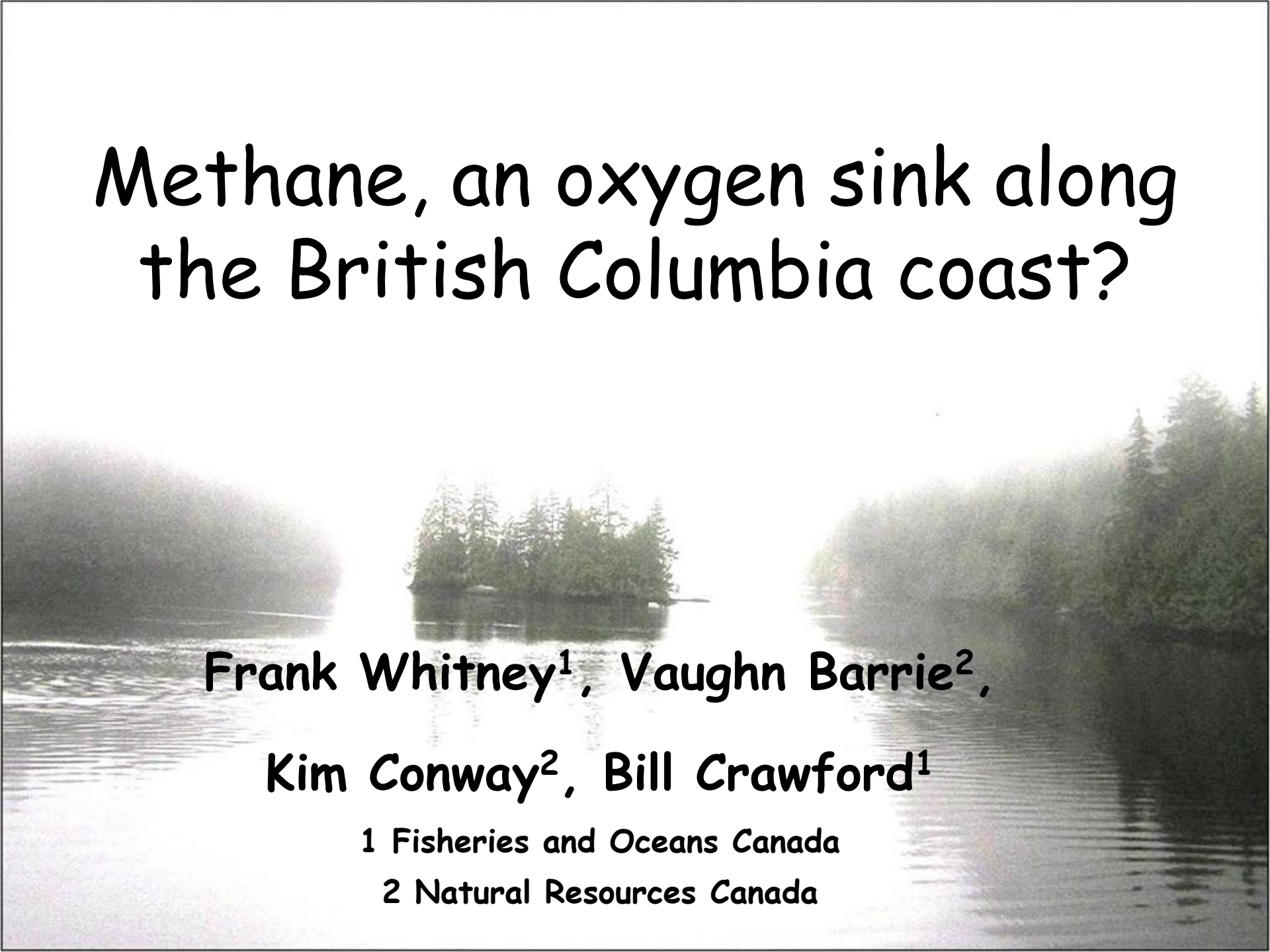
Methane, an oxygen sink along the British Columbia coast?



