Nutrients and Net Community Production in Arctic and Sub-Arctic Seas

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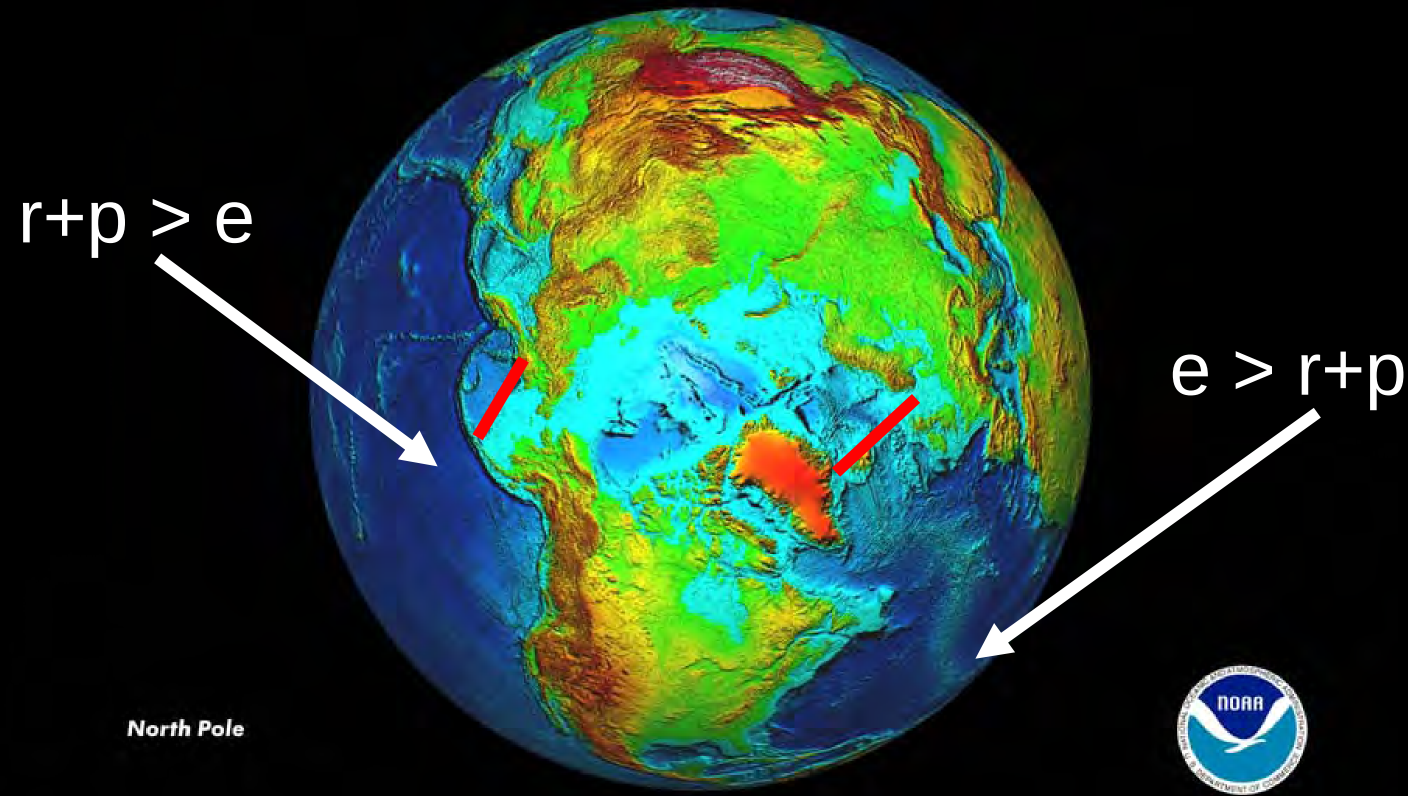
This talk will comment on the Nordic Seas,
the Bering Sea Shelf,
and the seas and basins of the Arctic Ocean.

Let's start with the large-scale set-up (shape of the bowl, inflow and outflow characteristics, etc.)

Large Scale Set-Up and the Shape of the Bowl

Ratio of shelf and slope to basins is high.



The Arctic marine system also receives high runoff, & with the notable exception of the Nordic Seas is highly salt stratified with winter convection limited to ~ 50 m. How this will change is at present an open question.

Inputs

Atlantic inflow ~ 80% of total,
S ~ 35, low Si ~10, PO4 ~ 1, NO3 ~15

Anadyr Water, S ~33, Si ~40, NO3 ~20, PO4 ~3

Alaska Coastal Water, S ~31, low nutrients

Note that rivers amount to only ~2% of total inflow, and have limited (~local) impacts on nutrient inputs.

In my opinion the characteristics of the
Pacific inflow are more sensitive to change than are the characteristics of the Atlantic inflow.

