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Interactive comment on "A cobalt plume in the oxygen minimum zone of the Eastern Tropical South Pacific" *by* N. J. Hawco et al.

N. J. Hawco et al.

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We are grateful for the time and effort extended by both anonymous reviewers, whose close attention to detail in reviewing our manuscript makes their praise all the more meaningful.

As both reviewers identified a need for clarity in structuring the results and discussion section and better ordering of figures, future revisions will focus on a more logical, straightforward presentation of arguments and observations. The revised manuscript will contain a better structured results section, split into three sub-sections for introducing dissolved cobalt, labile dissolved cobalt, and particulate cobalt datasets.

In turn, the discussion section will also be more explicitly ordered, as suggested by Anonymous Reviewer #2. Our intention for the discussion was to justify the importance

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of the Peru margin cobalt source by looking broadly at the basin scale cycling of cobalt (and its need for continuous input from low-oxygen regions to maintain steady state), then examine that source more explicitly and compare it to other potential sources, and finally discuss how the intensity of this cobalt source may impact phytoplankton communities. We feel that discussion of the potential for cobalt limitation of phytoplankton growth is more meaningful once the distribution, sinks, and sources of cobalt have been discussed in detail. The revised manuscript will contain a short paragraph at the beginning of the discussion section to explicitly introduce the logic of the discussion section and inform the reader of what topics lie ahead. Current sections will be grouped into three super-sections: 1) oceanographic observations and coupling, 2) Sources of cobalt to the South Pacific, and 3) Cobalt scarcity in the euphotic zone. More generous use of subsections will mark shifts in focus (e.g. coastal Cobalt sources, hydrothermal sources).

Finally, we appreciate Reviewer #2's interest in the nature of the coastal cobalt sources and their informative calculation regarding the pathway of manganese sources in the same region. We agree that sources of Co and Mn appear to be highly coupled in this region, both in our data and in sediment investigations presented by Boning et al. 2004. In a revised draft we would like to make more explicit reference to the Mn porewater fluxes as a constraint on cobalt sources, demonstrated in Reviewer #2's comment. We will clarify our language so that we discuss a "coastal" cobalt source, rather than one explicitly originating from the sediments. However, since sampling on GP16 avoided areas of coastlines directly influenced input of terrigenous sediments, it unresolved whether that the Co and Mn sources do originate from sediments along river deltas or do represent an immediate desorption, as Reviewer #2 implies. Regardless, we appreciate the opportunity to clarify hypotheses about source mechanisms.

Mak Saito and Nick Hawco

Below, we address all explicit line comments from Reviewer 1:

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Reviewer 1:

Line 57. I'm not sure you can definitively say that Co is the least abundant inorganic nutrient, Cd is similarly in the same range, I'd say, "one of the least"

Will be replaced. However, while surface Cd concentrations are extremely low, the mean oceanic Co concentration is significantly less than Cd, see Moore et al. 2013.

Line 64. which suggests. . .

Will be changed

Line 88. 100 pM – the space between the value and unit is missing. This error occurs frequently, but not every time. I have not listed this observation where it occurs later in the text.

We apologize for these errors and will comb the manuscript to fix them.

Line 170. Include the resistivity of the Milli-Q water here. As Milli-Q is a brand name it might be better to say ultrahigh purity water, or something similar, instead of Milli-Q

Will change.

Line 145. Delete " is measured"

Will change

Line 203. 1.5 mL of 1.5 M sodium nitrate

Will change. However the reagent is nitrite, not nitrate.

Line 215. Broader than what? Just "broad" will do, perhaps with the range of tested concentrations stated.

Will change

Line 216. Replace "deviation" with "variance"

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Will change

Line 234. in the lab

Will change

Line 253. You should probably include the initials; C. Parker and K. Bruland

Will change

Line 281. What was the ratio of HCl: NHO3: HF?

