Chromium Redox Speciation in Oxygen Minimum Zones in the South (SO289/GP21) and Equatorial (SO298/GP11) Pacific Ocean

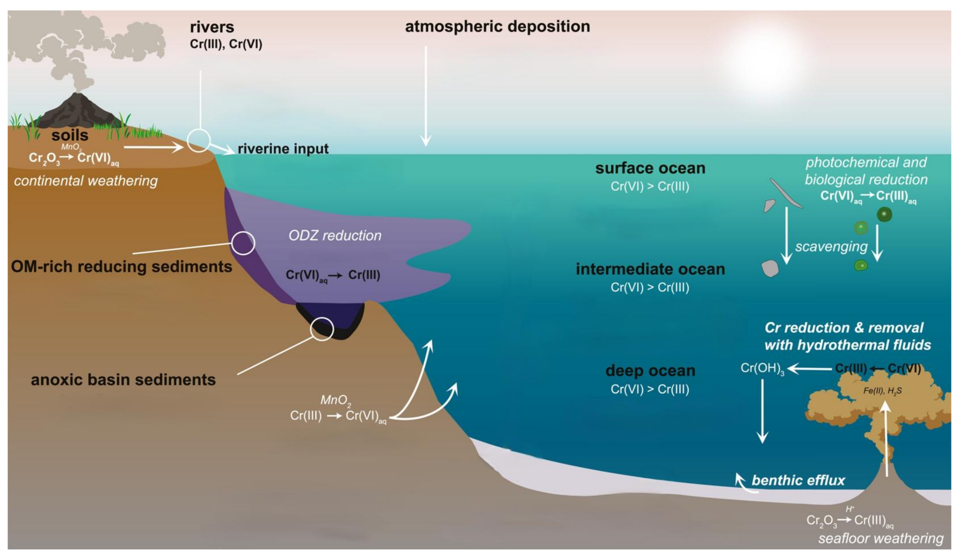
Natasha van Horsten*[1], Sandra Pöhle[1] and Andrea Koschinsky[1]
[1] School of Science, Constructor University Bremen gGmbH, Germany
***nvanhorsten@constructor.university**

Introduction

Main sources
- **Riverine input**
- **Benthic efflux**

Main sink
- **Reduced removal via scavenging**

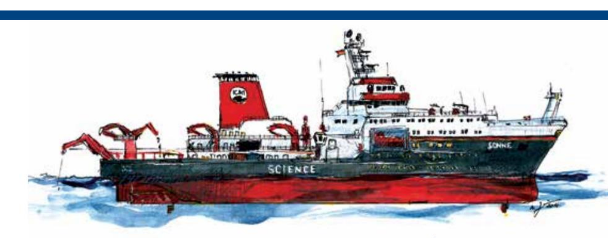
Internal redistribution via ocean circulation

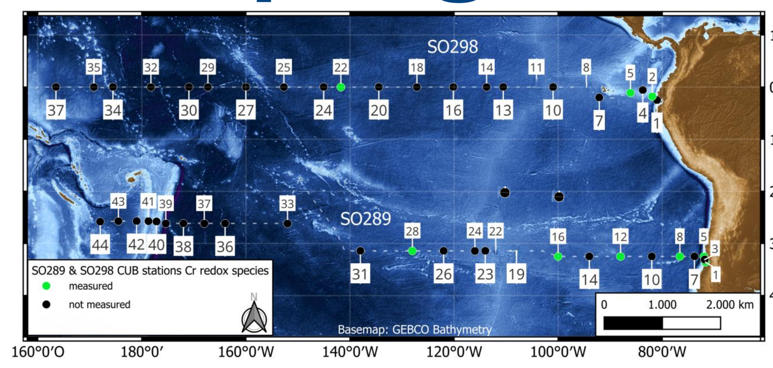


Simplified schematic of the marine Cr cycle, modified from Janssen et al. (2025)