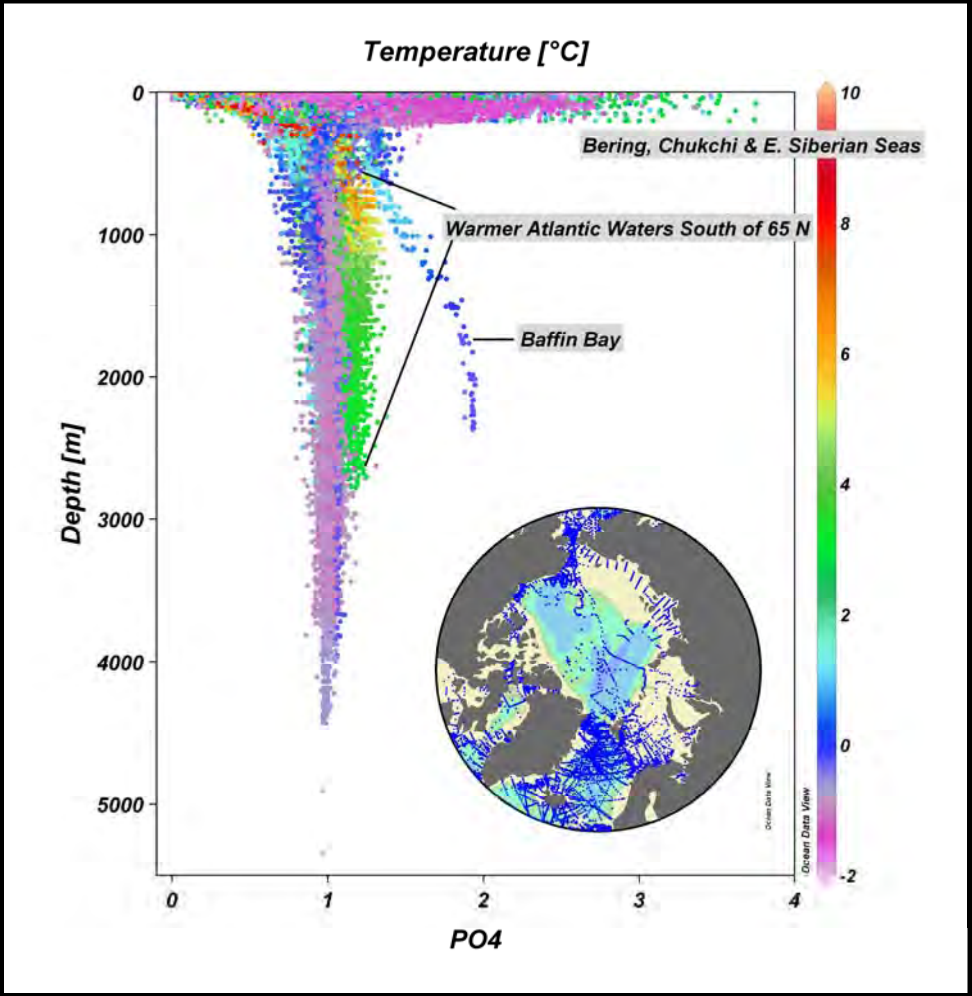
Outflows

Deep outflow not much different from Atlantic inflow

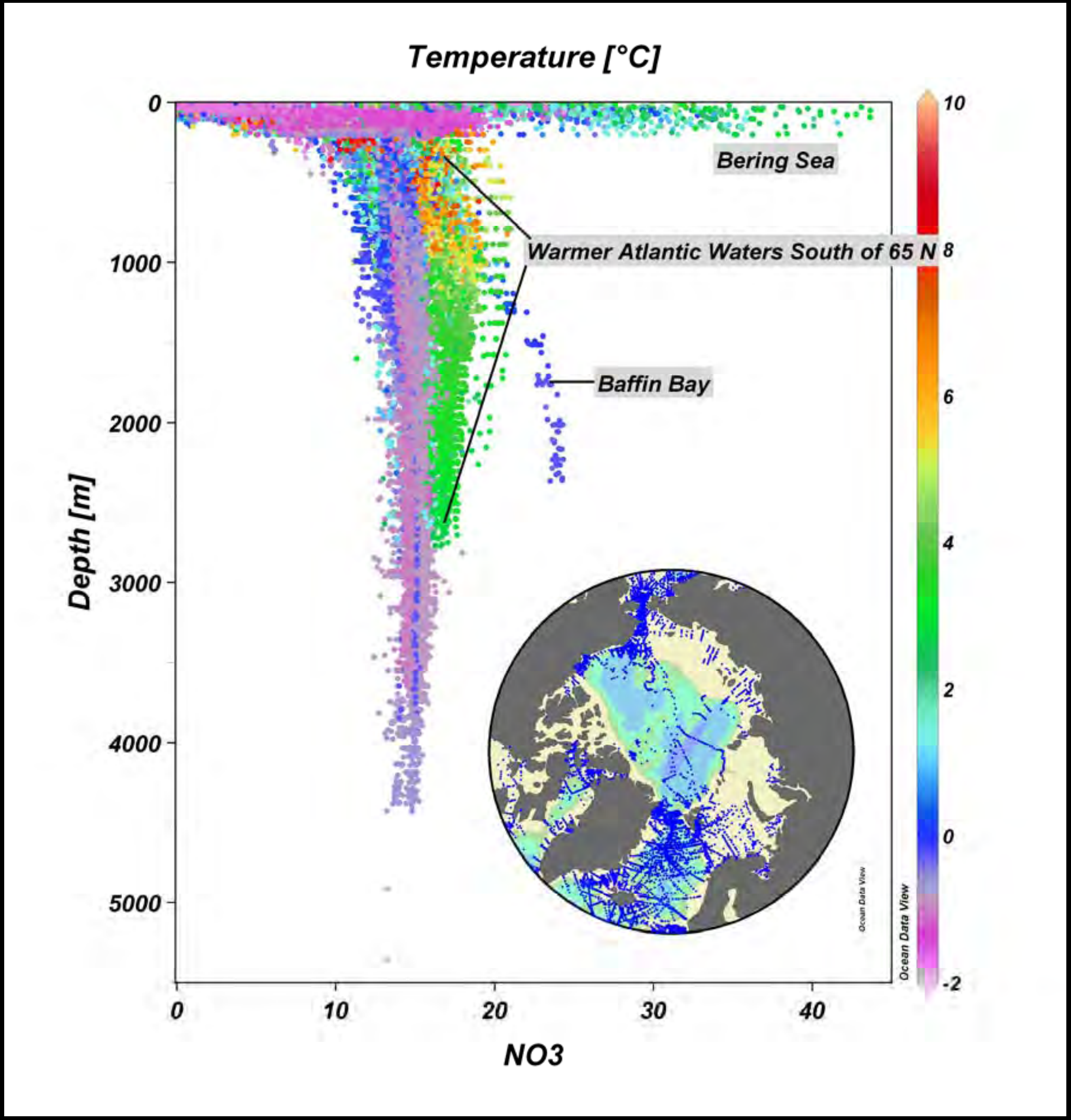
East Greenland Current negative N-Star, low S, low NO3 moderate PO4