Will add

Fig. 4. I think it would help the discussion to add some station numbers to this figure

We will modify this figure to add station numbers

Line 351. Baars and Croot (2015)

Will correct

Line 410. You shouldn't really be referring forward to Figure 13c here. This needs some rearranging so that you are not referring forward. You could simply use the values without referring to Figure 13c until later in the text. There are a number of instances that you are referring to figures that haven't been described yet, which you should try to avoid as much as possible

We appreciate this suggestion, will remove figure reference and change other figure references accordingly.

Line 445. ". . .new cobalt sourced from the shelf is rapidly incorporated into biological cycling and that the capacity for phytoplankton Co uptake. . ." - the biological cycle, or biological cycles

Line 502. delete "in the"

Will change

Line 527. Is there any documentation of reducing sediments on the South American continental shelf that could support your assertion?

This was address by Reviewer 2 as well. We will add more explicit reference to Scholz et al. 2011 (GCA),which documents metal reducing conditions in porewaters and their diffusive flux out.

Line 544. Consistent with release

Will change.

Line 547. Is this sentence reversed? ". . .sedimentation outpaces dissolution of Co and Mn only in very shallow water columns and/or proximal to input, which explains the lack of dissolved benthic maxima for both elements beyond Station 2". If sedimentation outpaced dissolution of Co and Mn in shallow water/close to source, then wouldn't we expect to see no benthic maxima?

Will change to "Most Co and Mn appears to be released directly to the water column rather than into sediment pore waters, although diffusive fluxes from porewaters are significant in very shallow water columns (<150m, Scholz et al. 2011, Boning et al. 2004).

Line 555. Delete second "should provide"

Will change

Line 603. As I understood the Noble et al (2012) study, the dCo and LCo plumes were extensive, but the dFe plume was much smaller and the dMn plume wasn't evident, at least in the ODV plot, although they do argue for a sedimentary source for all three elements, explaining the differences in plume areal extent by preferential scavenging of Mn>Fe>Co. This sentence needs rewording to reflect this.

This is correct that the dFe plume was much smaller than the dCo plume. We will clarify that it is smaller, in part due to faster scavenging kinetics for dFe. For Mn the

plume overlaps with the large surface maxima making the OMZ plume more difficult to observe. Moreover the larger abundances of Mn and its presumably labile form make it susceptible to faster removal than Co (which is scarcer and can be complexed).

Line 619. 20 μM dissolved O2

Will change

Line 627. This is also consistent with Sholkovitz and Copland (1981) who estimated that 97% of Co escapes from freshwater systems (Sholkovitz, E.R., and Copland, D., 1981. The coagulation, solubility and adsorption properties of Fe, Mn, Cu, Ni, Cd, Co and humic acids in river water. Geochimica et Cosmochimica Acta., 45, 181-189.)

We will include this reference. Reviewer #2 also suggested adding more nuance to our discussion of coastal cobalt source and the revised paper will mention the lack of Co coagulation in estuaries reported by Sholkovitz and Copland.

Line 683. counterpart?

Will change

Line 701. Or they can access the Co from the particulate pool? Is there any evidence for this in the literature?

This is an interesting point. As the particulate Co pool seems to be dominated by biomass, it is likely that much of the particulate dCo is continually recycled, as with other nutrients. We will add this to our list of possibilities outlined in this paragraph .It is somewhat uncertain, however, if the particulate biomass dCo represents free Co metal (i.e. labile Co) or strongly bound Co (such as cobalamins).

Line 706. Prochlorococcus produce ligands too. Might be worth mentioning this as you say that the Prochlorococcus abundance was high

We will add mention to this.

Line 729. Delete “of”

Will change.

Line 764: fluctuates

Will change.

References. Check your references as some of them are not displayed properly, e.g. Baxter et al (1998), Line 807, and there are some instances of extra, inconsistent punctuation.

We appreciate the detail undertaken in this review and will remove existing errors in reference formatting and punctuation.

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