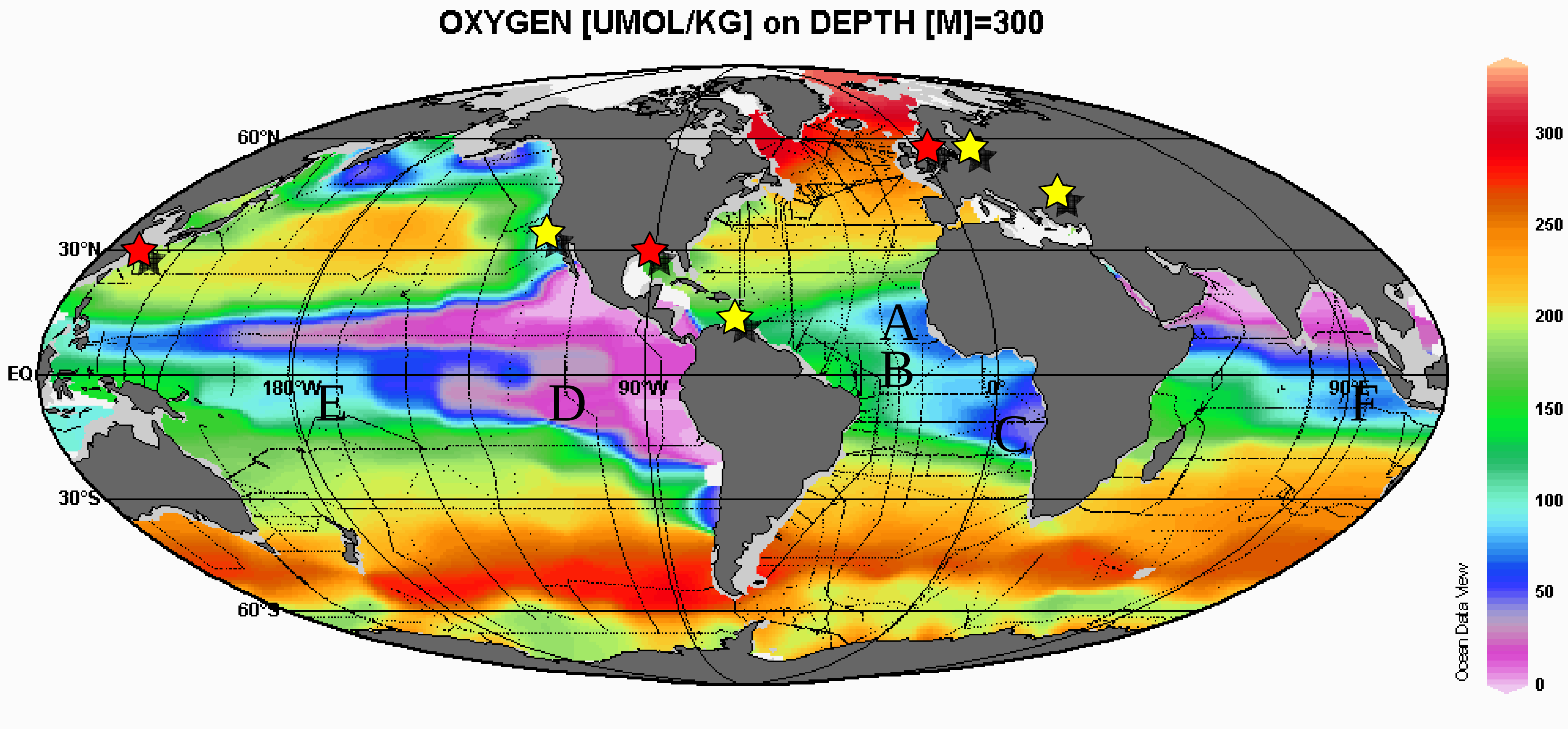
Biogeochemical Applications for Intense Oceanic O_2 Minimum Zones

- Small portion of oceanic volume, but have a central role for key biogeochemical cycles; e.g. N cycles
- Important influence on ocean release of trace gases; e.g. N_2O, CH_4
- Overlay high accumulation rate, organic C-rich sediments which hold important paleo-climate archives
- Impact the population and ecology of regionally important living marine resource species
- Concern over future expansion of both natural and anthropogenic low O_2 zones. Occur in climate sensitive regions; e.g. ETP (ENSO), Arabian Sea (Monsoon)

Global distribution of low O_2 zones



- High surface productivity and downward OM flux
- Poor subsurface water mass ventilation

