Natural Iron Fertilisation around Elephant Island: Sources and Systematics of the Added Fe

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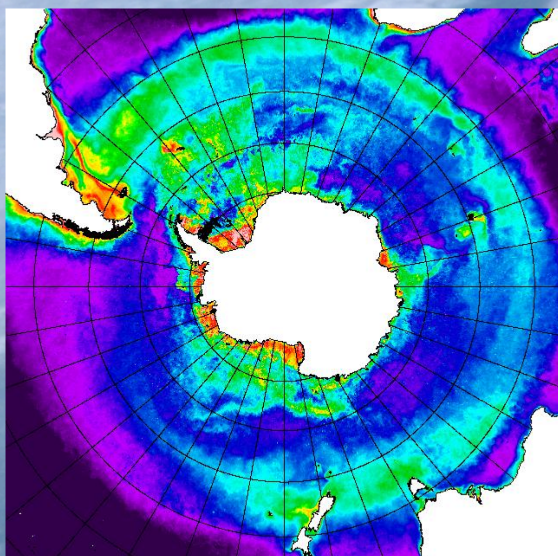
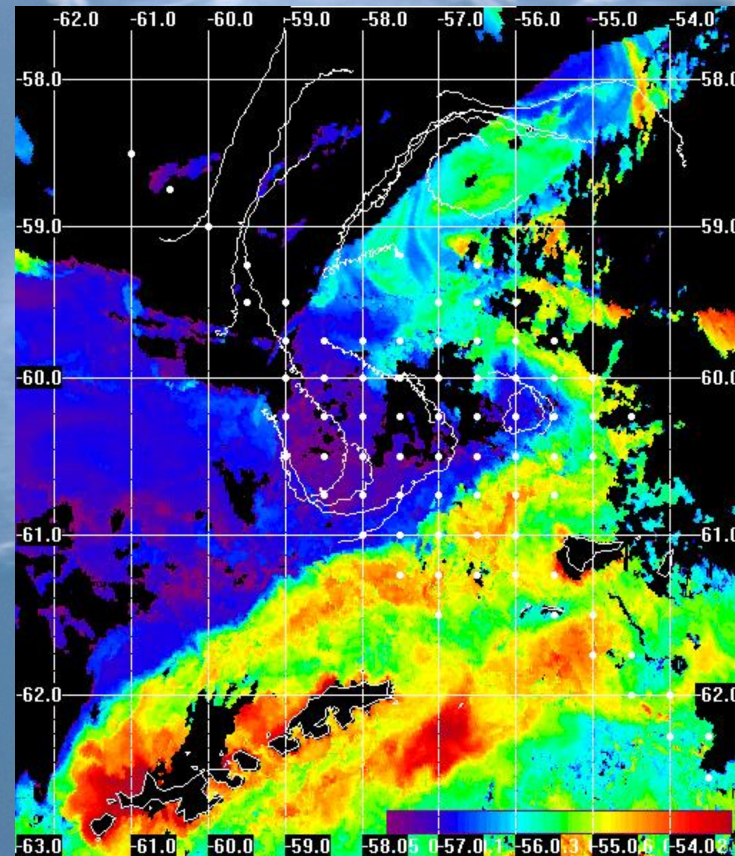
February mean satellite estimate of chlorophyll for 1997-2006



HNLC conditions encircle most of Antarctica



As circumpolar water passes through the Drake Passage, phytoplankton biomass suddenly increases dramatically

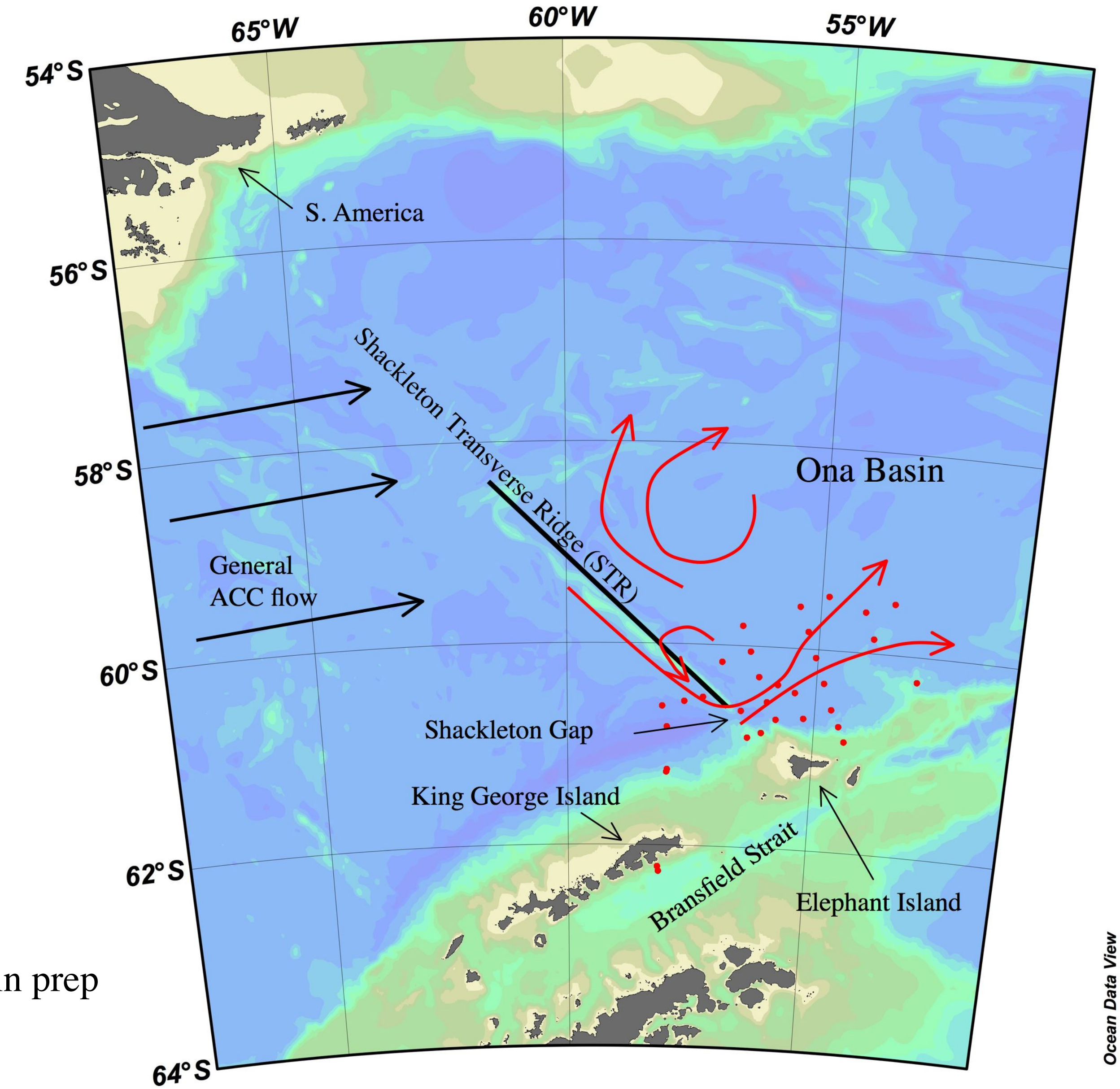
NASA Images courtesy G Mitchell

Three potential sources of Fe

Eolian deposition of mineral dust

Upwelling of Fe rich deep water

Entrainment of Fe shelf water



Measures et al in prep

Which ship to take?