Canadian Archipelago outflow contains a high proportion of Pacific origin water

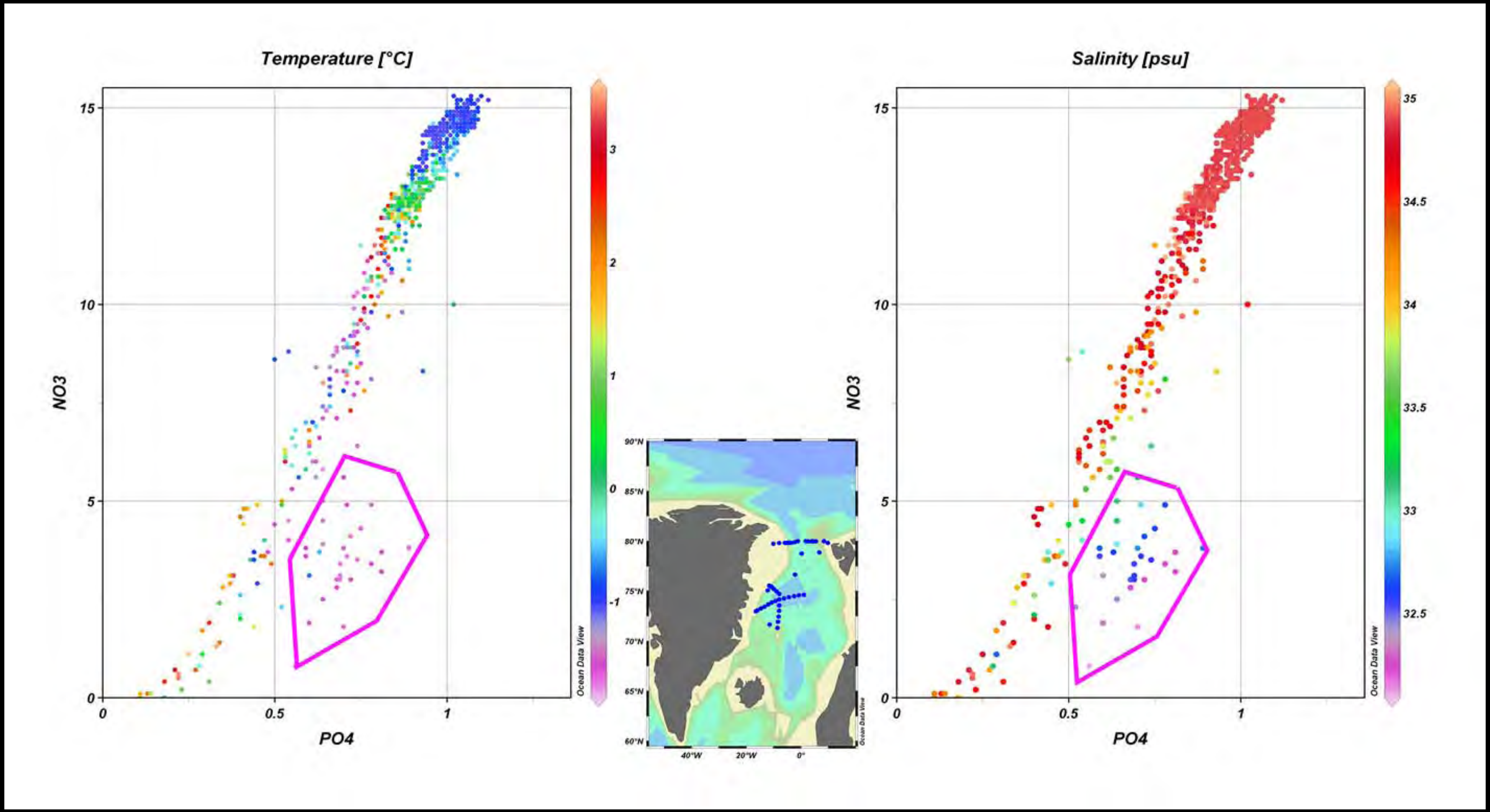
Phosphate Data Remaining After Editing



Nitrate Data that Survived Editing



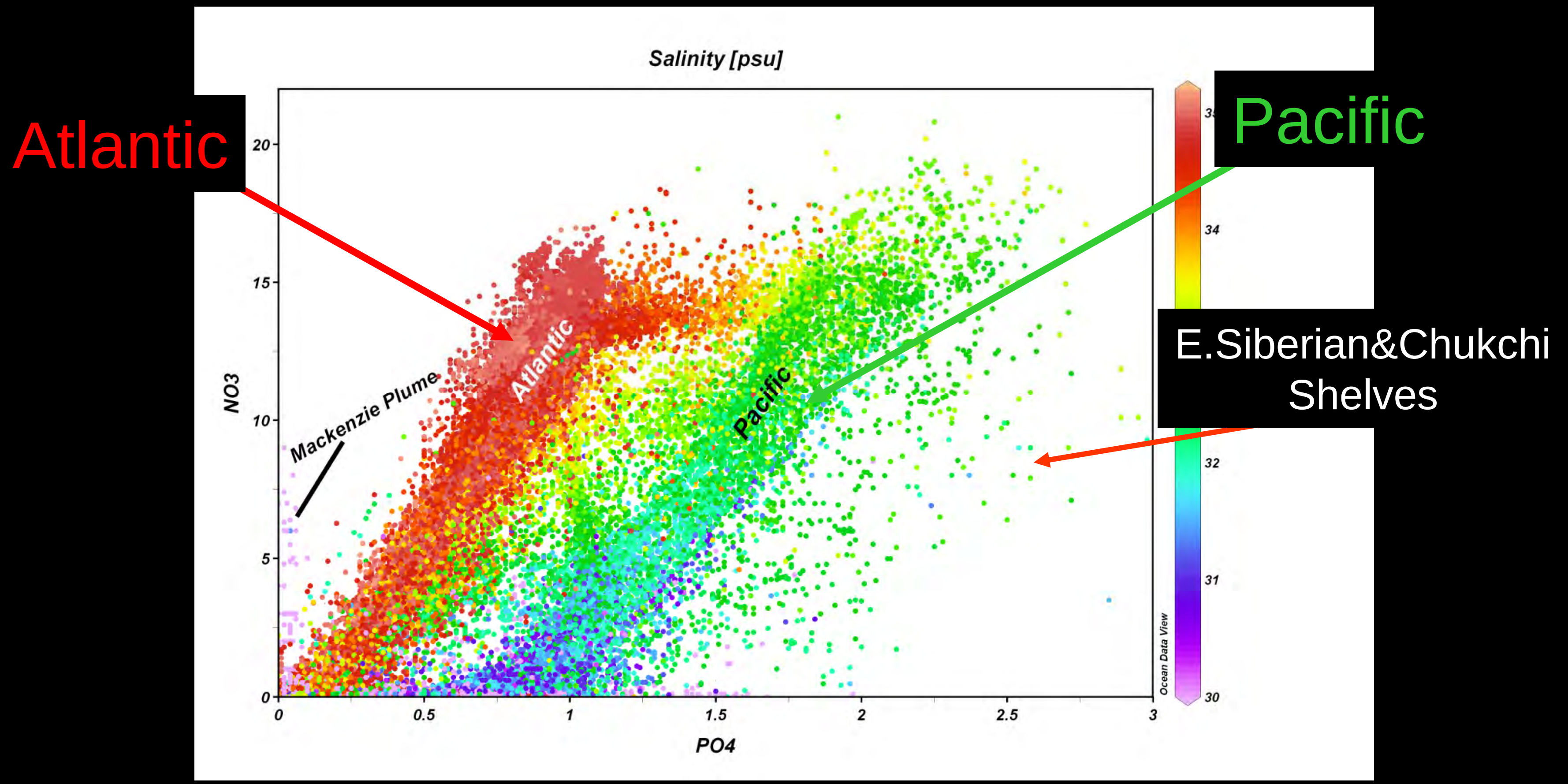
Data that include the Atlantic Inflow and the E.G.C. outflow