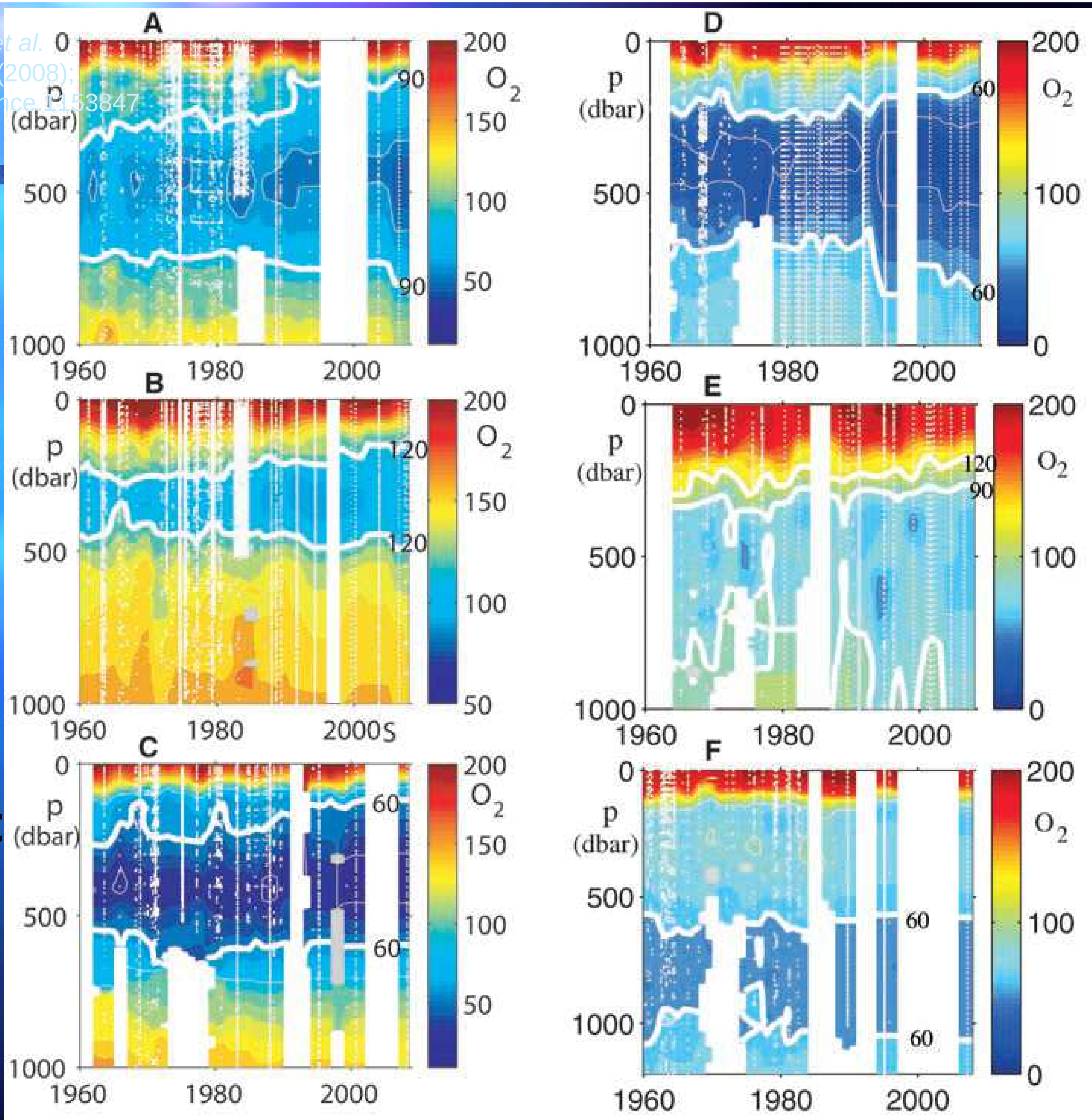
-closed regional circulation (shadow zone)

-remote surface (outcrop) ventilation zone

Lothar Stramma, *et al.*
Science **320**, 655 (2008);
DOI: 10.1126/science.1153847

A1: Monitoring future changes in extent and intensity.

