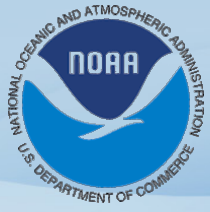


PMEL

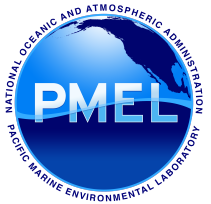
Pacific Marine Environmental Laboratory

Earth-Ocean Interactions

Basin-Scale Impacts & Processes

Joseph Resing (JISAO)
John Lupton (Newport)
Edward Baker(JISAO)

EOI PIs:
W. Chadwick, Dave Butterfield, Bob Embley,
W. Lavelle, S. Hammond



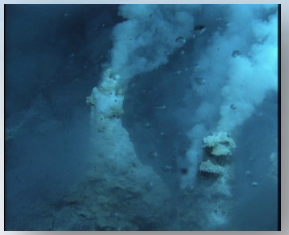
Scientific Contributors

- **EOI Research Scientists:**
  - Nathan Buck
  - Sharon Walker
  - Ron Greene
  - Leigh Evans
  - Kevin Roe
  - Susan Merle
  - Andra Bobbitt

- **Graduate Students:**
  - Pamela Barrett (UW Oceanography, Resing)
  - Susanna Michael (UW Oceanography, Resing)
  - Lia Slemons (UW Oceanography, Murray)
  - Maxime Grande (Univ. of Hawaii, Measures)
  - Clifton Buck (Florida State University, Landing)
  - Tamara Baumberger (ETH Zurich)

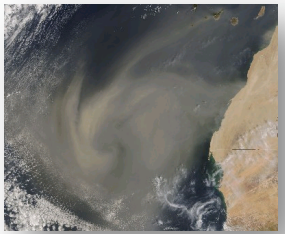
- **Undergraduate Students:**
  - Cole Perkinson (JISAO Intern)
  - Amanda Shu (Hollings Scholar)
  - Dondra Biller (Hollings Scholar)

The influence of solid Earth on Ocean chemistry



Submarine **Hydrothermal and Volcanic** activity adds ^{3}He , Fe, Mn, CO_2 (and others chemicals) to the Ocean on a continual and consistent basis.

Rivers and coastal sediments provide Fe and other metals to the distal ocean.



Natural Aerosols: **Atmospheric dust** is transported from continents and supplies micronutrients (e.g., Fe, Zn) to the surface ocean.
Volcanic eruptions, glacial flour.

Fossil-fuel and bio-mass burning supply highly soluble aerosols with both potentially toxic trace metals (e.g., Cu, As, Se, Pb) and bioavailable Fe and other elements (V, Cr, Ni).

Tracers

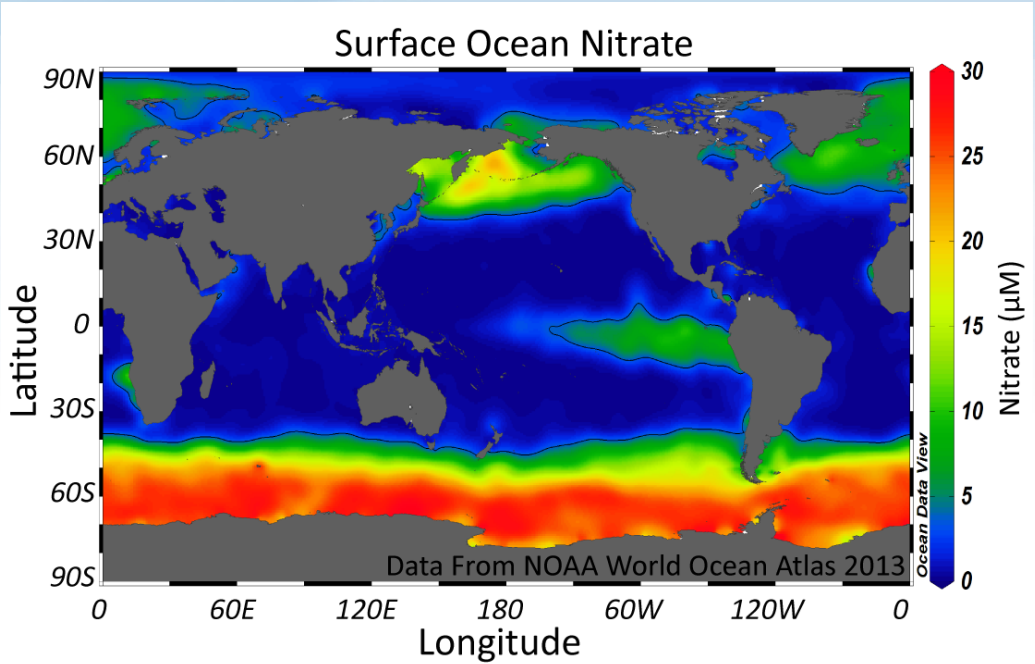
Al -Dust and submarine eruptions
Mn -Hydrothermal activity and trace nutrient
Fe -Hydrothermal activity and trace nutrient
^{3}He -Unambiguous, conservative tracer of magmatic activity

Light Scatter -Relative particle abundance

Analytical sensitivity (weight basis)

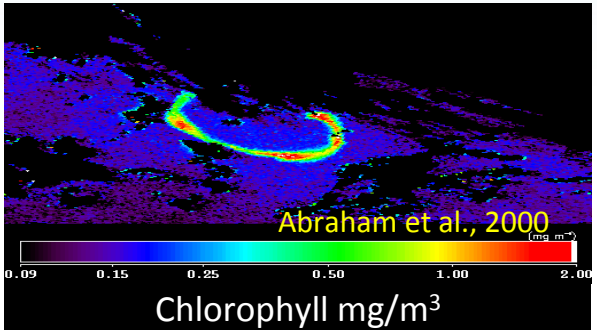
•	**Al**	0.000000000001	$1x10^{-12}$
•	**Mn**	0.0000000000006	$6x10^{-13}$
•	**Fe**	0.0000000000006	$6x10^{-13}$
•	**^{3}He**	0.00000000000000000001	$1.20E^{-20}$

Relevance



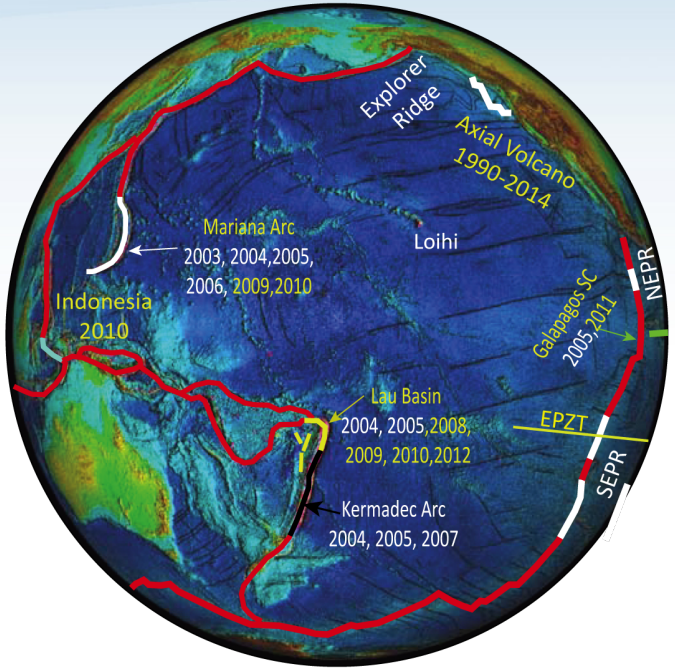
In ~1/3 of the ocean, excess nutrients are perennially available yet phytoplankton biomass is relatively low.