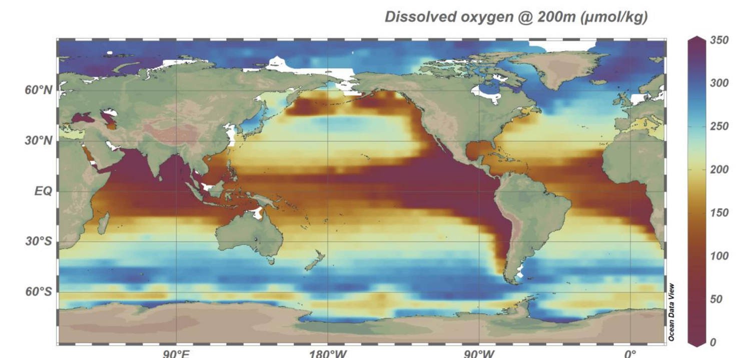
Cr(VI) – Highly soluble, mobile, toxic and thermodynamically favoured in oxic waters
Cr(III) – Thermodynamically favoured in anoxic waters, poorly soluble, particle reactive removed down to low concentrations via scavenging
Higher concentrations of Cr(III) observed than thermodynamically expected stabilization by organics and colloids
Cr redox speciation acts as a marine oxygenation paleo-proxy

Sampling area





Sampling map of samples collected for Cr redox speciation analysis during SO289/GP12 and SO298/GP11. Green dots indicate profiles analysed and black dots indicate stations to be analysed.



Global ocean dissolved oxygen concentration at 200m depth, highlighting the OMZs in red.

Analysis

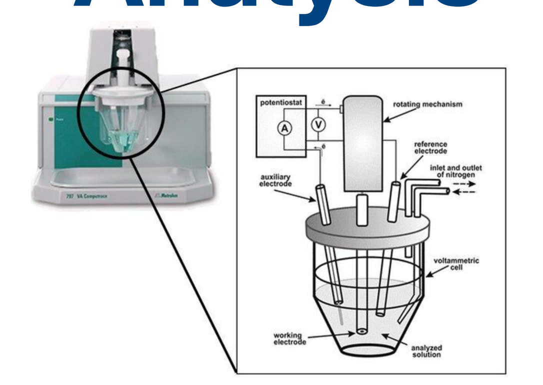
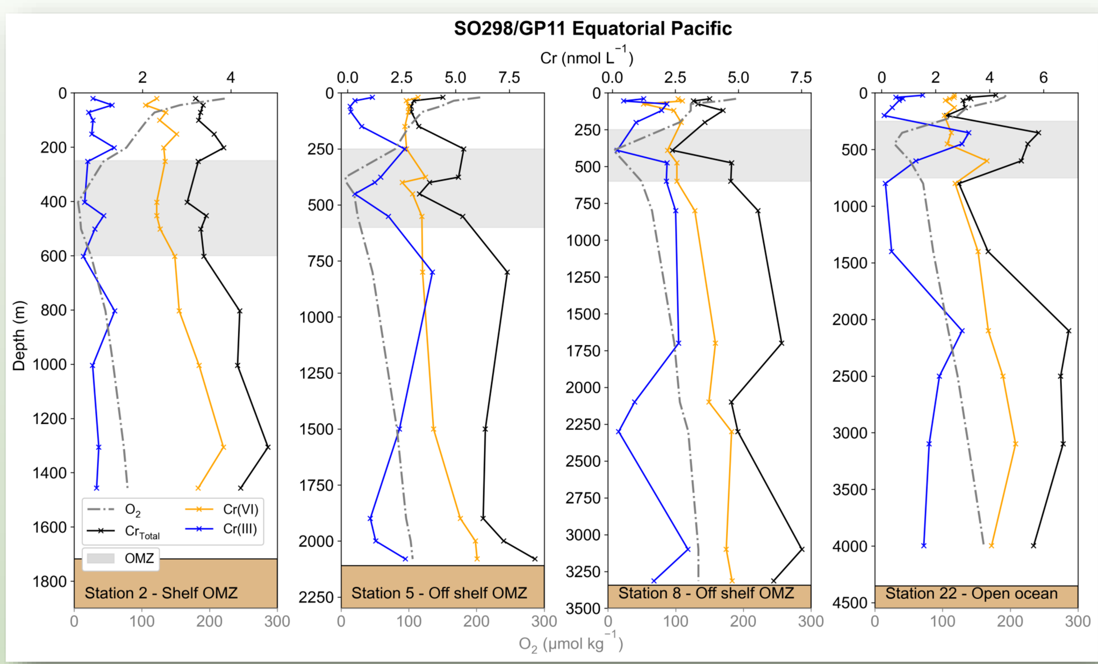