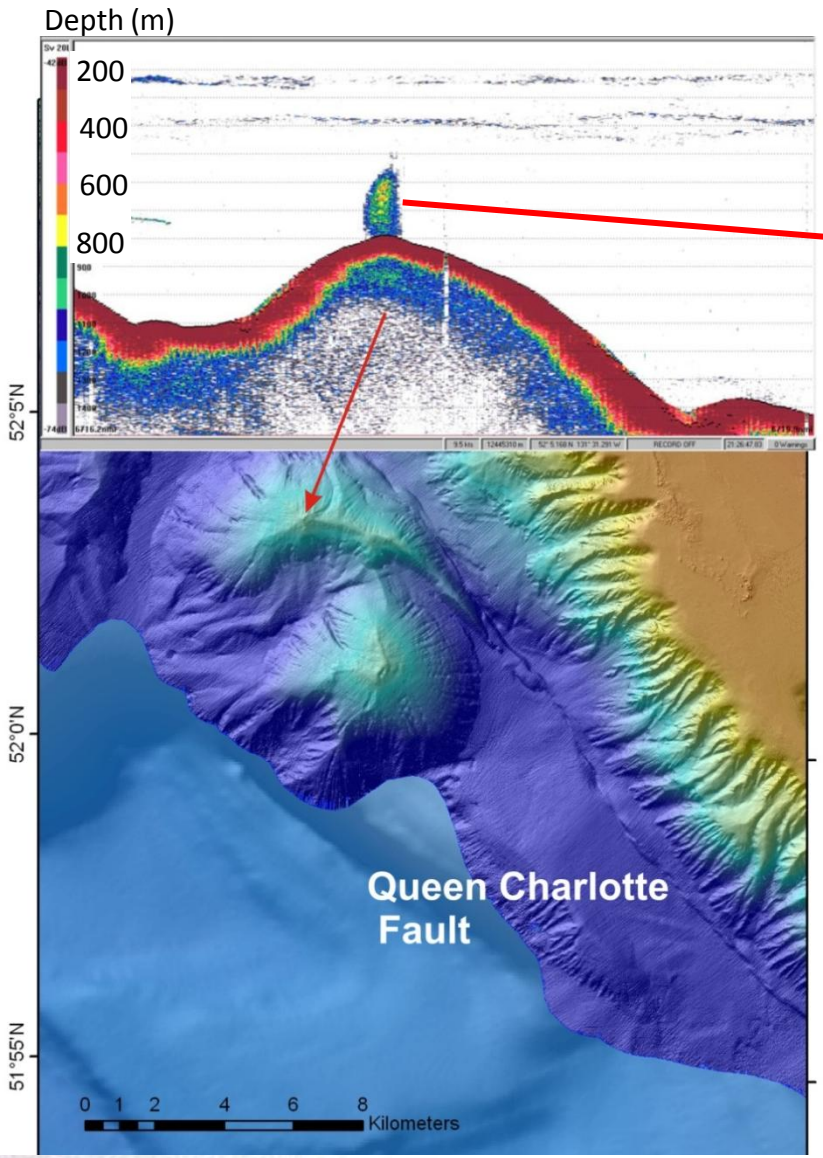
Frank Whitney[1], Vaughn Barrie[2],

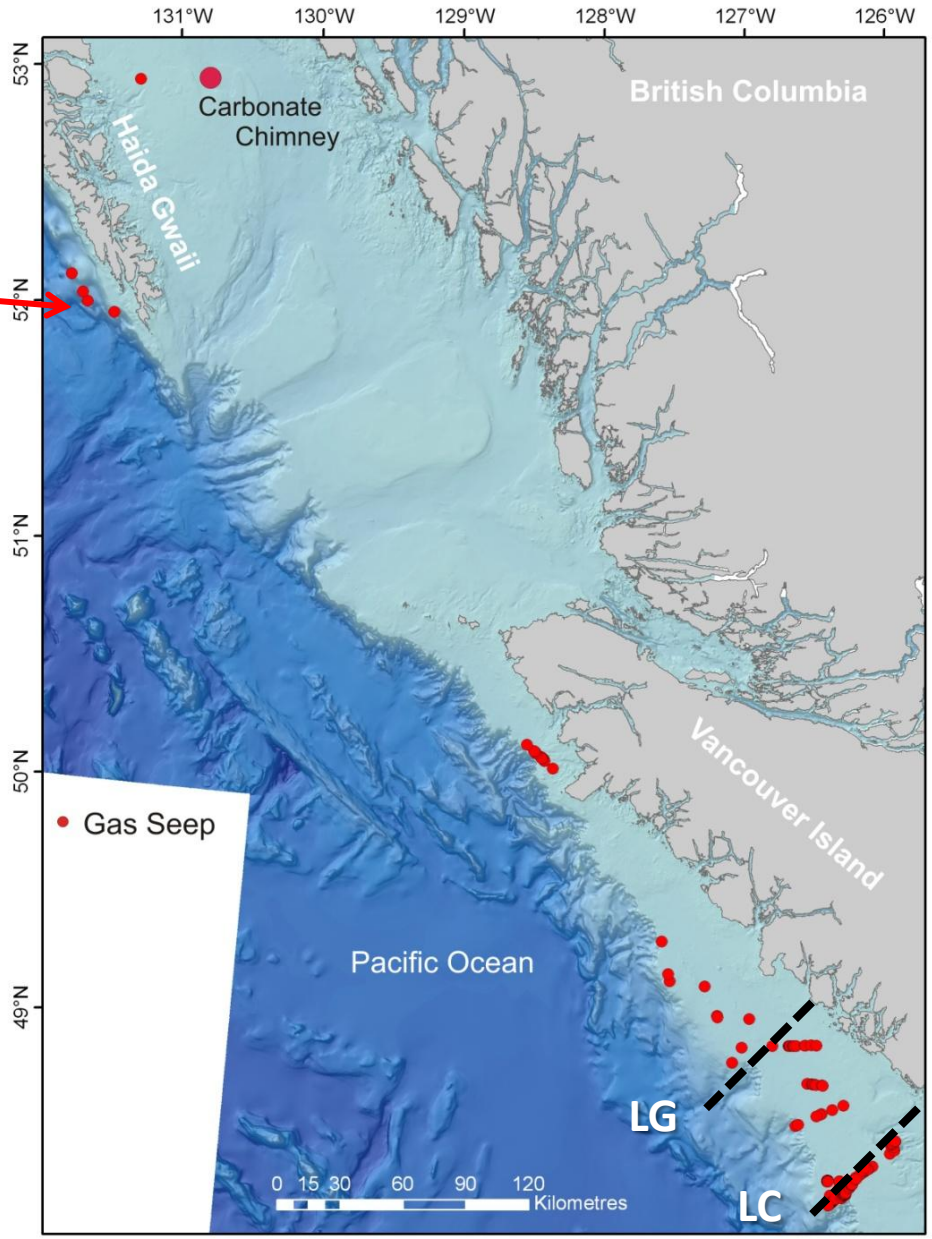
Kim Conway[2], Bill Crawford[1]