Fe- Fertilization

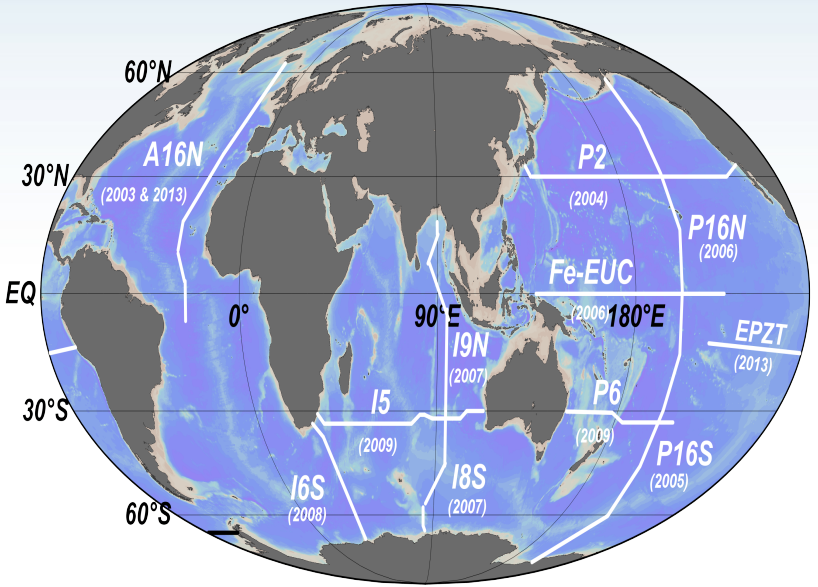


Earth-Ocean Interactions

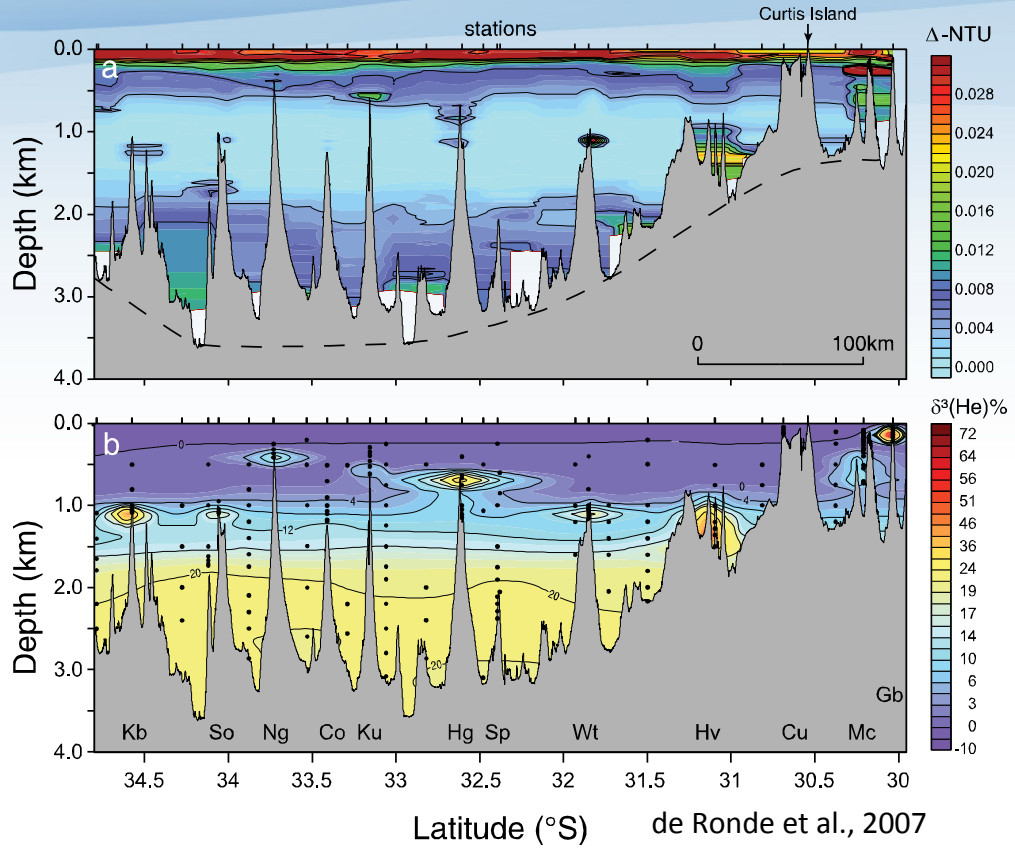
Basin Scale Hydrothermal Impact



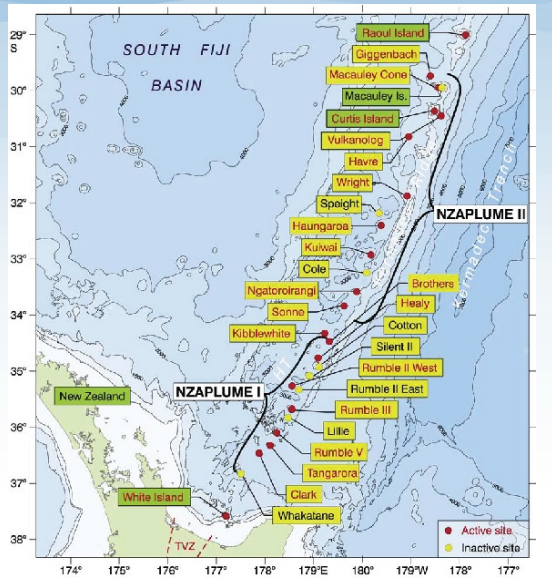
Basin Scale Trace Element Chemistry



Quality

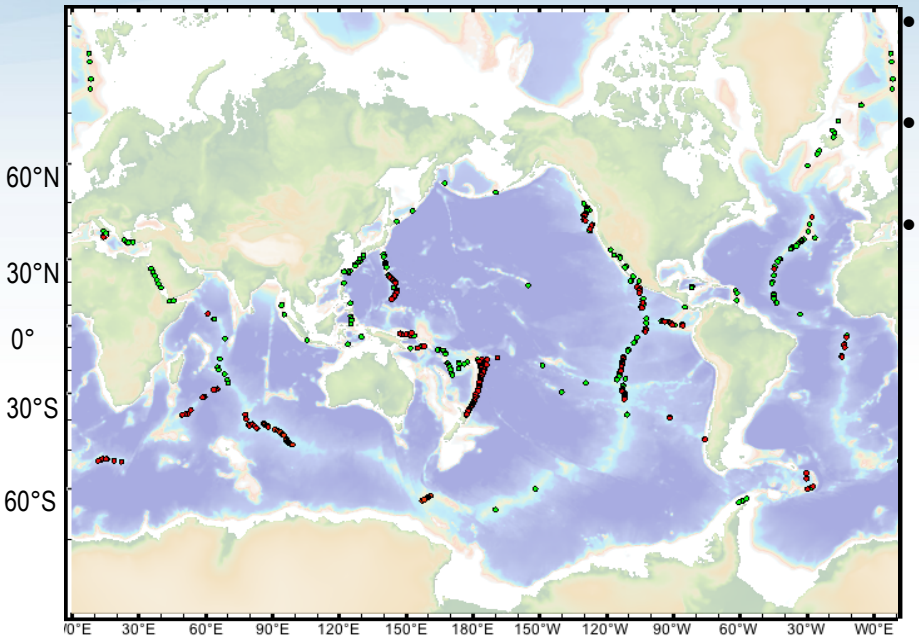


de Ronde et al., 2007

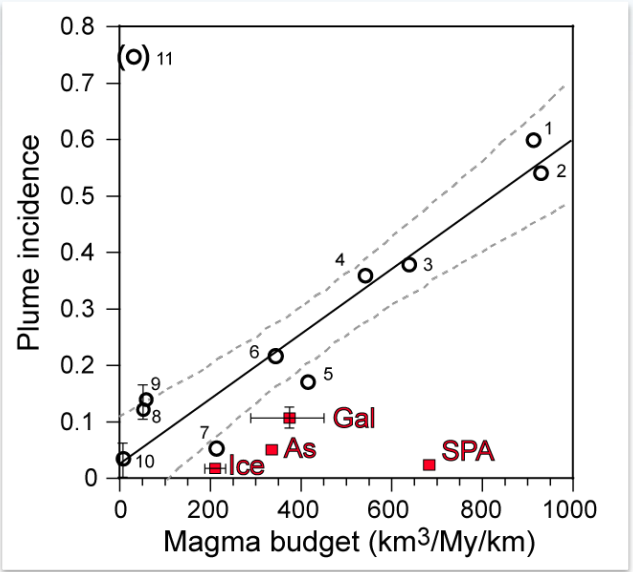


de Ronde et al.,2005, 2007**, 2011, 2012** Leybourne**., 2012a 2012b,** Baker et al., 2002, 2003, **2012**, Embley et al., **2008, 2012,** Caratori et al., **2012**, Chadwick et al., **2008**, Dziak et al., **2008**, Lavelle et al., **2008**

Hydrothermal Activity is a Global Scale Phenomena