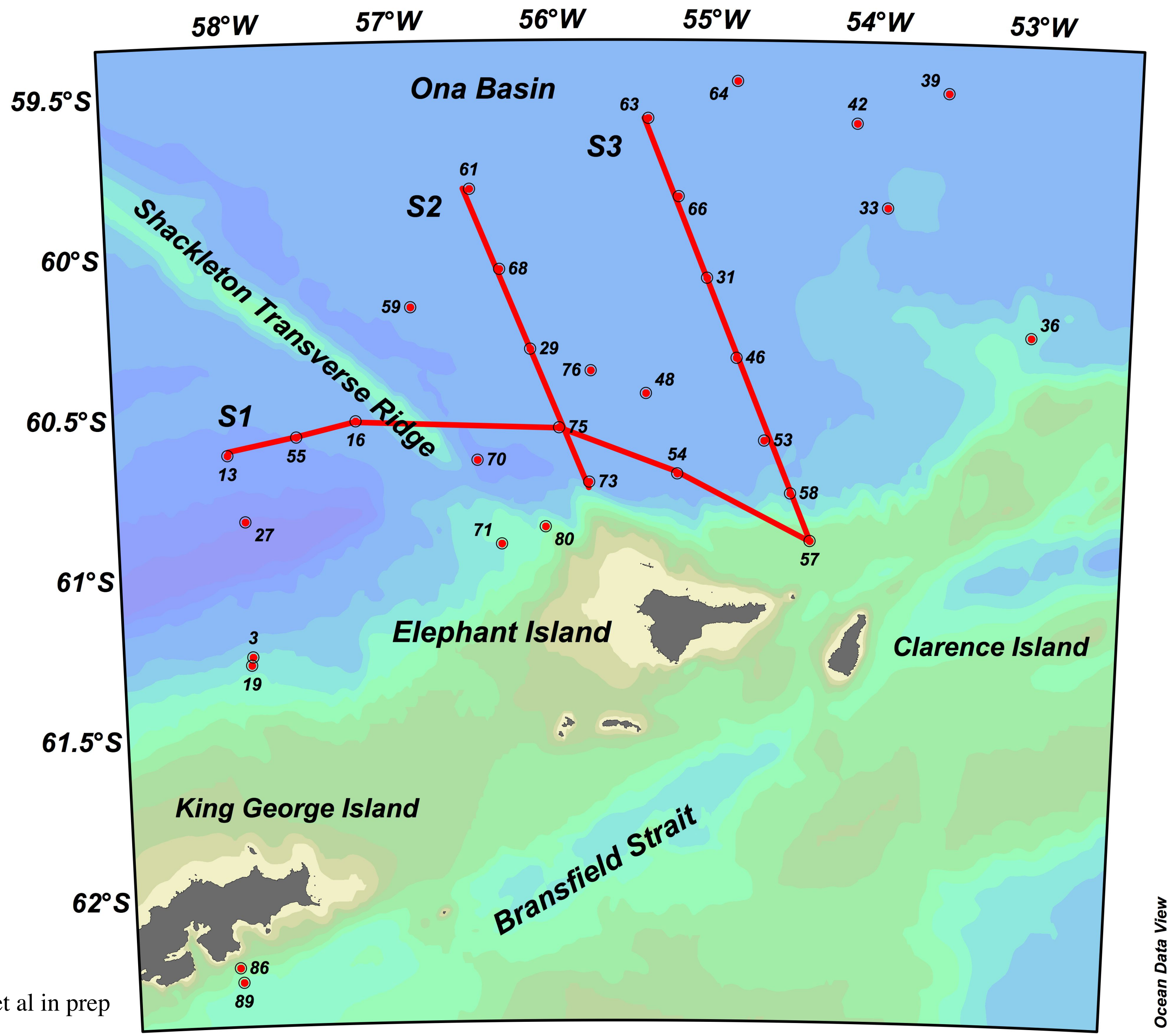
UH trace metal van being lifted onto the Gould

