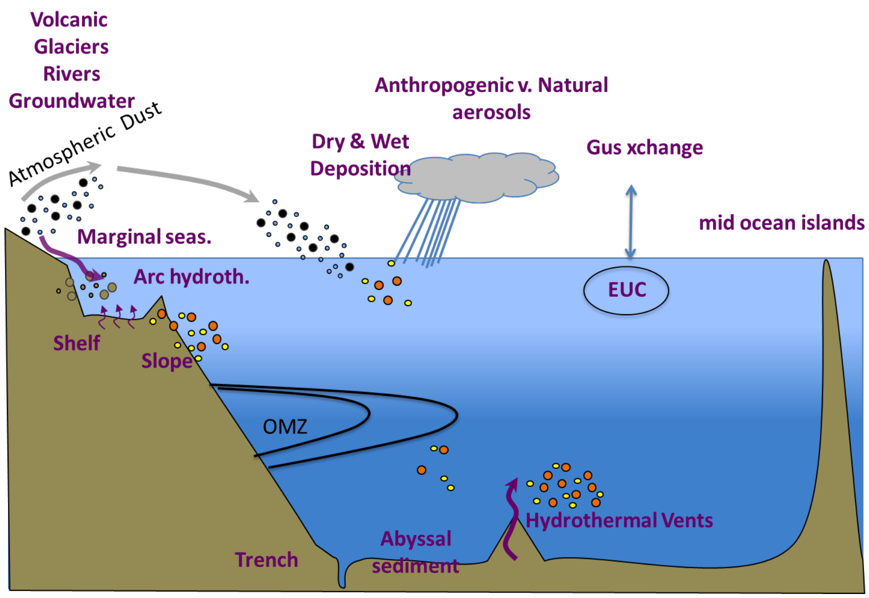
1) Boundary Exchange Working Group



Boundary processes listed from our figure **See Supplementary Materials**:

- Air-sea exchange: dust, volatiles, wet vs. dry
- Shelf sediment fluxes (volcanic and not)
- Hydrothermal vents
- Bottom sediment fluxes
- Slope sediment fluxes
- Trench
- High and low oxygen
- EUC
- Glaciers, rivers
- Marginal seas
- Sediment resuspension
- Regions of low vs. high Kz

Questions to be answered

- What is the relative contribution of different aerosol sources down the transect? What is the effect of aerosol source on TEI solubility?
- What is the relative contribution from dust, sediments, hydrothermal down transect, especially to surface waters? Does this match Fe model predictions?
- What is the effect of geology, spreading rate, deep ocean biogeochemical conditions, and productivity/dust in overlying waters on the long-range fate of hydrothermal trace elements?
- Can we distinguish margin sources of trace elements inputs? Peru, African, North American, and Alaskan.
- What is the effect of boundary process and sources composition on metal speciation (bioavailability, scavenging fate, etc.)

- Are sediments sources of ligands or colloids, sulfides etc.
- How does metal speciation change across the oxycline?

- How does topography affect diapycnal mixing?
- What is the effect of various boundary processes on TEI removal?
- What is the role of particle scavenging on this and that?
- Will we see the impacts of narrow current jets and/or eddies either as relic/active signals?
  - Can/should we respond to signals in ADCP, hydrography, or satellites as we approach the margin?
  - Current jets are strong and may scour margin sediments, carrying dissolved and particulate matter from the east. May also carry melt/river water
- What is the volcanic impact on TEIs in waters transported by the EUC?
  - What is the margin input?
  - Is there a discernible anthropogenic impact?
- What are the **fluxes** from dust, margin sediments, hydrothermal plumes?
  - **Ra from margin sediments**
  - **Th, Be, 210Pb for dust**
  - **He, Ra, Ac from** hydrothermal plumes
  - Can we use models to calculate rates?
- What information do models require to correctly simulate observations, and are we providing that information?

Discussion about location of the shelf segment near Alaska – do we instead want a station on the wider region of the shelf?