Distinguish natural vs. anthropogenic climate forcing

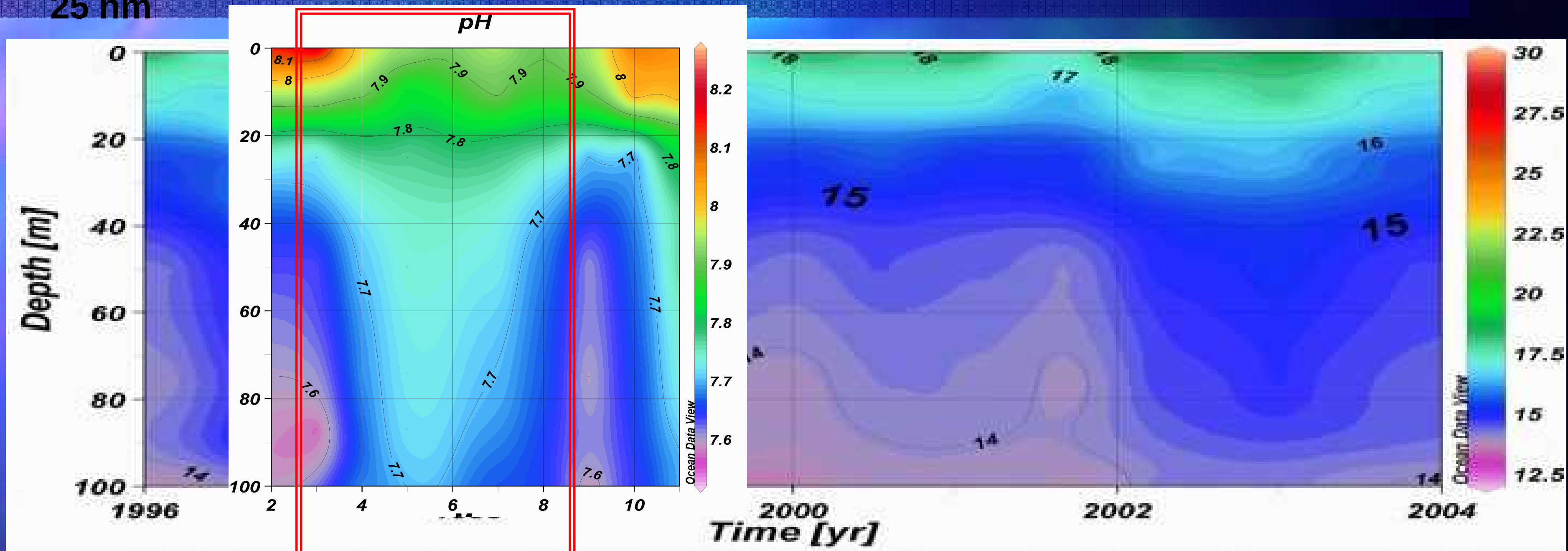


IMARPE - JESUS LEDESMA

Temporal Variability: 1996-2004

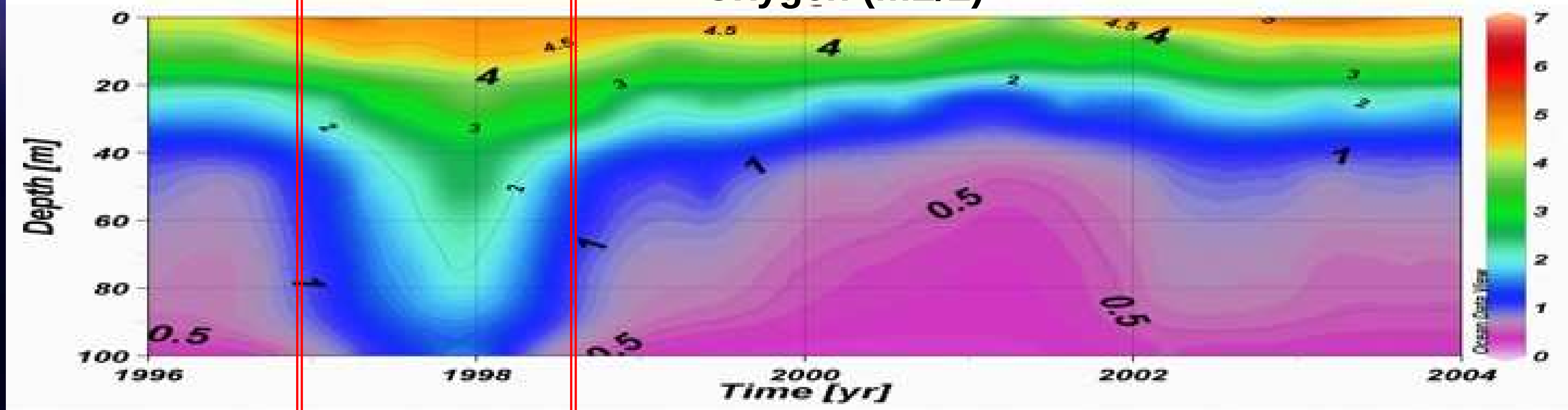
Callao (12°04'S - 77°35'W)
25 nm

Temperature (°C)