Commercially available rosette system

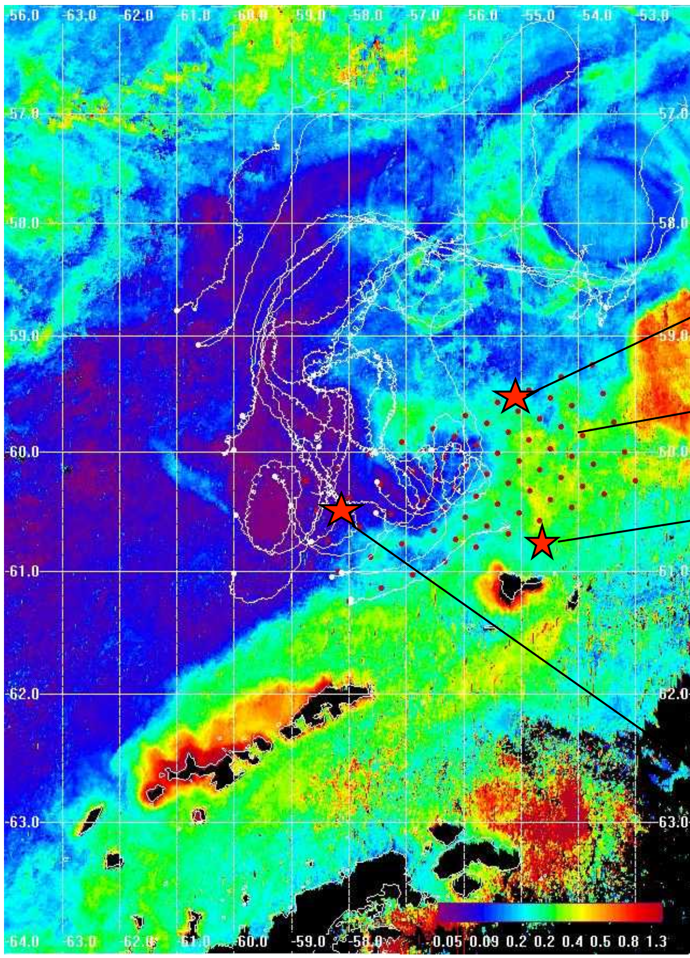
Real girly-man unloading the rosette



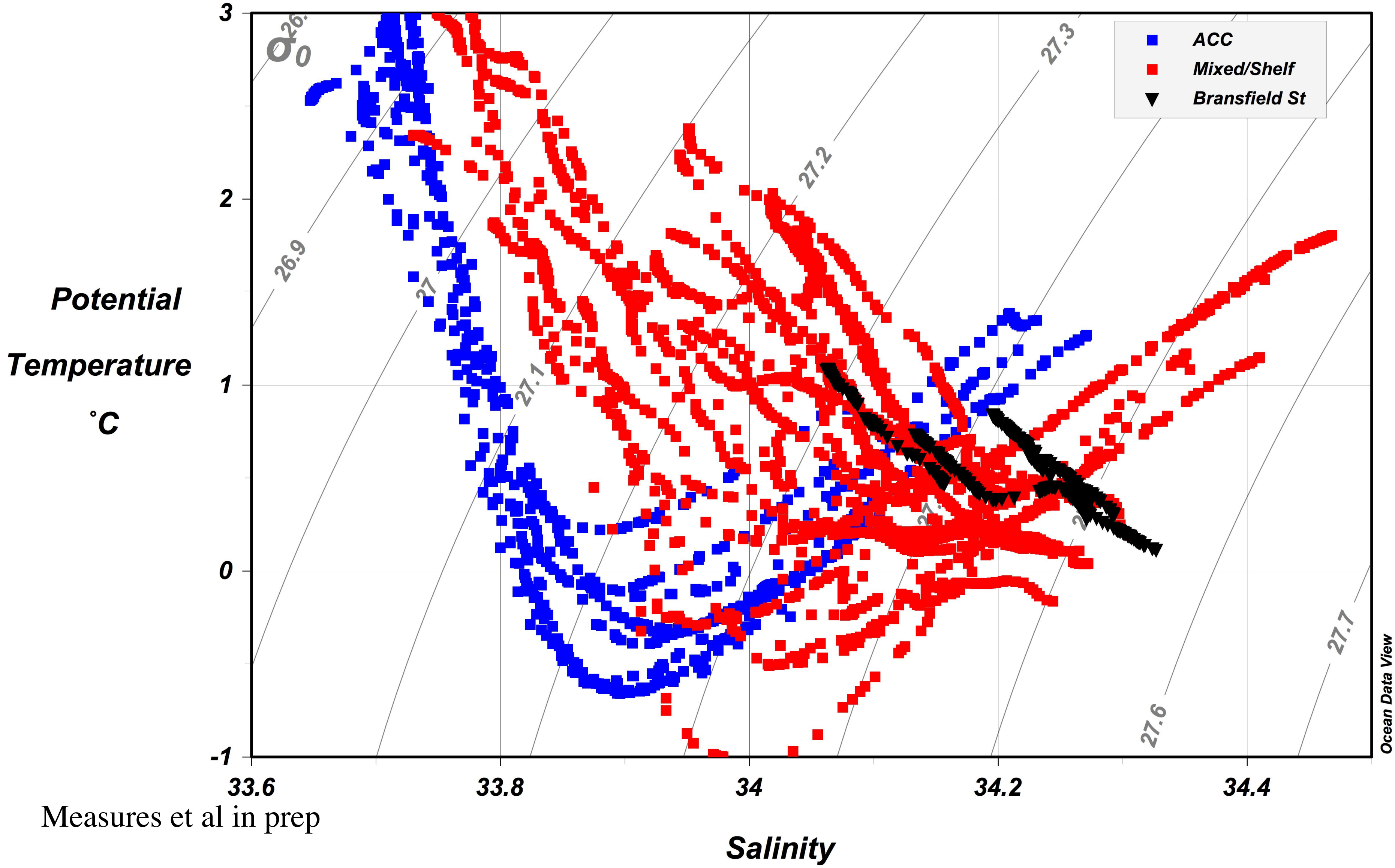

FIA equipment and flow bench



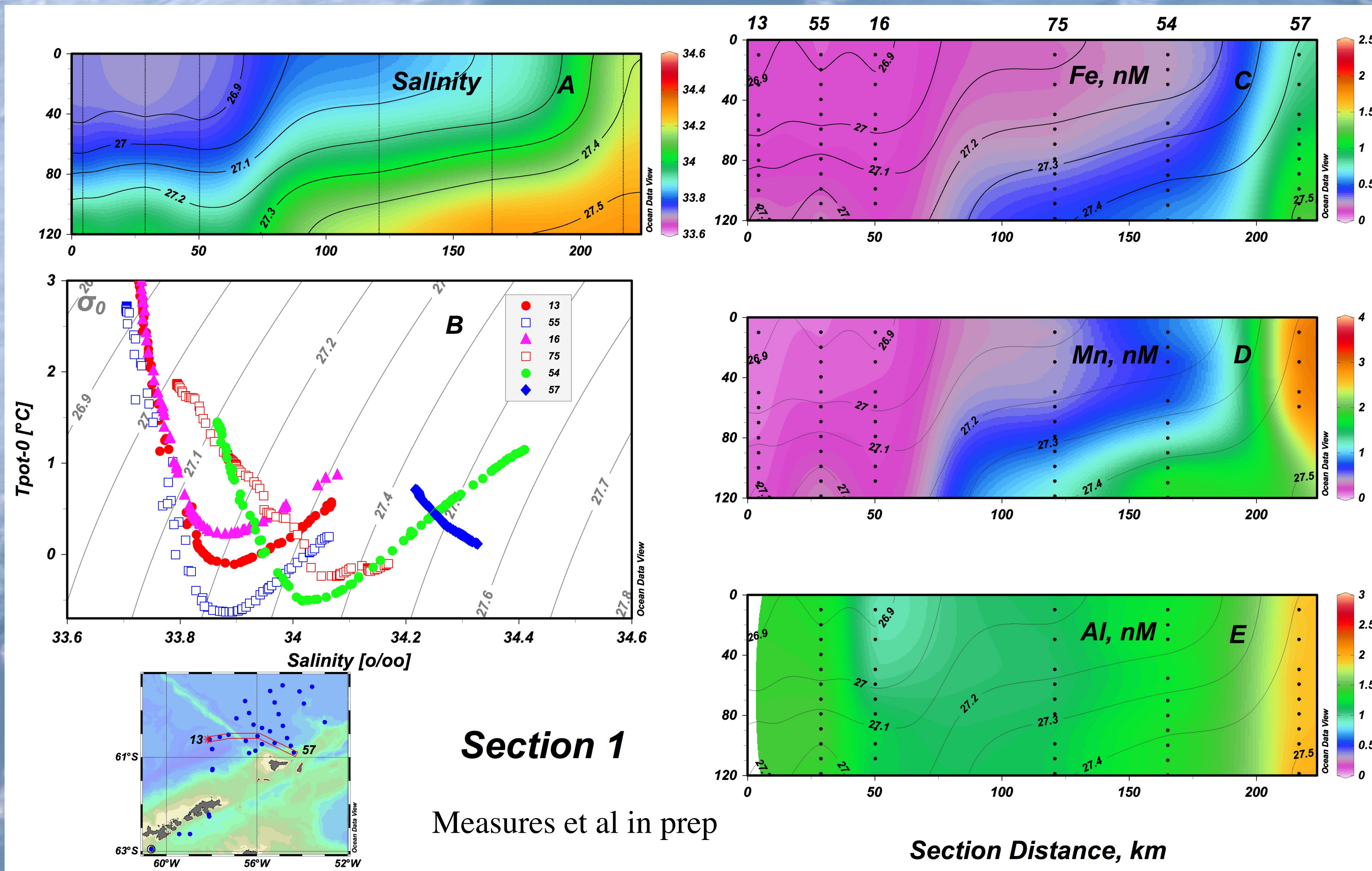
Measures et al in prep



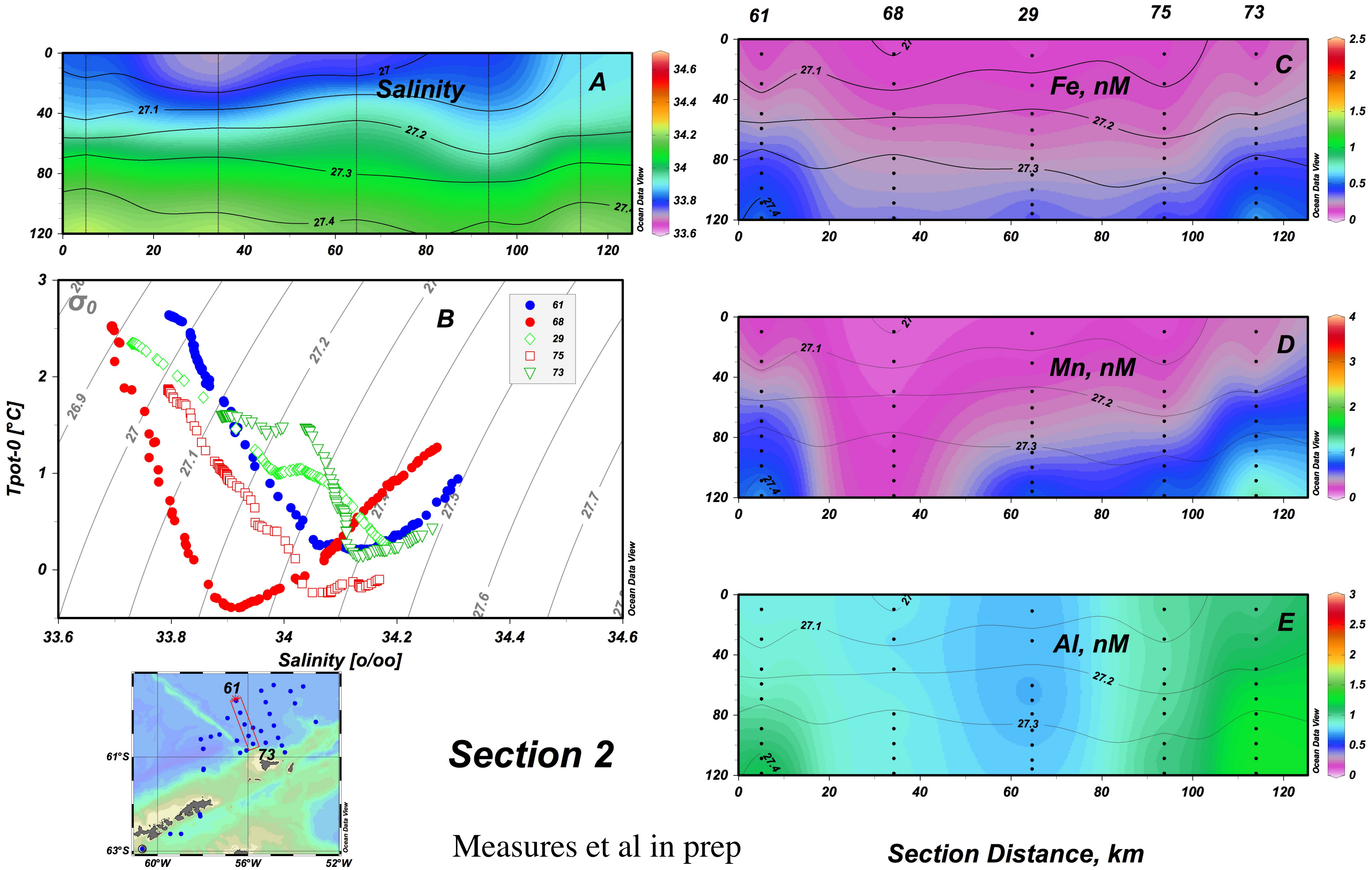