- Current location of shelf stations prioritizes volcanic inputs over broad shelf sediment inputs
- Move a station to cross a broader shelf
- Eddies wouldn't be captured on the existing transect – that is probably a good thing ☺
- Is volcanic sediment or wide shelf sediment source more representative of North Pacific metal source?
- If we move to the wider shelf spot, we get more influence of Alaska Coastal Current, which then turns northward through Unimak Strait. Some ACC still continues southwestward along Aleutian islands.
- Analogy of the Aleutian shelf to Antarctic Peninsula

Influence of the Marquesas Islands in Southern hemisphere

- Enhanced productivity downstream
- Nepheloid layers associated with Marquesas

Trench

- High Ra inputs in EPZT, potentially because sources from two sides
- Rember said that Aleutian trench had not been well studied
- Goes to 7000 m depth, so CTD sensors won't make it to bottom

Equatorial Currents

- Undercurrent carry margin material from the west
- Deeper equatorial currents carrying material from the eastern OMZ

Tracers

- **Margin influences** (shelf and slopes have same tracers)
    - Nd isotopes
    - REEs, light-heavy patterns Eu anomaly = can help distinguish volcanic or shelf sediment sources
    - Fe isotopes = can also distinguish volcanic or reducing sources
    - Si and Si isotopes
    - Al:Ti ratio distinguishes volcanic source
    - Sedimentary inputs:
        - Dissolved Fe, Mn, Co, and Cu concentrations; Fe:Mn
        - Ra isotopes
        - Methane, sulfides = tracers of shelf sediments
        - Fe(II)-Fe(III)
        - Fe colloids
        - Barium
        - Particles – Fe speciation (synchrotron), Mn enrichment
        - N isotopes, N2-Ar
        - Methyl-Hg
        - Th isotopes
        - Zn:Si ratios
- **Atmospheric deposition**
    - Water tracers
        - Th isotopes
        - 210Pb
        - Al, Ga, Mn, Fe
        - Fe colloids
        - 7Be
        - Fe, Cu isotopes
        - Hg
        - Nd & REEs
    - Aerosols
        - V, Ni (pollution, petroleum burning)
        - Al, Ga, Mn, Fe
        - Nd isotopes
        - Pb isotopes
        - Fe isotopes
        - Major anions
        - Soluble nitrate isotopes
        - 7Be, 210Pb, 210Po
        - Sb – unique to distinguish Asian coal burning and volcanic
    - Wet deposition collection

        - V
        - Major ions
        - Soluble nitrate
        - 7Be
        - Hg
- **Air-sea gas exchange**
    - Hg
    - N2-Ar
    - Full suite of noble gases in surface waters
    - CO2-pCO2/underway TCO2 on Thompson?
    - methane
- **Abyssal sediments – Nepheloid layers**
    - Water column
        - Ac-227
        - Nd isotopes
        - REEs, light-heavy patterns, Eu anomaly
        - Fe isotopes
        - Si and Si isotopes
        - Sedimentary inputs:
            - Dissolved Fe and Mn and Cu concentrations; Fe:Mn
            - Ra isotopes
            - Fe(II)-Fe(III)
            - Fe colloids
            - Barium:radium
            - Particles – Fe speciation (synchrotron), Mn enrichment
            - Th isotopes
- **Hydrothermal**
    - Fe, Mn, Al, Zn
    - 3He-Ne
    - Ra and Ac
    - Fe isotopes
    - LMW thiols
    - Fe colloids, ligands
    - Particles: Fe, Mn
    - Elements removed:
        - REEs, Pb
        - Sc?
        - Th
- **Oxygen minimum**
    - N*, N2O, N isotopes
    - Mn, Co
    - Fe and Fe isotopes
    - LREEs

2) Scavenging breakout group:

Initial questions:

- Where in the water column does scavenging happen?
  - Co scavenging on Mn oxides seems to happen in only specific depths of the water column – are other elements like that?
- How much are particulate and dissolved metals exchanged?
  - Cu isotopes are different on particles than in dissolved; could be from fractionation as exchange occurs, or maybe there is not much exchange
- Adsorbed vs in particles – how can we tell?
  - Weak leaches
    - Operationally defined; may not get at just the adsorbed fraction
  - What about adding filtered surface seawater to some deep water and leaching with that?
    - Too many artifacts, including wall loss
  - Adsorption/desorption incubation experiments?
    - Too many artifacts, including wall loss
    - Would be a process study
- What is the impact of age of the water on scavenging?
  - Old ligands – decayed?
  - Colloidal partitioning?
  - Change in reactivity of a dissolved TEI with water mass age?
- Can we use the particle veils to answer some questions about how particles impact other constituents in the seawater?