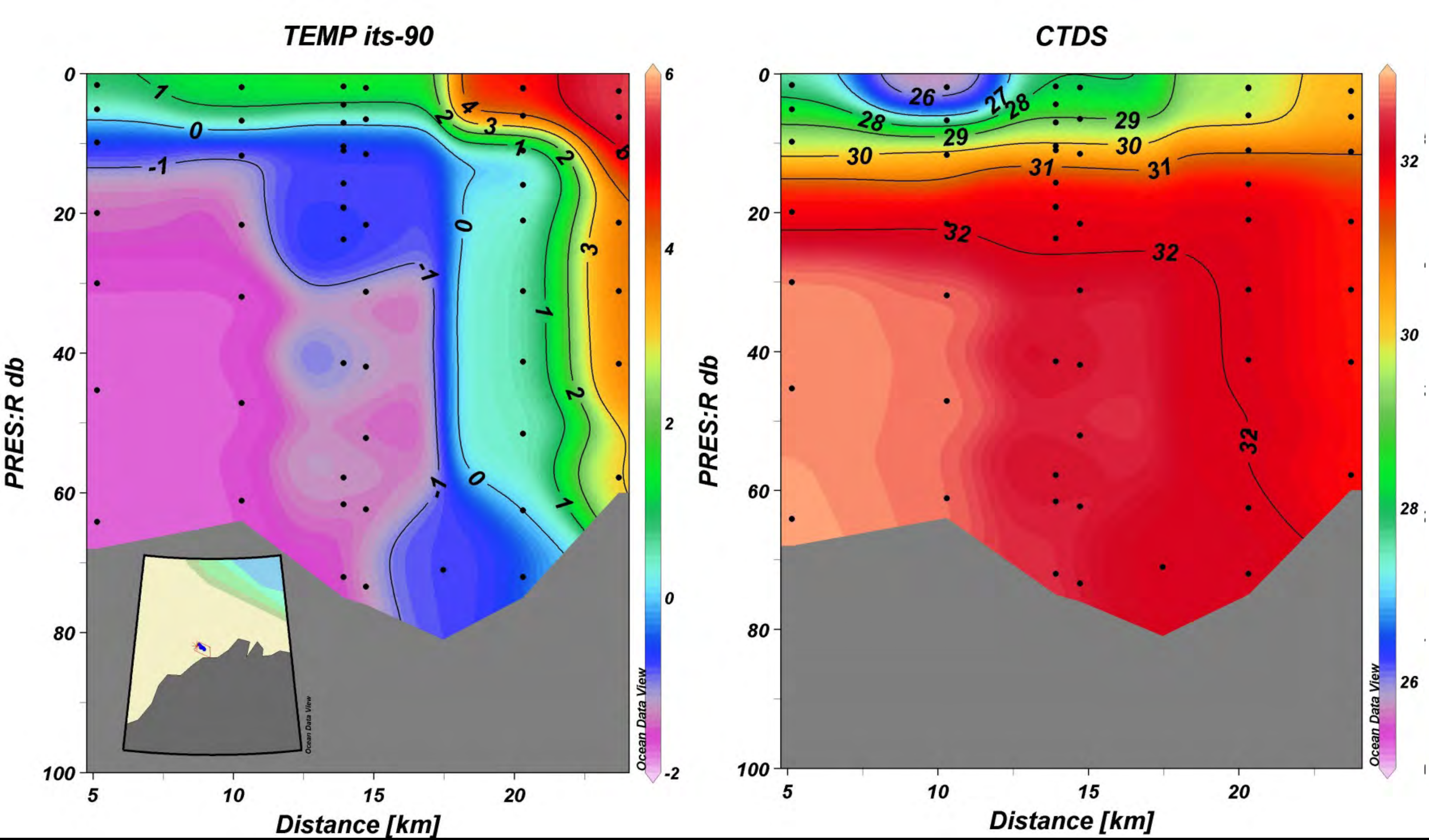
The Arctic nutrient regime is heterogeneous. i.e. Large differences in Atlantic and Pacific inputs, and large differences *within* the Pacific sector.

The Pacific inflow is only about ~1/5 of the Atlantic inflow, but its low salinity confines it to the upper ~125 m where biological cycling is strongest.

Nitrate vs Phosphate with Salinity indicated by color scale



An example of Strong Intra-Sea Gradients in the Pacific/Western Arctic



To me, there are three notable features of this system's nutrient regeneration regime.