NASA Image courtesy G Mitchell



Measures et al in prep

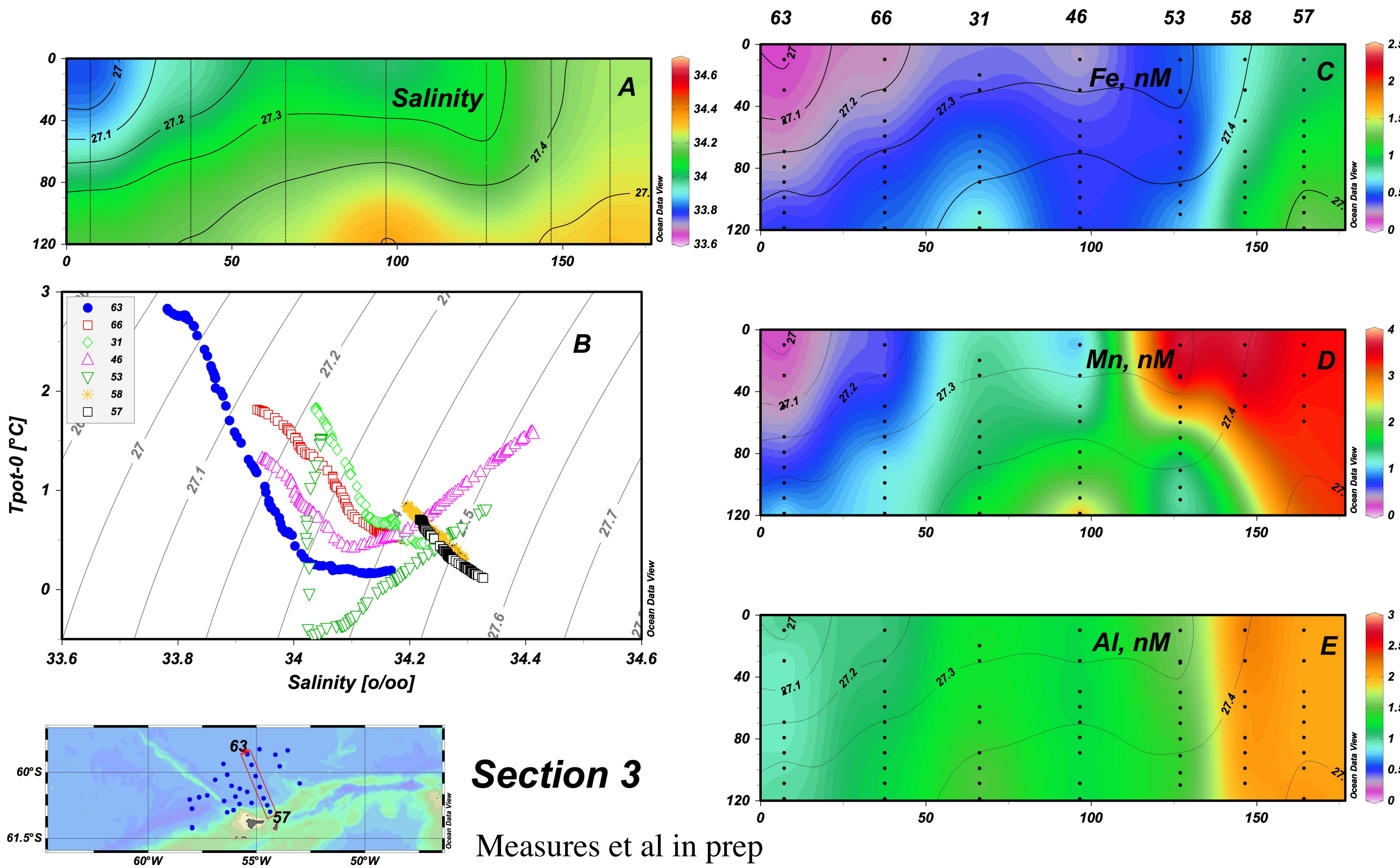


Salinity
A
B
σ0
Tpot-0 [°C]
Salinity [o/oo]
13
55
16
75
54
57
Fe, nM
C
Mn, nM
D
Al, nM
E
Section Distance, km
61°S
63°S
60°W
56°W
52°W
Ocean Data View
Section 1
Measures et al in prep