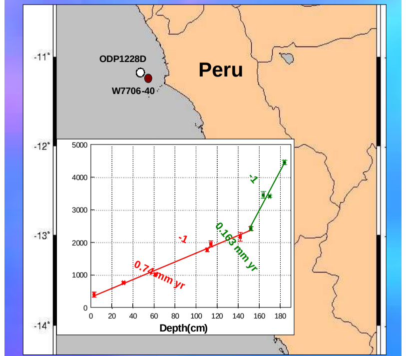


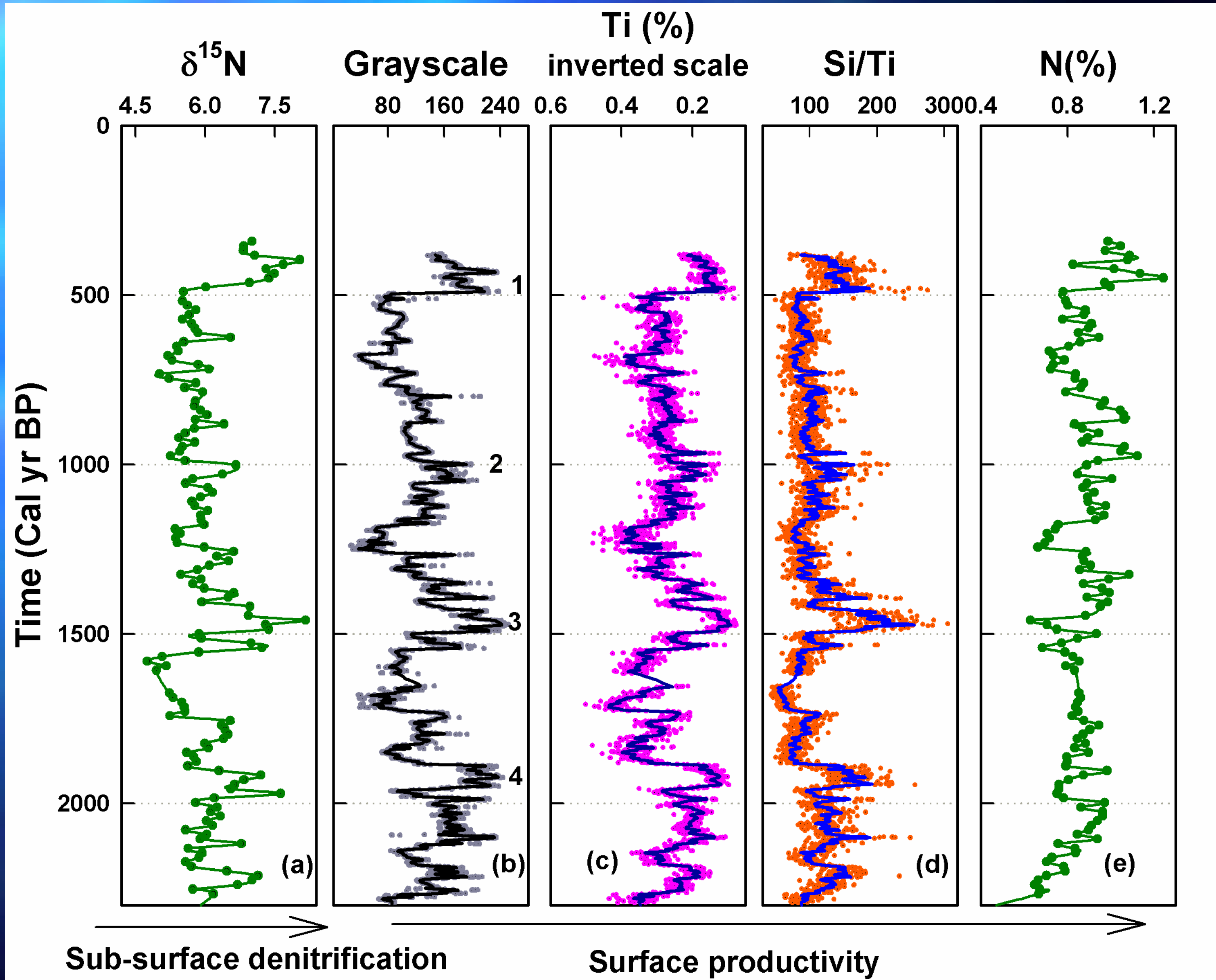
El Nino

Oxygen (mL/L)



Past large changes in suboxic zone intensity off Peru. Centennial version of ENSO?





A2: Resolve current questions regarding N cycling microbial pathways and stoichiometry

A.H. Devol et al. / Deep-Sea Research I 53 (2006) 1533–1547

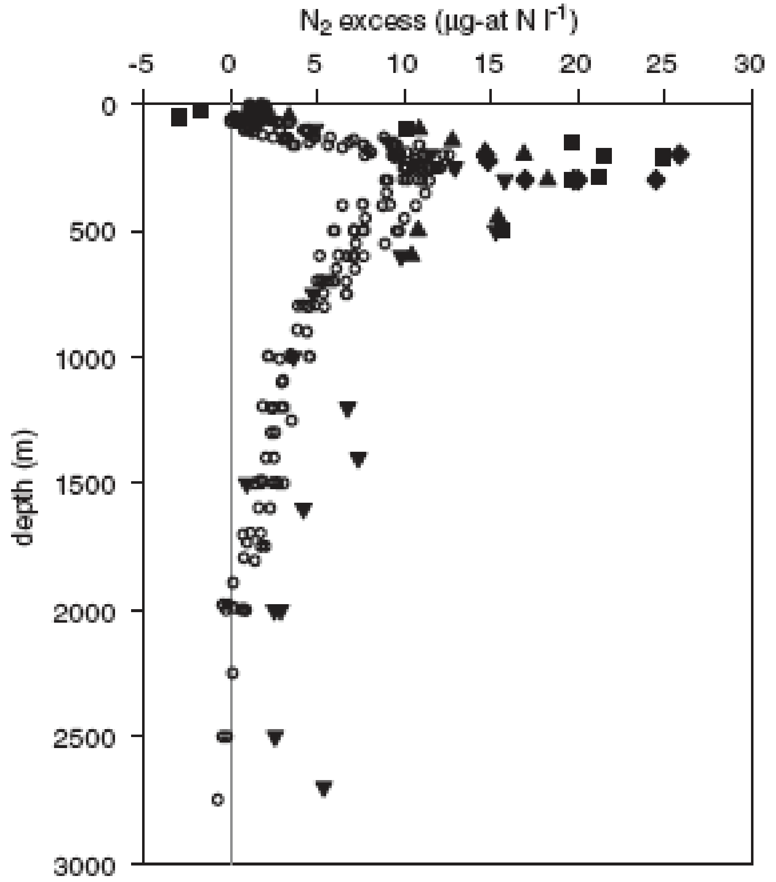


Fig. 10. Comparison of N_2-excess derived from N_2:Ar ratios (solid symbols) with the nitrate deficit derived from N:P stoichiometry by Codispoti et al., 2001 (open symbols).