1 Fisheries and Oceans Canada

2 Natural Resources Canada

>160 methane seeps – a partial survey of BC coast





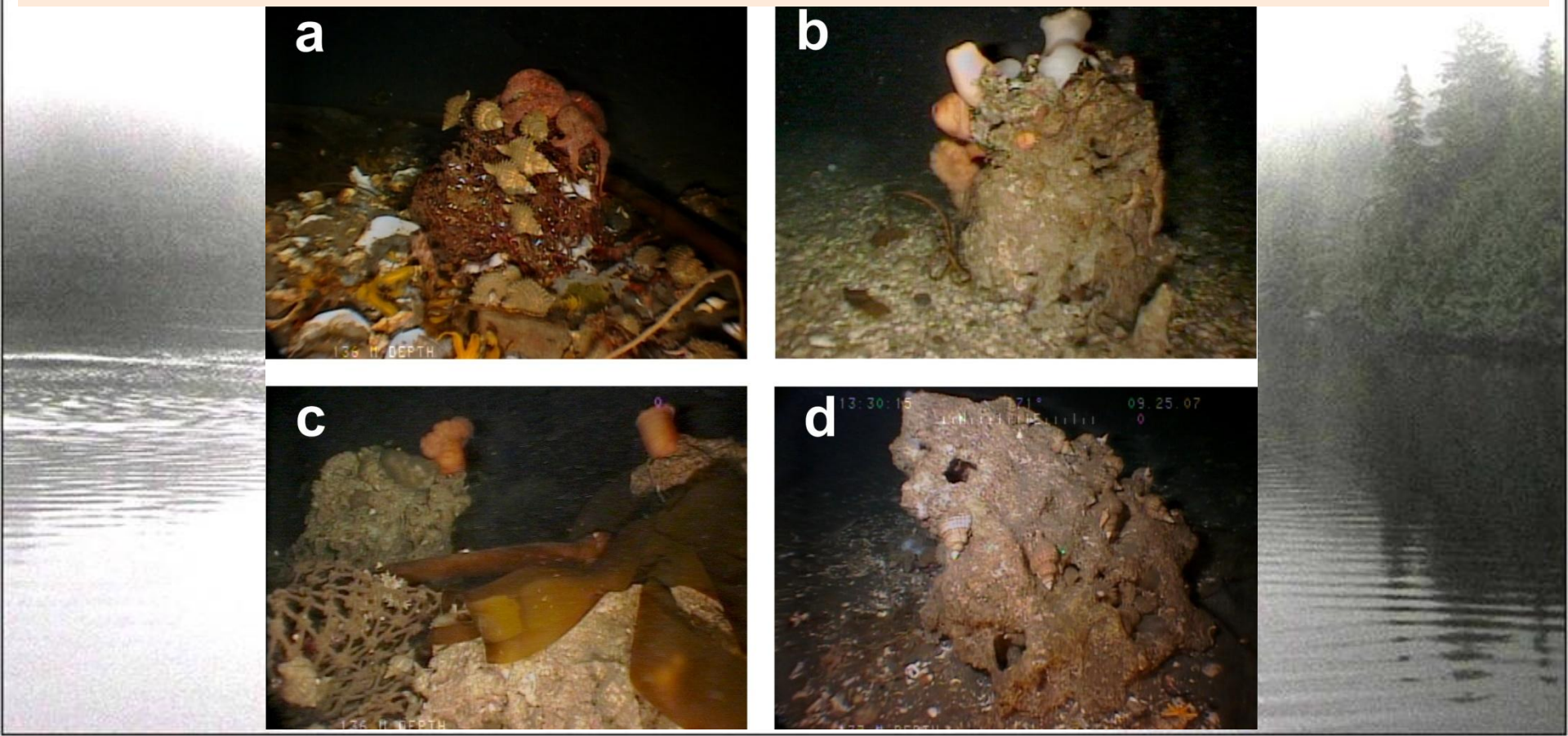
Anaerobic oxidation of methane results in an alkalinity increase, favouring precipitation of calcium carbonate, so that

$$CH_4 + SO_4^{2-} + Ca^{2+} = CaCO_3 + H_2S + H_2O$$

while aerobic oxidation of methane results in an increase in acidity,

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

resulting in carbonate dissolution.



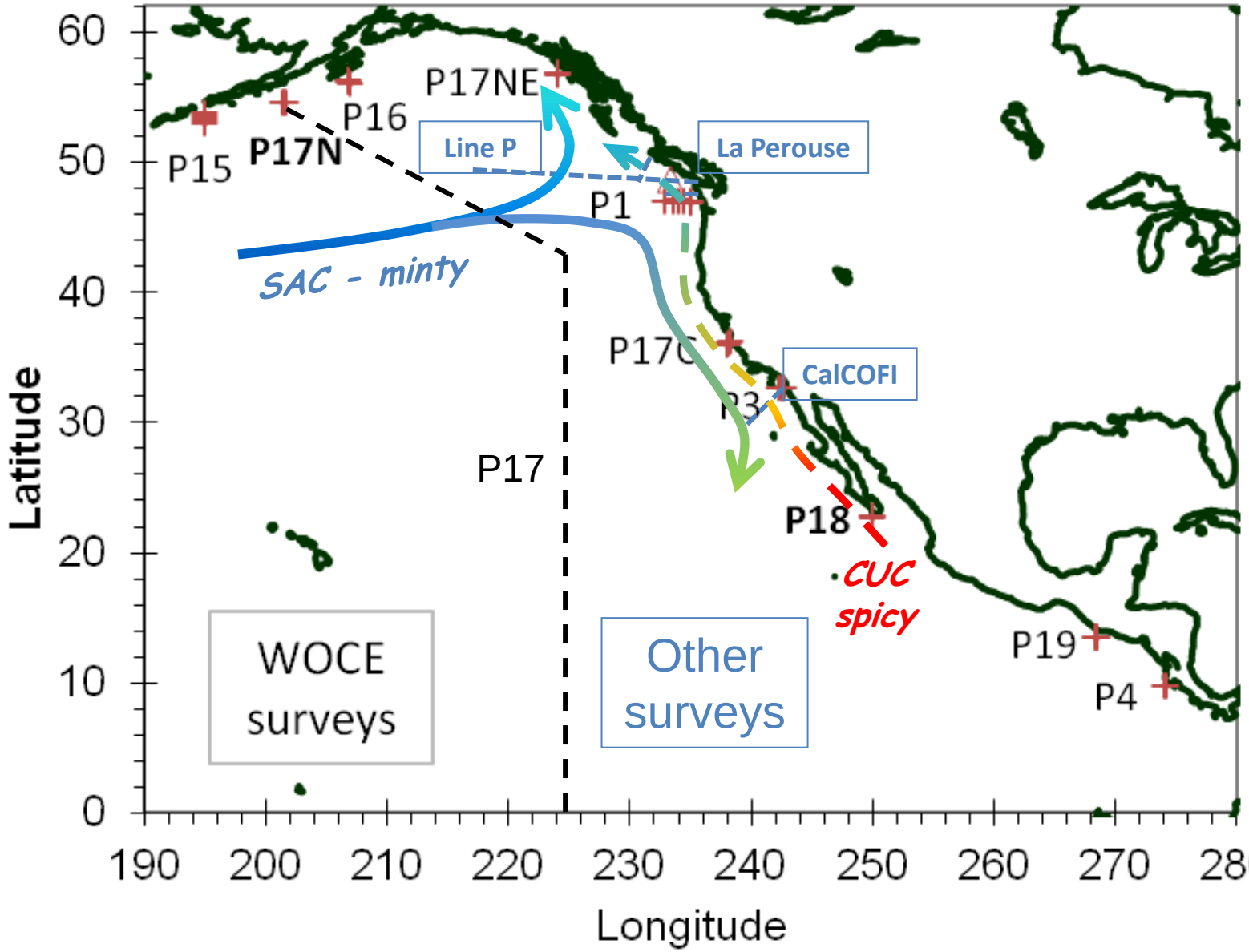
Two chemical tracers are combined to assess CH_4 oxidation:

1. $NO = O_2 + 9NO_3$ (Broecker, 1987)
   a "conservative" property of seawater isolated from surface processes.
2. $N^* = (NO_3 - 16P + 2.9)0.87$ (Gruber and Sarmiento, 1997)
   a measure of nitrate loss due to denitrification

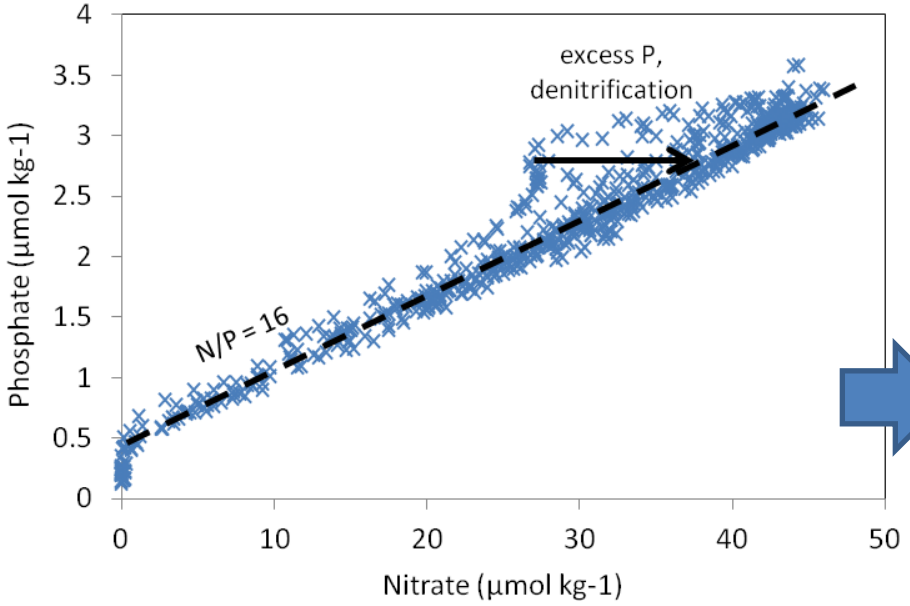
From these, I derive:

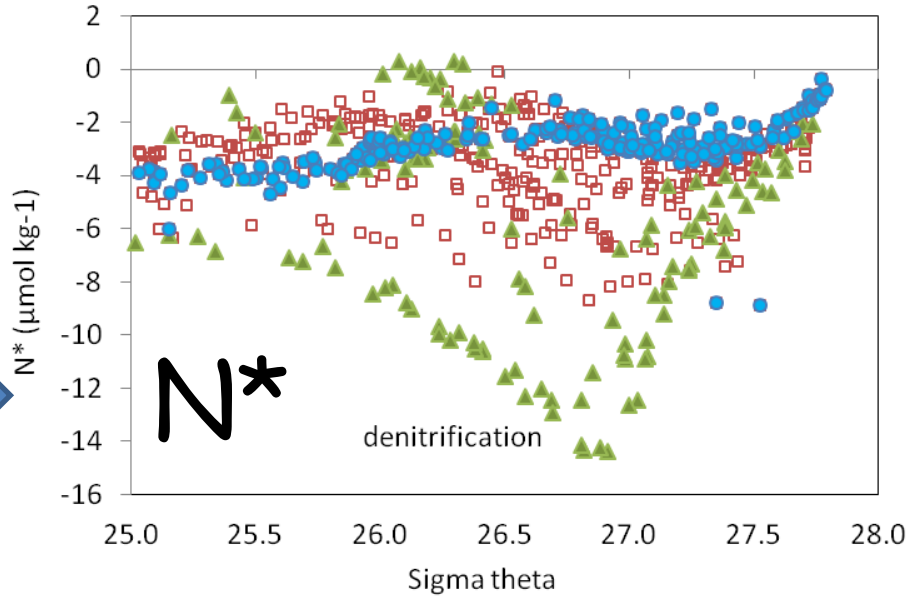
3. $N^*O = O_2 + 9(NO_3 - N^*)$
   to remove the effects of denitrification on NO

