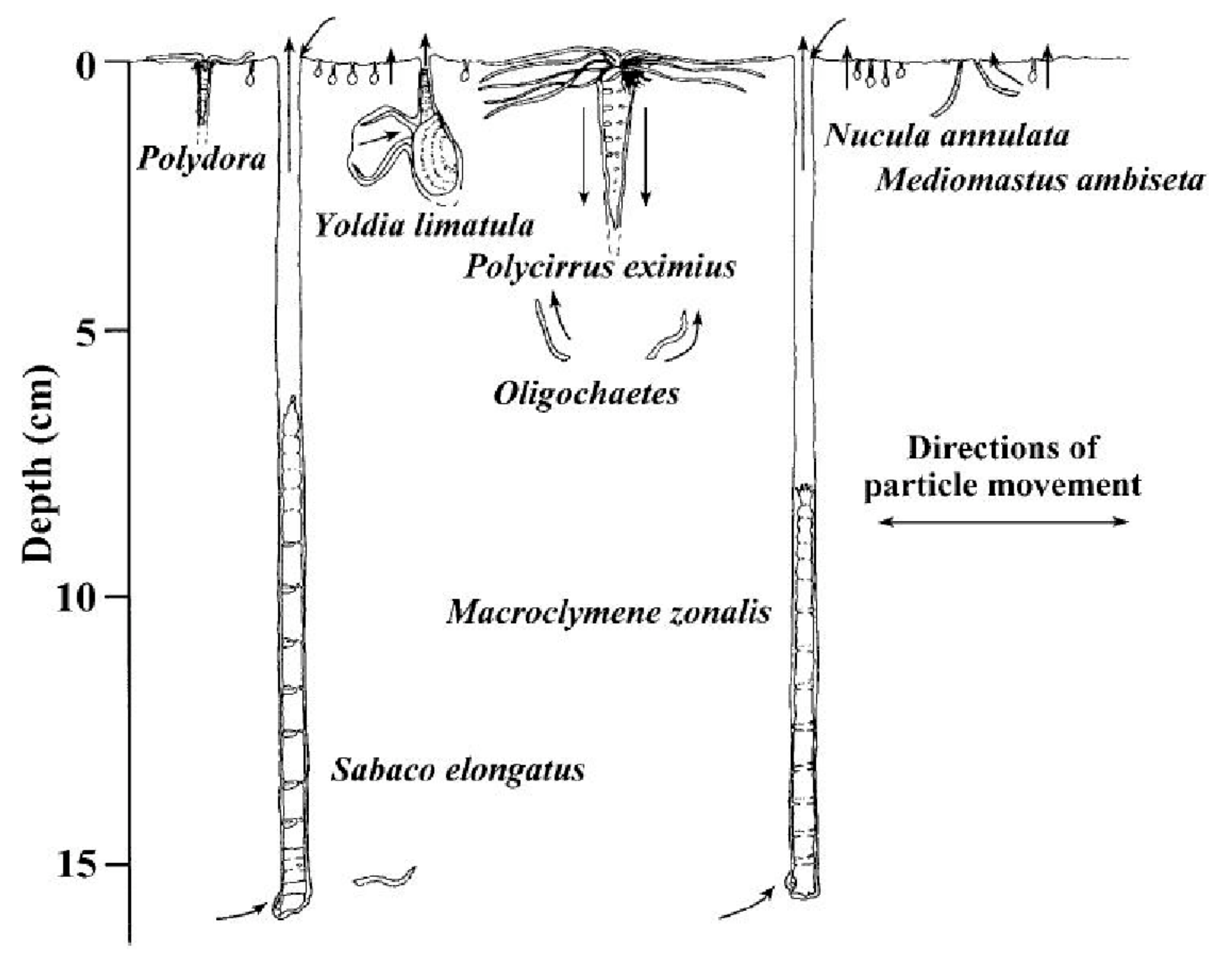
*dentirification*

PON → $NH_4^+$ → $NO_2^-$ → $NO_3^-$ → $NO_2^-$ → $N_2O$ → $N_2$

