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# Trace Elements as Tracers

**Biochemical Tracers Workshop**

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**for 'Micronutrients and Primary Production' Team**

National Research FLAGSHIPS
Wealth from Oceans

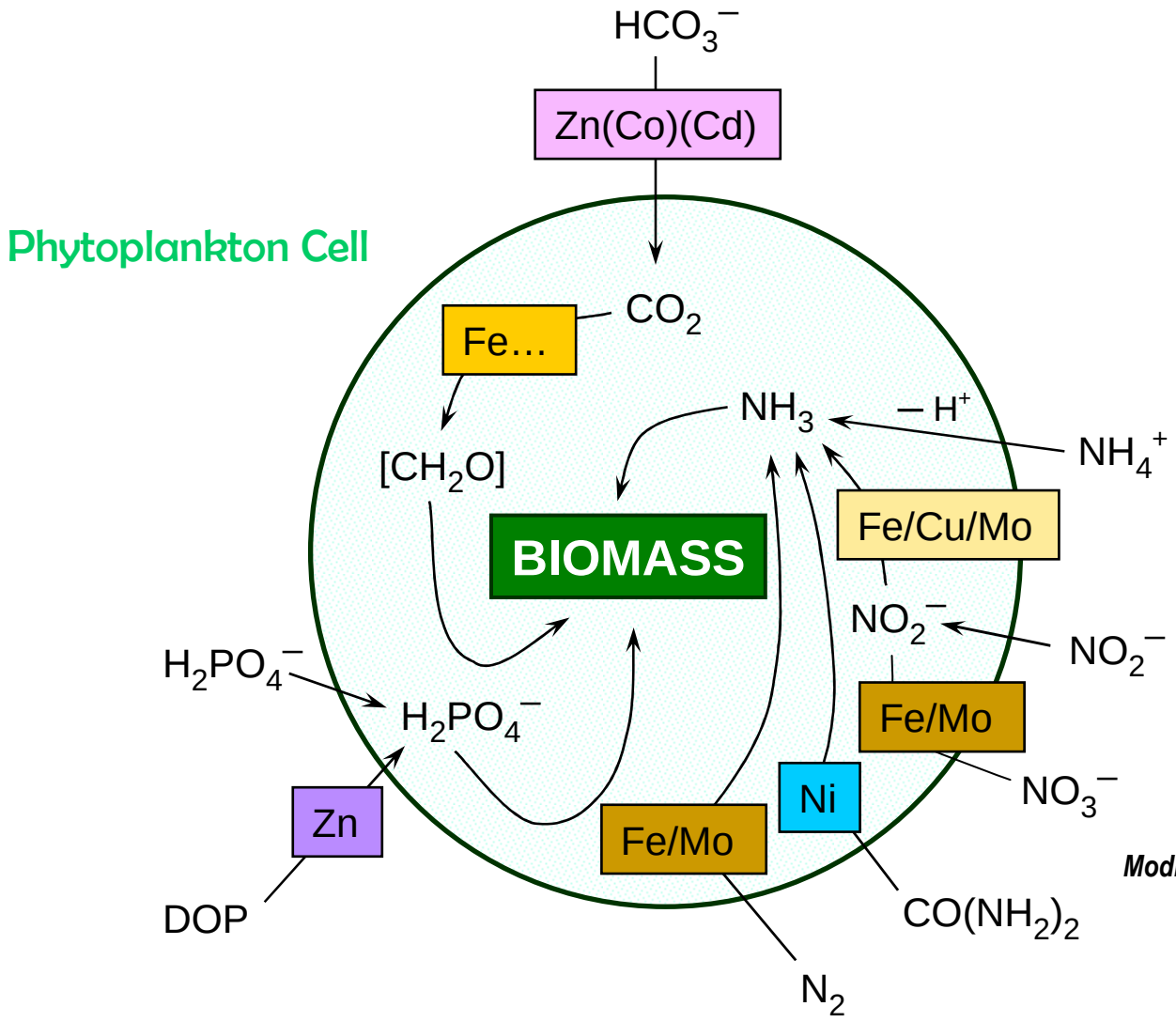
CSIRO

# Which trace elements?

- Scope of ICP-MS measurements


<http://www.csiro.au/places/CleanRoomFacility.html>

# Micronutrients in key C, N & P pathways



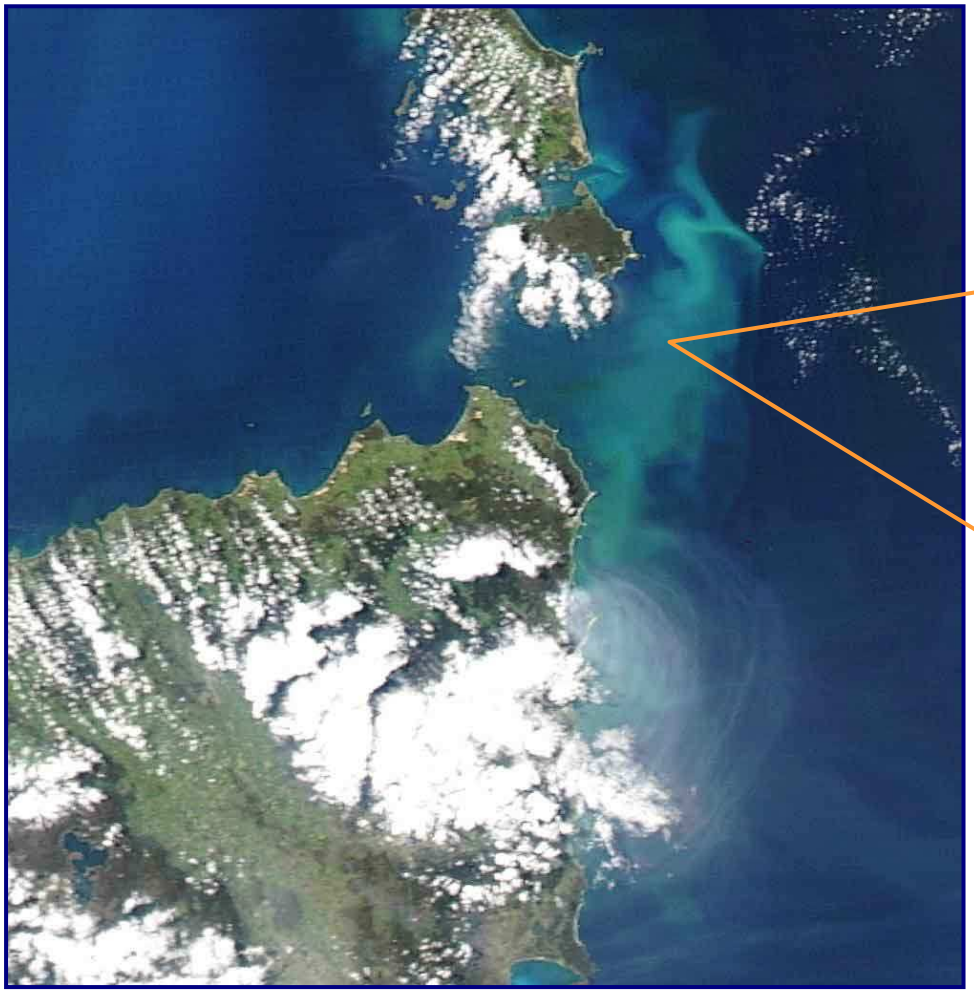

*Modified from Morel & Price 2003*

# COBALT — a “bio-influential” micronutrient

- Cyanobacteria (*Synechococcus & Prochlorococcus)* and the cocco-lithophorid *Emiliania huxleyi* have a demand for cobalt.
  [*Thalassiosira* spp. diatoms prefer zinc over cobalt]
  (Sunda & Huntsman 1995, Saito 2002)

- Southern Ocean transect across Antarctic Polar Front … declining bioavailable cobalt poleward … corresponding decrease in *Synechococcus* sp.
  (Ellwood *et al*. 2005)

# Coccolithophorid bloom off NE Tasmania



***Emiliania huxleyi***

***Gephyrocapsa* sp.**

MODIS – Aqua, 19 Oct 2004

# Trace elements and marine biota – 1.

*Analyses of hard parts of marine organisms*

- otoliths of fish
- statoliths of squid
- styles of octopus
- mollusc shells
- diatoms / coccoliths
- corals

— total analysis, or location-specific (linked to temporal variation of life form via pattern of growth rings)

# Trace elements and marine biota – 2.

*Examples of the use of trace elements as markers:*

- Fish life-histories (e.g. migrations)
  - — Sr:Ca ratios, Ba, Mg, Li, Mn, Cu, Zn, …
- Stock identification
  - — e.g. Orange Roughy via 10-element suite (Ba, Cd, Cu, K, Mg, Na, Pb, S, Sr, Zn)
- Nursery habitat
  - — natal rivers via K, Li, Mg, Mn, Ba, Sr …
- Exposure to contaminants
  - — otoliths, but also scales / fins Hg, (Se), Cu, Pb, V, Zn, …