Sampling particulate veils at the equator (narrow) and the subarctic pacific (wider):

- Could be a natural incubation of how trace metals are impacted by particle field
- Look at concentration, isotope ratios, speciation, etc etc
- Test hypotheses about
  - whether metals stay associated or exchange with particles
  - where in terms of depth in the water column scavenging/exchange happens
  - what the impact of scavenging is on isotopes, speciation, etc
- Do we expect there to be a "hole" in the dissolved concentrations in the particle veil?
  - Depends on relative rates of scavenging and currents.
    - East-West currents are relatively fast; North-South currents are slow. Small particles move further in the East-West directions.
    - The equator currents are stronger and the particle field is narrow: we don't expect a hole there, but maybe in the subarctic pacific

Sediment traps:

- Would be great to have a sinking flux, quantifying/qualifying the particles that are actually sinking
- Could also get size distribution of flux with more work
- Quantitative fluxes hard to get with just a snapshot

  - Probably not worth the extra time and work to get qualitative numbers a flux estimate that isn't very good.

Priority Parameters for scavenging

- **Al, Mn**
- **^{226}Ra, ^{210}Pb, ^{210}Po**
- **UVP/LISST**
- **Electrochemistry ligands**
- **Colloidal metals**
- **Molecular techniques for ligands at depth – to see how ligands are changing with age and depth**
- **^{234}Th – fast scavenging events**
- **^{230}Th and ^{231}Pa**
- **weak leaches**
- **Elements with a range of particle reactivity: Al, Ga, Sc (decreasing reactivity) and REE (heavy vs light)**
- **Elements with a range of potential types of scavenging behavior (reversible e.g. ^{230}Th; regenerative e.g. Zn; irreversible e.g. Al?)**
- **Particulate S – where is it? Just in curtains? Upper ocean? Everywhere?**

Ideal Super station locations from a scavenging perspective:

- 47°N – fixed
- ~35-40°N – subarctic pacific particle veil
- 20°N – for comparison between oligotrophic gyre and the particle veil; for an old age location
- 0°N – equator particle veil
- 12°S – fixed

3) Working Group – Internal Cycling/Biotic Circulation

>Characterization of regimes (Shelf/Slope, Subarctic, Chlorophyll Front, North Pacific, South Pacific, Equatorial, OMZ):
-residence time
-upwelling/downwelling
-horizontal advection
-mixed layer depth
-ventilation time
-water mass endmembers/mixing

>Biotic uptake:
-community characterization
-macro- and micro-nutrient distributions
-export/particle flux
-drivers and indicators of particle regimes
-primary production

-Calculate fluxes from high resolution gradients (need rates)
-Confirmation of fluxes expected from gradients
-Connect subsurface properties to remote sensing rates
-Strength of program is redundancy of tools to evaluate processes on a variety of timescales (ID mismatches/coherence)
-Integrating local and distal forcings to explain TEI distributions
-Strength of GEOTRACES program is redundancy of tools to evaluate processes and quantify processes on a variety of timescales (and to identify mismatches/coherence)

Main questions/goals:

1. How do circulation and mixing influence distributions of TEIs?
2. Can we infer what controls productivity, export, and regeneration within and across regimes?
3. How does productivity, export, and regeneration influence distributions of TEIs?
4. How does ecological stoichiometry vary within regimes?
5. What are depth scales of regeneration of TEIs?

Parameters:

- Uptake
    - Size fractionated particulate TEIs, major composition
    - Productivity tracers:
        - TOI (triple oxygen isotopes)
        - dissolved TEIs and nutrients

- **Ecosystem state**:
  - Pigments
  - Taxon specific trace metals
  - *Size fractions? Smaller size fraction?*
  - LISST
  - POC/PIC/scattering optics
  - UVP5
  - Flow cytometry
  - Genomics/Transcriptomics
  - Proteomics
- **Export**
  - O_2/Ar
  - transport tracers (He, Be7, noble gases, CFCs, SF6)
  - ^{13}C
  - Th-224, Th-228, Po-210, Pb-210
  - DOC
  - Sediment traps at super stations?
  - McLane size s.f.
  - PSD's: UVP5
  - CFEs
- Importance of temporal integration
- Regeneration (water column)
  - TEI/AOU(R)
  - OMP
  - Nitrate isotopes, N_20
  - CFC, SF6, He, tritium, Be-7
  - Argo- O_2 (1 way?), Bio Argo, CFEs
- OMZ influence
  - N2/Ar
  - Dual nitrate isotopes
  - TEIs - SSF
  - Metalloenzymes
  - CFC/SF6
- Zonal currents
  - ADCP/LADCP

<u>Sampling/station needs:</u>

- Equatorial Pacific
  - 1 - 1.25° station spacing?
  - Spread out stations in the gyre to gain higher resolution at equator
  - Higher sampling resolution in the EUC
- Subarctic front
  - Closer spaced stations across subarctic front, maybe add extra demi stations
  - Move Aleutian trench station to a depth accessible to particle pumps
- Depth resolution responsive to sampling depth in ODZ