- Green dots—~600 confirmed and inferred vents
- Red dots—those discovered by PMEL (~50%)
- ~25% of all known vents discovered by MAPRs



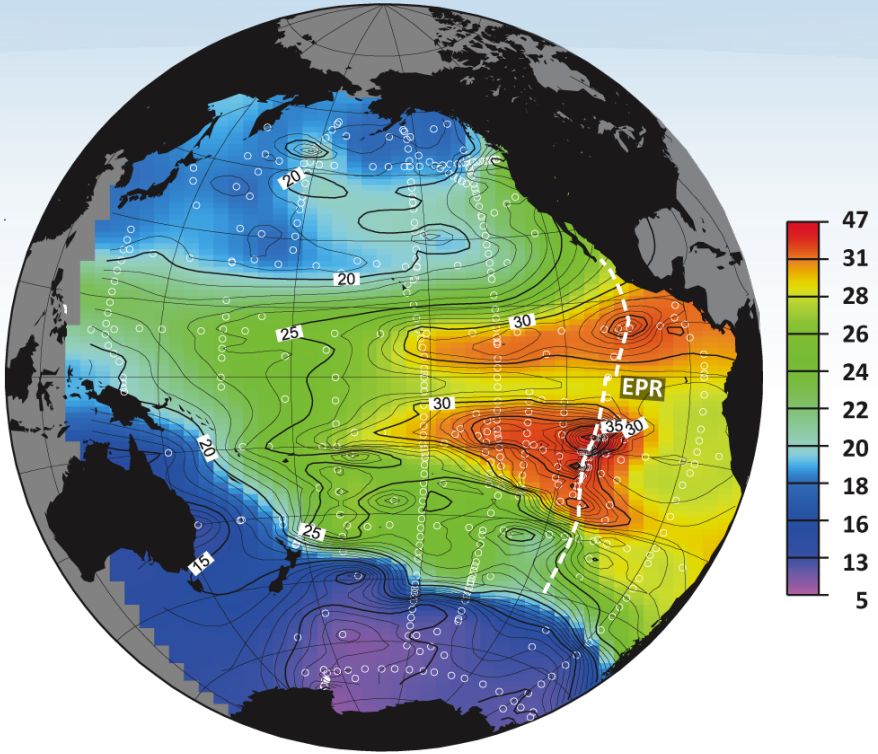
Baker et al., 2007, **2008, 2009, 2010, 2014a, 2014b** submitted

Basin Scale Impacts

$\delta(^3He)\%$ at 2500m

Hydrothermal activity influences the chemistry of the ocean basins.

^3He is a conservative tracer of magmatic activity.

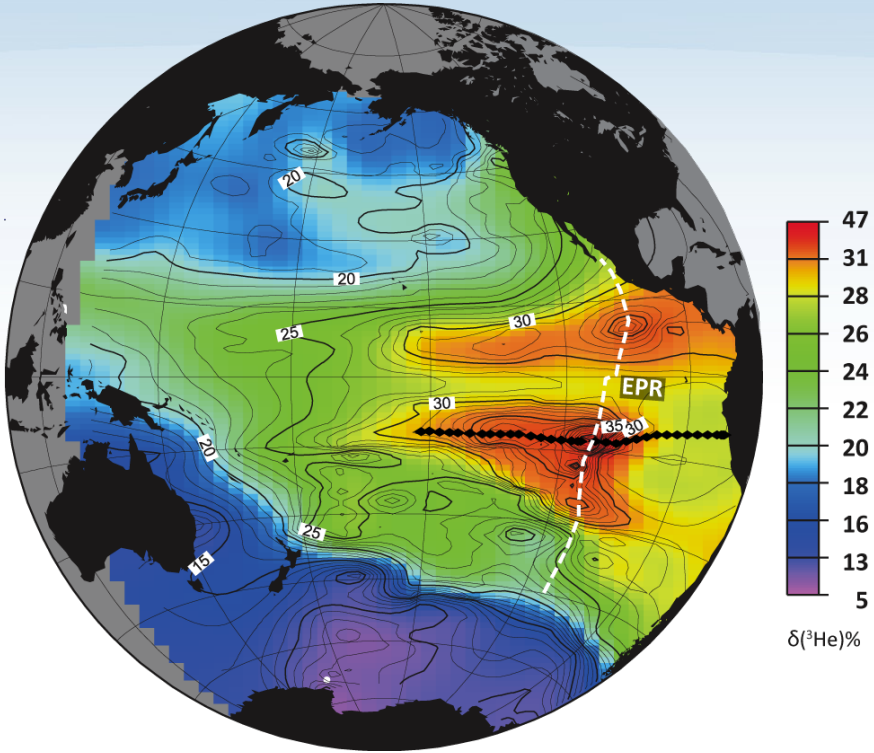


^3He enables us to track deep ocean flow

Data from Lupton, 1998

Eastern Pacific Zonal Section
US-GEOTRACES Program

GEOTRACES
An international program designed to understand the broad-scale trace-element chemistry of the oceans.

