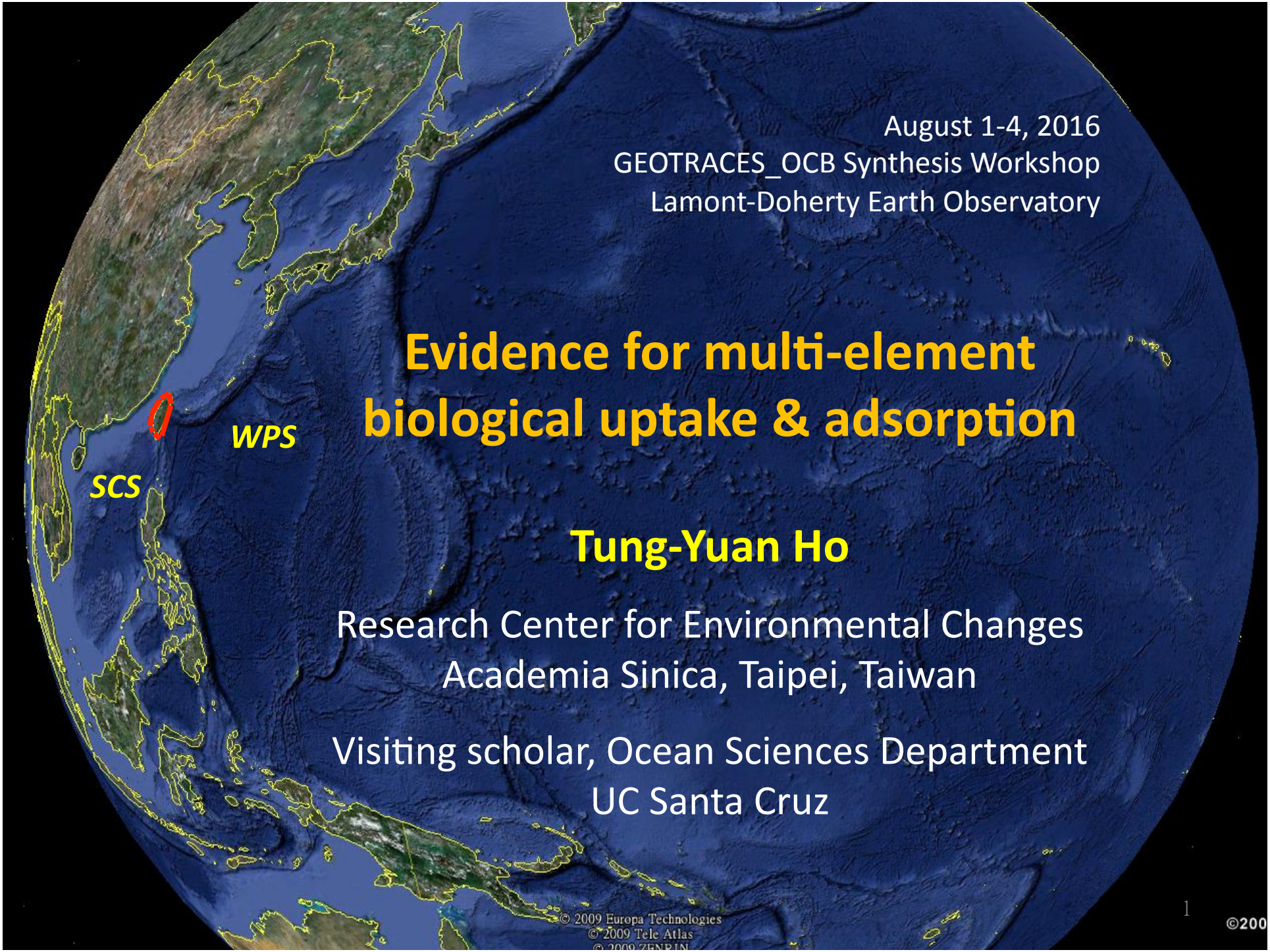


August 1-4, 2016
GEOTRACES_OCB Synthesis Workshop
Lamont-Doherty Earth Observatory

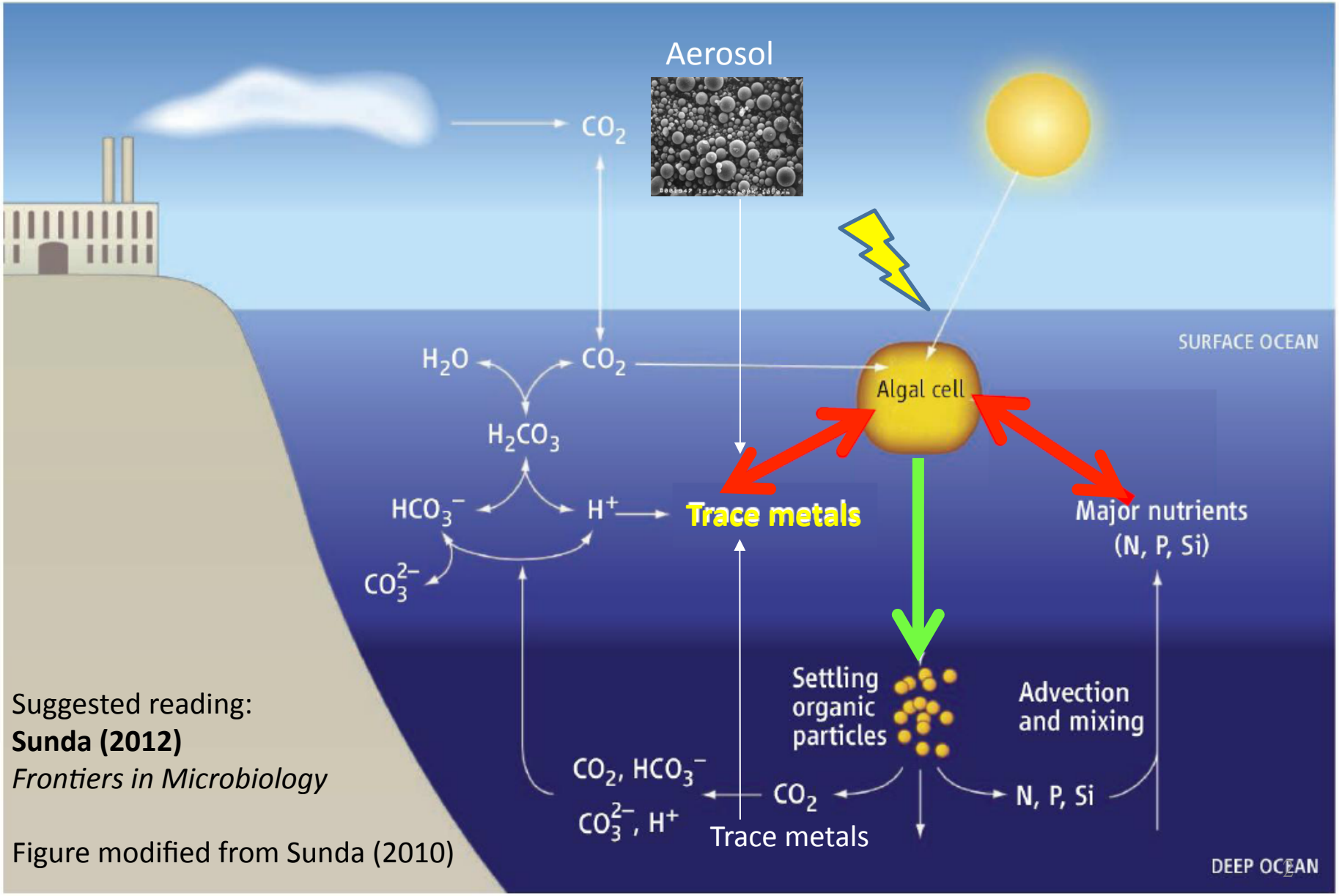
Evidence for multi-element biological uptake & adsorption

Tung-Yuan Ho

Research Center for Environmental Changes
Academia Sinica, Taipei, Taiwan

Visiting scholar, Ocean Sciences Department
UC Santa Cruz

Major factors regulating uptake:
M', Cellular requirement, Growth factors



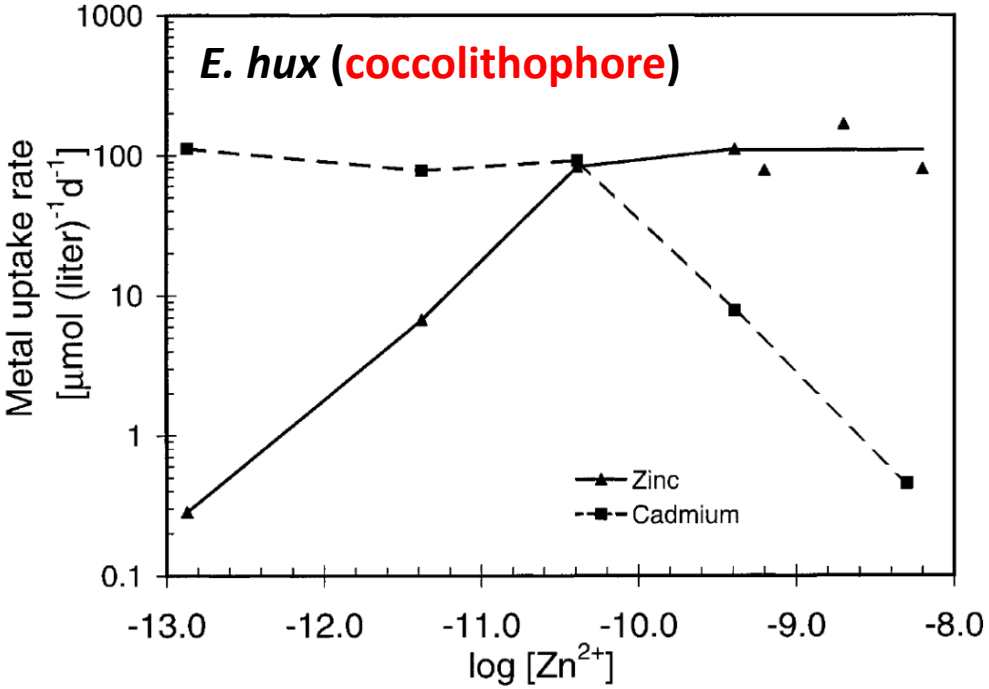
Suggested reading:
Sunda (2012)
Frontiers in Microbiology