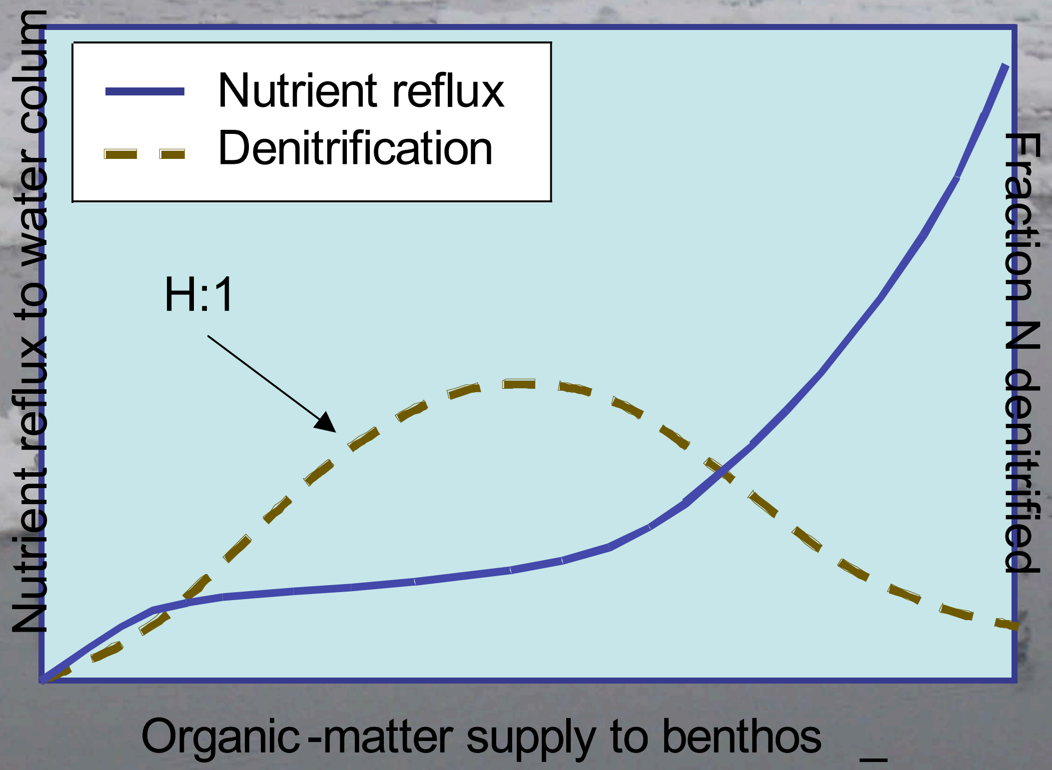
Sediment

*anammox*

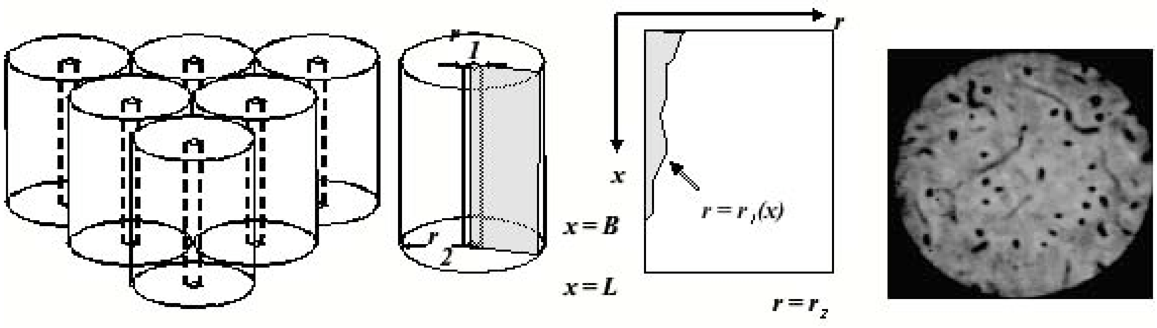
# Bioturbation complication:

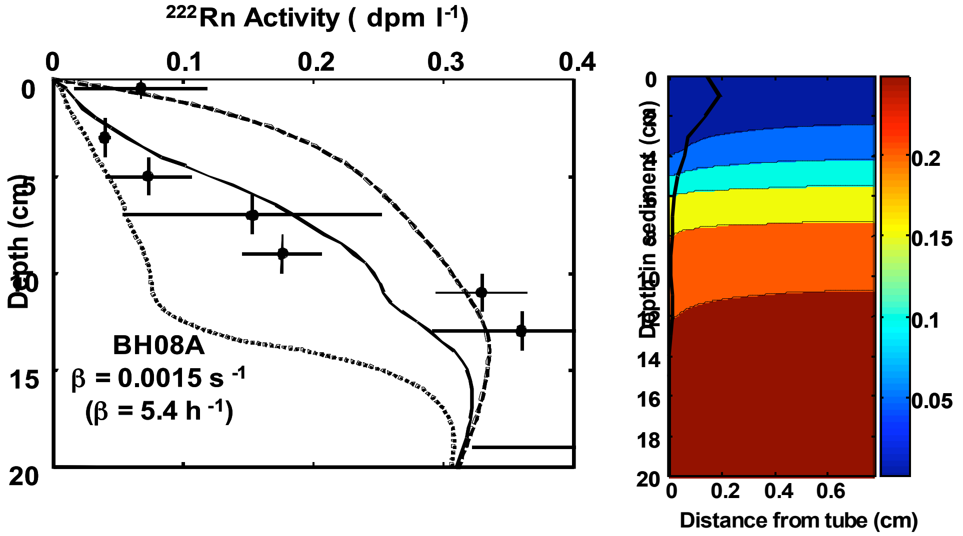


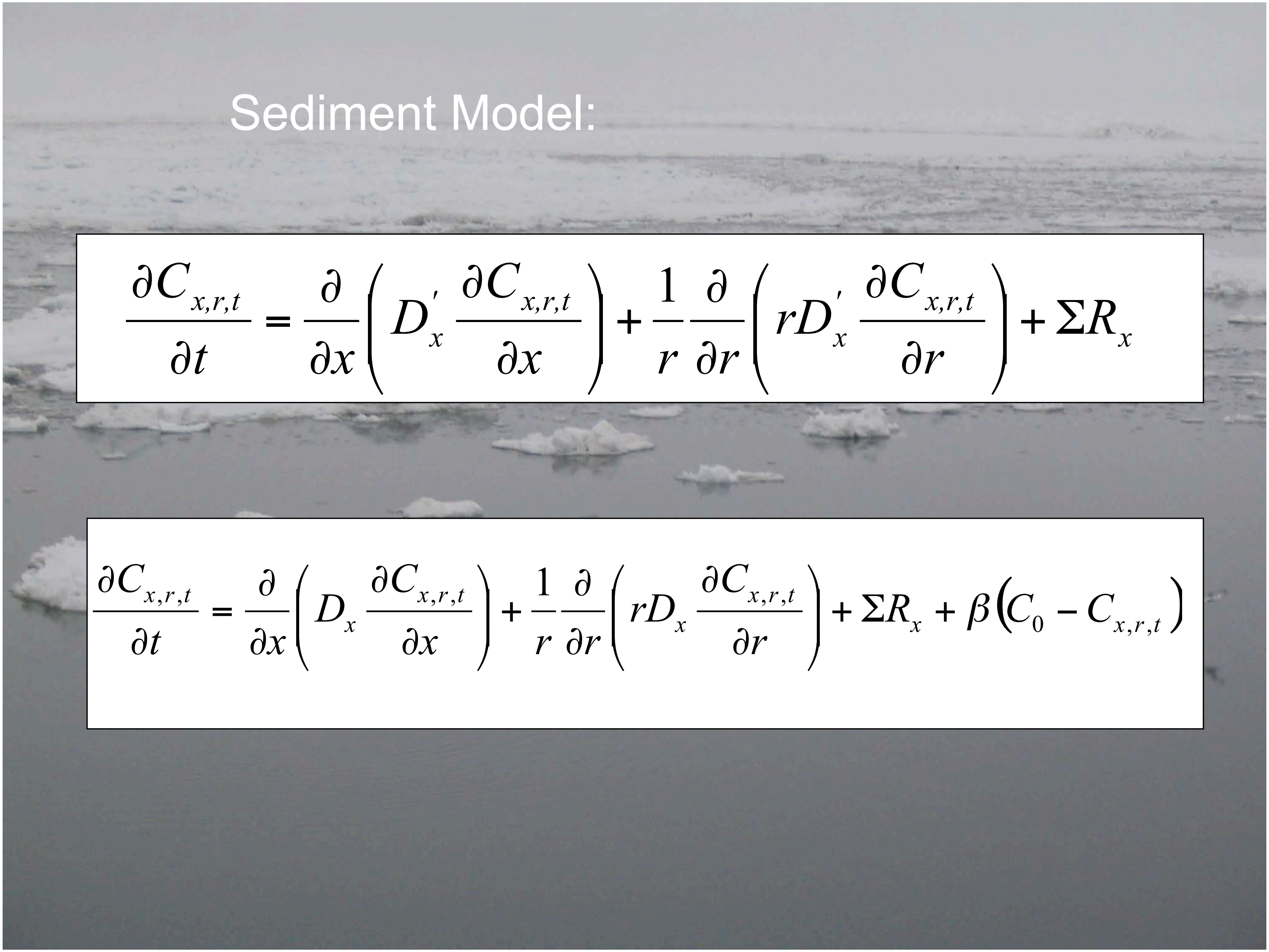
H1: The fraction of fixed-N raining to sediments that is denitrified is a function of the rain rate and macrofaunal density