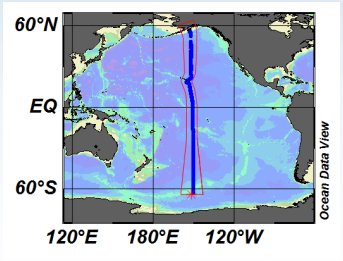


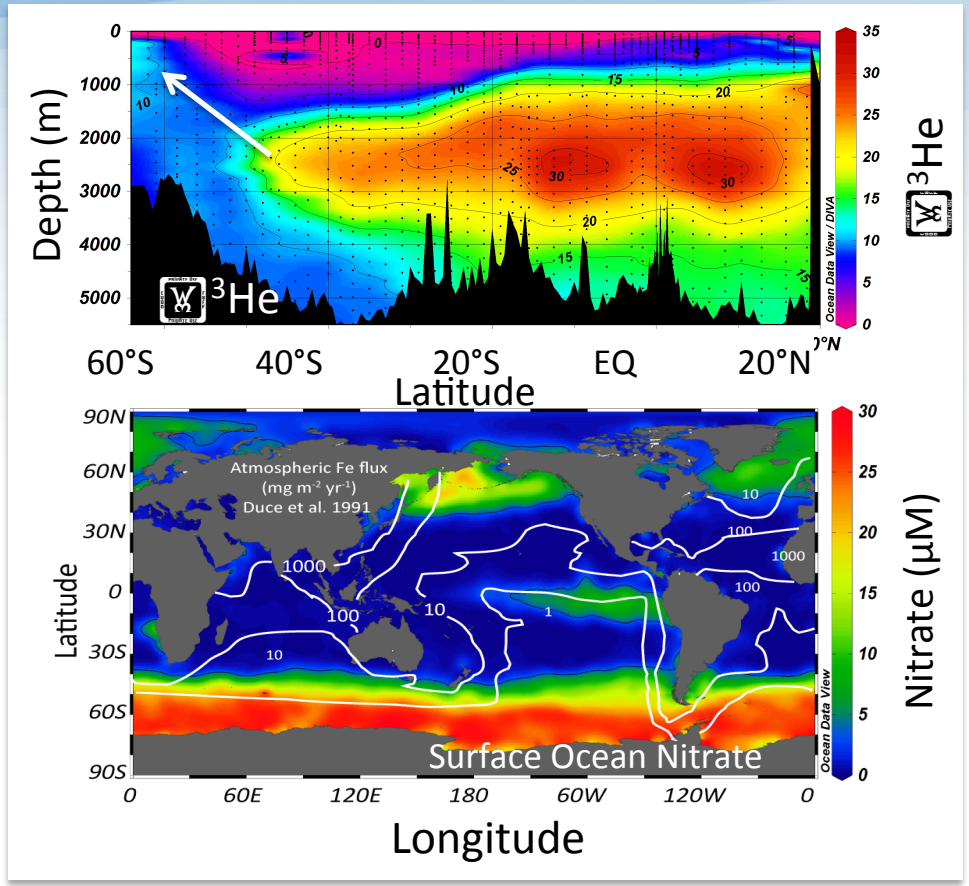
The ^{3}He plume from the EPR enables us to evaluate hydrothermal impacts.