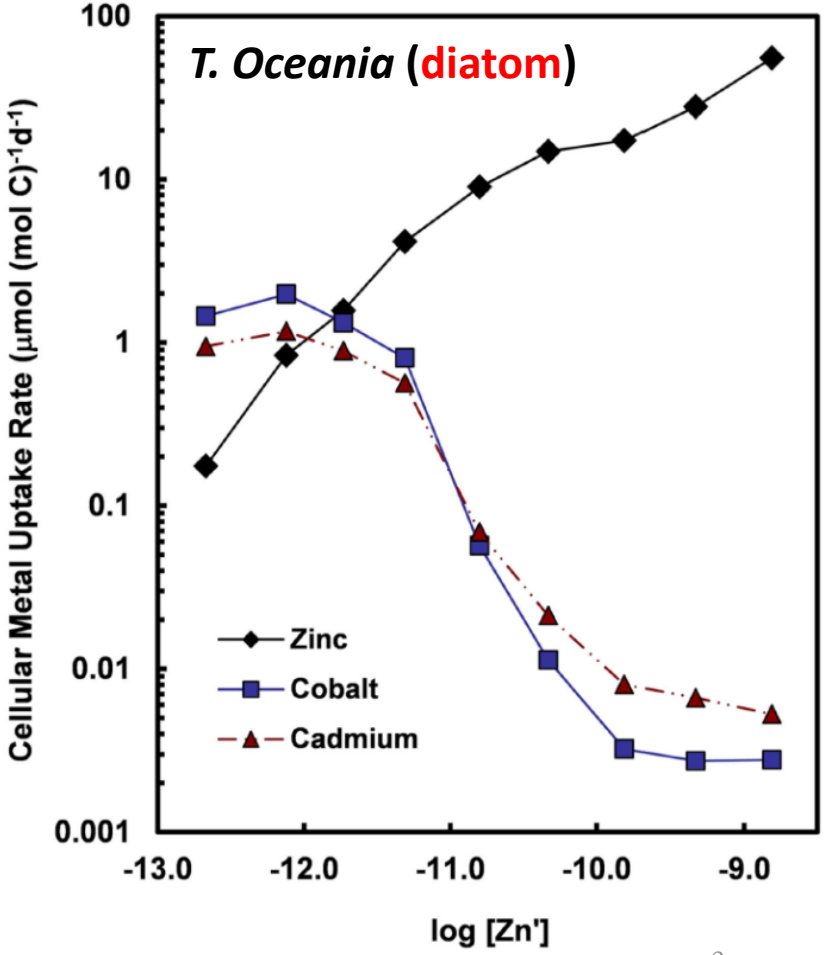
Figure modified from Sunda (2010)

M', other M', Cellular requirement (or uptake)

- Metal transporters are not highly specific.
- Cellular requirement (& uptake) can be highly different among different species or phylum.

$$\text{Uptake rate} = \frac{V_{max}[M]}{(K_s + [M])}$$

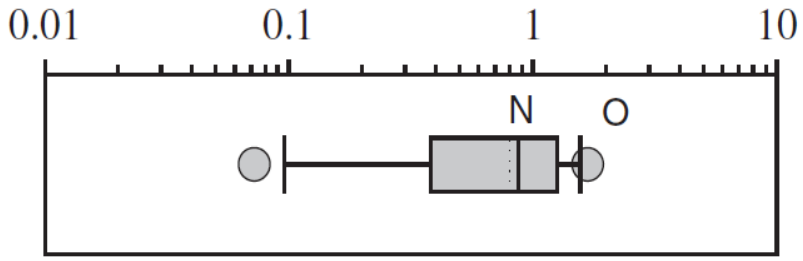




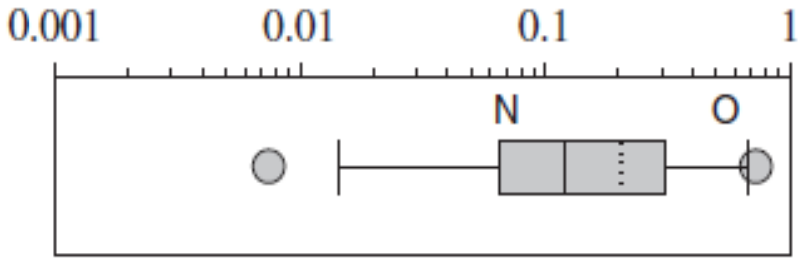
Sunda & Huntsman (2000)

Quota variations & range: averaging & repackaging

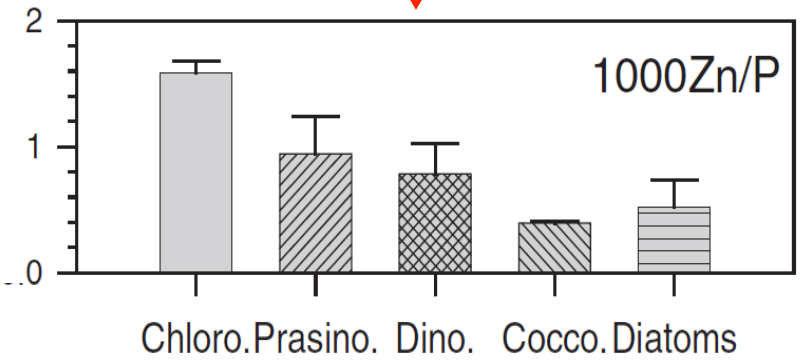
1000Zn/P

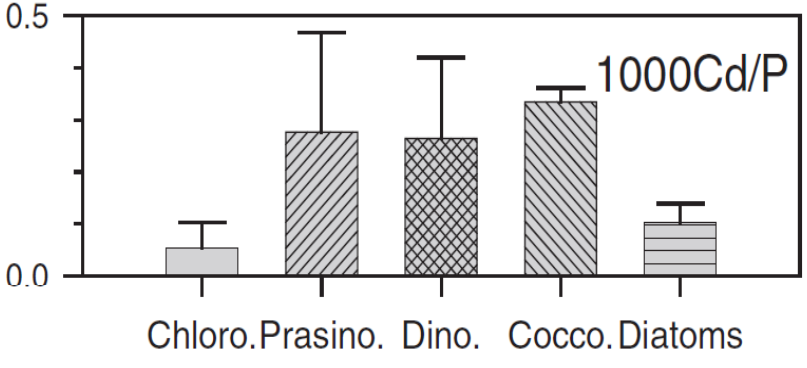


1000Cd/P



Assemblage or Average





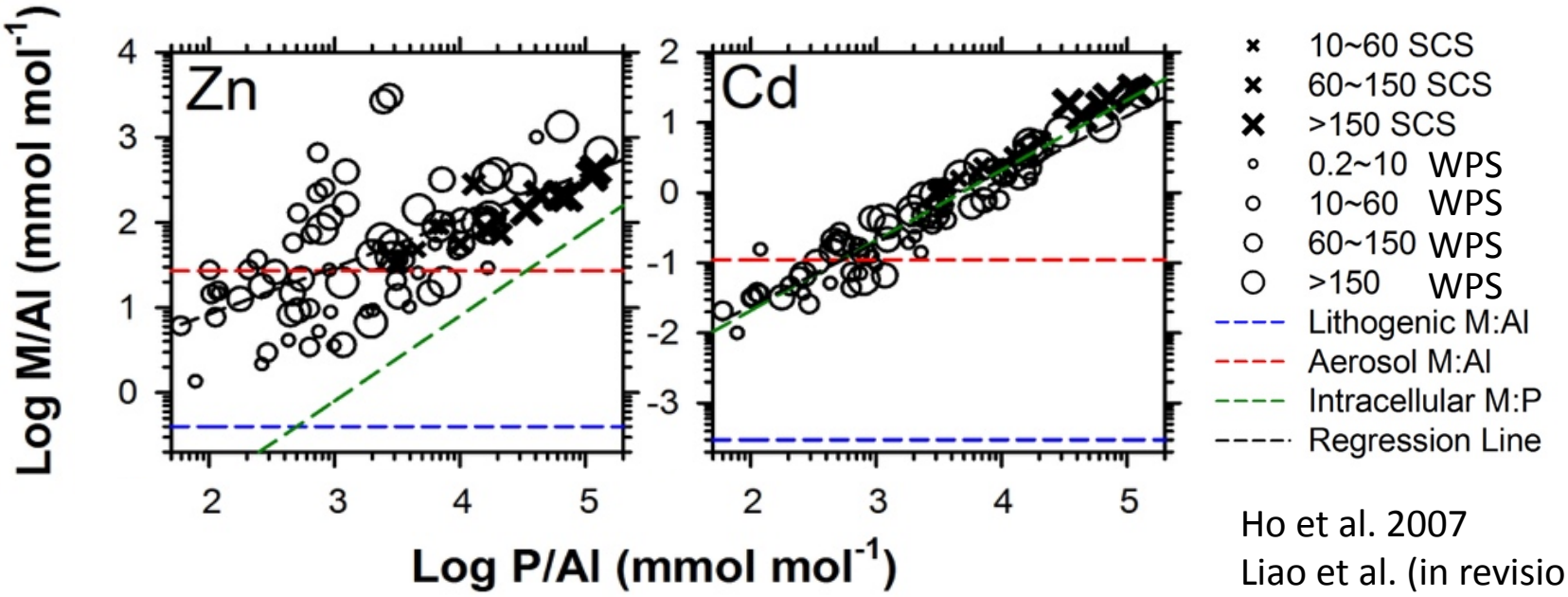
0.80±0.52 (mmol/mol)

0.20±0.21 (mmol/mol)

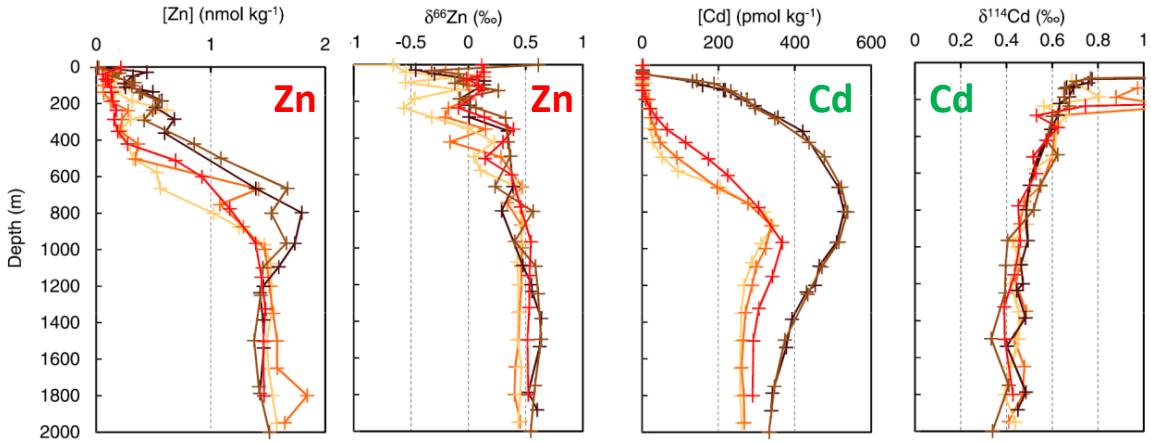
Repackaging

Ho *et al*. 2003

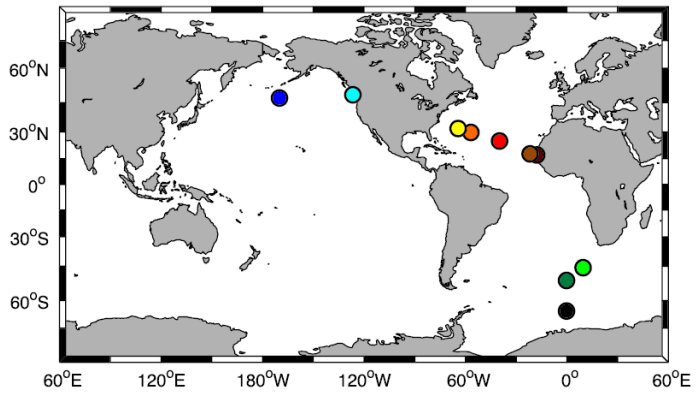
Uptake or adsorption: elemental & isotopic evidence



Ho et al. 2007
Liao et al. (in revision)