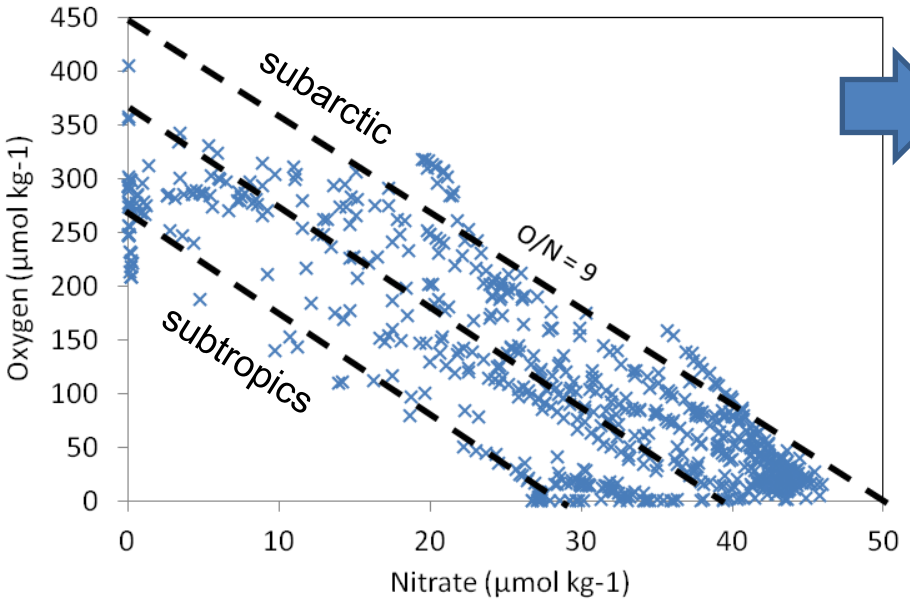
Survey Locations

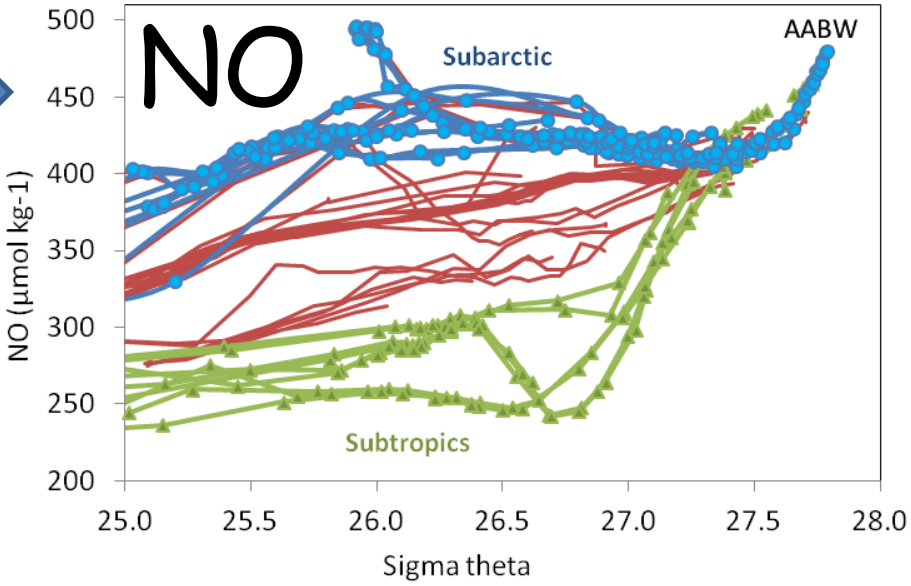


WOCE data along N American coast









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