Data at Biological and Chemical Oceanography Data Management Office

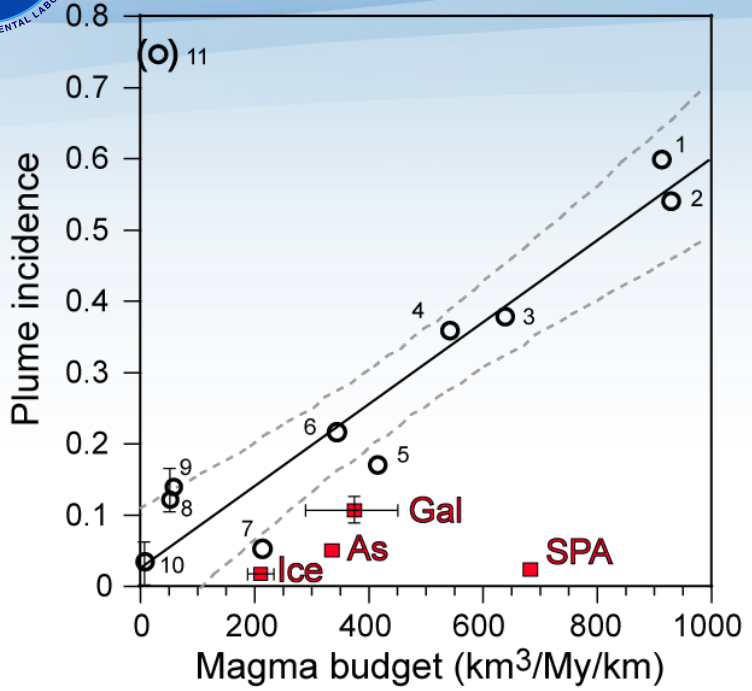
Relevance

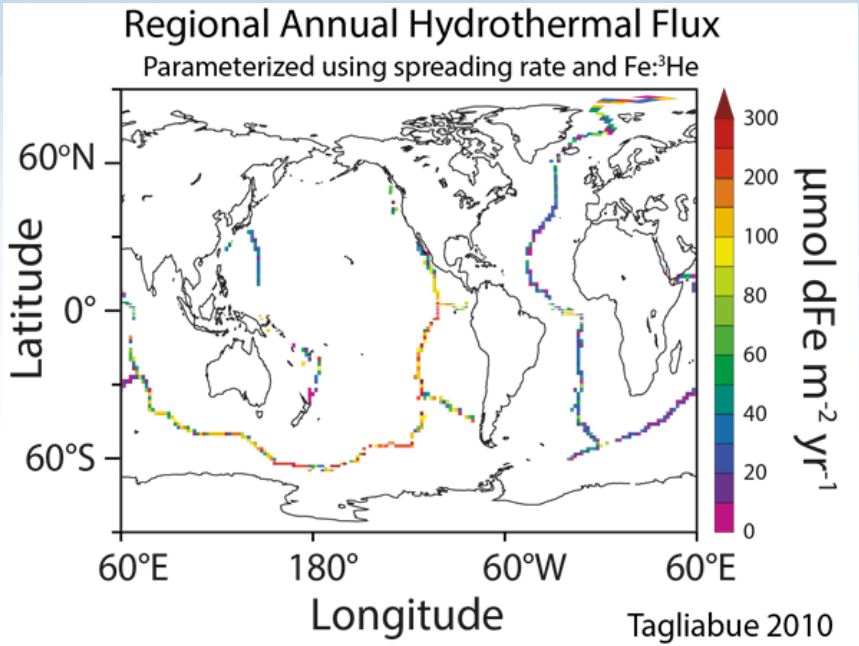
P16





Relevance

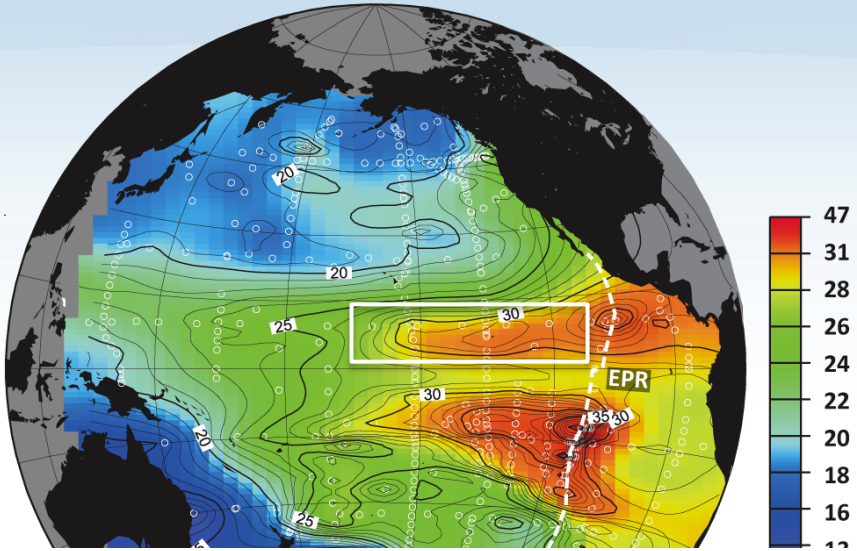


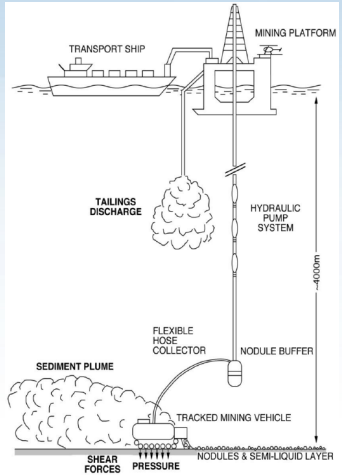


Baker et al., 2007, **2008, 2009, 2010, 2014a, 2014**b submitted

Relevance

δ(³He)% at 2500m

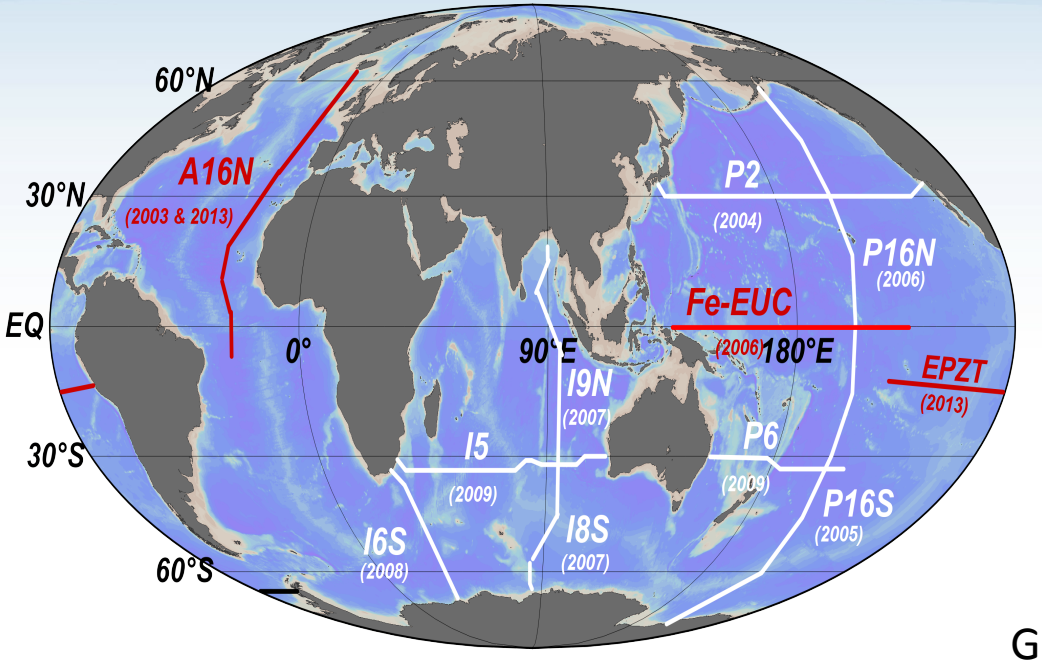




Korea Institute of Ocean Science and Technology

Joint Project Agreement: Development of a Monitoring & Research Plan for Korean Benthic Environmental Impact Study

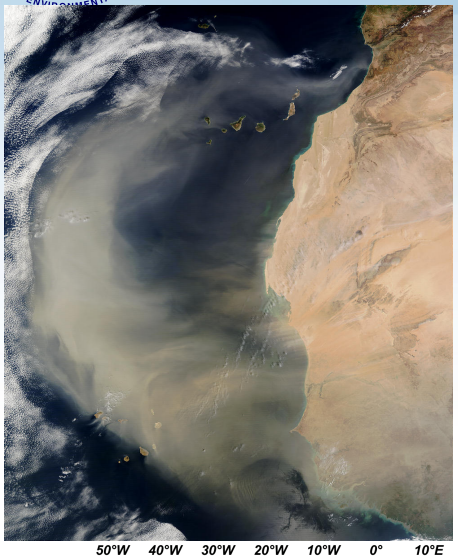
Trace Element Chemistry Repeat Hydrography and Other Transects