# H2: Macrofaunal irrigation is a function of the OC rain rate





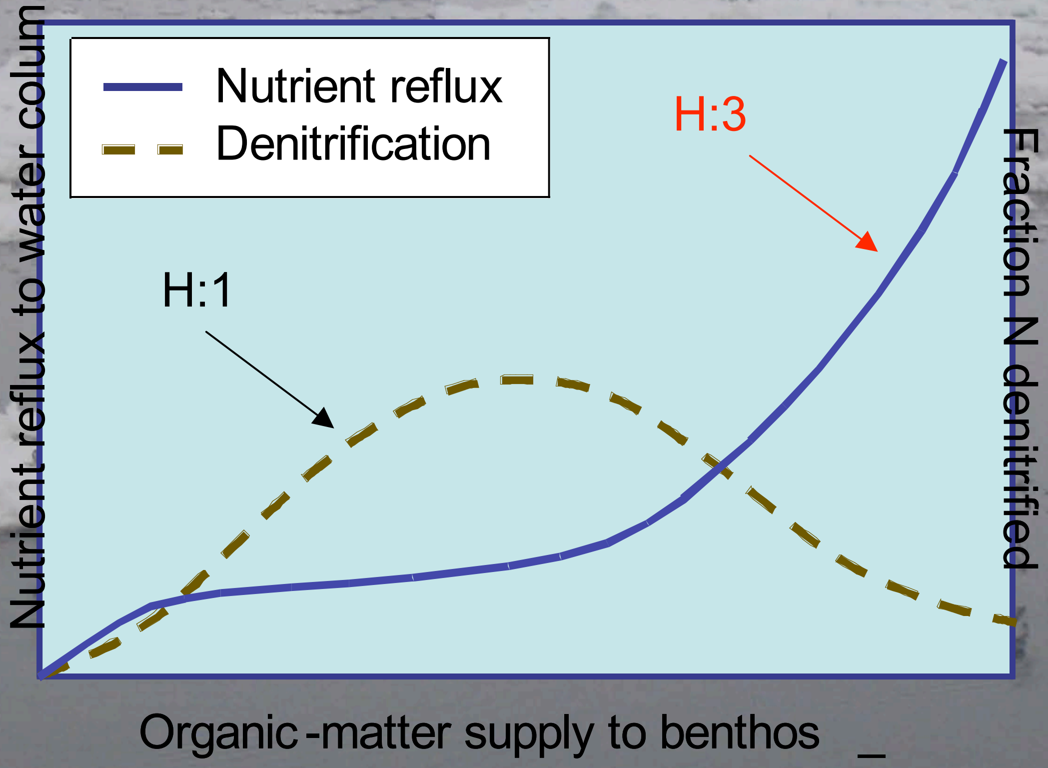


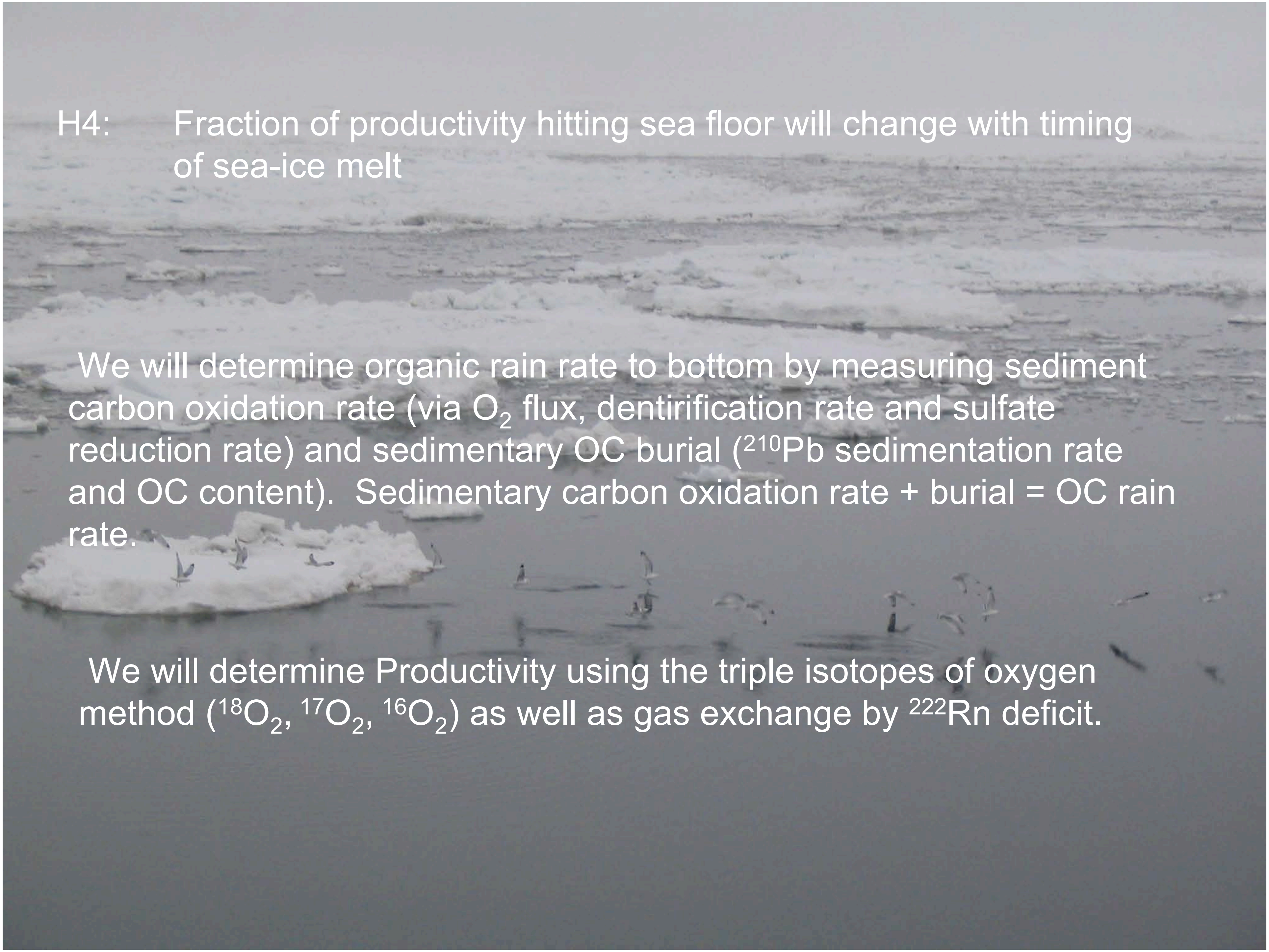
# Sediment Model:

$$\frac{\partial C_{x,r,t}}{\partial t} = \frac{\partial}{\partial x}\left( D_x^{'} \frac{\partial C_{x,r,t}}{\partial x} \right) + \frac{1}{r}\frac{\partial}{\partial r}\left( rD_x^{'} \frac{\partial C_{x,r,t}}{\partial r} \right) + \Sigma R_x$$

$$\frac{\partial C_{x,r,t}}{\partial t} = \frac{\partial}{\partial x}\left( D_x \frac{\partial C_{x,r,t}}{\partial x} \right) + \frac{1}{r}\frac{\partial}{\partial r}\left( rD_x \frac{\partial C_{x,r,t}}{\partial r} \right) + \Sigma R_x + \beta\left(C_0 - C_{x,r,t}\right)$$