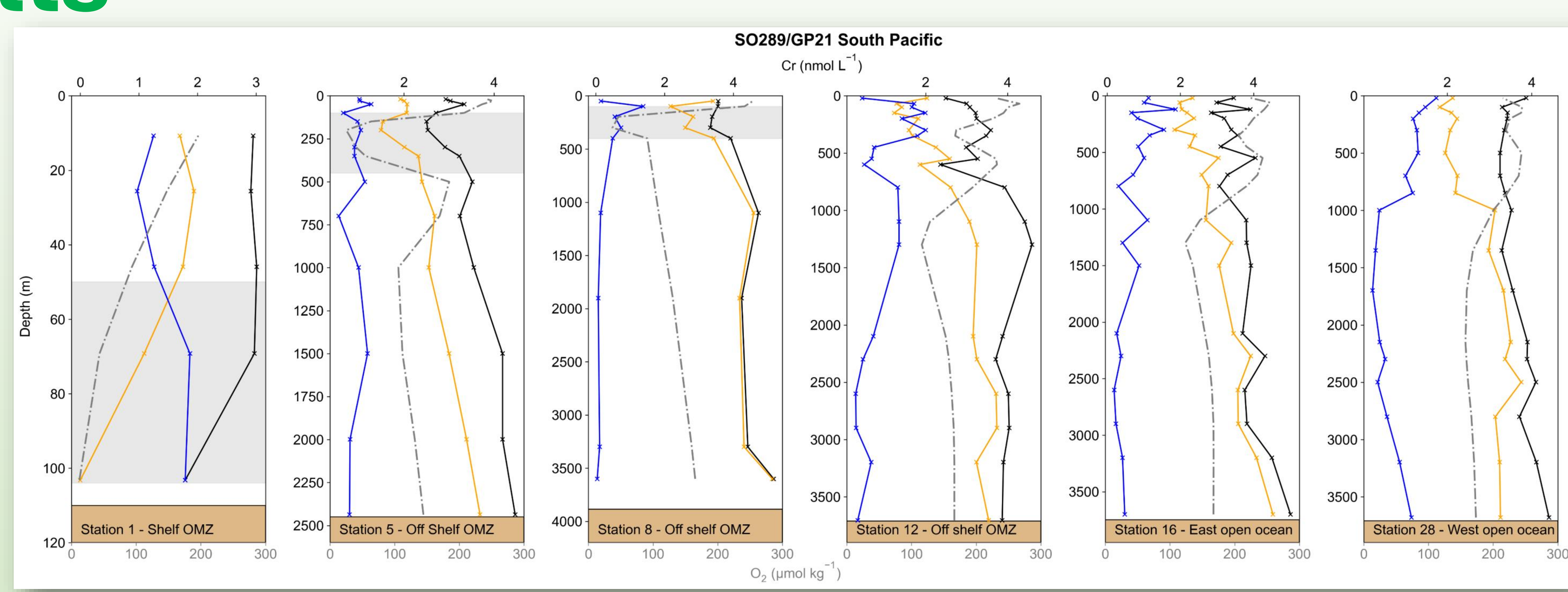
Figure from Mohamed et al. (2019)

Cr(VI) and analysis using adsorptive cathodic stripping voltammetry
Cr_{Total} UV digestion and analysis using adsorptive cathodic stripping voltammetry
Cr(III) calculated by difference