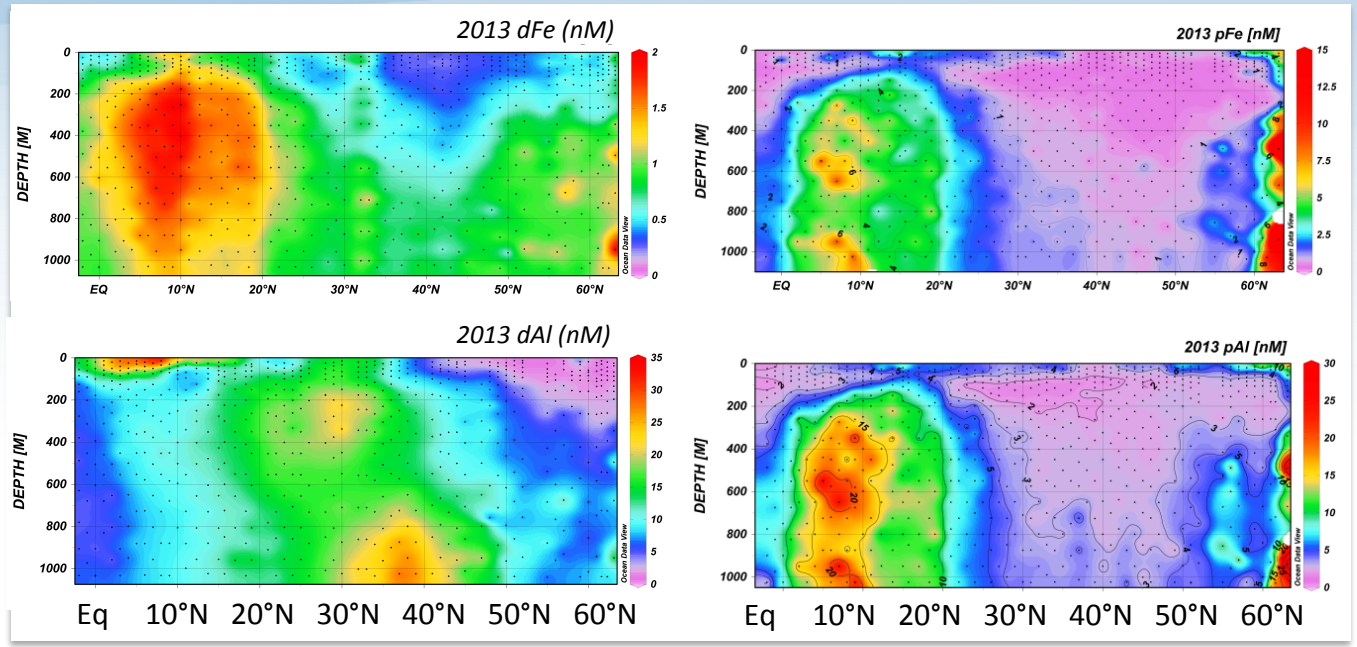


Synergy:
Dick Feely
John Bullister
Greg Johnson

Grand et al., 2014a
Grand et al., 2014b

Performance-Atlantic Ocean



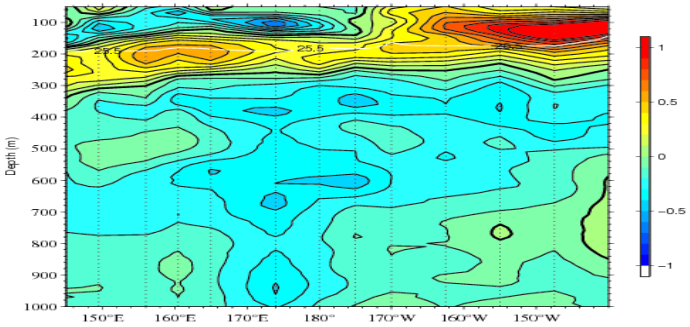


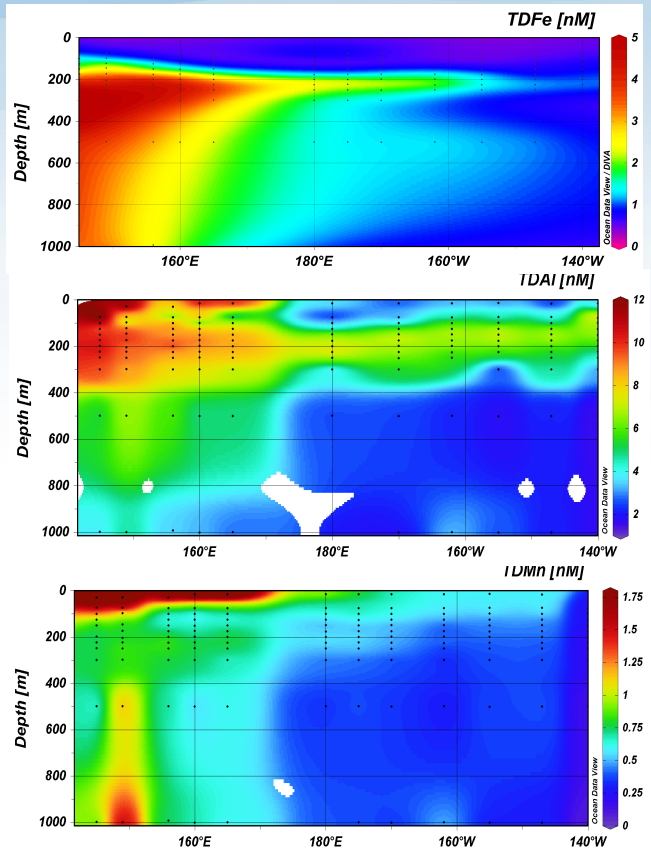
Partners:
W. Landing, Florida State
C. Measures, University of Hawaii

Resing et al 2014
Barrett et al., 2013, 2014
Buck et al 2013a, 2013b

Performance-Pacific Ocean

Zonal Velocity along Equator



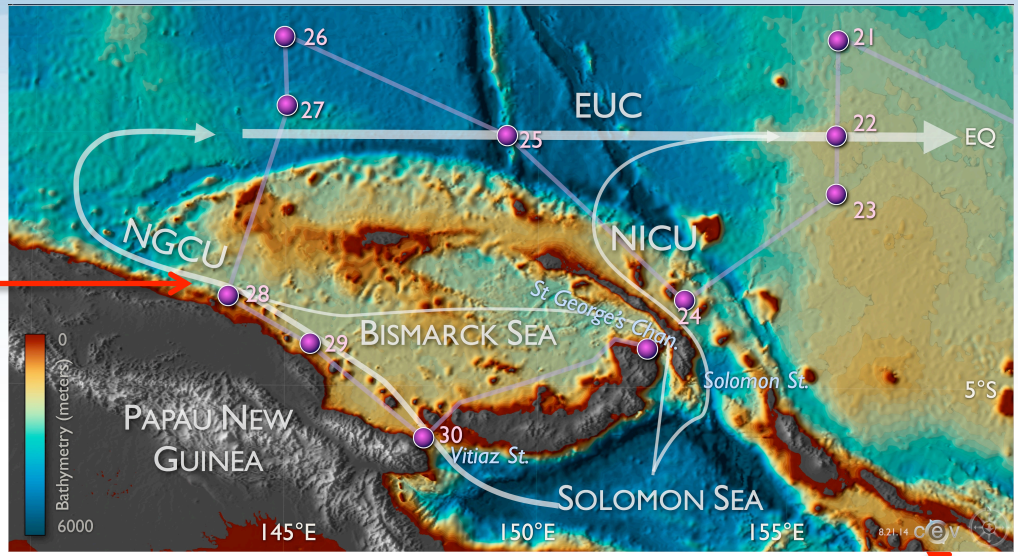


Partners:
J. Murray, UW
F. Lecan, LEGOS

Slemons et al., (2010),
Slemons et al., (2011).

Sources of Fe

Previously we have implicated coastal sediments rivers



Synergy:
William Kessler

Mackey et al 2002; Wells et al 1999, suggested that Fe may be supplied to the EUC by shallow hydrothermal activity.