# H3: Sediment reflux of fixed nitrogen ($NO_3$ & $NH_4$) to the overlying water will be a non-linear increasing function of organic supply to sediments

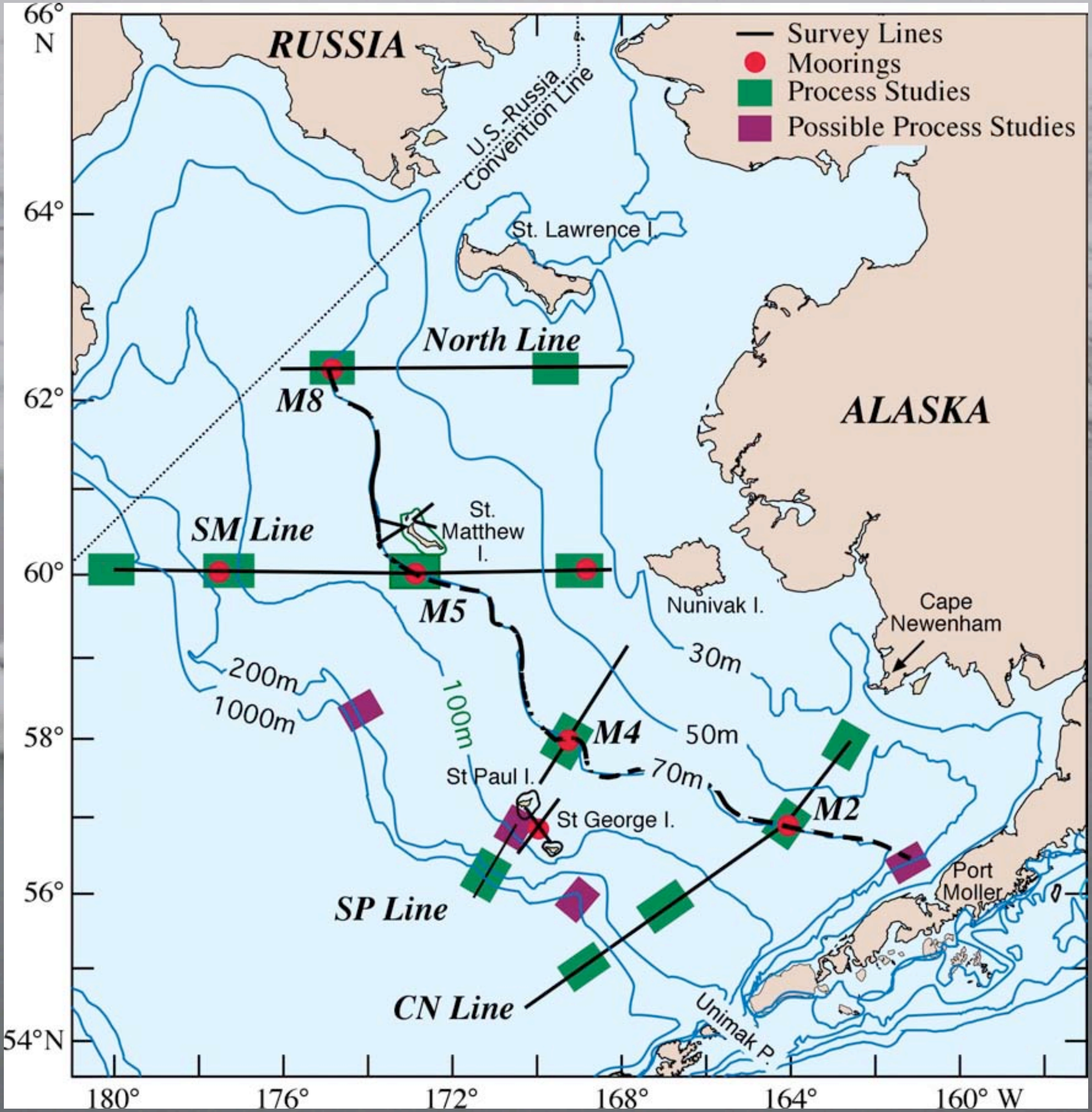




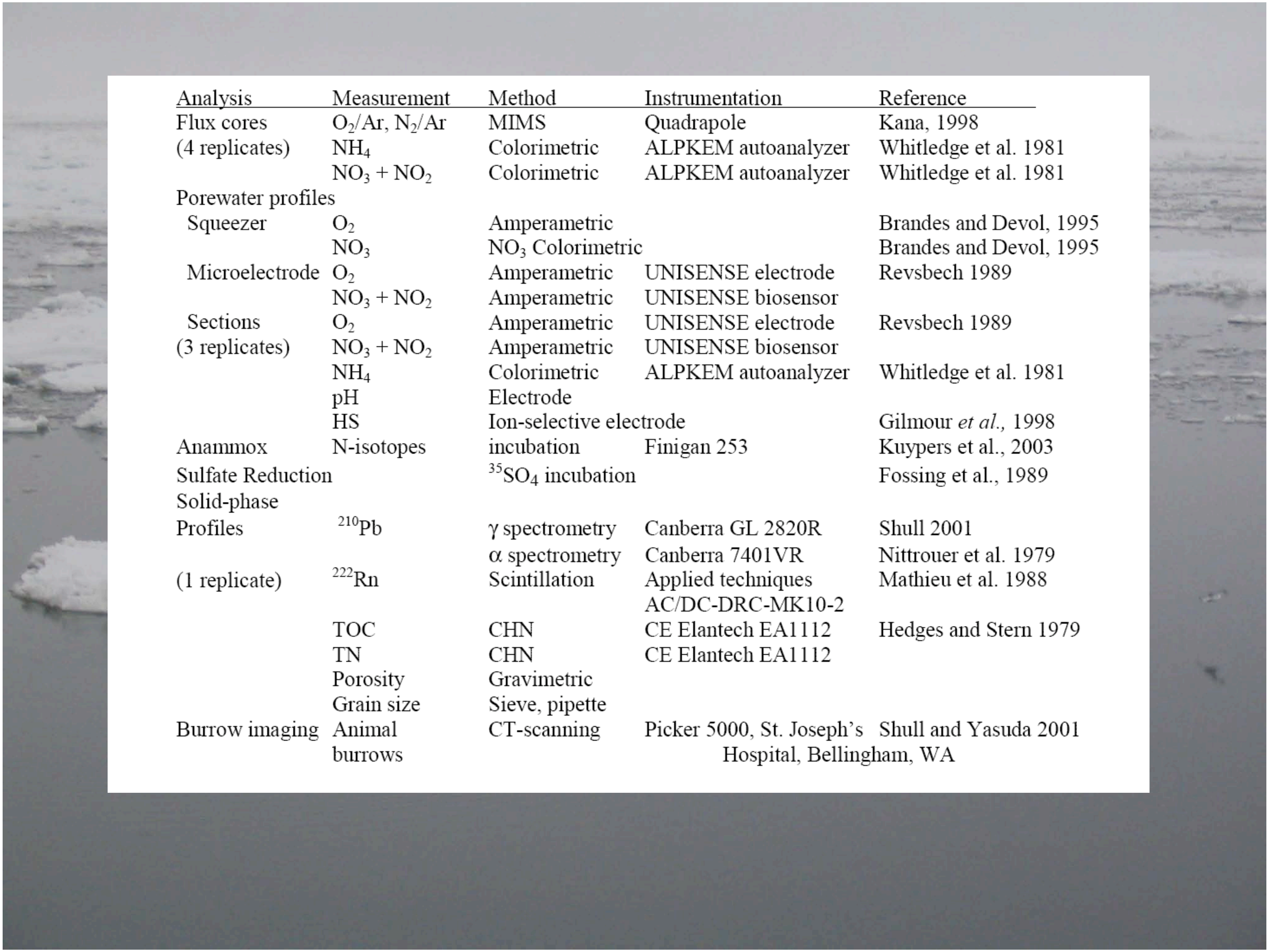
# H4: Fraction of productivity hitting sea floor will change with timing of sea-ice melt

We will determine organic rain rate to bottom by measuring sediment carbon oxidation rate (via $O_2$ flux, dentirification rate and sulfate reduction rate) and sedimentary OC burial ($^{210}Pb$ sedimentation rate and OC content). Sedimentary carbon oxidation rate + burial = OC rain rate.