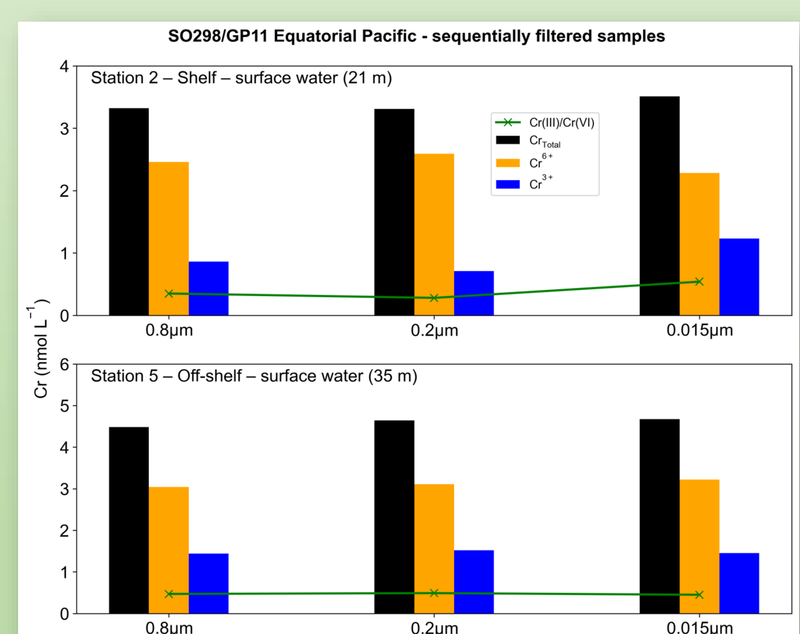
Results



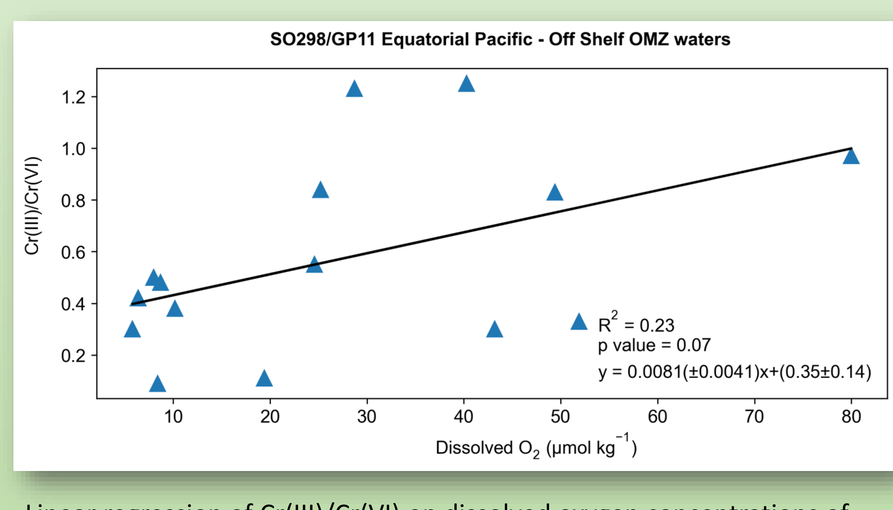
Cr concentration profiles of 4 stations sampled during the SO298 cruise. Station 2, in the OMZ on the Ecuadorean continental shelf, station 5 and 8 in the OMZ off the continental shelf, and station 22 sampled in the open ocean. Cr_{Total} in black, Cr(VI) in orange, Cr(III) in blue and oxygen in grey.



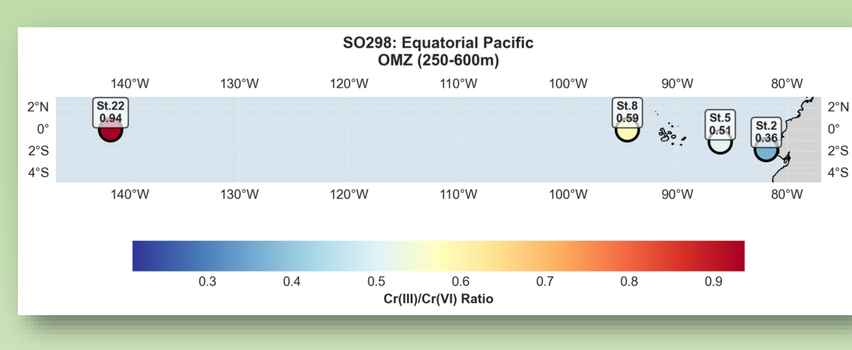
Cr concentration profiles of 6 stations sampled during the SO289 cruise. Station 1, in the OMZ on the Chilean continental shelf, stations 5, 8 and 12 in the OMZ off the continental shelf, station 16 sampled in the eastern open ocean, and station 28 in the western open ocean. Cr_{Total} in black, Cr(VI) in orange, Cr(III) in blue and oxygen in grey.