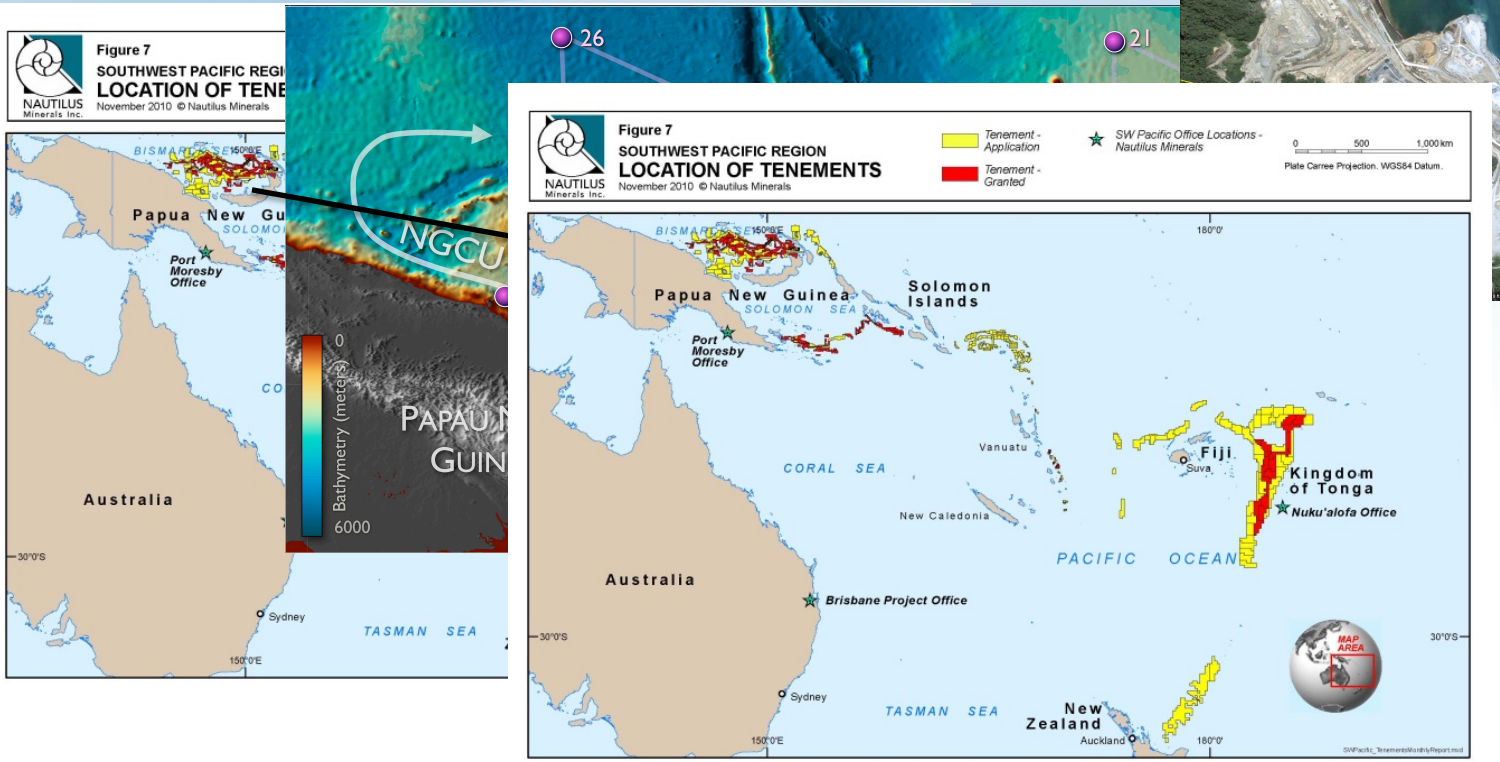
Shallow hydrothermal and eruptive activity

Kavachi

Baker et al 2002

Relevance

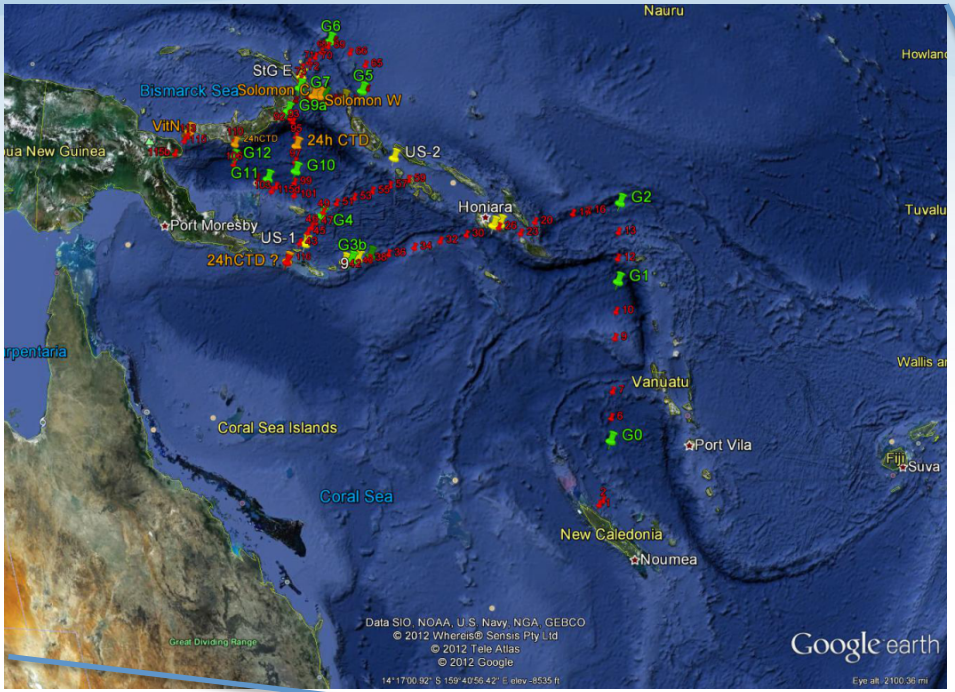
Lihir



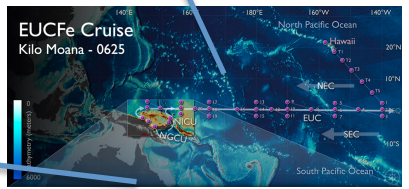
Future Directions-Pandora

French Collaboration
(LEGOS)
Cathrine Jeandel,
Francois Lecan

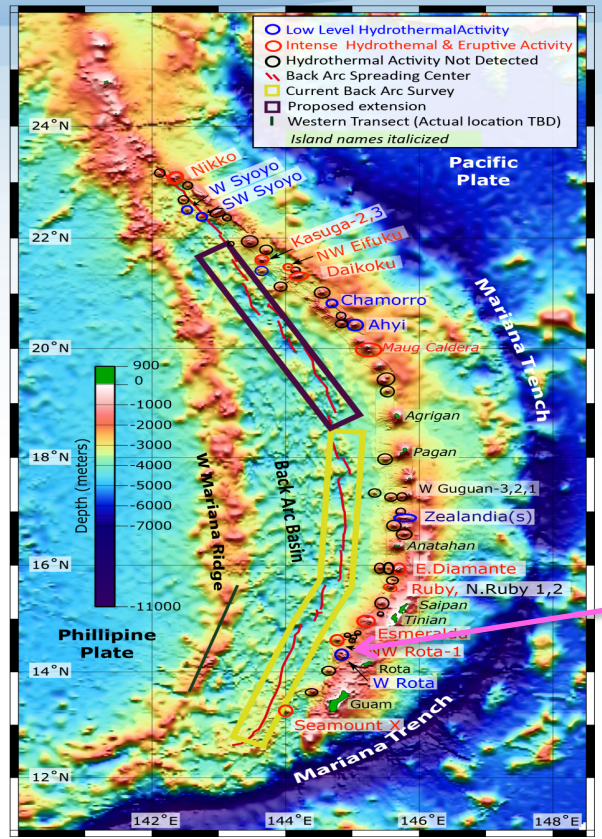
PMEL:
William Kessler
U. Hawaii
M. Grand