Section 2

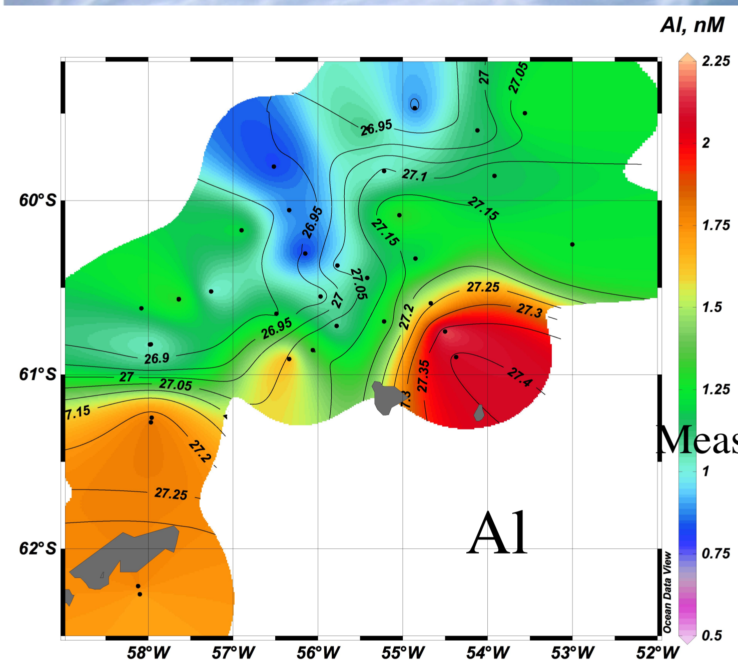
Measures et al in prep

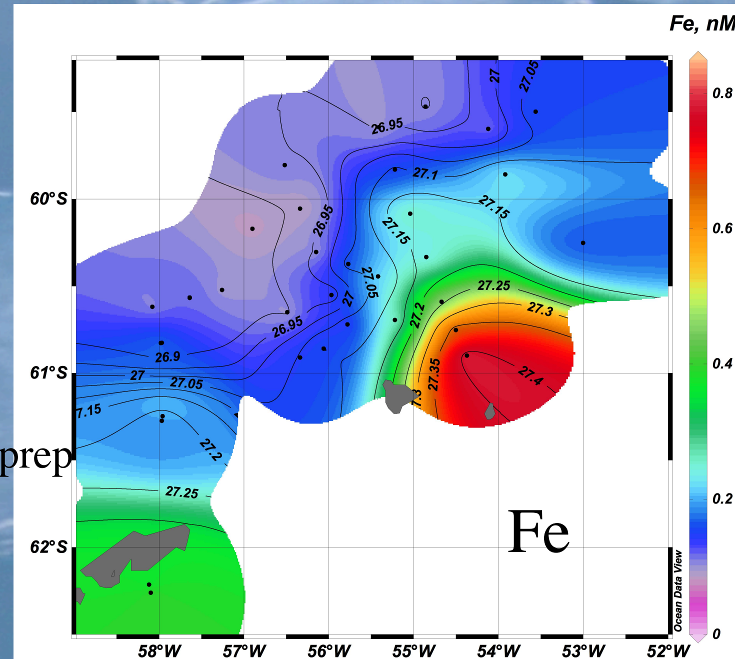


Section 3

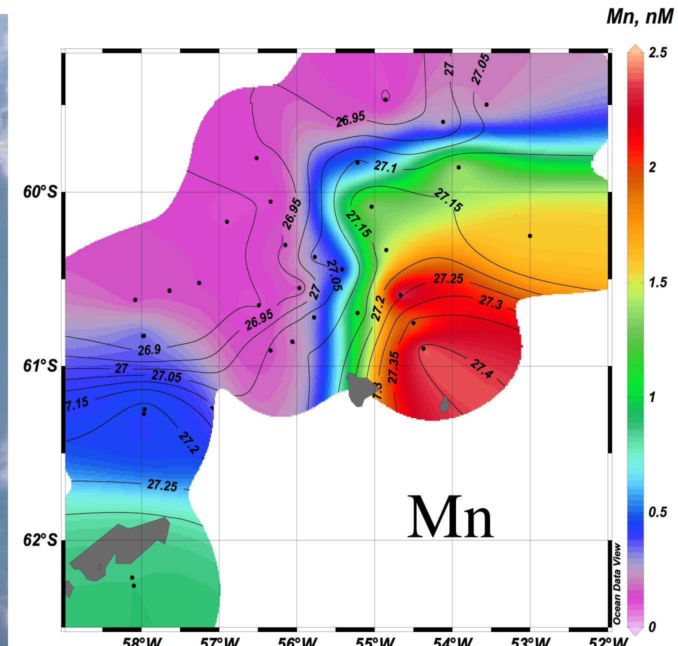
Measures et al in prep

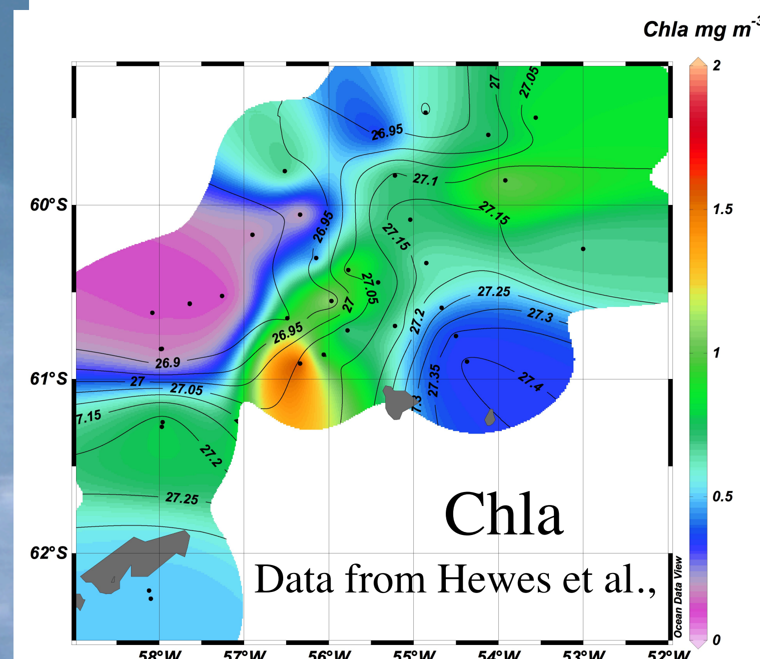
Surface water distributions





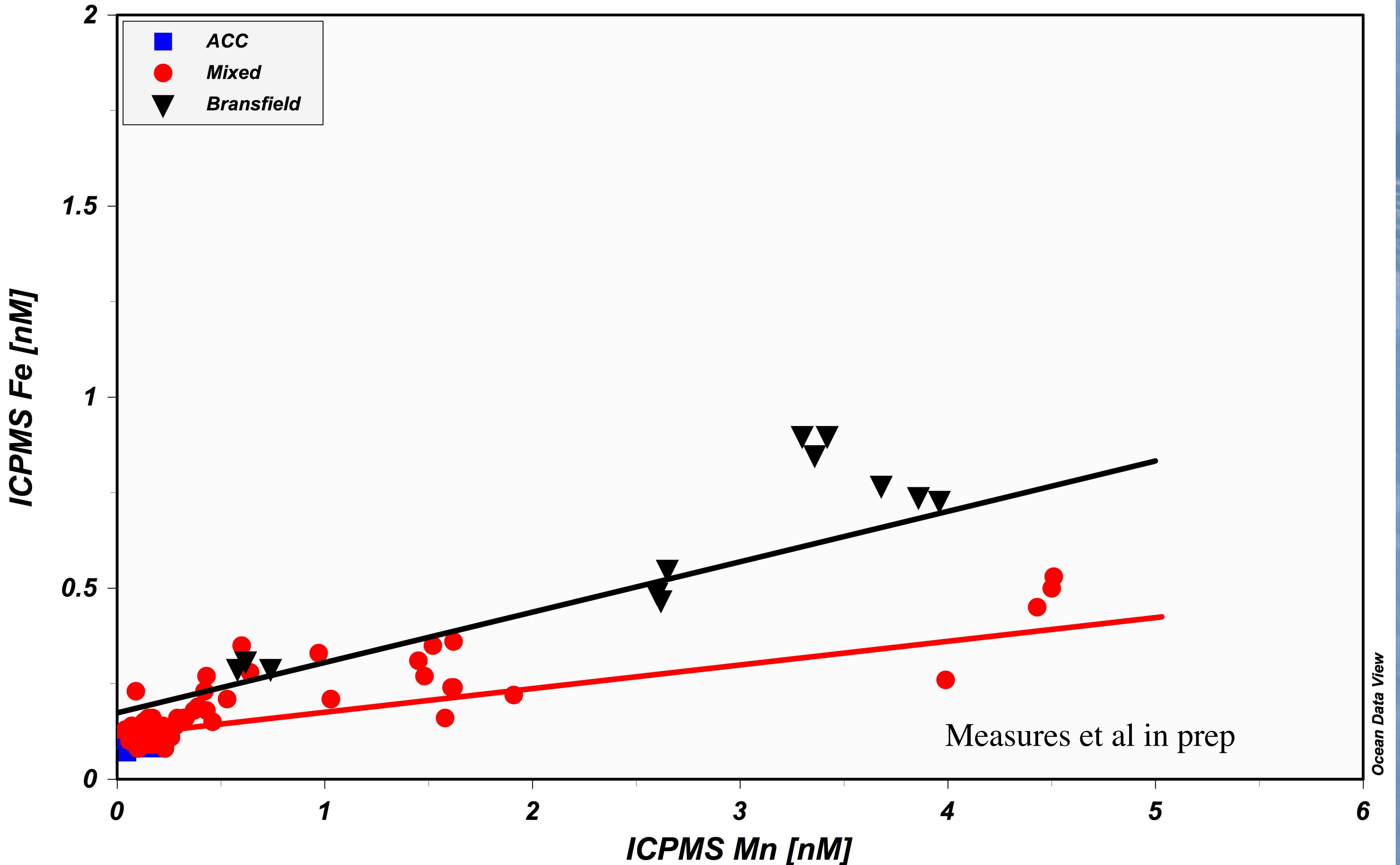
Measures et al in prep





Data from Hewes et al.,

Upper 50m dissolved Fe and Mn