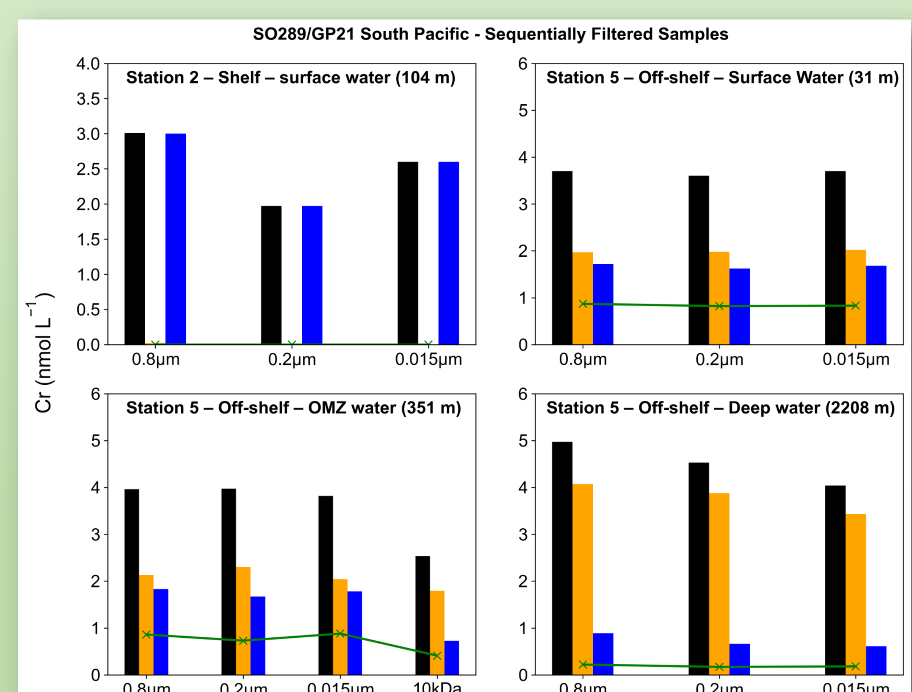
Cr concentrations of samples filtered sequentially through 0.8µm, 0.2µm and 0.015µm filters. Top: Surface water sample taken at station 2 – Shelf OMZ; bottom: Surface water sample taken at station 5 – off shelf OMZ. Cr_{Total} in black, Cr(VI) in orange, Cr(III) in blue, and Cr(III)/Cr(VI) overlayed in green.



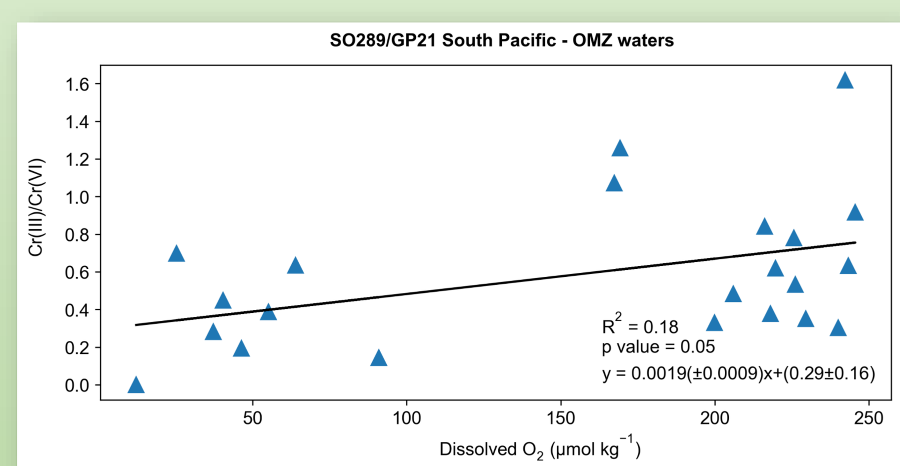
Linear regression of Cr(III)/Cr(VI) on dissolved oxygen concentrations of samples collected in the OMZ depth range, at off shelf OMZ stations.