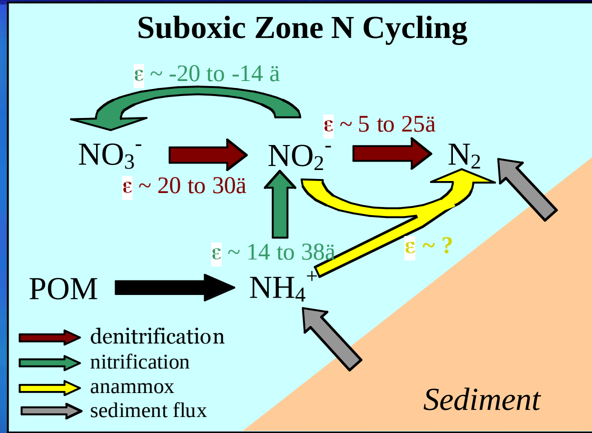


Fig. 3: Schematic of major and possible suboxic zone N cycle pathways and associated ^{15}N fractionation factors (see text). NO and N_2O intermediates are not shown. POM originates from surface productivity and produces NH_4^+ with little isotopic fractionation. Ultimate sources for excess biogenic N_2 must be either sediment fluxes or POM remineralization in the water column.

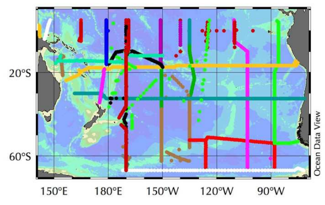
Canonical Denitrification

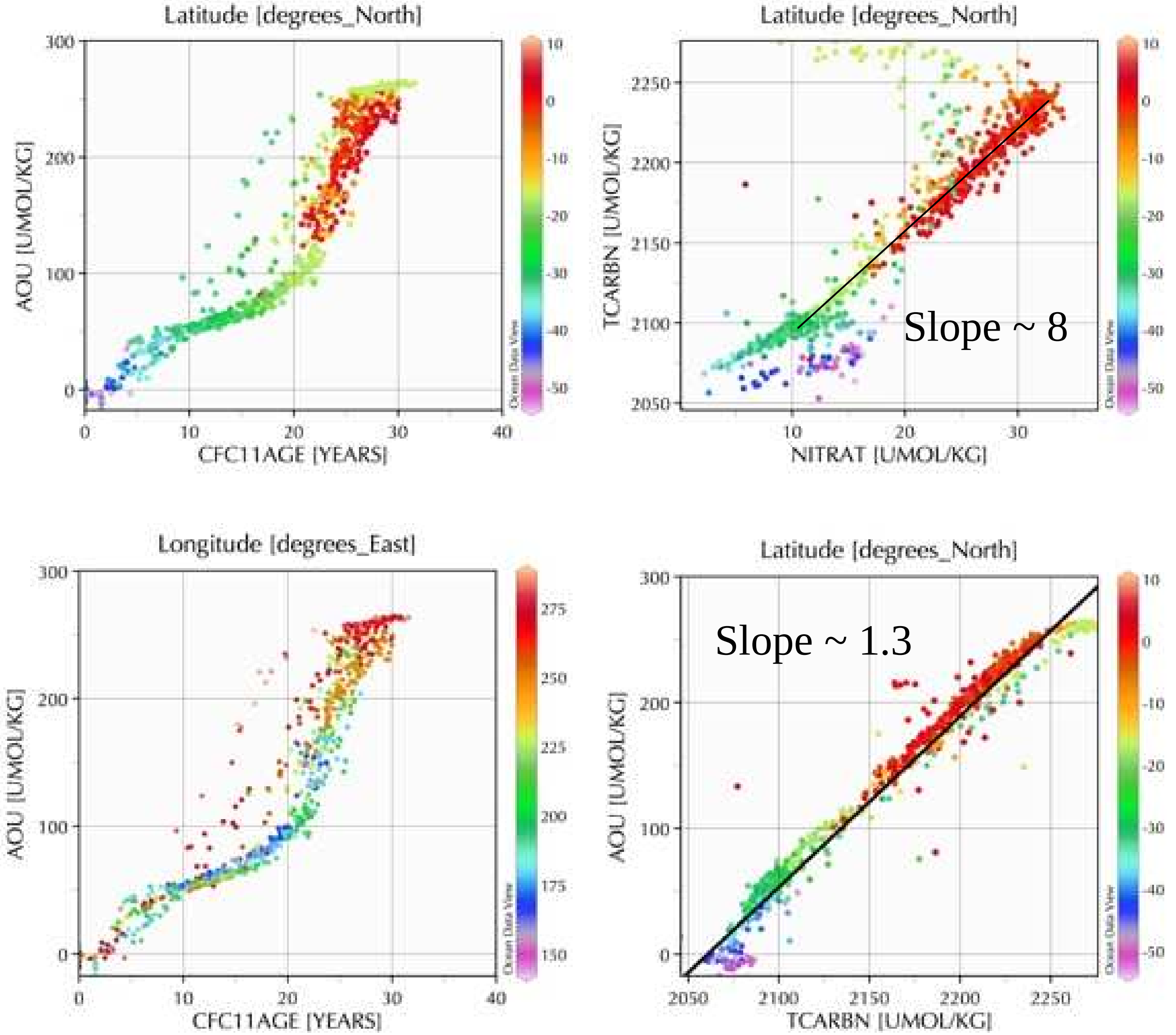
$$(CH_2O)_{106}(NH_3)_{16}H_3PO_4 + 94.4\,HNO_3 = 106\,CO_2 + 55.2\,N_2 + 177.2\,H_2O + H_3PO_4$$