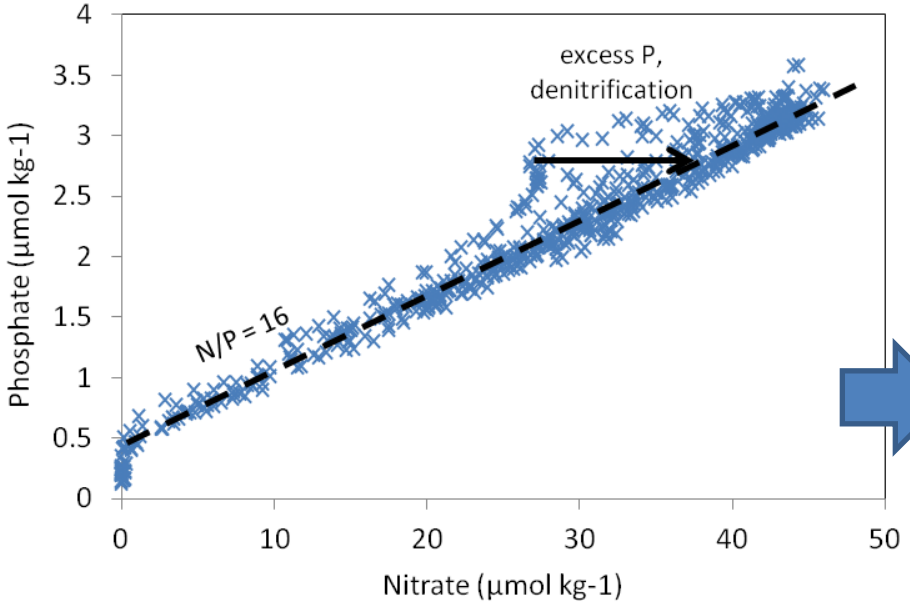
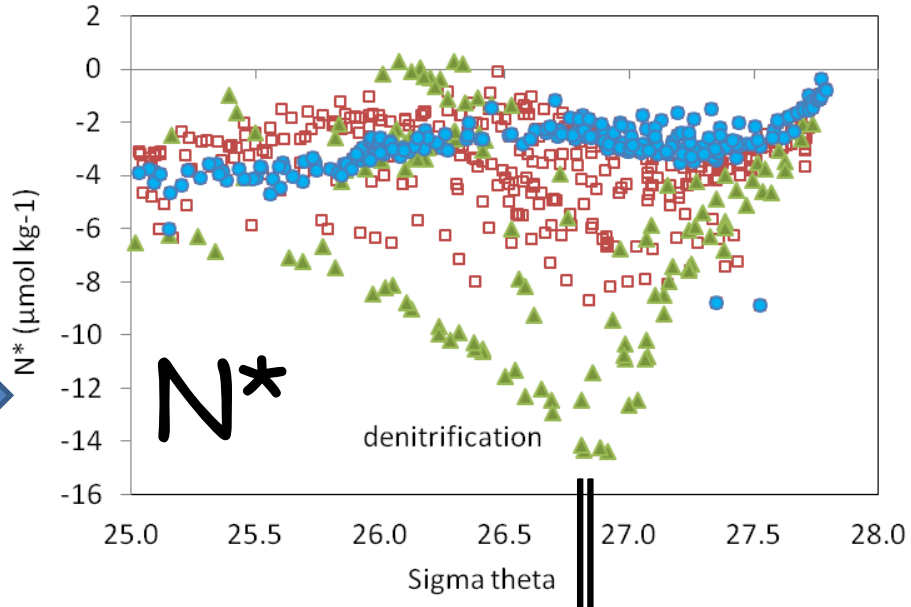
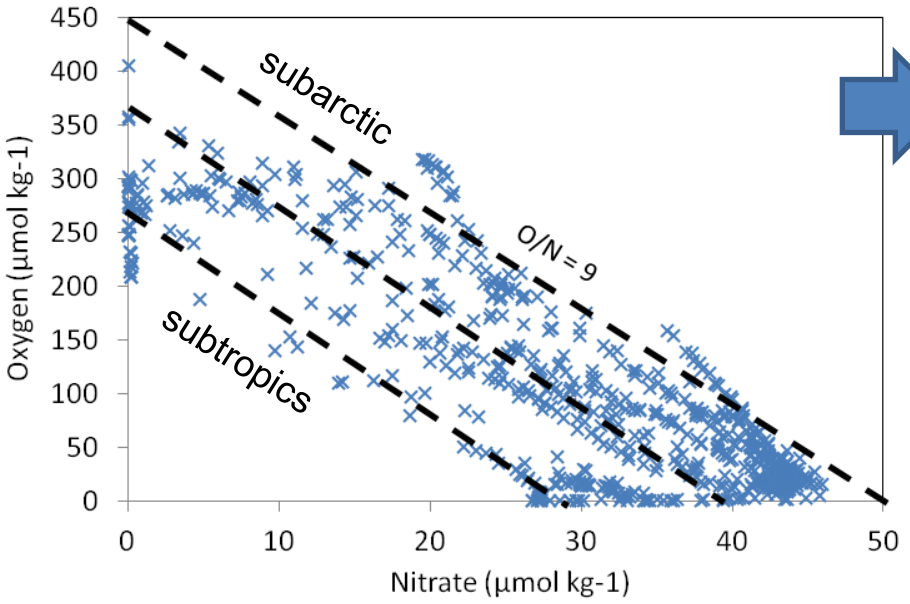
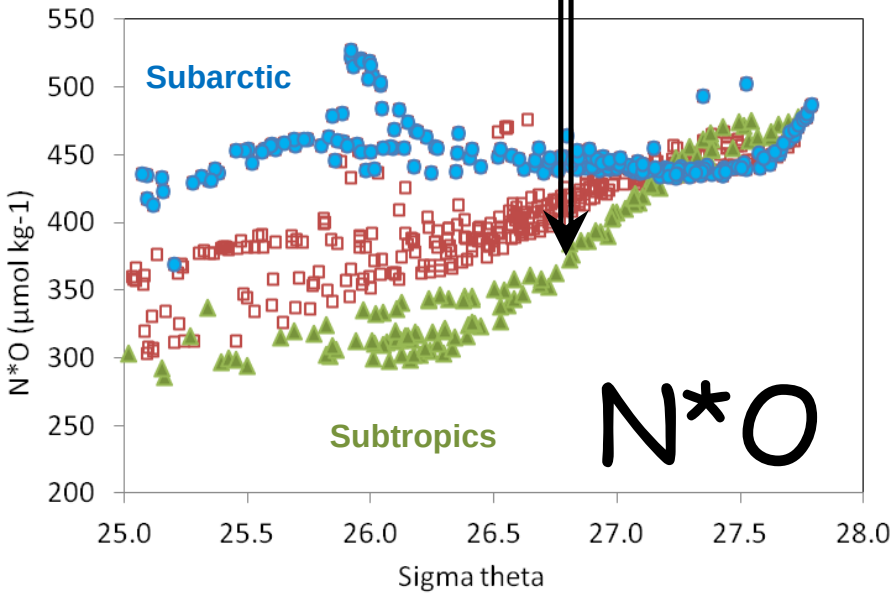
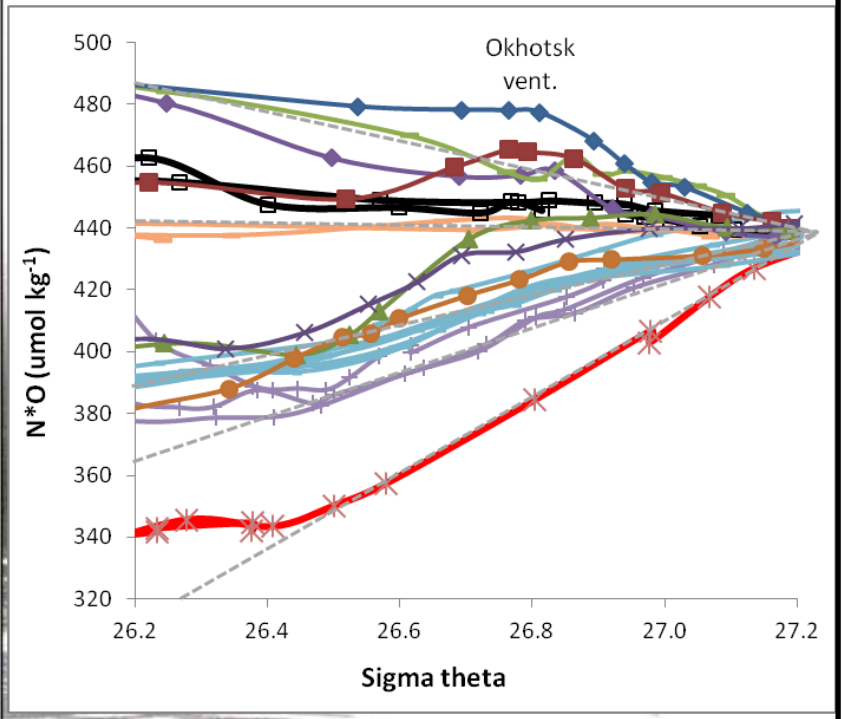