Most of the Fe is being advected off the shelf

Geostrophic offshore transport in the upper 100 m is 0.18 Sv (calculated by M. Zhou, Umass Boston)

End member Fe @ 0.5 nM = 2.8 x 10^6 moles Fe yr^{-1}

Using C:Fe 10^5:1, could support export of 0.28 x 10^{12} moles C yr^{-1}

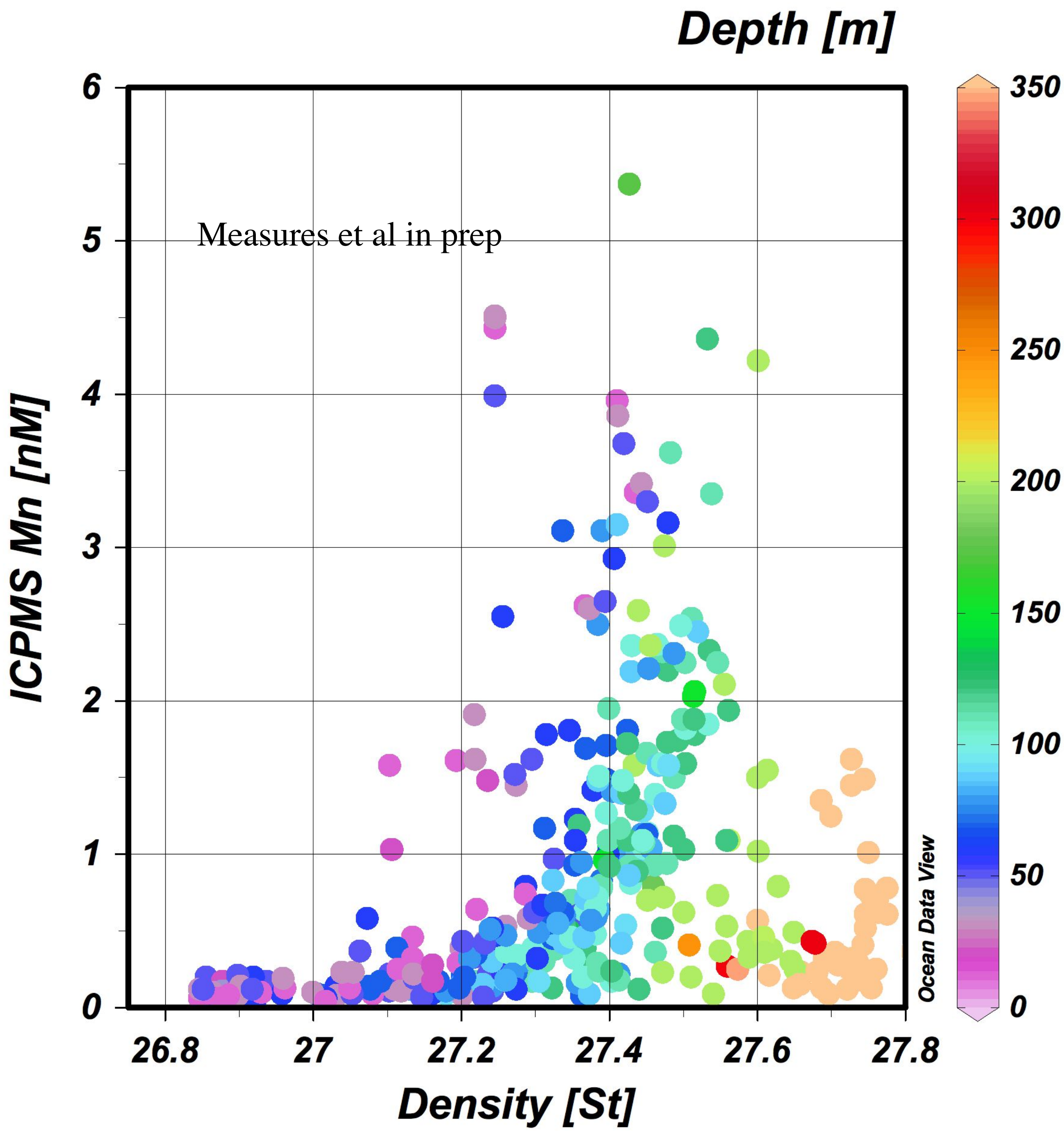
Winter end member 3 nM Fe, export = 1.7 x 10^{12} moles C yr^{-1}