Anammox

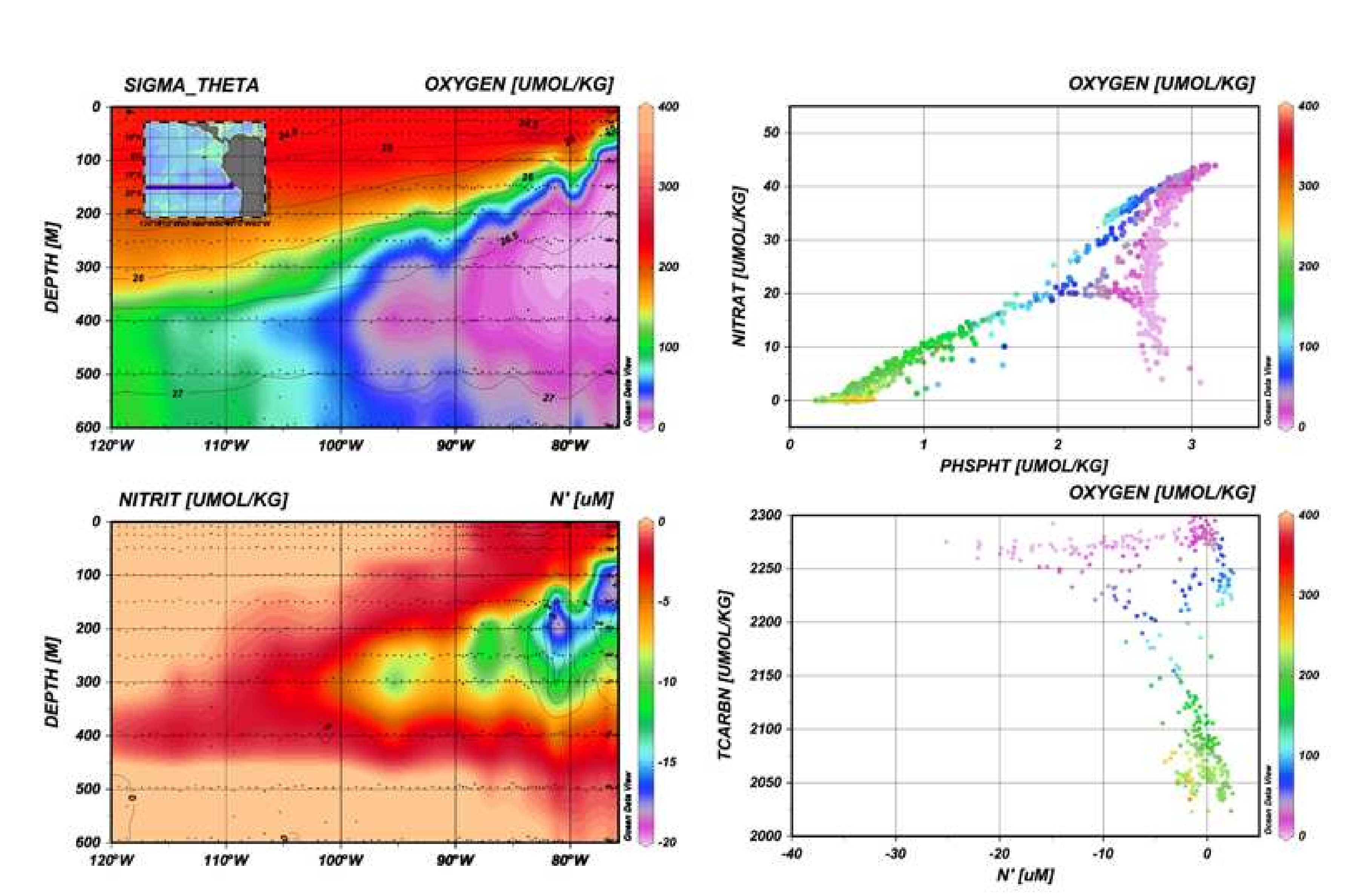
$$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$$