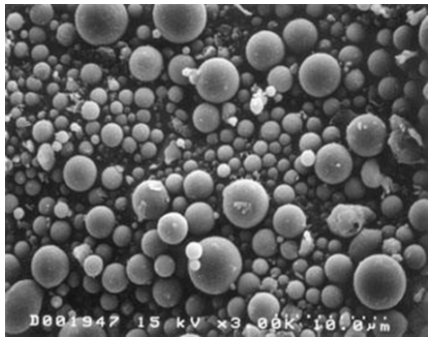
Cu Ni



John and Conway 2014

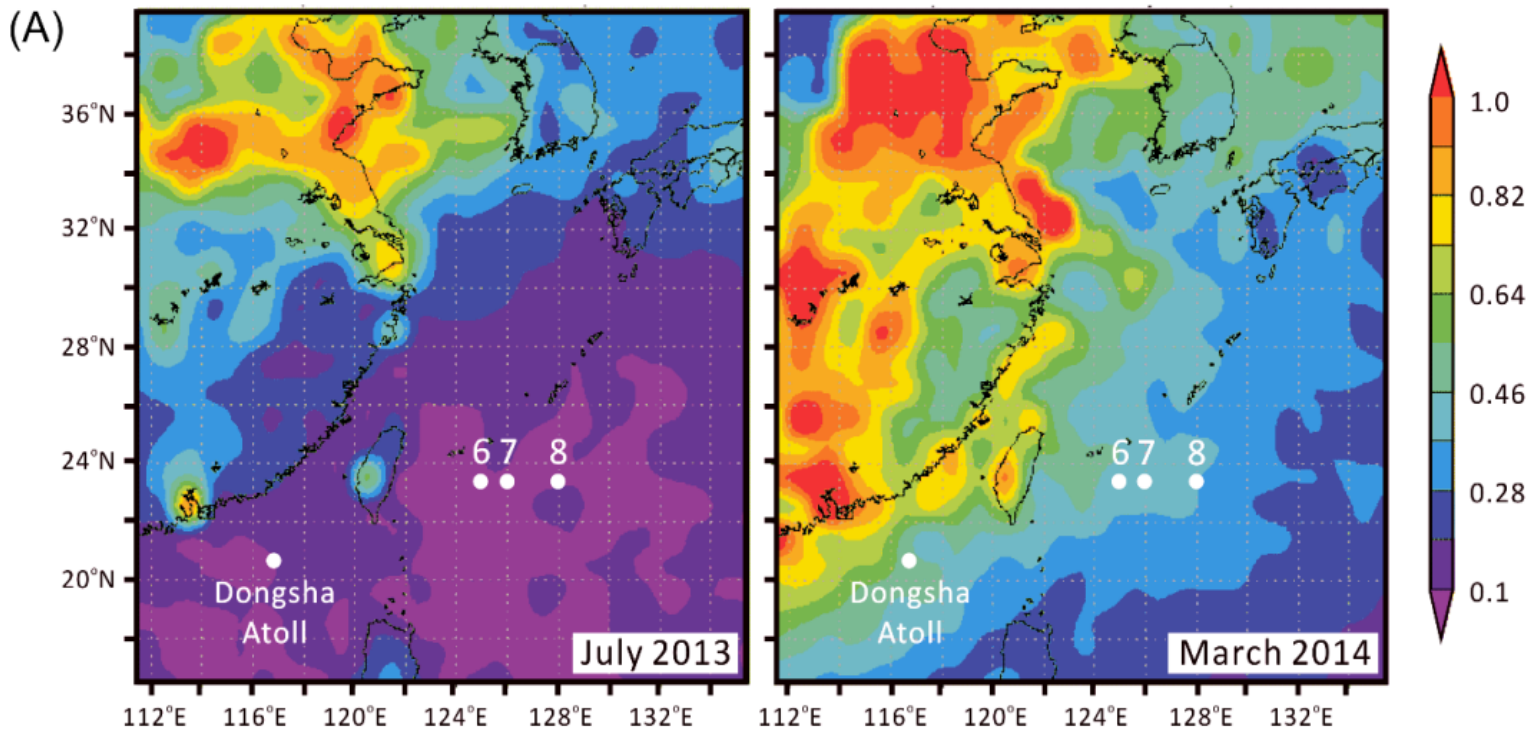
Taiwan GEOTRACES process study

An International Study of the Marine Biogeochemical Cycles of Trace Elements and their Isotopes



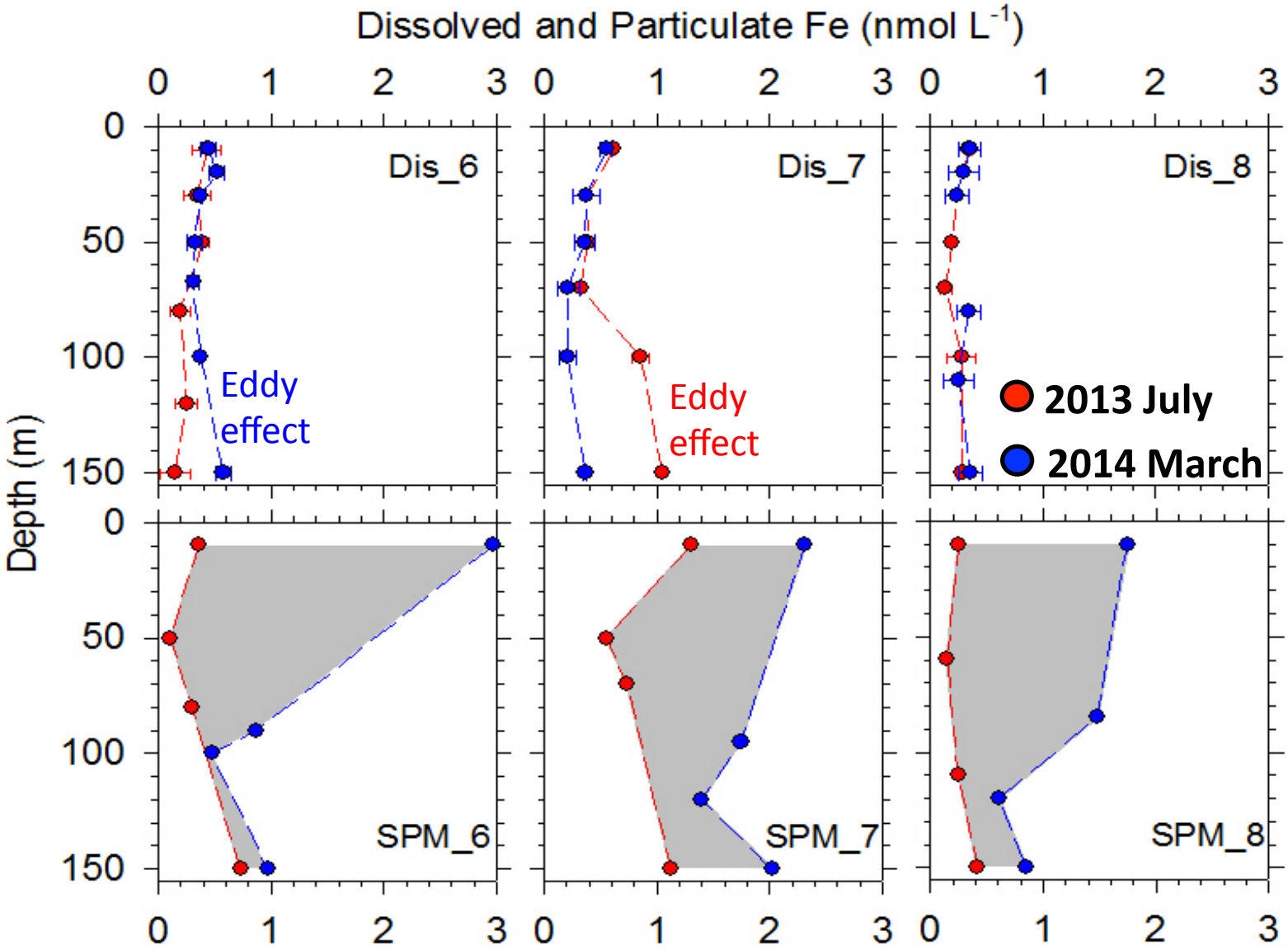
Coal burning flying ashes Wiki

Seasonal transformation of anthropogenic aerosol metals in the surface water of the NWPO: aerosol, dissolved, particulate, sinking particles



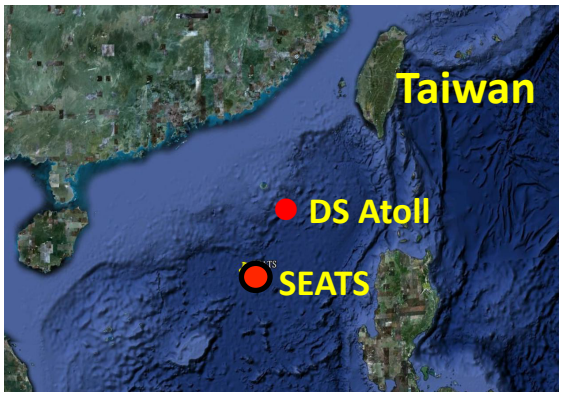
Wang and Ho (in prep.)

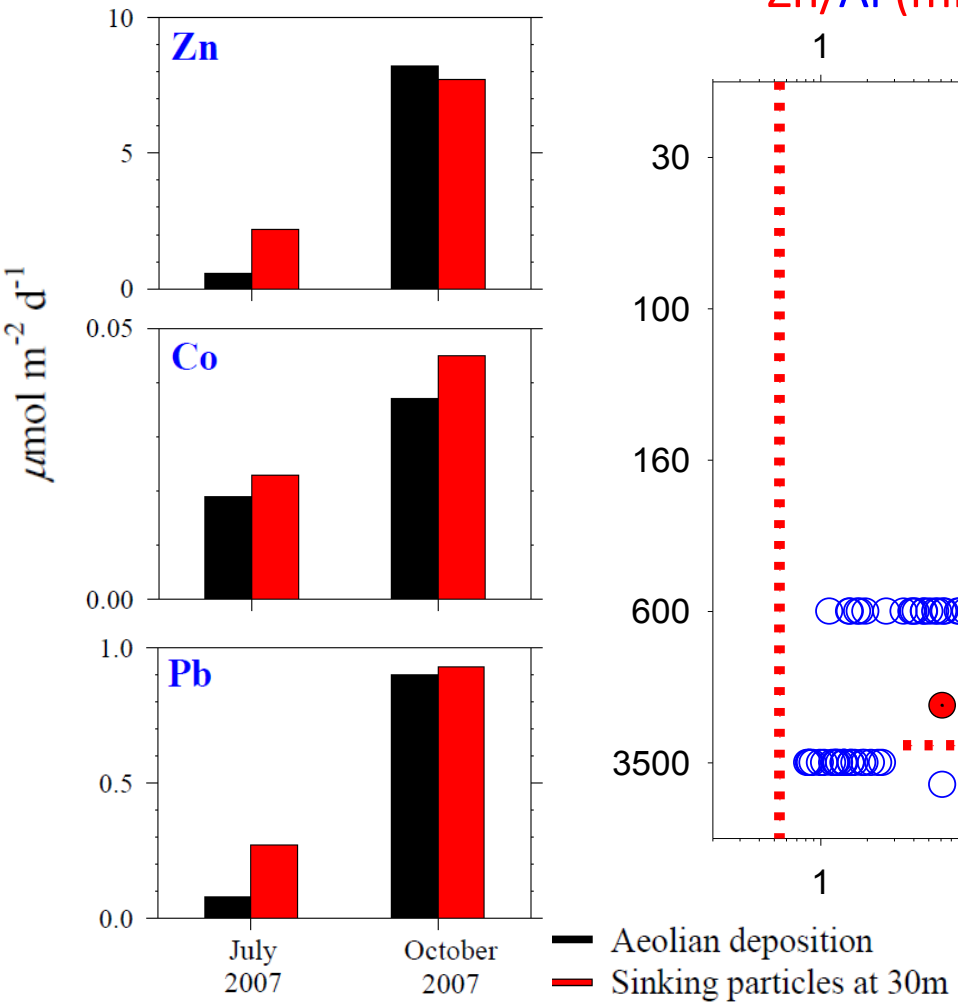
Seasonal variation of dissolved & particulate Fe