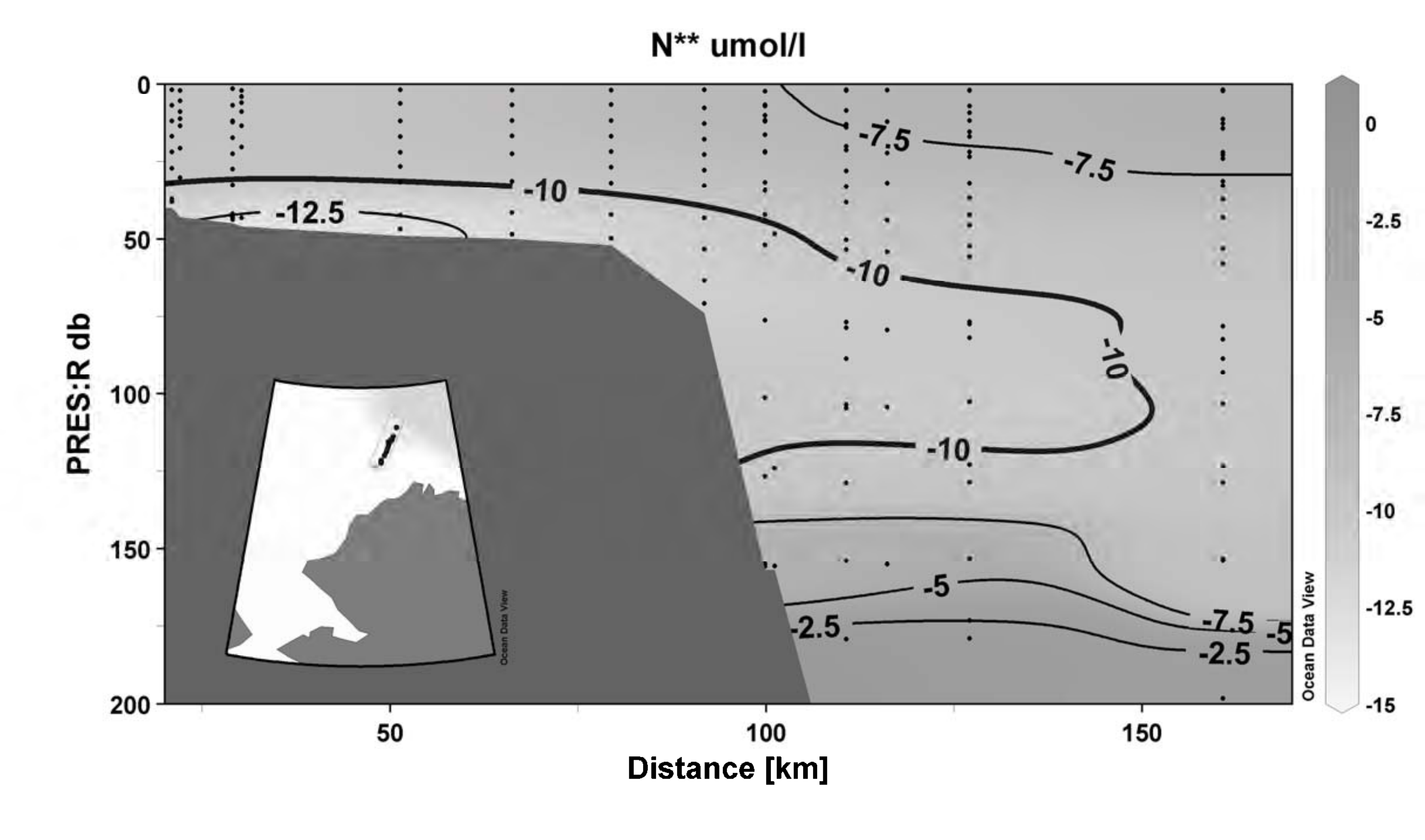
1. Because of the strong salt stratification seasonal re-supply of nutrients to the surface layer by convection is reduced.

2. Large build-ups of ammonium during and after blooms.

3. Globally significant denitrification occurs over productive shelves.

Also, my squinting at data from the Chukchi region suggests that the transport of labile matter to the interior is small.