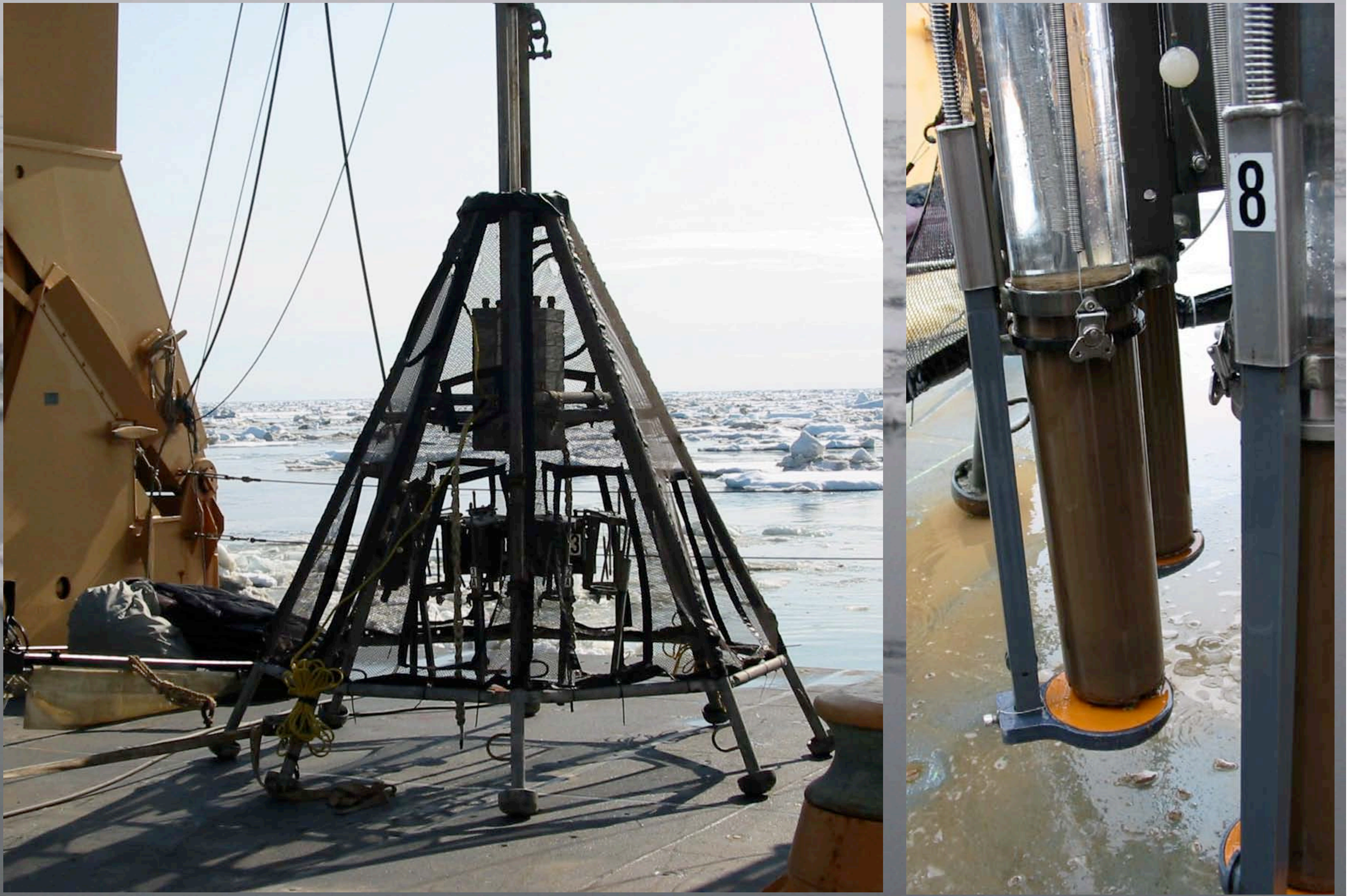
We will determine Productivity using the triple isotopes of oxygen method ($^{18}O_2$, $^{17}O_2$, $^{16}O_2$) as well as gas exchange by $^{222}Rn$ deficit.



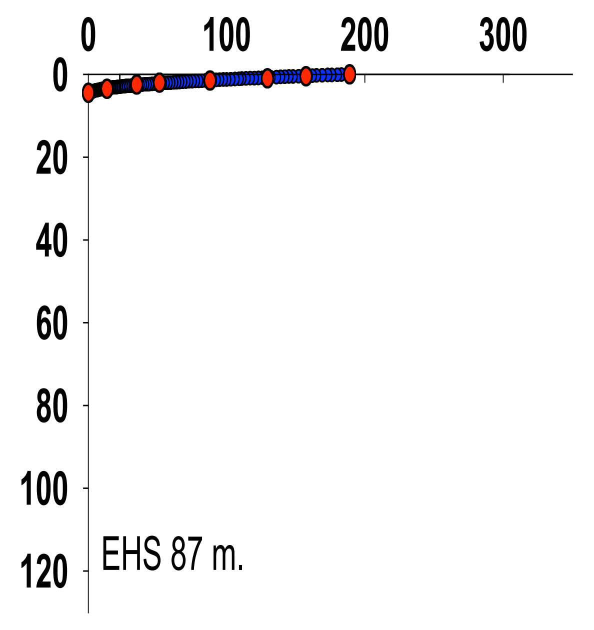
Survey Lines
Moorings
Process Studies
Possible Process Studies
RUSSIA
ALASKA
U.S.-Russia Convention Line
St. Lawrence I.
North Line
M8
SM Line
St. Matthew I.
M5
Nunivak I.
Cape Newenham
200m
1000m
100m
30m
50m
70m
M4
St Paul I.
St George I.
M2
Port Moller
SP Line
CN Line
Unimak P.
66° N
64°
62°
60°
58°
56°
54°N
180°
176°
172°
168°
164°
160° W