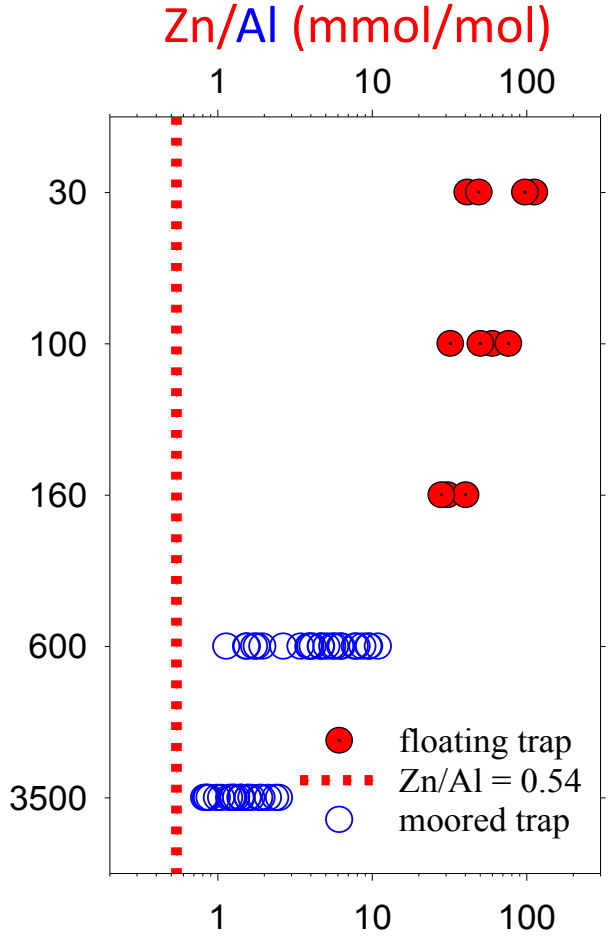


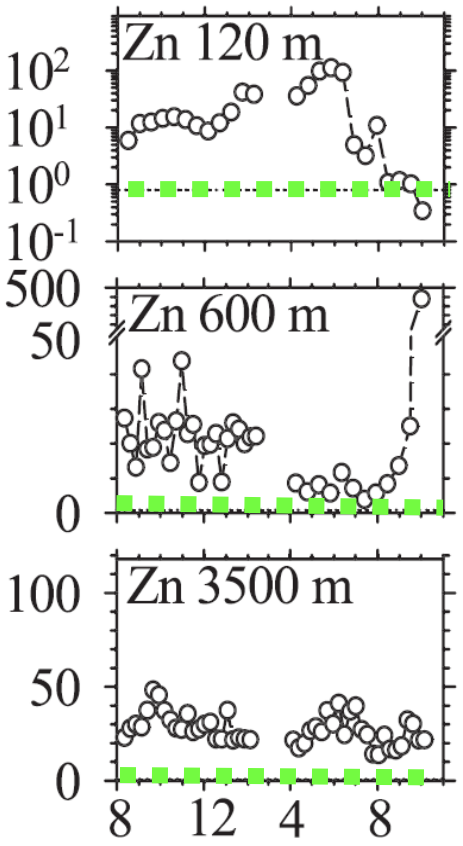
Wang and Ho (in prep.)

Anthropogenic aerosol Zn in sinking particles at SEATS



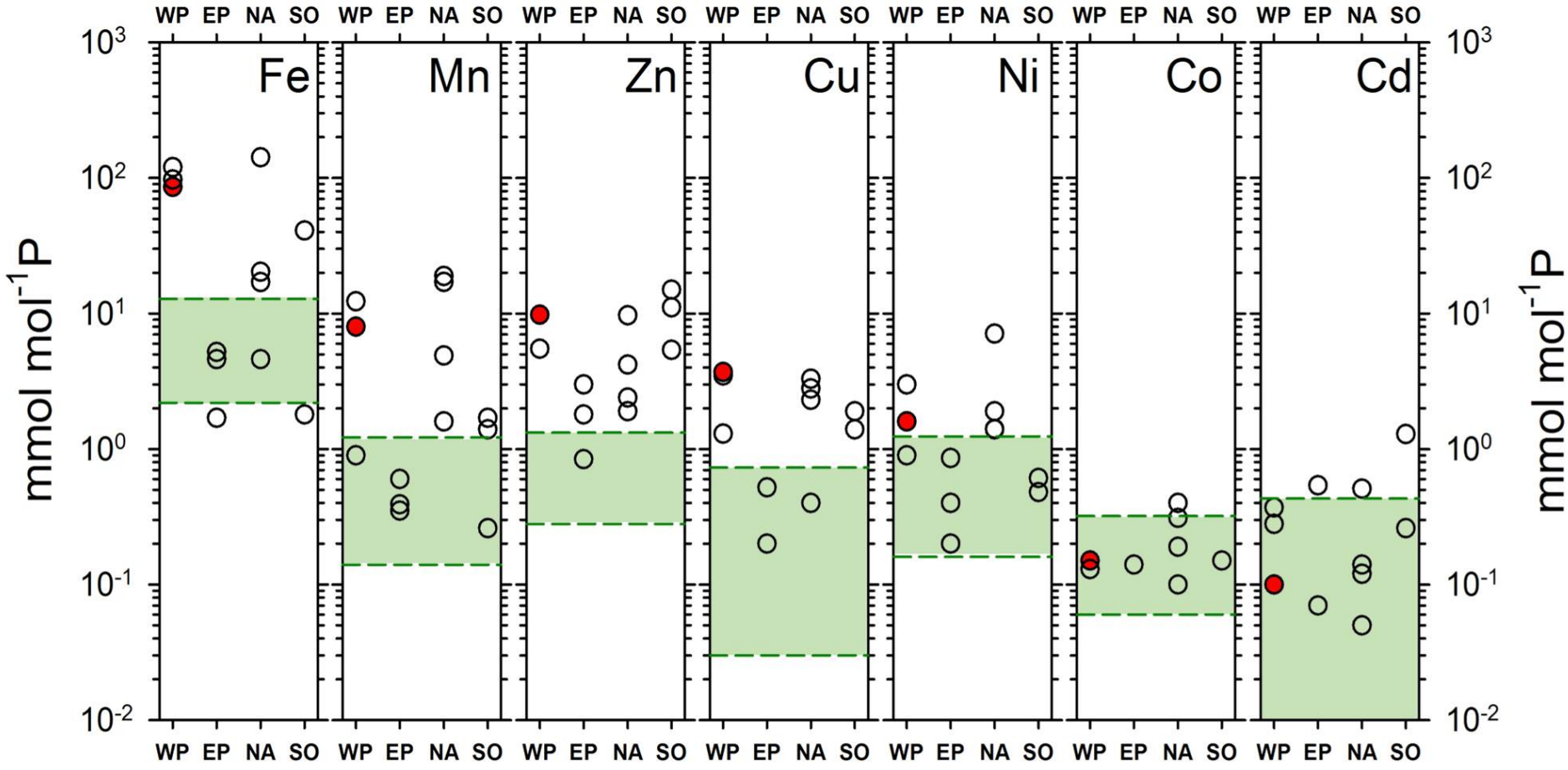






(Ho *et al*. 2010; 2011)

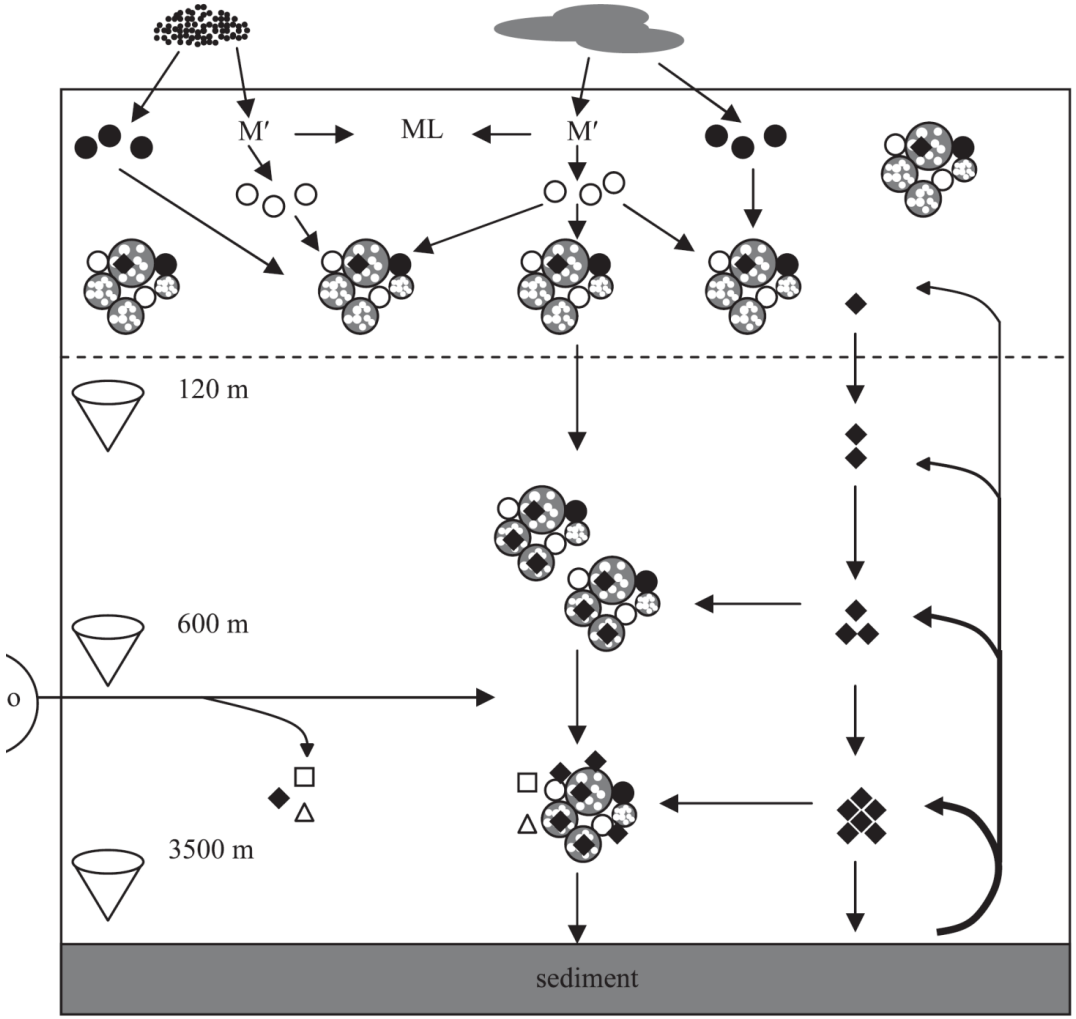
Metal quotas in marine plankton or total SPM in the surface water of global oceans (>200 m)