Negative N** = a net conversion of fixed nitrogen to N_2

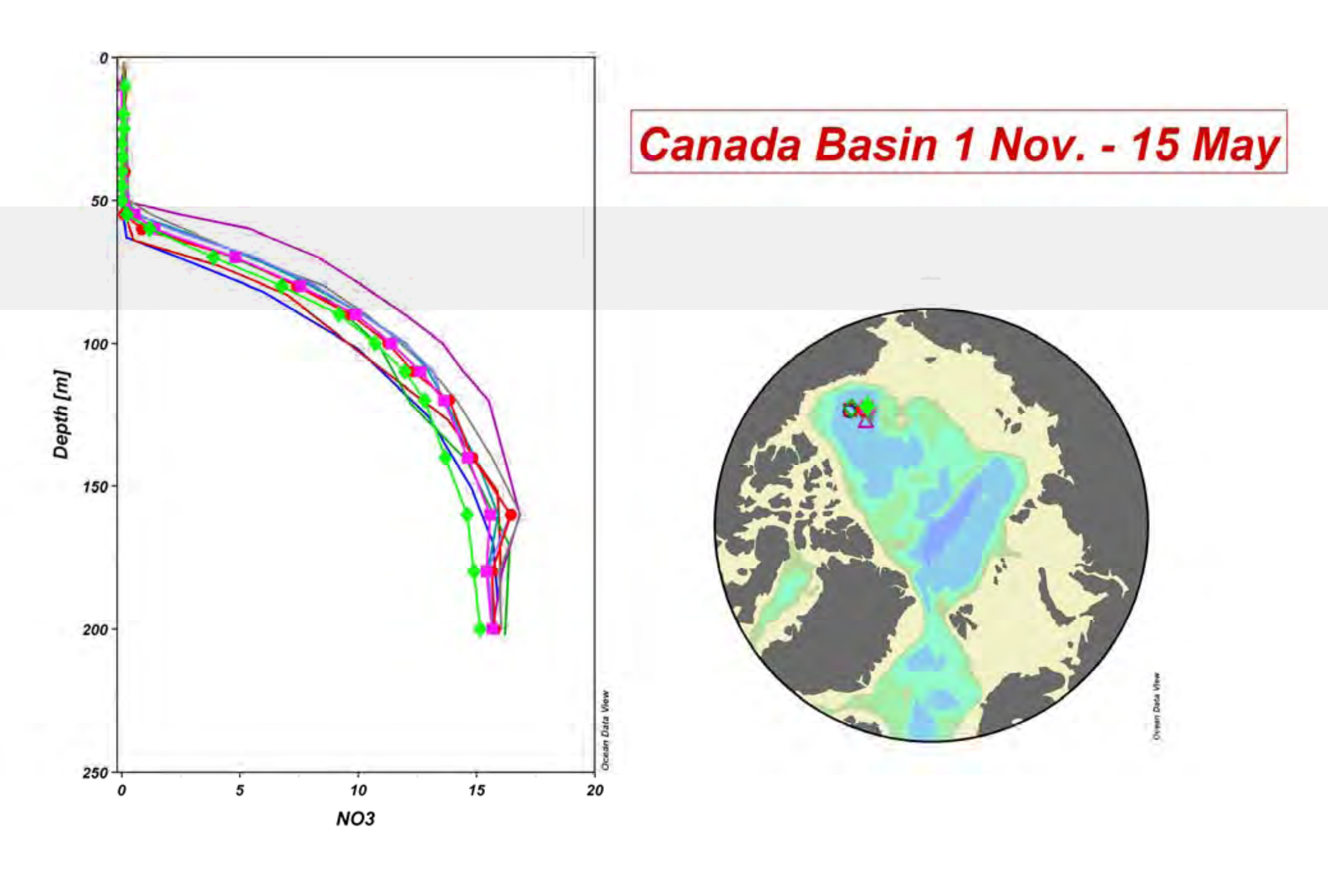


Some of the most negative N** values found anywhere occur in association with sediments on the Chukchi and E. Siberian Sea shelves.

All other things being equal, increased productivity over shelves will increase denitrification, but a shift to a more pelagic system will decrease it. Increased coastal erosion and methane releases should increase denitrification as should increased temperatures via their impact on oxygen solubility and (perhaps) the rate of re-cycling.

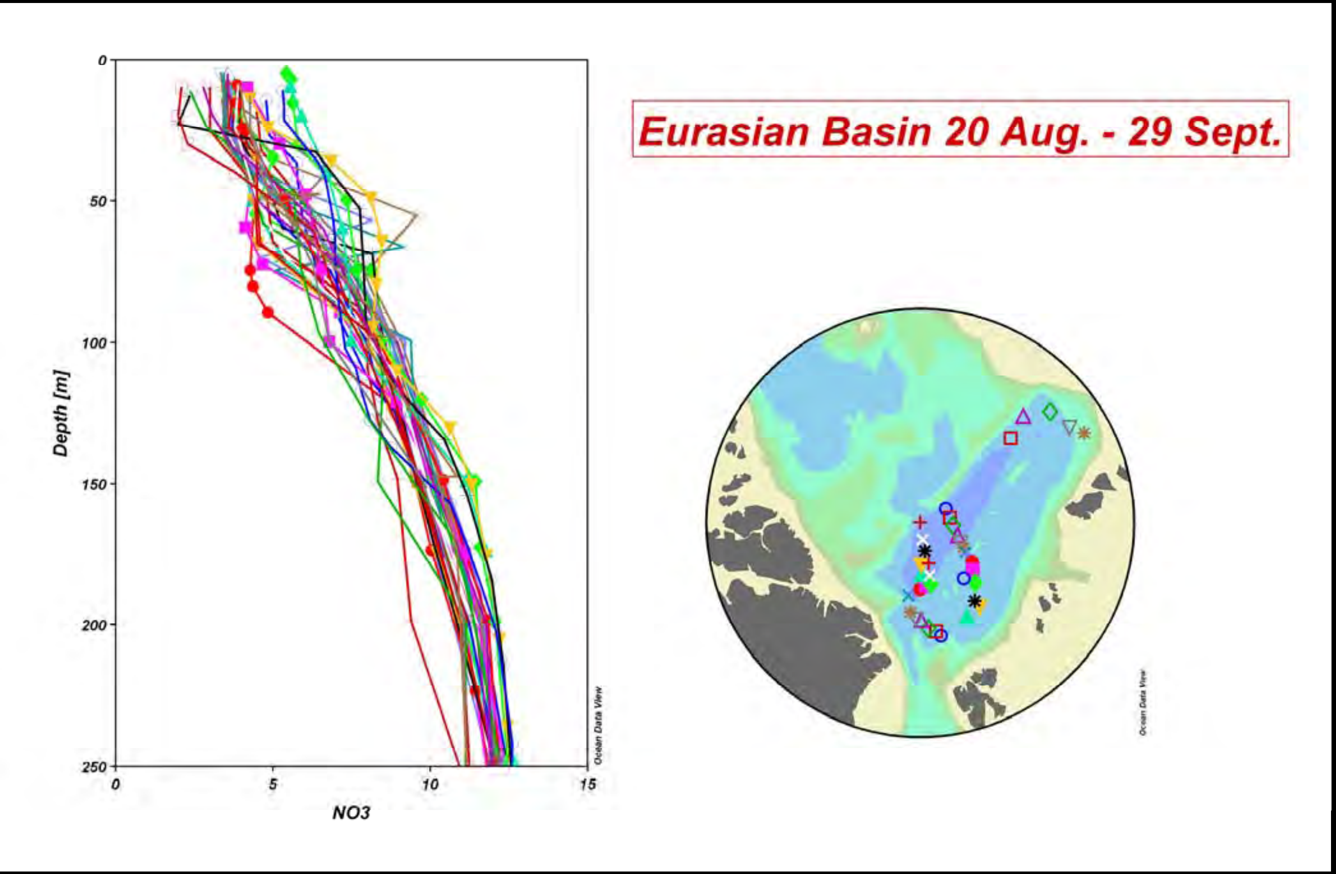
Arctic Ocean Basins differ and this may impact their sensitivity to change!