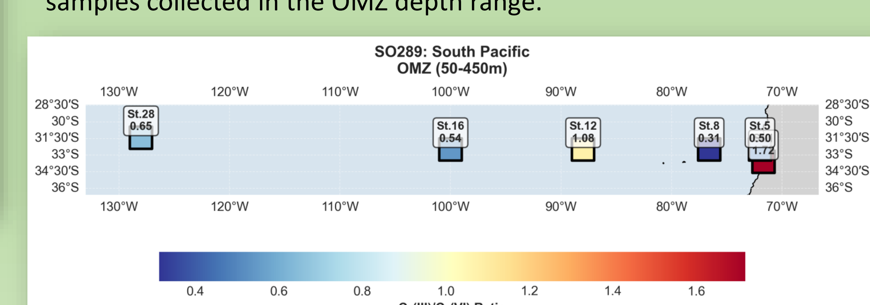
Map displaying the mean Cr(III)/Cr(VI) within the OMZ depth range, along the SO298/GP11 transect.



Cr concentrations of samples filtered sequentially through 0.8µm, 0.2µm and 0.015µm filters. Top left: Surface water sample taken at station 2 – Shelf OMZ; Top right: Surface water sample taken at station 5 – Off Shelf OMZ; Bottom left: OMZ water sample taken at station 5 – Off Shelf OMZ, and Bottom right: Deep water sample taken at station 5 – Off Shelf OMZ. Cr_{Total} in black, Cr(VI) in orange, Cr(III) in blue, and Cr(III)/Cr(VI) overlayed in green.



Linear regression of Cr(III)/Cr(VI) on dissolved oxygen concentrations of samples collected in the OMZ depth range.



Map displaying the mean Cr(III)/Cr(VI) within the OMZ depth range, along the SO289/GP21 transect.

Conclusions and Perspectives

- Cr(III)/Cr(VI) ratios have a **weak but statistically significant correlation with dissolved oxygen →** Oxygen concentrations appears be one of the factors controlling Cr redox speciation → not the main driving factor in the eastern Equatorial and South Pacific Ocean.
- Controls on Cr redox speciation appear to be heterogenous → biological factors can be a stronger control in shelf waters.
- **No significant size fractionation** is observed → both Cr redox species appear to be in the **soluble phase**
- A steady **westward increase in mean Cr(III)/Cr(VI)** is observed in the OMZ, along the **Equatorial Pacific** transect, whereas no consistent trend is observed along the South Pacific transect, where the highest ratio is observed at the coastal station.
- This data will be combined with data from studies in the southeastern and northeastern Atlantic, and the southwestern Indian oceans for a global view of environmental controls on Cr redox speciation in OMZs/upwelling areas

Acknowledgements

Funding by BMBF: project no. 03G0289NB and 03Go298B
David Janssen and Sylvia Sander insightful discussions.
Eric Achterberg (Chief scientist) and team (GEOMAR) for cruise organisation and trace metal clean sampling.
Crew and research participants of the SO289 and SO298 cruises

References

Janssen, D. J., Bauer, K. W., Bruggmann, S., & Crowe, S. A. (2025). The global biogeochemical cycle of chromium at the Earth's surface. *Global Biogeochemical Cycles*, *39*(6), e2025GB008525.
Mohamed, K. N., Godon, E., Johan, S., & Jaafar, F. S. (2019). Distribution of dissolved Aluminium (dAl) in seawater at Pulau Perhentian, Terengganu. *Malaysian Journal of Analytical Sciences*, *23*(6), 1044-1053.
Nakayama, E., Kuwamoto, T., Tsurubo, S., & Fujinaga, T. (1981). Chemical speciation of chromium in sea water: Part 2. Effects of manganese oxides and reducible organic materials on the redox processes of chromium. Analytica Chimica Acta, 130(2), 401–404. https://doi.org/10.1016/S0003-2670(01)93020-X.