[a] Ho et al. 2003 (culture study), [b] Ho 2006 (field and culture study), [c] This study, excluded data collected from coastal stations 1, 3, A, and B, [d] Ho et al. 2007 (size-fractionated plankton net), [e] Bowie et al. 2010 (1 µm, pump filtration), [f] Kuss & Kremling 1999 (pump filtration), [g] Tovar-Sanchez et al. 2006 (100 µm, plankton net), [h] Nuester et al. 2012 (100 µm, plankton net), [i] Sherrell and Boyle 1992 (1 µm, pump filtration), [j] Twining et al. 2015 (0.45 µm, pump filtration), [k] Martin & Knauer 1973 (76 µm, plankton net), [l] Collier & Edmond 1984 (44 µm, plankton net), [m] Twining et al. 2011 (single cell, synchrotron), [n] Twining et al. 2004 (single cell, synchrotron), [o] Cullen et al. 2003 (0.45 µm, pump filtration), [p] Planquette et al. 2013, (0.45 µm, pump filtration)

(Liao *et al*. in review)

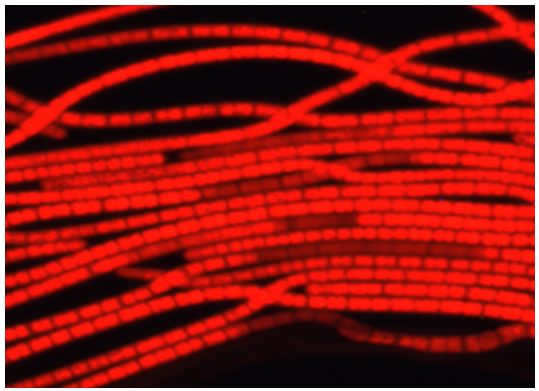
A schematic model for trace metal transport in the surface & deep water of the SCS



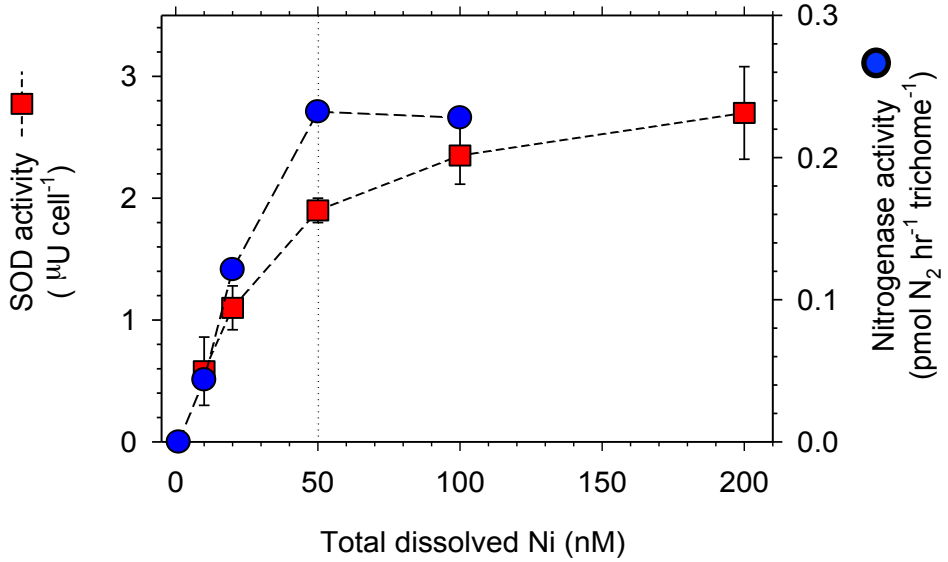
With the increasing inputs of anthropogenic aerosol over the NWPO, the coupling and transport of anthropogenic aerosol metals with biogenic material has become an important pathway for trace metal cycling not only in the euphotic zone, but also in the twilight zone and deeper waters.

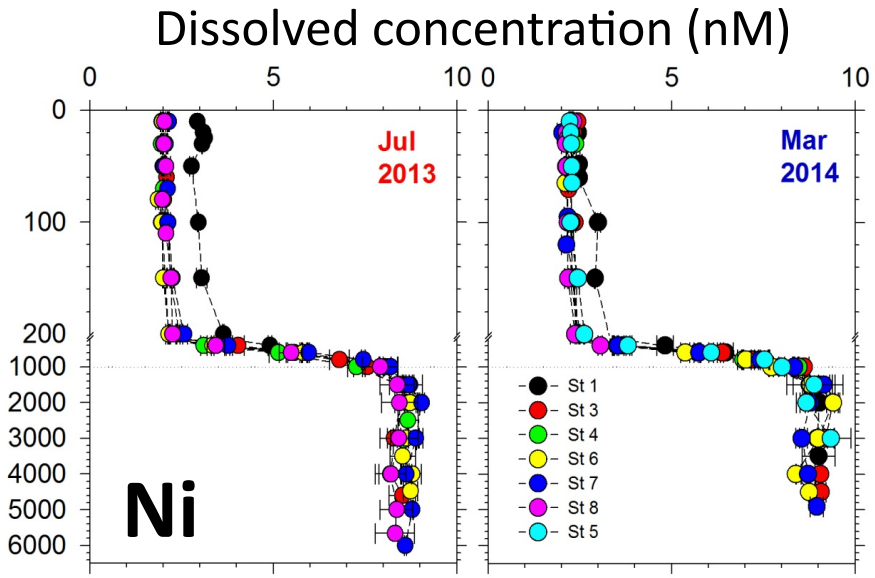
Ho et al. (2011)

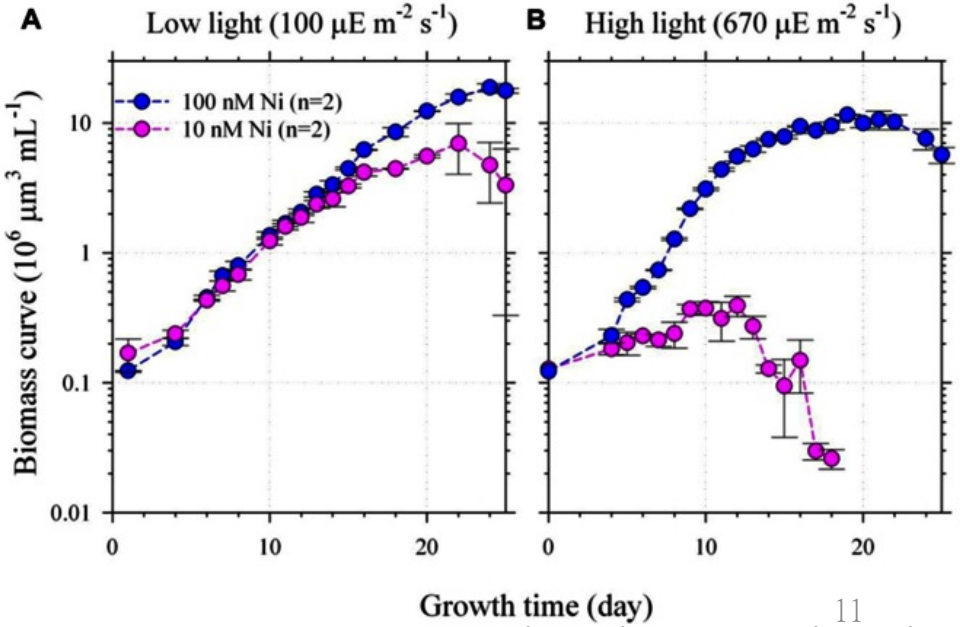
Ni requirement in *Tricho*: light quality & metal demand



non-heterocystous diazotroph &
carry out N fixation during day time

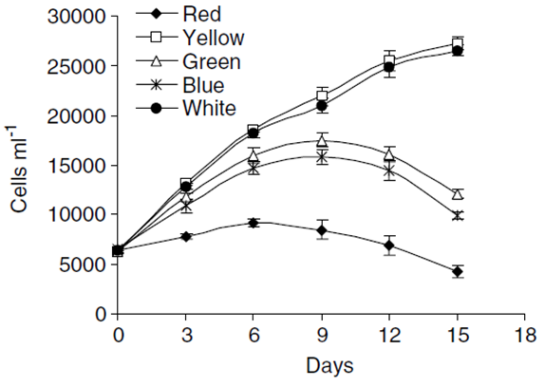




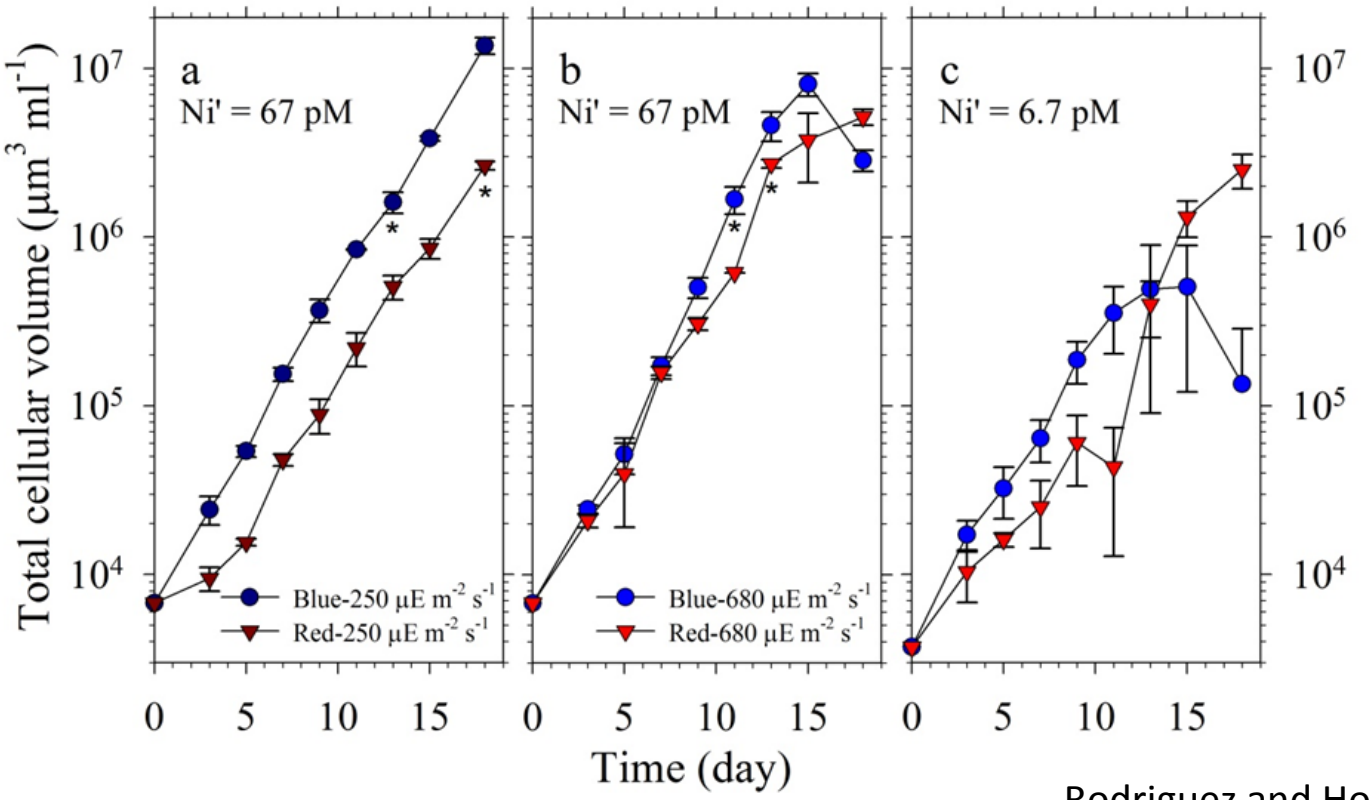


Ho (2013); Ho et al. (2013)