Property Relationships along σ_θ 26.3 to 26.5 in S. Pacific





Restrict to Peru suboxic zone; no increase in DIC with NO_3^-

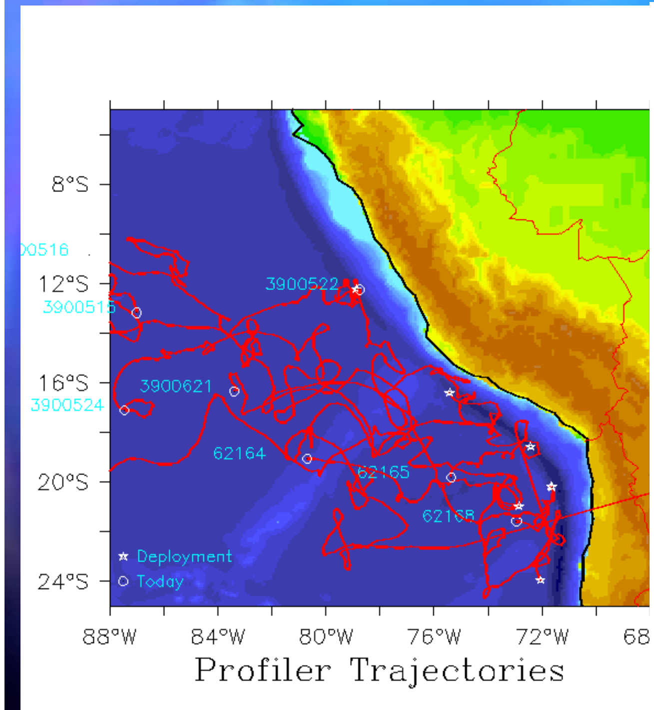


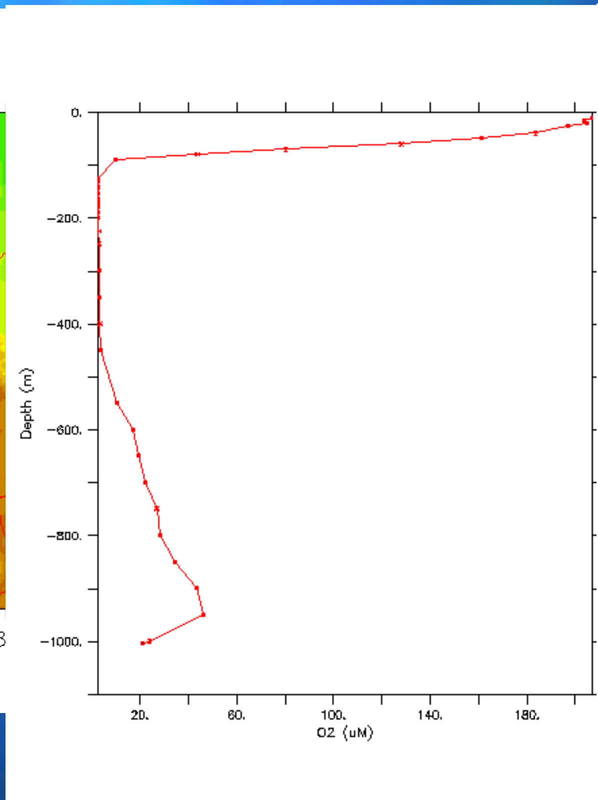
Needs and Feasibility

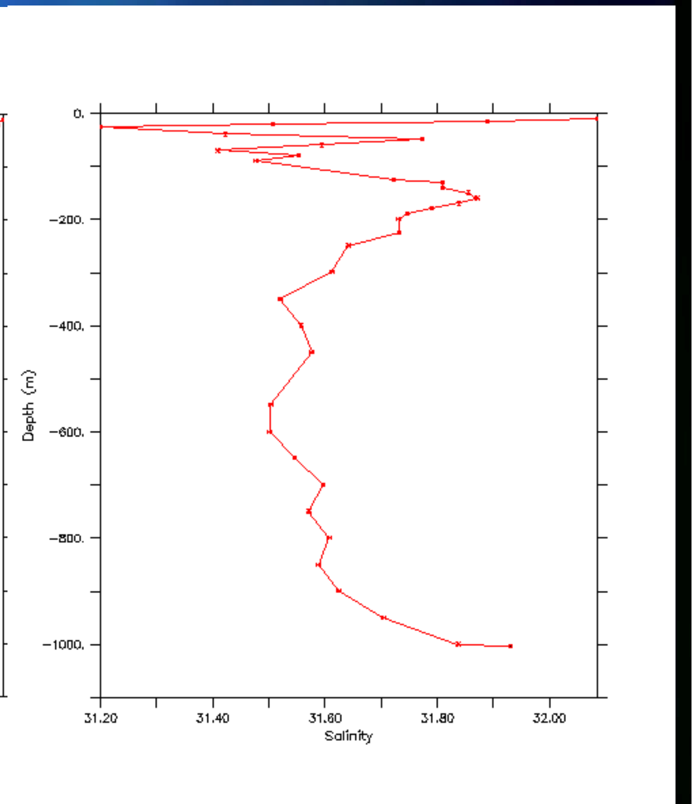
1. A1; stable, accurate O_2, ready now, existing deployments (examples at end)
2. A2; novel combination of measurements using existing sensors
   a. $[NO_3^-]$ ± 1 μmol/kg (ISUS)
   b. $[NO_2^-]$ ± 1 μmol/kg
   c. $[N_2]$ ± 1 μmol/kg (~ GTD P_t - P_{O2})
   d. $[DIC]_{org}$ ± 2 μmol/kg (pH & pCO_2)