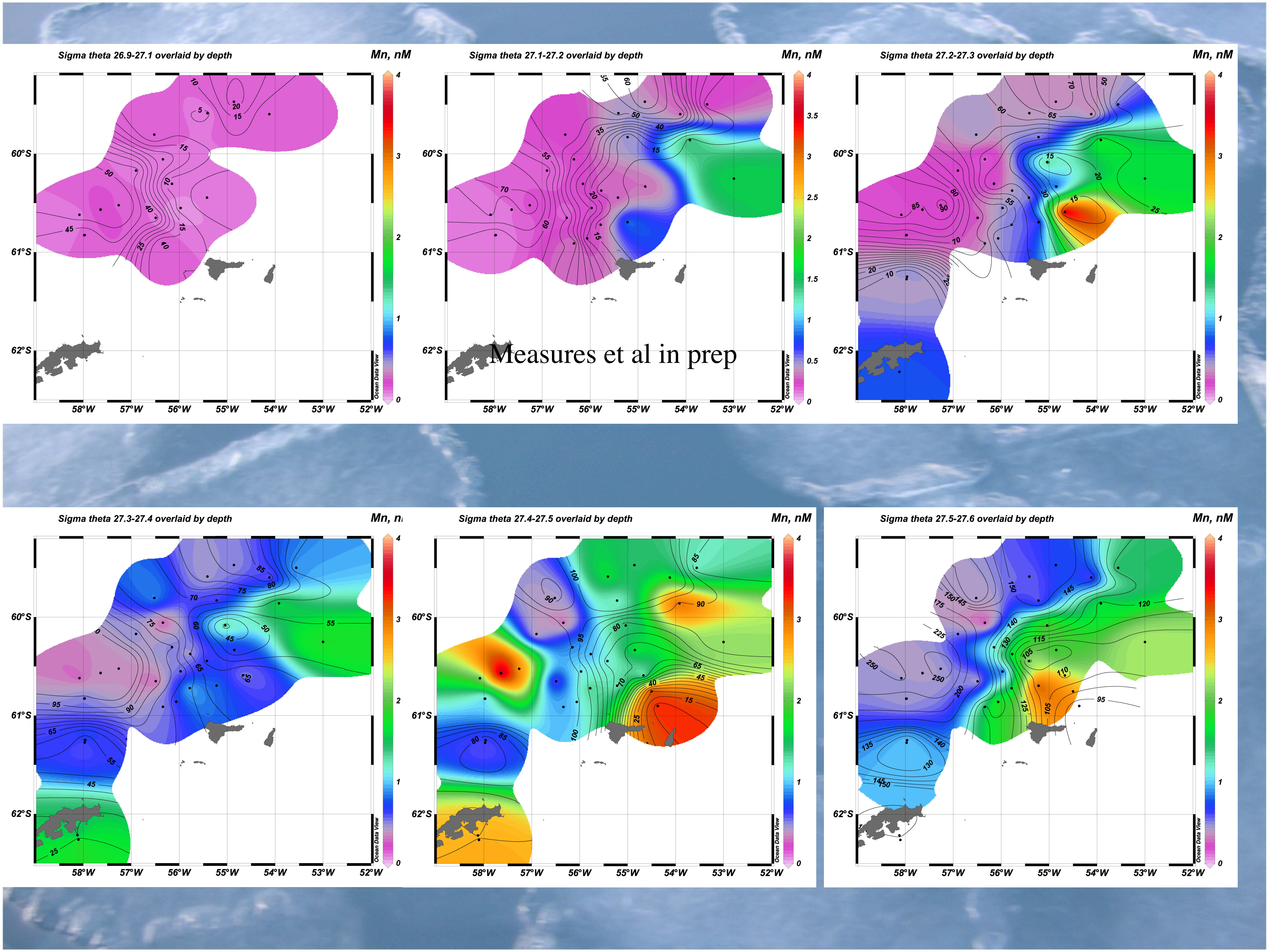
= 7 % of estimated new production in So. Ocean south of 60˚S

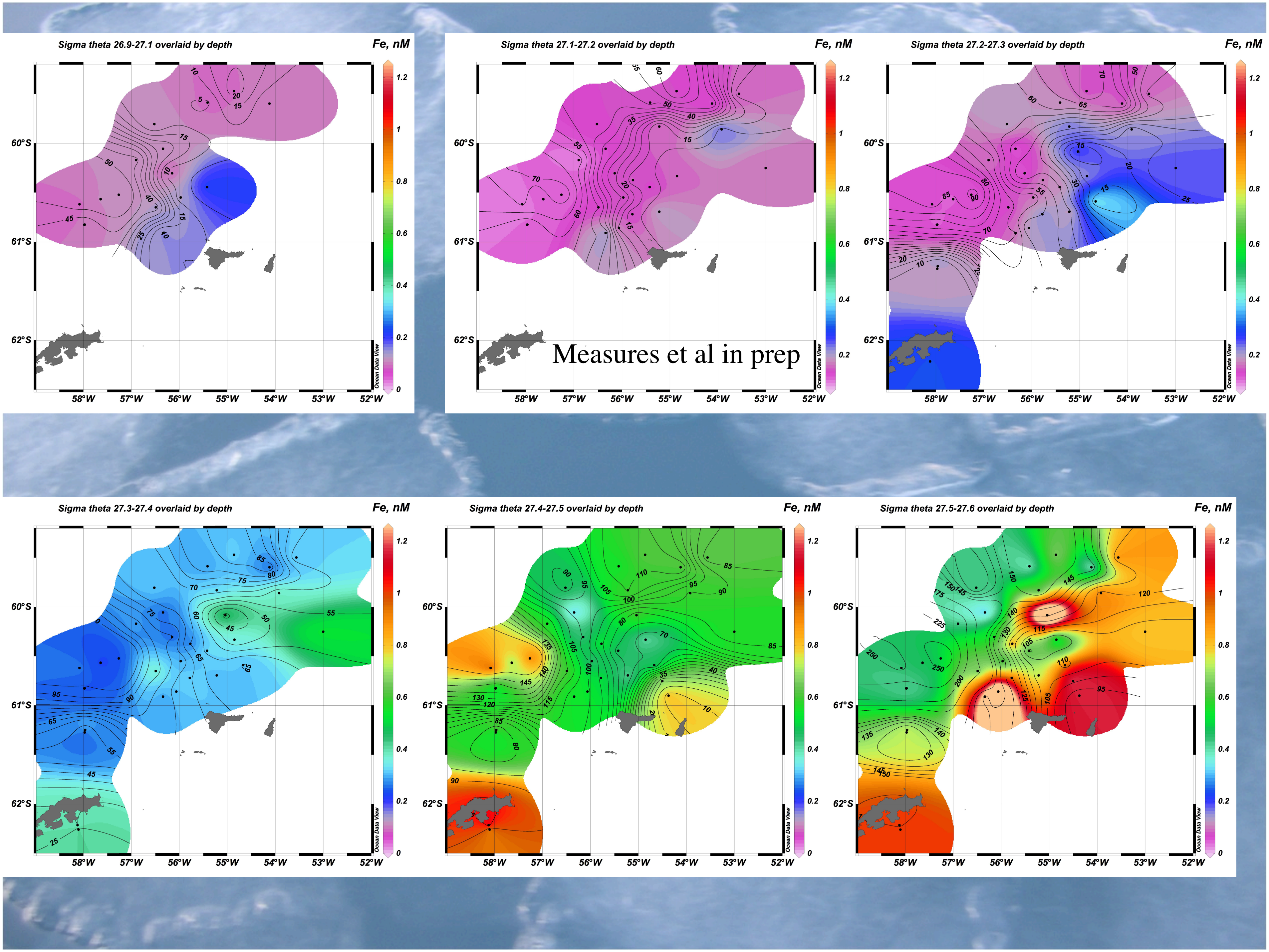
BUT

If significant amounts of Fe are scavenged, particularly at high Fe then fluxes will be much lower