The Beaufort High, salt stratification, and biological transport of nutrients below 50 m cause the upper layer of the Canadian Basin (or parts of this basin) to be depleted in nitrate even inwinter (thank you SHEBA).



Reduced ice cover *per se* cover is therefore likely to
cause only a modest increase in NCP in this region since photons will need to penetrate to depths of ~50 m before encountering the nitracline

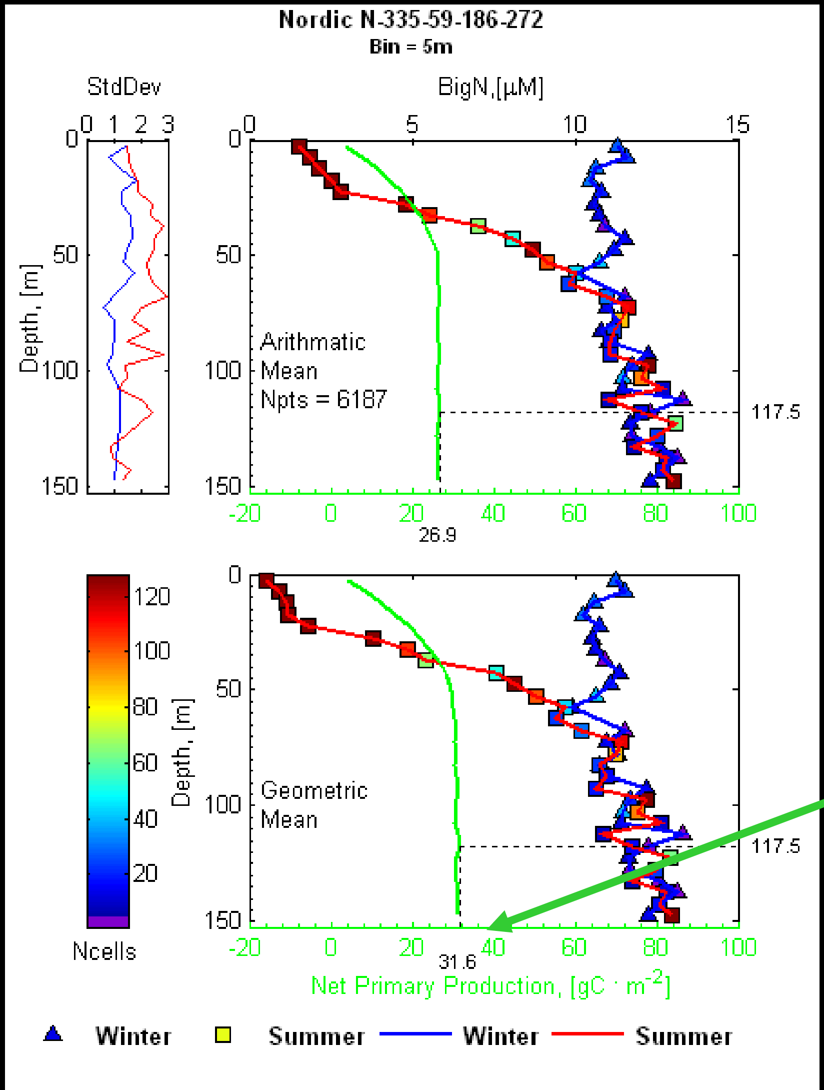
The Eurasian Basin provides a contrast with appreciable nitrate present near the surface *even in summer.*



One might expect therefore that a decrease of ice

cover would have a bigger impact on NCP in the Eurasian Basin.

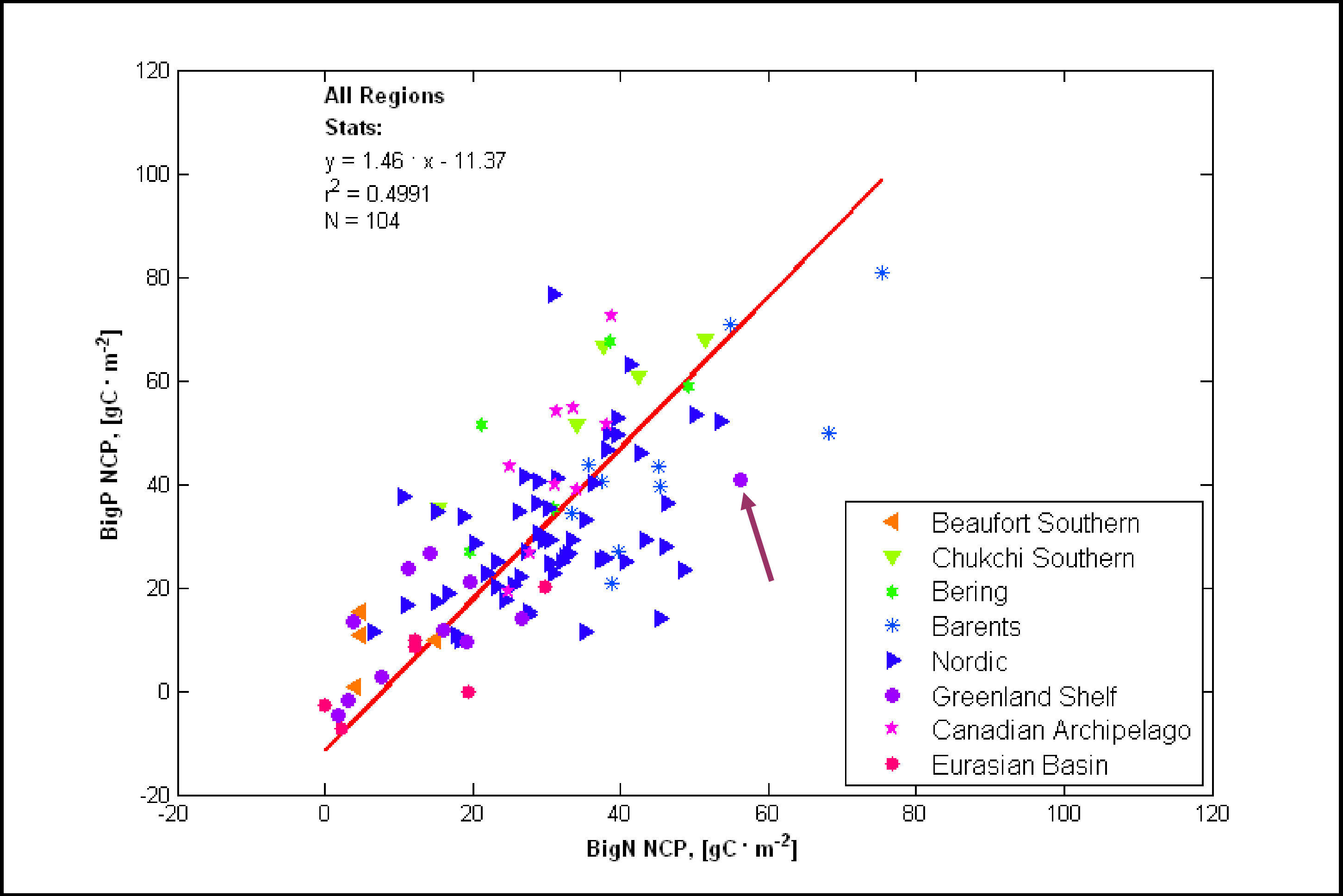
We estimated net community production from seasonal changes in phosphate and nitrate in Arctic regions in 3 ways. One way was to lump data from a sub-region.