Tricho growth rates: light quality & Ni' dependent

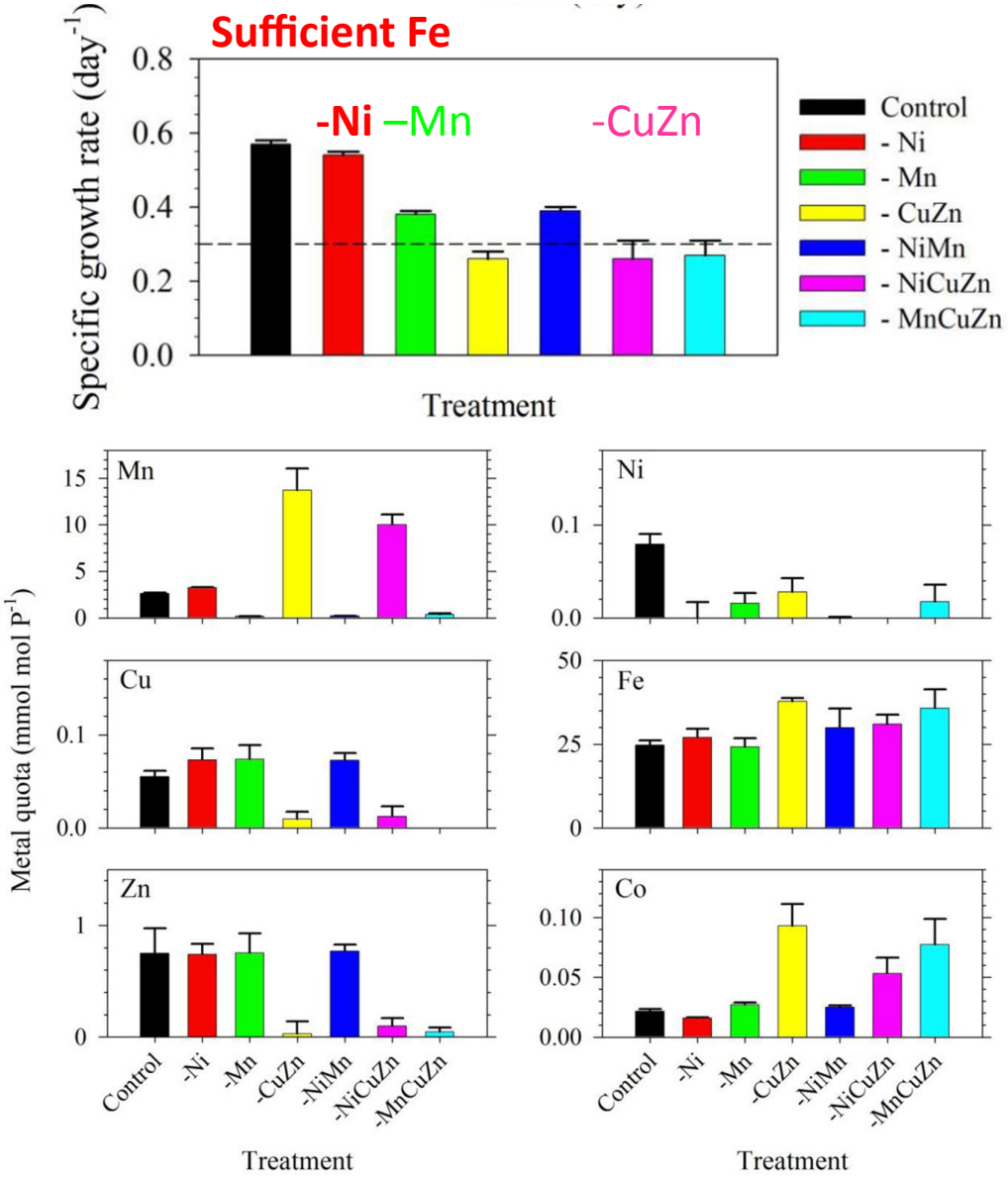


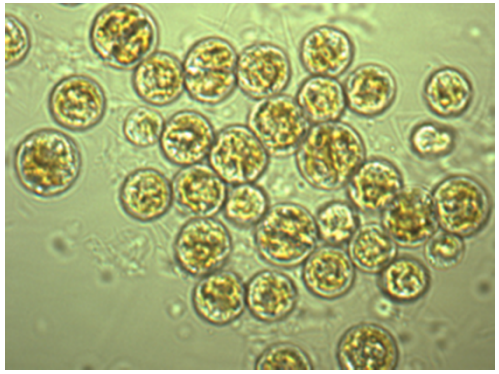
- Previous study indicates that light quality influence *Tricho*'s growth (Bell and Fu 2003).
- We found that when Ni' is sufficient, the growth rates under **red light** can be as high as blue light.



Rodriguez and Ho (under revision)

Growth curves & metal uptake of *Symbiodinium k.* (dino) grown in different metal availability





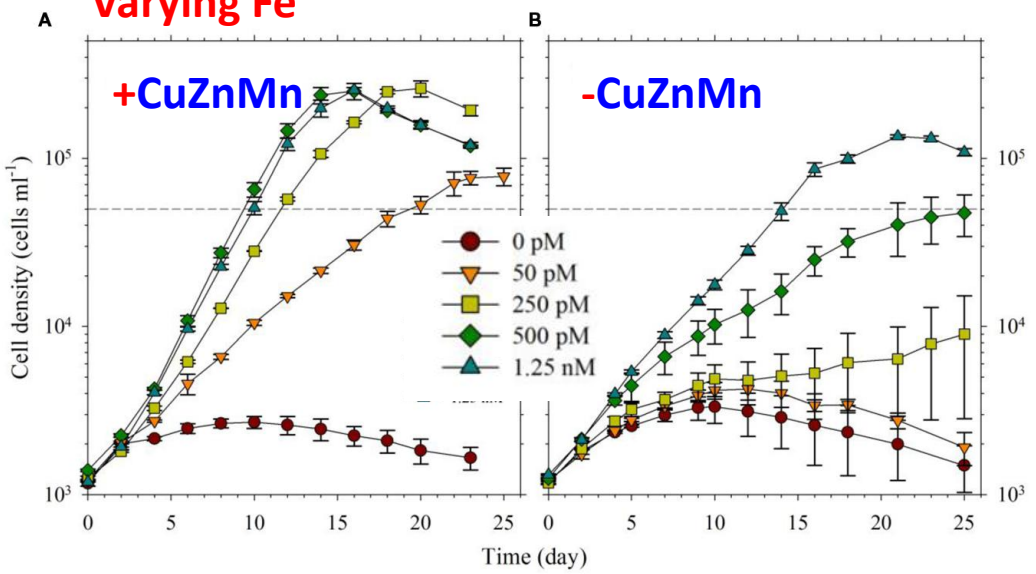
- **Dino** possesses **4 SODs** (Fe, Mn, Cu/Zn, and **Ni**).
- Fe >> Cu/Zn/Mn >> Ni
- Intensive metal replacement

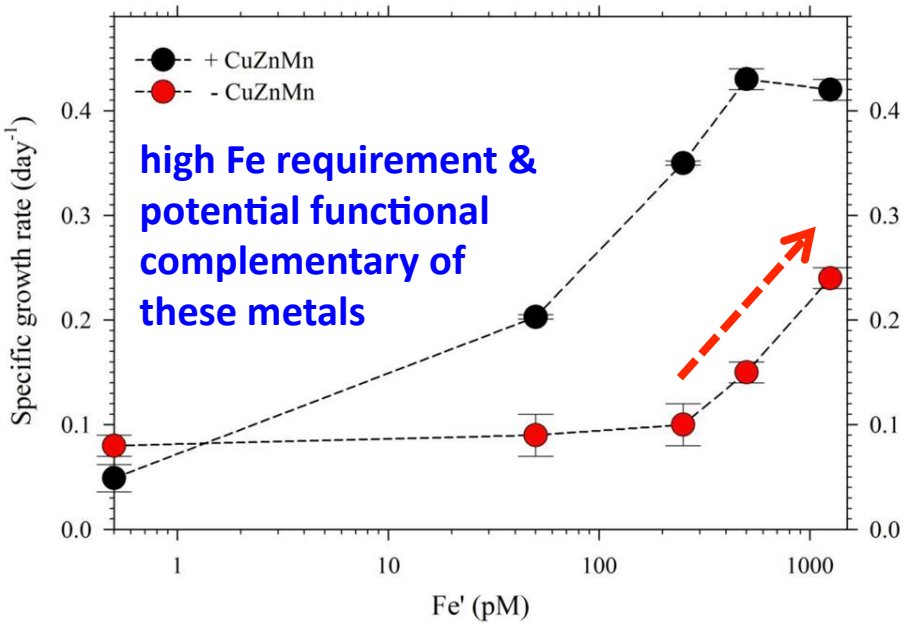
Control: M' are 2.5 nM, 42nM, 67 pM, 125pM, and 0.50 pM for Fe, Mn, Ni, Zn, and Cu, respectively

Rodriguez et al. (2016)