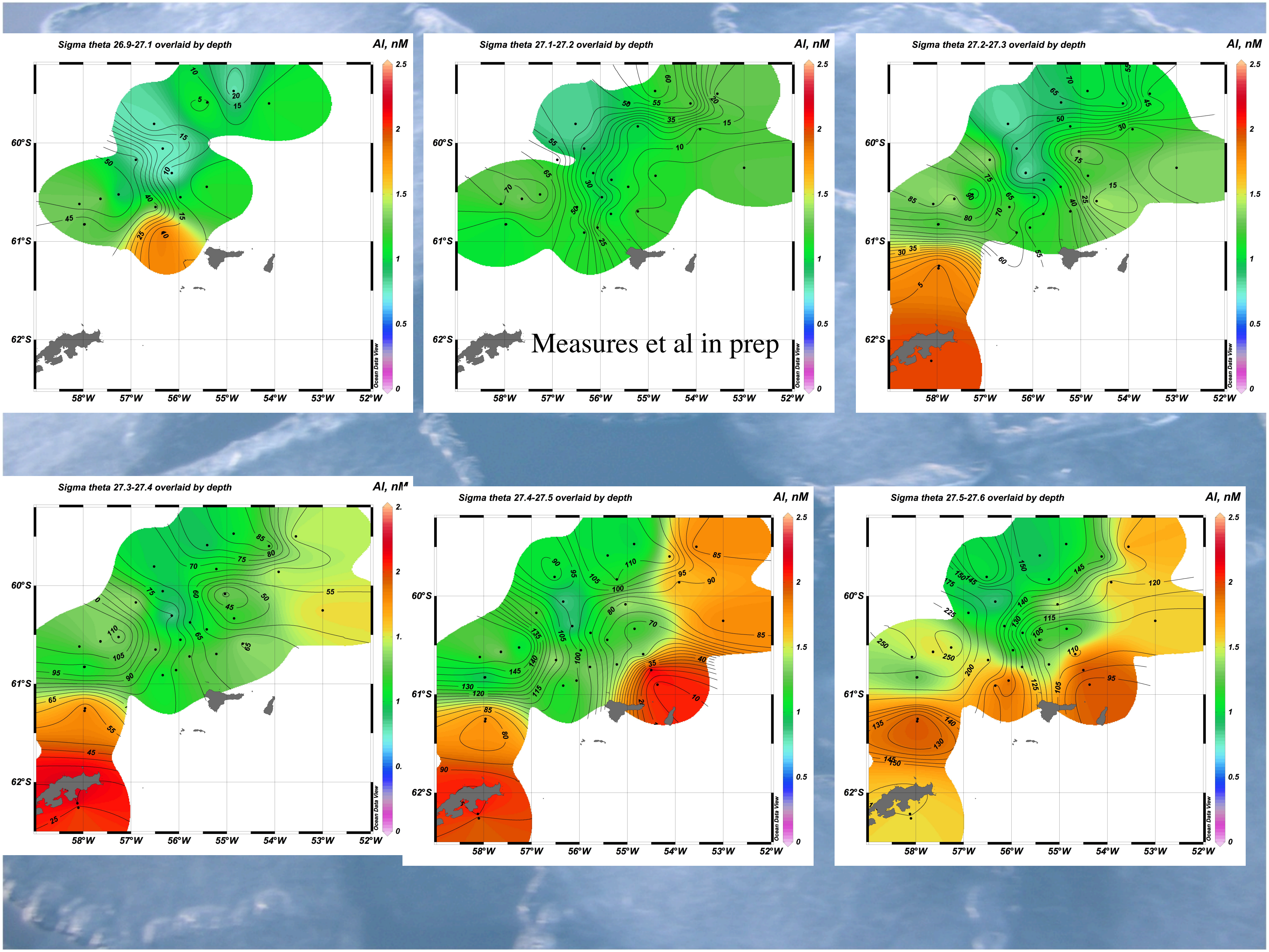
Measures et al in prep


Depth [m]
Measures et al in prep
ICPMS Mn [nM]
Density [St]
Ocean Data View
0
1
2
3
4
5
6
26.8
27
27.2
27.4
27.6
27.8
0
50
100
150
200
250
300
350


Sigma theta 26.9-27.1 overlaid by depth
Mn, nM
Sigma theta 27.1-27.2 overlaid by depth
Mn, nM
Sigma theta 27.2-27.3 overlaid by depth
Mn, nM
Measures et al in prep
Sigma theta 27.3-27.4 overlaid by depth
Mn, nM
Sigma theta 27.4-27.5 overlaid by depth
Mn, nM
Sigma theta 27.5-27.6 overlaid by depth
Mn, nM
60°S
61°S
62°S
58°W
57°W
56°W
55°W
54°W
53°W
52°W
Ocean Data View



Sigma theta 26.9-27.1 overlaid by depth
Fe, nM
Sigma theta 27.1-27.2 overlaid by depth
Fe, nM
Sigma theta 27.2-27.3 overlaid by depth
Fe, nM
Measures et al in prep
Sigma theta 27.3-27.4 overlaid by depth
Fe, nM
Sigma theta 27.4-27.5 overlaid by depth
Fe, nM
Sigma theta 27.5-27.6 overlaid by depth
Fe, nM
60°S
61°S
62°S
58°W
57°W
56°W
55°W
54°W
53°W
52°W
0
0.2
0.4
0.6
0.8
1
1.2
Ocean Data View


Sigma theta 26.9-27.1 overlaid by depth
Al, nM
Sigma theta 27.1-27.2 overlaid by depth
Al, nM
Measures et al in prep
Sigma theta 27.2-27.3 overlaid by depth
Al, nM
Sigma theta 27.3-27.4 overlaid by depth
Sigma theta 27.4-27.5 overlaid by depth
Al, nM
Sigma theta 27.5-27.6 overlaid by depth
Al, nM
60°S
61°S
62°S
58°W
57°W
56°W
55°W
54°W
53°W
52°W
Ocean Data View

Fe is a necessary, but not sufficient condition for bloom development

Development of blooms in this region only occurs when:

Potential density 27.2-27.4

Salinity > 38.95

Water has passed over the AP

The water is in the euphotic zone

AND

The Mixed layer < Critical depth

Measures et al in prep

Conclusions:

- Fe is being added to the ACC water
- Upwelling and atmospheric deposition are not important: The shelf is the source of Fe
- Interactions with anoxic sediments are the most likely source
- Simple mixing dominates distributions
- Phytoplankton growth is enhanced by Fe, BUT flushing rate compared to growth rates precludes large scale Fe removal on shelf

Measures et al in prep

Suboxic/anoxic diagenesis an interesting feedback loop

Need large C inputs

Shallow shelves, more C buried

Anoxic diagenesis releases dissolved Fe

Dissolved Fe promotes biological activity

Biological activity results in large C fluxes

Measures et al in prep

Acknowledgements

Chief Scientist: Greg Mitchell, SIO
Meng Zhou and the UMass PO group
Barbeau group, SIO (Sue, Kathy, Brian) for sub-sampling help
NSF OPP for funding