O_2 on Argo floats data available on-line

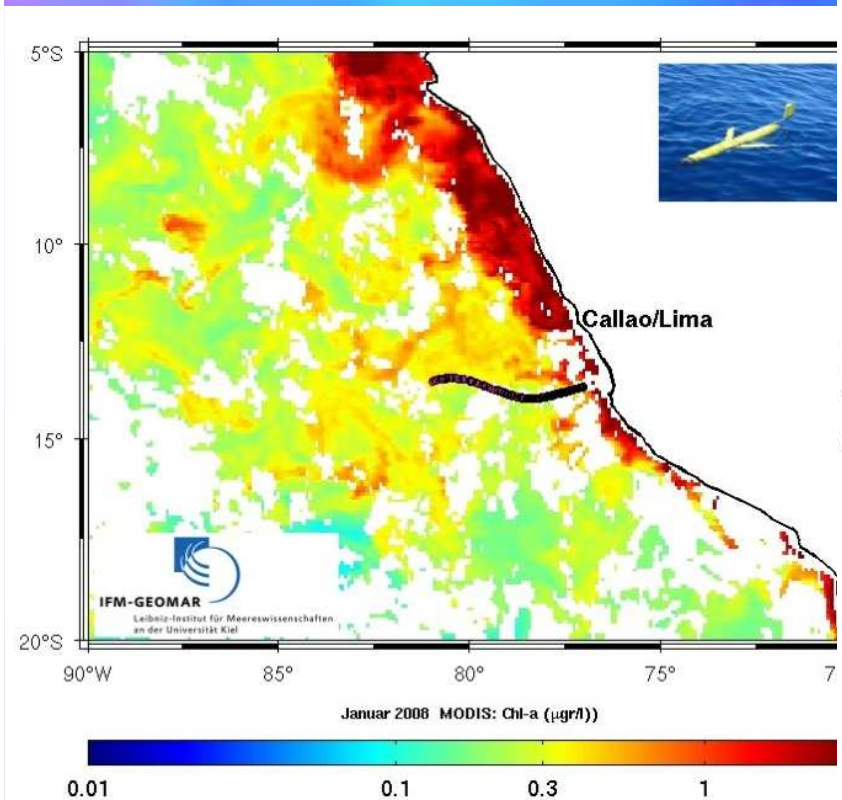
The Eastern South Pacific Oxygen Minimum Zone

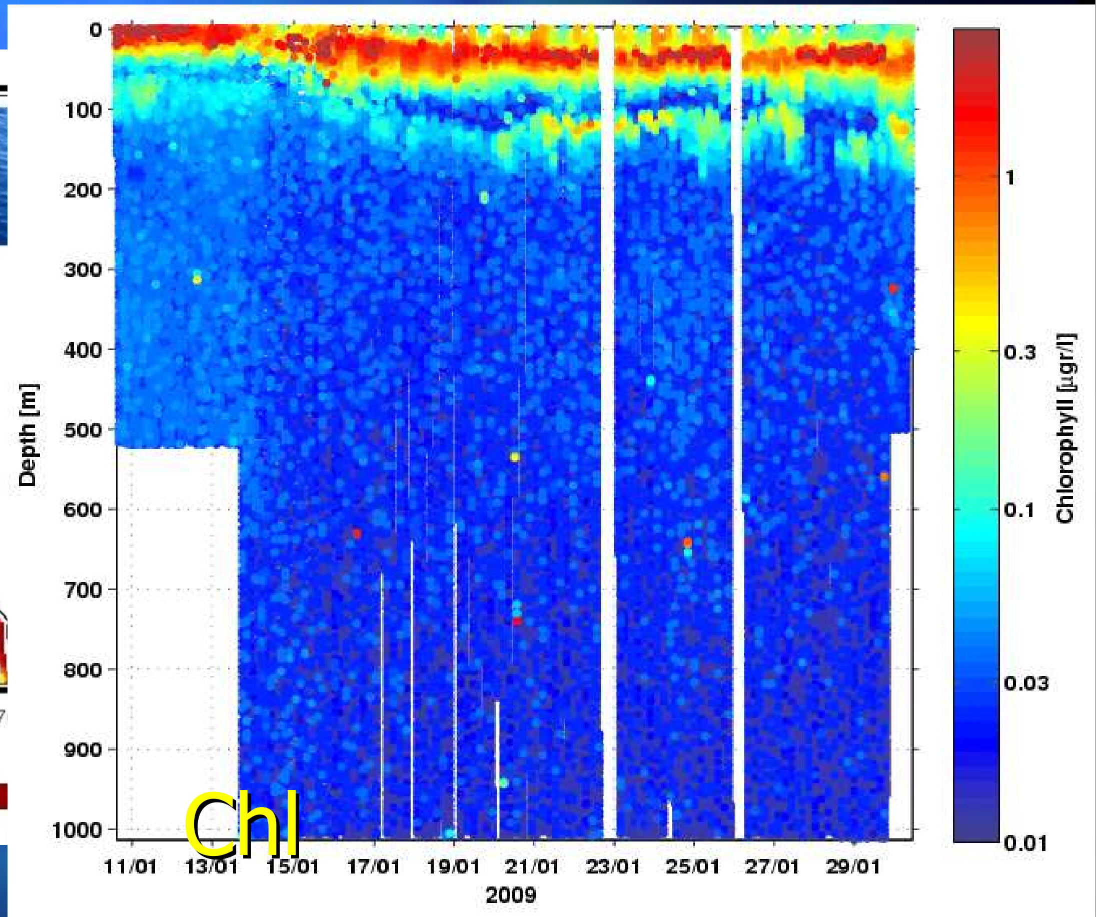






20 day glider deployment during Meteor 77 leg 4 in Jan. 2009





20 day glider deployment during Meteor 77 leg 4 in Jan. 2009