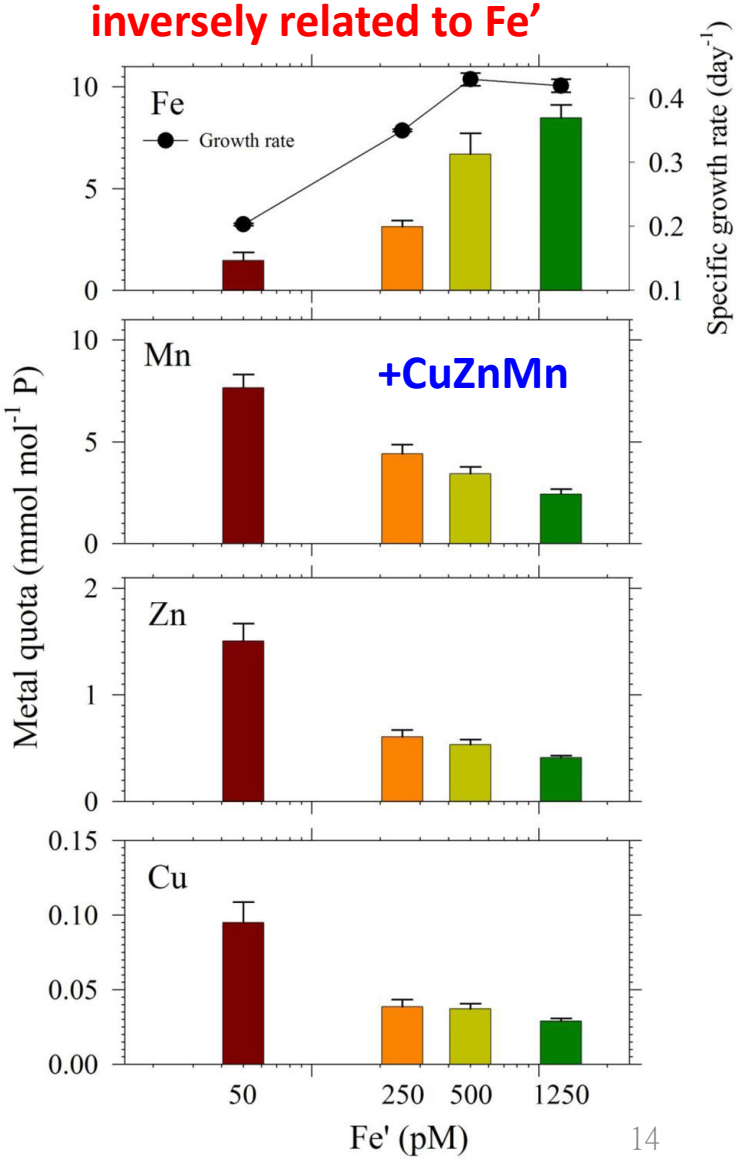
Replacement under various Fe' treatments

Varying Fe'



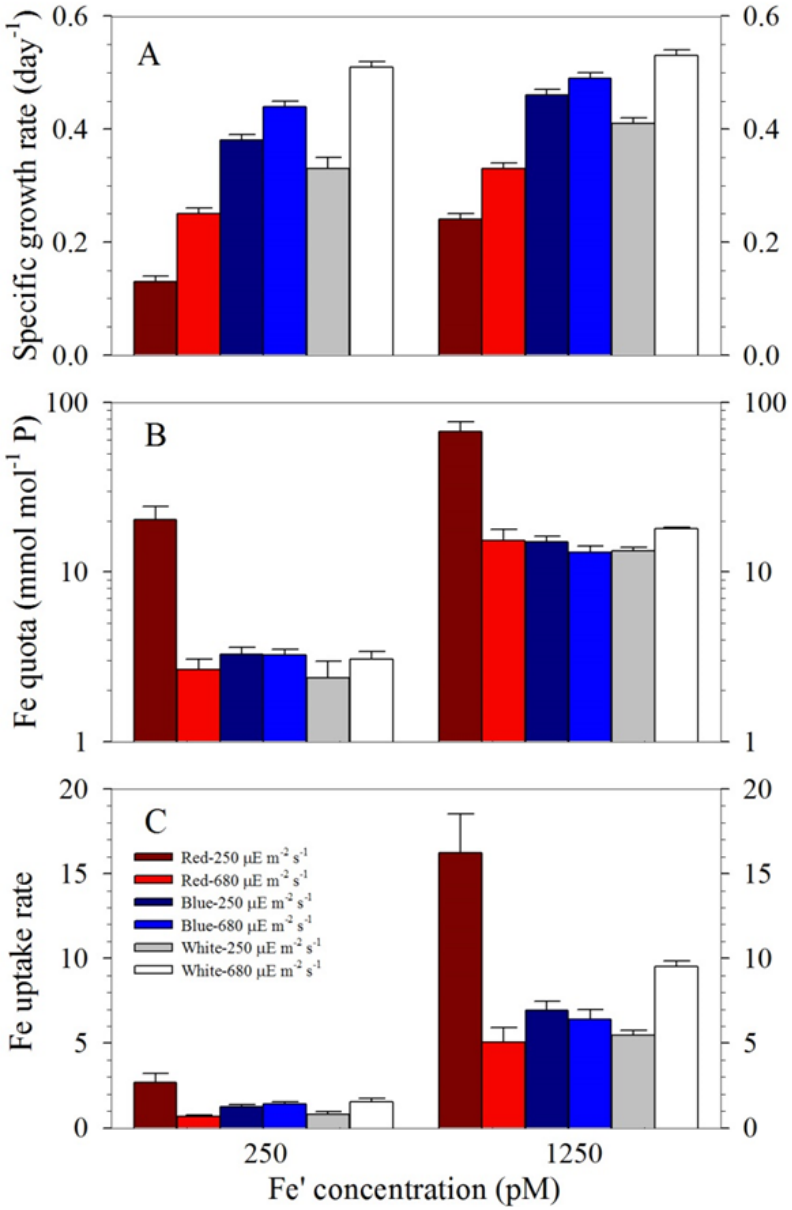


Cu, Zn, and Mn quotas were inversely related to Fe'



Rodriguez et al. (2016)

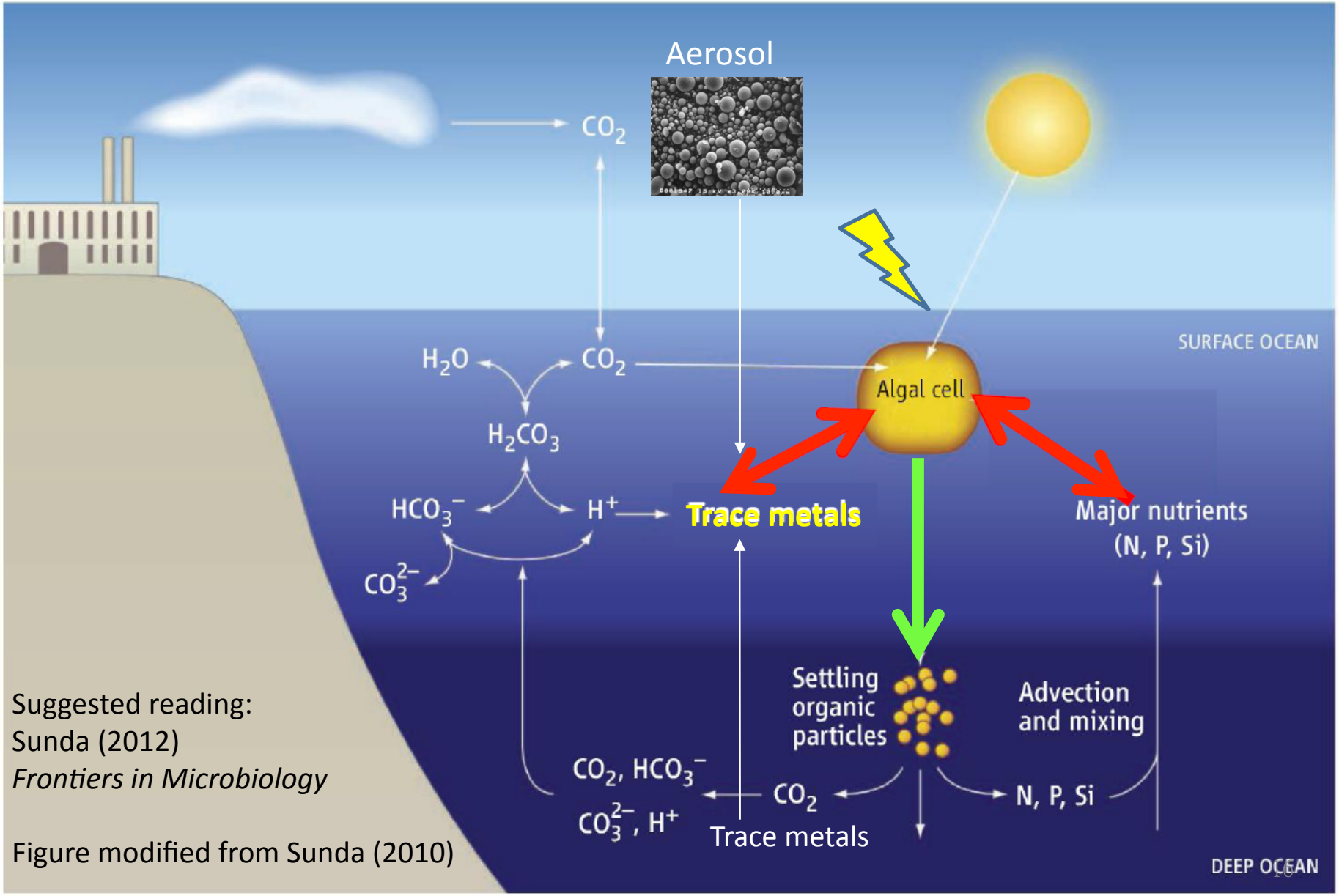
Symbiodinium growth curves under blue & red lights condition with various Fe'



- The growth rates under red light are much lower than blue & white lights under both low & hi Fe'.
- Fe uptake rates are greatly enhanced under low red light.

Rodriguez and Ho (in revision)

Conclusion: Major factors regulating uptake: M', Cellular requirement, Growth factors

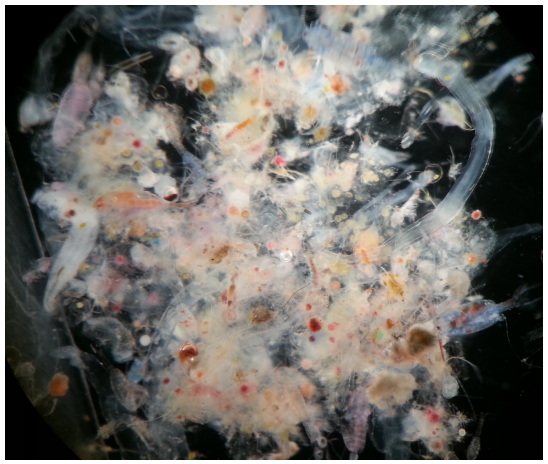


Suggested reading:
Sunda (2012)
Frontiers in Microbiology

Figure modified from Sunda (2010)

Questions & Challenges

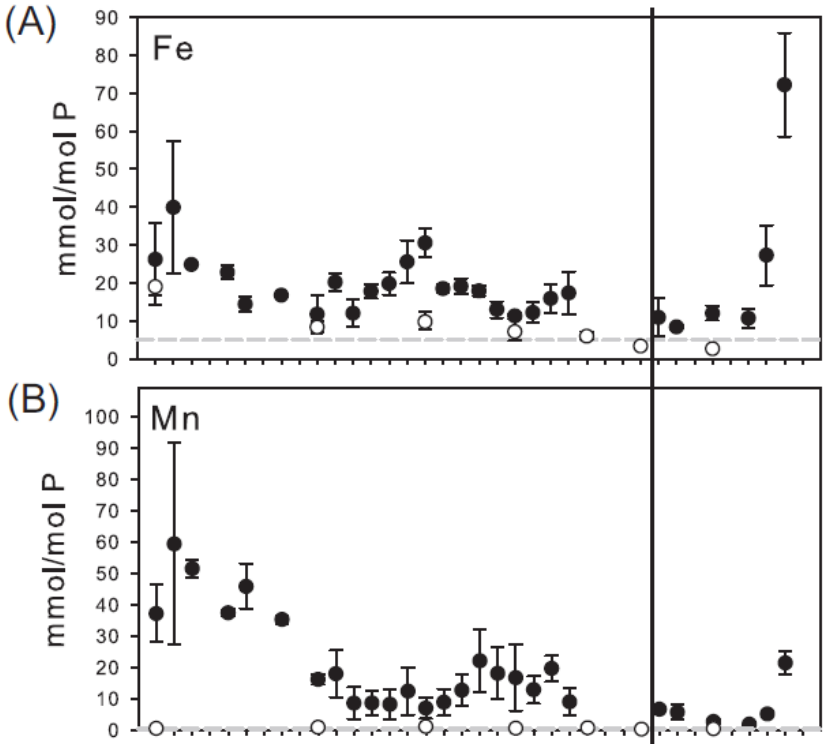
- Differentiate biological uptake or adsorption (field studies on plankton quota)
- Study cellular requirement of prokaryotes (e.g., *Pro*, *Syn*, various diazotrophs…)
- Understand metal requirement under varying growth conditions (e.g., major nutrients, light quality)