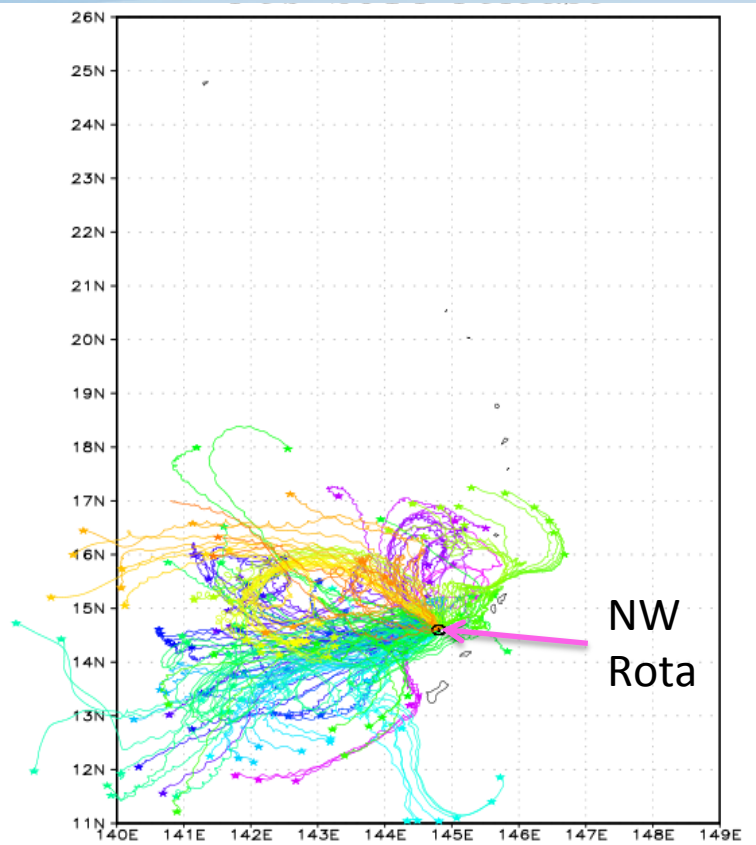
Graduate Student
S. Michael



Future Directions



NW Rota



NW Rota

Future Directions

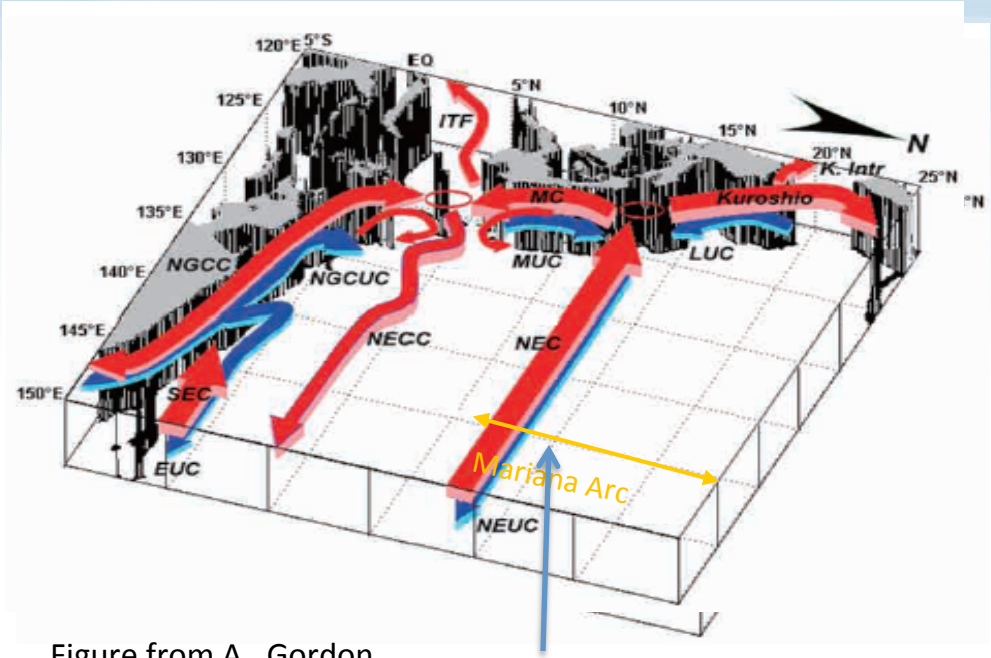
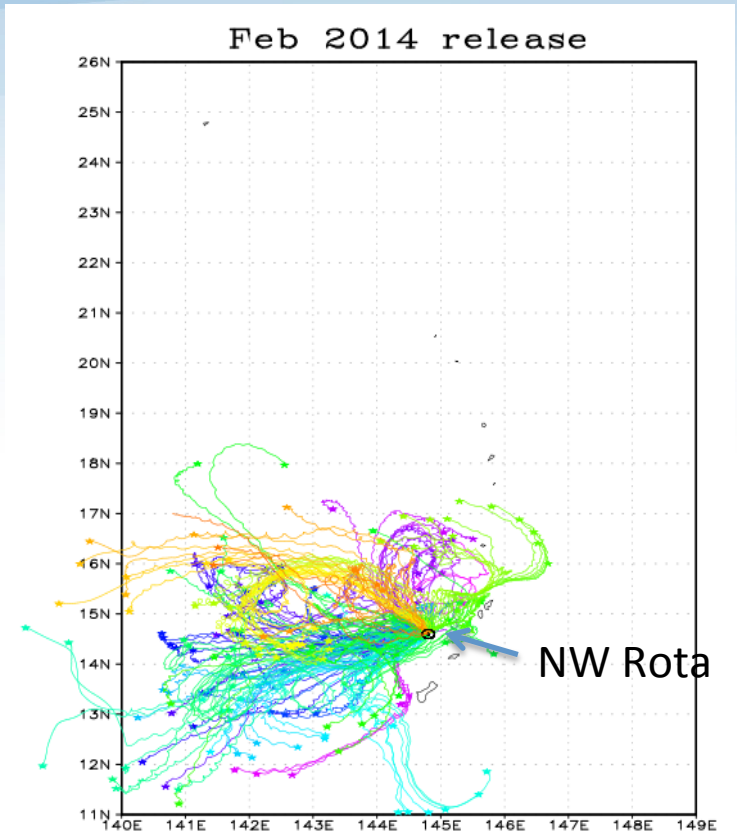


Figure from A. Gordon

NW Rota



Summary

- Global Exploration and Research reveal how the solid Earth interacts with the Ocean.
- Submarine Hydrothermal and Volcanic activity affect the chemistry of the ocean basins.
- Conservative tracers like ^{3}He (and CFCs and SF_6) provide critical information on ocean transport.
- Fe from shallow and deep hydrothermal sources reach the surface ocean.
- The impacts of ocean mining are not well understood.
- Processes responsible the input, processing, and transport of Fe throughout the ocean needs to be understood to properly model anthropogenic and natural effects on ocean productivity.