| Analysis | Measurement | Method | Instrumentation | Reference |
|---|---|---|---|---|
| Flux cores | $O_2$/Ar, $N_2$/Ar | MIMS | Quadrapole | Kana, 1998 |
| (4 replicates) | $NH_4$ | Colorimetric | ALPKEM autoanalyzer | Whitledge et al. 1981 |
|  | $NO_3 + NO_2$ | Colorimetric | ALPKEM autoanalyzer | Whitledge et al. 1981 |
| Porewater profiles |  |  |  |  |
| Squeezer | $O_2$ | Amperametric |  | Brandes and Devol, 1995 |
|  | $NO_3$ | $NO_3$ Colorimetric |  | Brandes and Devol, 1995 |
| Microelectrode | $O_2$ | Amperametric | UNISENSE electrode | Revsbech 1989 |
|  | $NO_3 + NO_2$ | Amperametric | UNISENSE biosensor |  |
| Sections | $O_2$ | Amperametric | UNISENSE electrode | Revsbech 1989 |
| (3 replicates) | $NO_3 + NO_2$ | Amperametric | UNISENSE biosensor |  |
|  | $NH_4$ | Colorimetric | ALPKEM autoanalyzer | Whitledge et al. 1981 |
|  | pH | Electrode |  |  |
|  | HS | Ion-selective electrode |  | Gilmour *et al.,* 1998 |
| Anammox | N-isotopes | incubation | Finigan 253 | Kuypers et al., 2003 |
| Sulfate Reduction |  | $^{35}SO_4$ incubation |  | Fossing et al., 1989 |
| Solid-phase |  |  |  |  |
| Profiles | $^{210}Pb$ | γ spectrometry | Canberra GL 2820R | Shull 2001 |
|  |  | α spectrometry | Canberra 7401VR | Nittrouer et al. 1979 |
| (1 replicate) | $^{222}Rn$ | Scintillation | Applied techniques AC/DC-DRC-MK10-2 | Mathieu et al. 1988 |
|  | TOC | CHN | CE Elantech EA1112 | Hedges and Stern 1979 |
|  | TN | CHN | CE Elantech EA1112 |  |
|  | Porosity | Gravimetric |  |  |
|  | Grain size | Sieve, pipette |  |  |
| Burrow imaging | Animal burrows | CT-scanning | Picker 5000, St. Joseph's Hospital, Bellingham, WA | Shull and Yasuda 2001 |

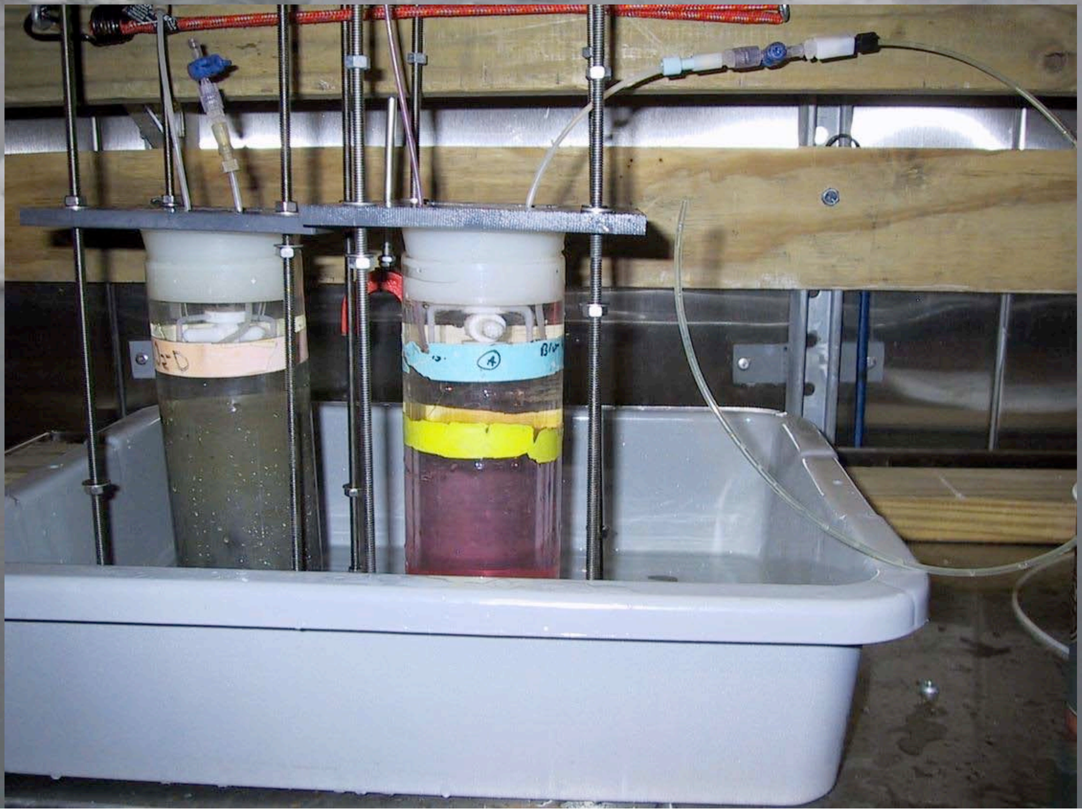

8


GLASS
Blue Yel
Blue


0
100
200
300
0
20
40
60
80
100
120
EHS 87 m.

# Sampling and Methods

- Whole core incubations (only in Spring 2004)
  - Incubated at in situ or near in situ temperatures
  - $N_2$ was measured in overlying water using membrane inlet mass spectrometry, MIMS



# Quadrupole mass spectrometer in *USCGC Healy* cold room