# Otolith example – distinguishing fish habitat

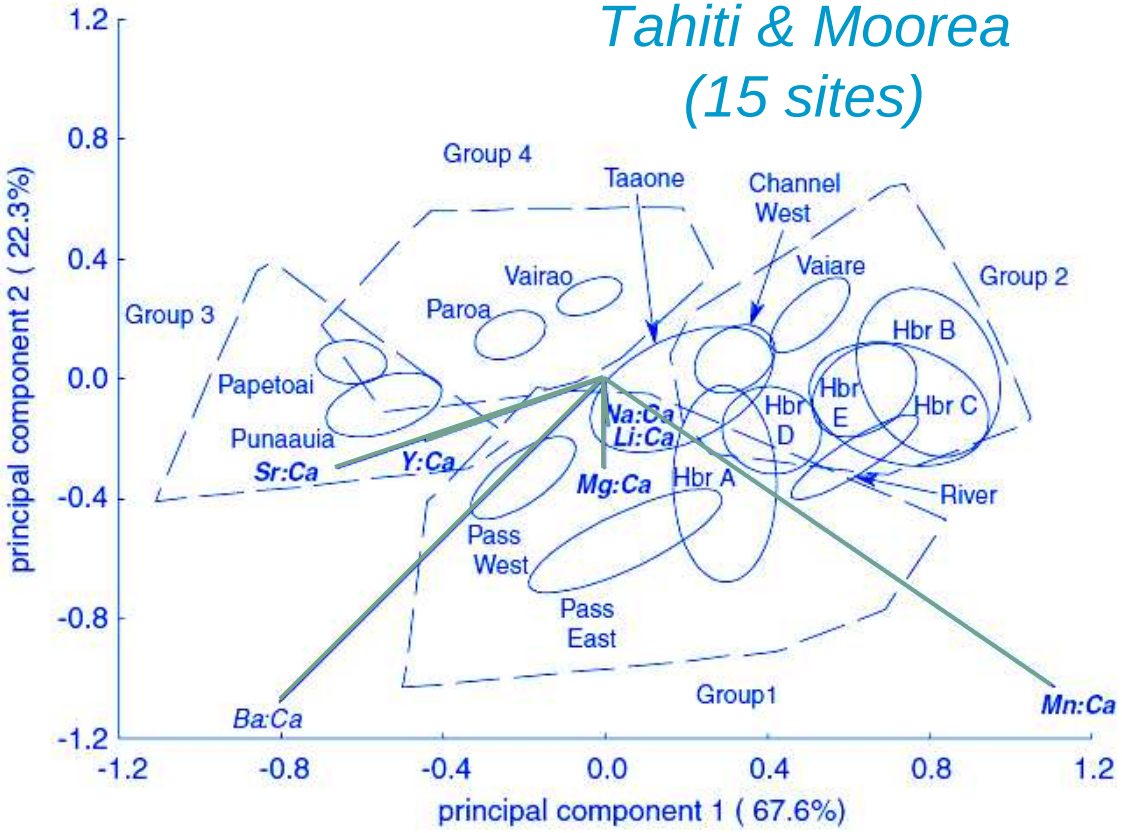
*Stegastes nigricans*

(a damselfish)

Whole sagittal otoliths
(n = 293)

Ba, Ca, Li, Mg, Mn, Na, Sr and Y

*Tahiti & Moorea (15 sites)*




***Lo-Yat et al. 2005, Coral Reefs 24:646***

# Corals: longer term tracers – 1.

Tropical corals have been used to track coastal contamination (e.g. Ba, Cd, Cr, Cu, Mn & Sb), but also historical upwellings * …

| Indicators/ Processes | SST | Salinity | Upwelling/ Nutrients | Human Inputs | ENSO | Land Runoff | Rainfall | Light |
|---|---|---|---|---|---|---|---|---|
| $^{18}O/^{16}O$ | ×× | ×× | | | ×× | | × | |
| $^{13}C/^{12}C$ | | | × | × | × | | | × |
| Sr/Ca | ×× | | | | × | (×) | | |
| Ba/Ca | × | × | ×× | | × | × | | |
| Cd/Ca | × | | ×× | × | × | | | |
| Mn/Ca | | | × | | | | | |
| Pb/Ca | | | | ×× | | | | |
| Bomb radionuclides | | | × | ×× | × | | | |
| UV Fluor | | | | | | ×× | | |

×× strong signals ubiquitously; × strong signals at some sites

***Chen 1993, Bull Inst Fr Etud Andines 22: 125***

* the M:Ca ratio in the substrate can be used to reconstruct past concentrations of M in seawater, assuming Ca levels have remained unchanged in seawater

# Corals: longer term tracers – 2.

- Real potential is with climate variability / change
  - *the hope*: "century-long records of ocean chemistry and temperature with weekly time resolution"
- The potential is gradually being realised, esp. with deep-sea corals, e.g.
  - more precise dating / calibration with U-Th series
  - multiple tracer records
  - past ocean circulation ($^{3}H$ in coral organics?)
  - $^{7}Be$ and $^{10}Be$ – insights to particle dynamics?
  - …
- Some challenges ahead understanding coral accretion fully (e.g. ultra-structural variations)

# Future prospects

- Other trace elements (e.g. REEs)
- Stable isotopes of trace elements
  - sources, dynamics, etc.
- Trace element speciation
  - cycling of elements within organisms, food webs, etc.
- …