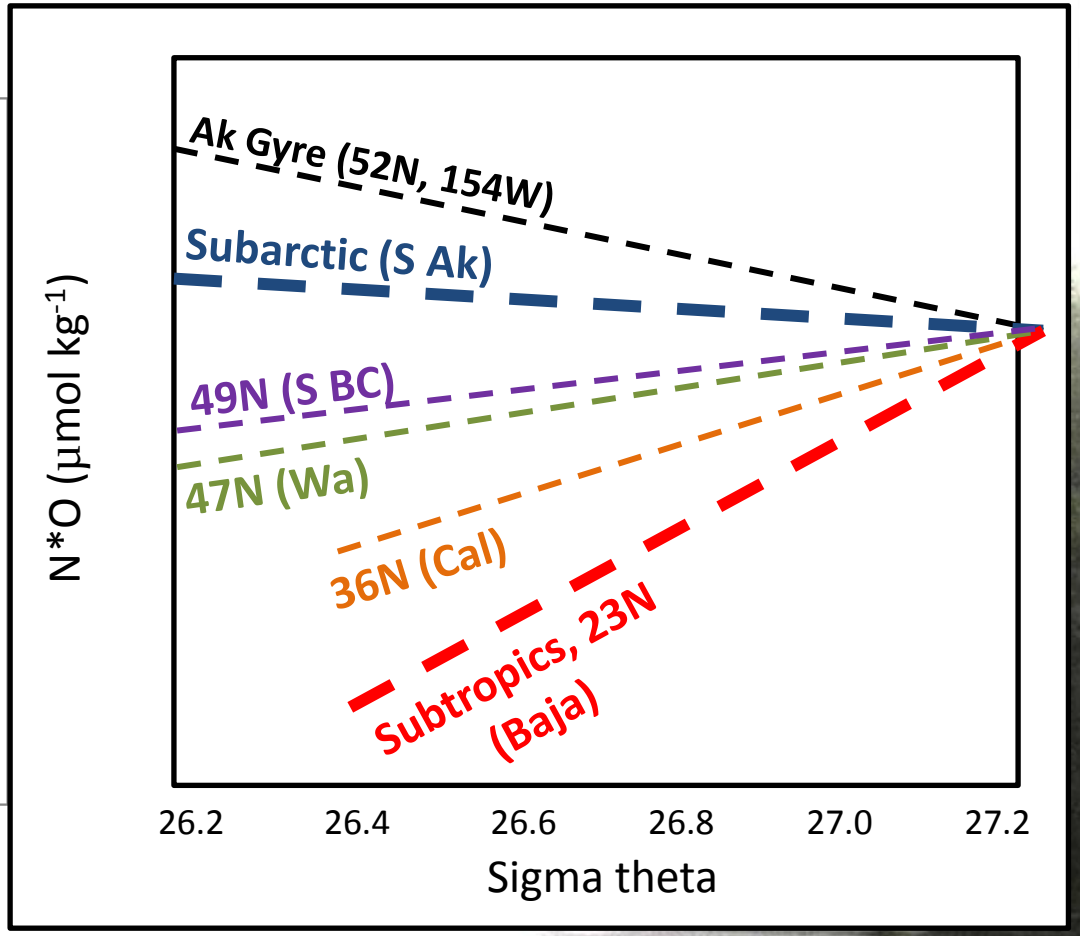


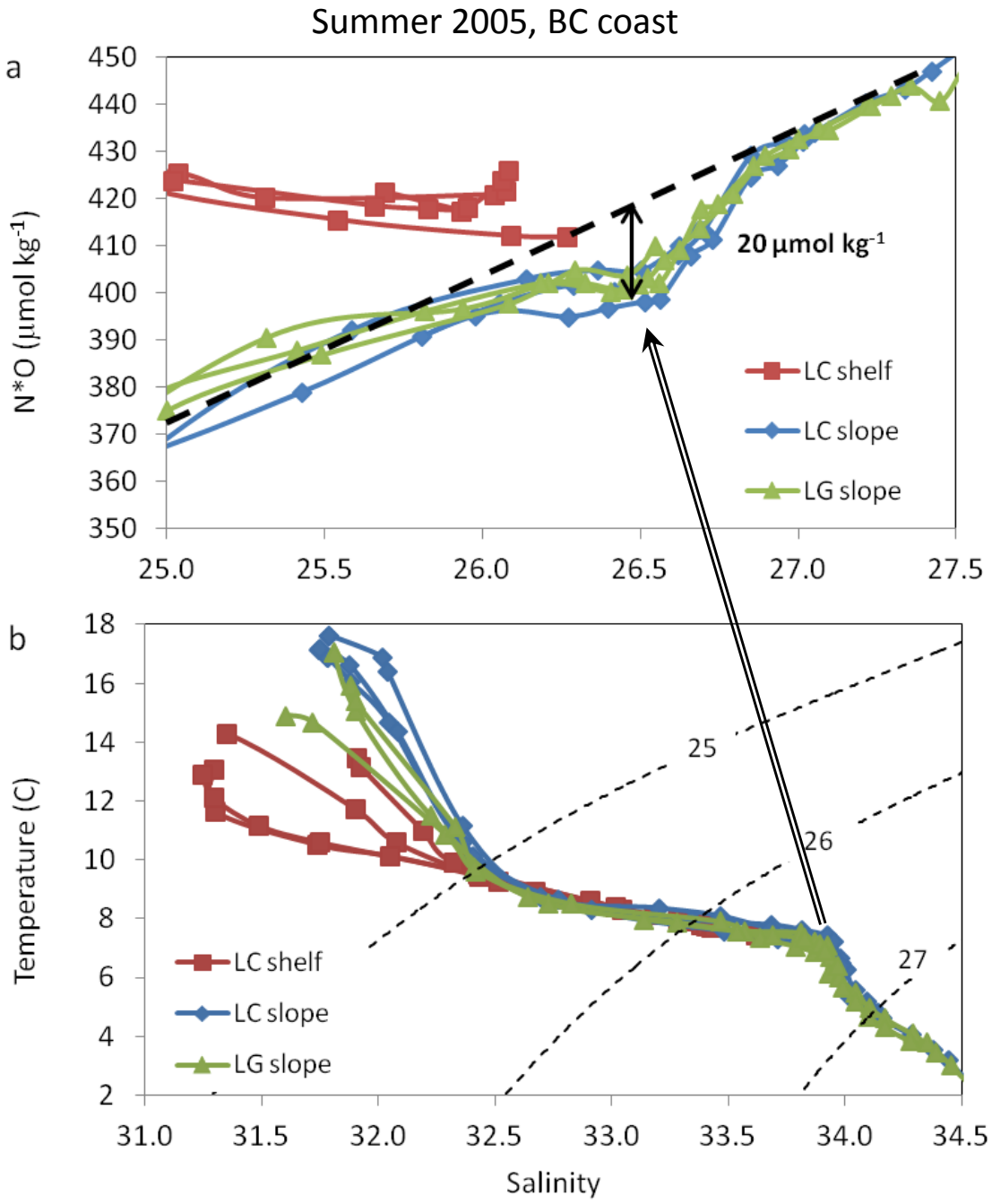




N*O characteristics of NE Pacific Oceanic Waters







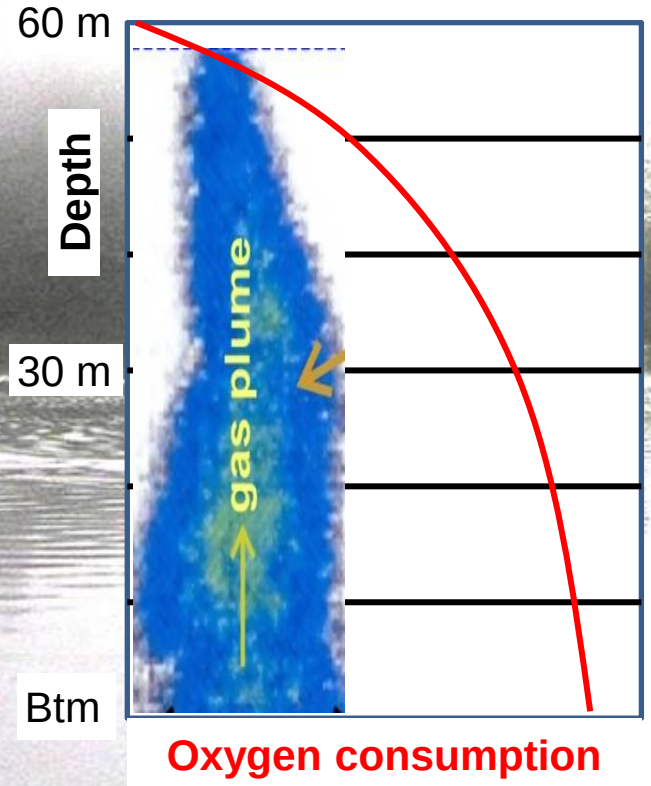
La Perouse 2005

Over the correct depth range (80-200 m), a deficit in N*O suggests methane oxidation may account for ~10-20 µM loss of oxygen.

Unfortunately, the signal occurs at the core of the CUC. Is it local or transported northward?

Methane flux estimate:

- One vent ~**30 l/min CH_4** (18 mol/min at 150 m)
- 3 vents per km across some shelf regions (**one survey line**)
- Complete bubble dissolution over 60 m (20 to 100 m observed)
- Average current speed 0.03 m s^{-1} (Thomson and Krassovski, 2010)



Flow over 1 km of shelf, in a 10 m thick layer,
1000 m x 10 m x 0.03 m/s x 60 s/min = 18,000 m^3/min

Methane flux into 10 m thick layer from 3 seeps
9 mol CH_4 or **18 mol/min O_2 consumption**

Oxygen loss rate ~ $\frac{18{,}000{,}000\ \mu mol/min}{18{,}000{,}000\ l/min}$ ~ **1 µM**

Summary:

- recent PGC surveys have identified numerous methane seeps in waters 80 to 800 m deep along the BC coast.
- by removing a denitrification signal in BC coastal waters, an estimate can be made of the amount of oxygen being consumed by methane (~10-20 μM).
- a significant part of this signal could be transported northward since methane sources are common along the Pacific coast of N America.