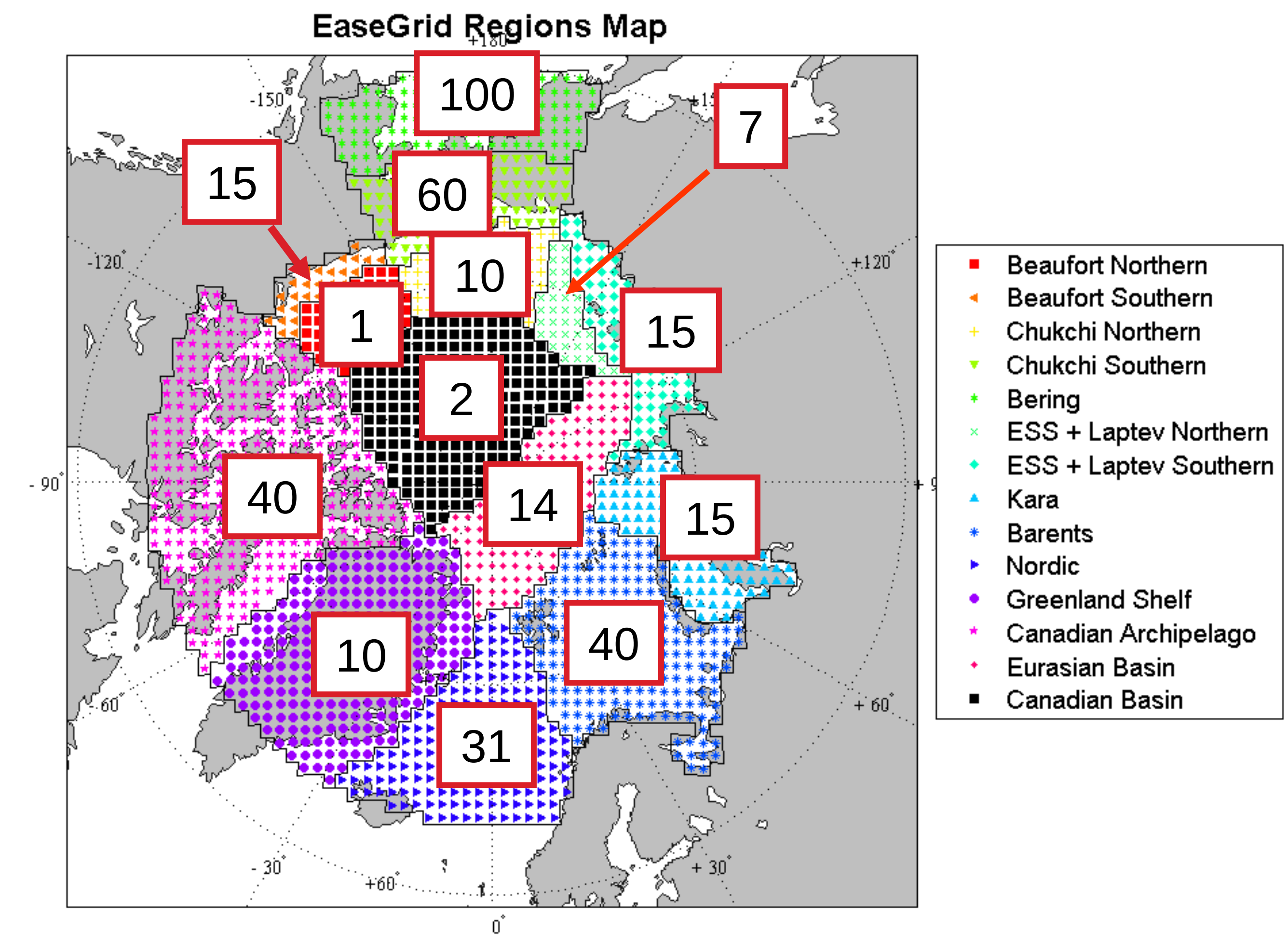
The Nordic Seas were particularly suited to this approach.

NCP estimate based on seasonal nitrate changes ~ 32 g C m^{-2}

Sometimes there was enough data to break down a region by 100x100km grid squares.



Here are the NCP results in g C m^{-2} using Redfield ratios to convert from nitrate and phosphate uptake to organic carbon production.



Two things to note:

1. NCP within this system varies by ~ 2 orders of magnitude.
2. NCP values which *should* be much smaller than primary production estimated from incubations, are similar. This is common when estimates of production based on changes in nutrients or inorganic carbon in the Arctic and sub-Arctic are compared with the results of incubations. In my opinion, the incubation based estimates are generally too low.

The End, thank you!