Plankton aggregates

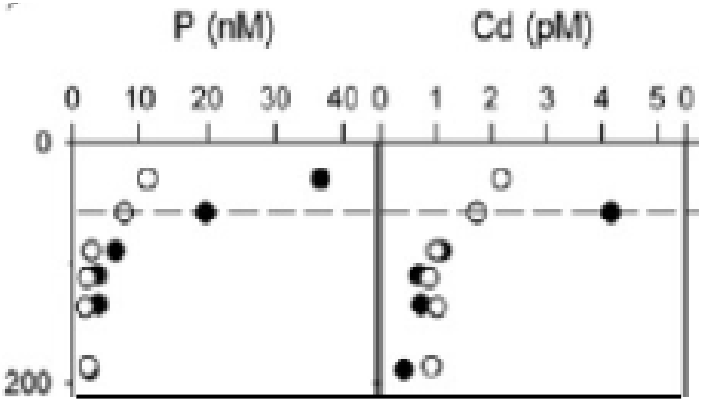
Technical challenge

- Uptake or adsorption (e.g., TEP)
- Filtration method

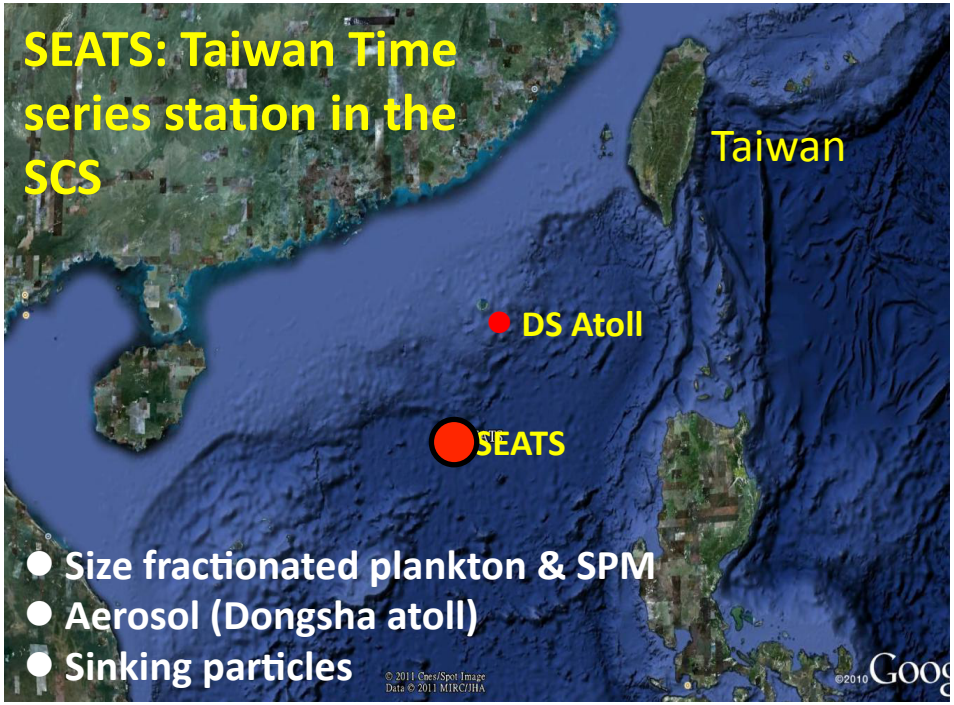


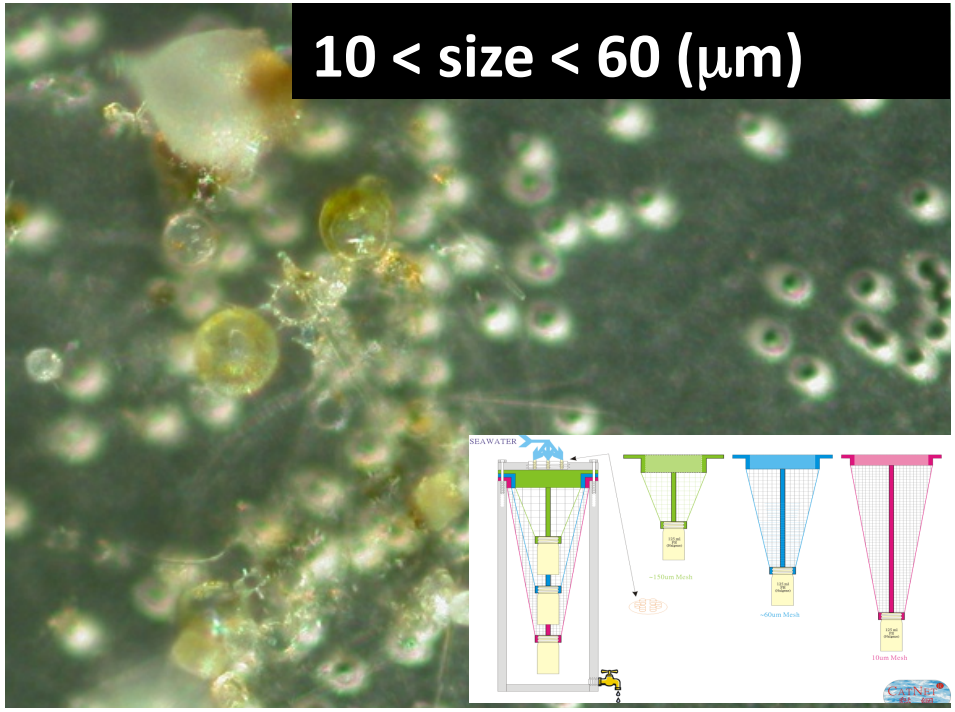
Twining et al. 2015

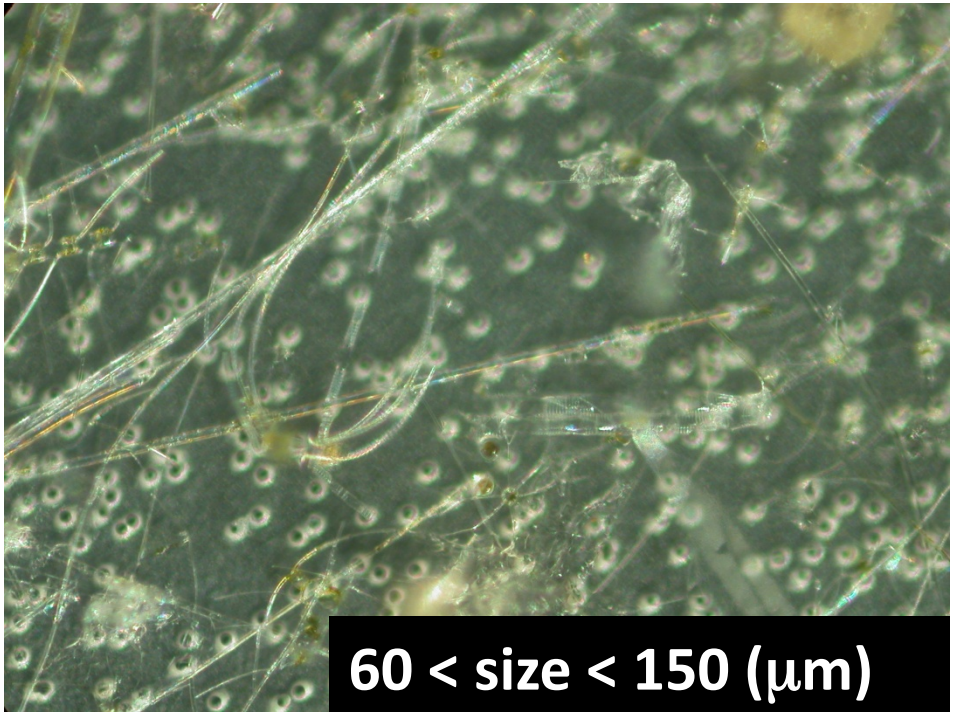
Comparison of particulate trace element concentrations bottle sampling and in situ pumping



Twining et al. 2015


SEATS: Taiwan Time series station in the SCS
Taiwan
DS Atoll
SEATS
Size fractionated plankton & SPM
Aerosol (Dongsha atoll)
Sinking particles


10 < size < 60 (μm)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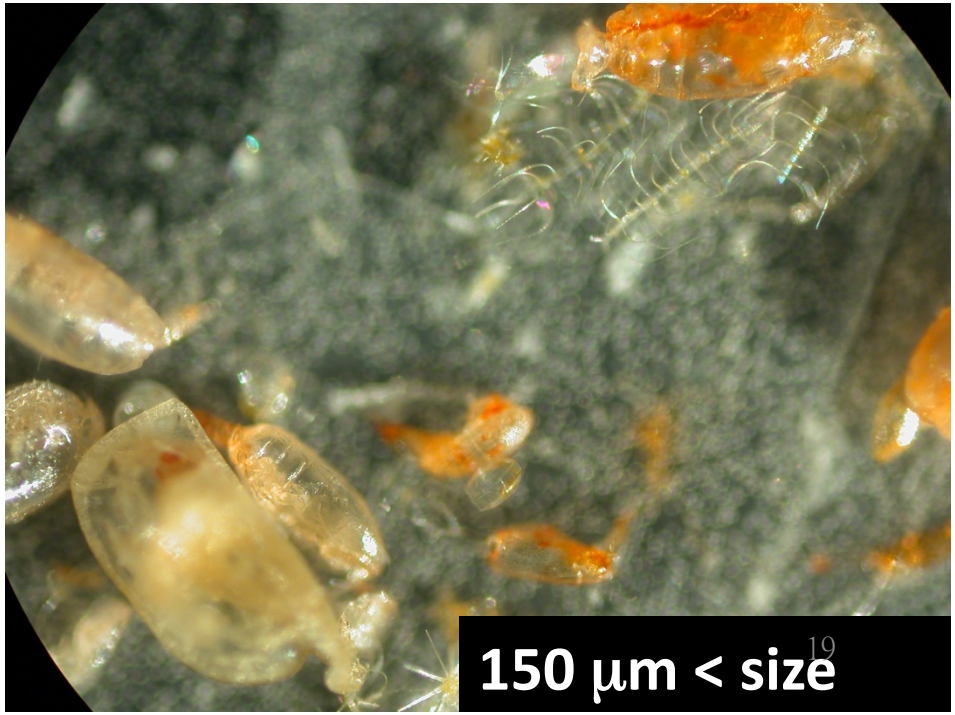
150 μm < size