SO298

RV Sonne

Cruise SO298 Equatorial Pacific GEOTRACES GP11

14th April – 2nd June 2023

Guayaquil (Ecuador) – Townsville (Australia)

6. Weekly Report

Reporting Period: 15th – 21th May 2023

Along the equator with currents, nutrients, bioassay experiments and mercury measurements

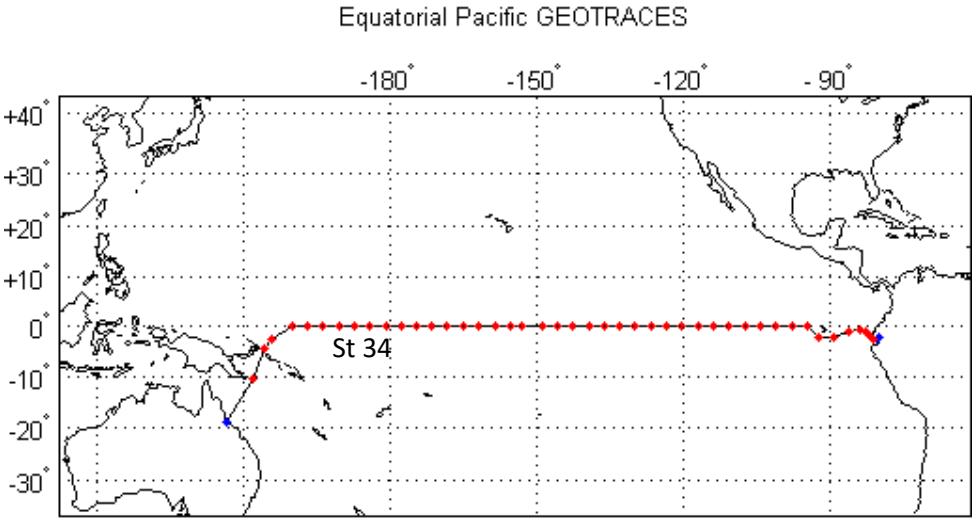


Fig. 1: Map of Pacific Ocean with our cruise track (black line), stations (red dots) and current station 34 indicated.

Progress: We are 5 weeks into our cruise programme, and sailing along the equator at 175°E towards the in the third island group of Kiribati (Fig. 1). Finally the opposing currents the direction of the vessel have disappeared, and the surface currents are now pushing us towards the west. We have conducted whale watching activities in recent days near the US islands of Howard and Baker. Again, no

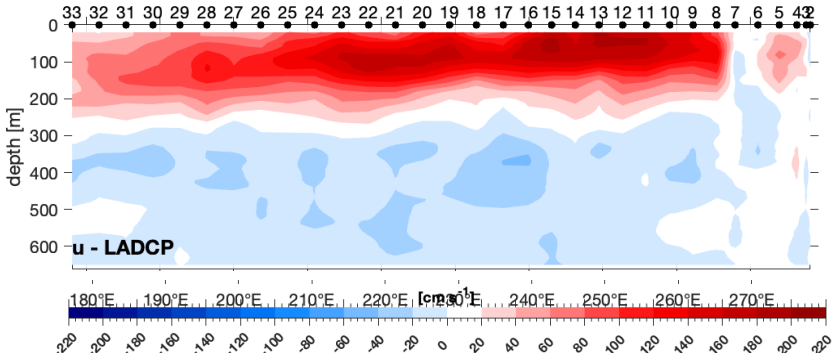


Figure 2. Zonal (west to east) ADCP observations in top 600 m of water column. Core of the EUC with currents deepening towards the west, and now at more than 150 m (at ~1 knots). Data from Rena Czeschel.

sightings of whales, just a few terns who had lost their way.
The core of the Equatorial Undercurrent (EUC) is now deeper and weaker at < 1 knots (Fig. 2). In Figure 2 we see observations made with the lowered ADCP, with the west to east flowing EUC (red colour) at greater depths and also the intensity of the red colour (current strength) is decreasing. Nutrient concentrations have not yet declined in surface waters. We are still sampling surface waters with nutrient concentration of ~3 µmole/kg nitrate.

Controls on surface ocean productivity: The study region is understudied with regards to nutrient limitation; for example the basic experimental data is lacking to demonstrate limitation by nitrogen (N), phosphorus (P), iron (Fe), or other essential micronutrients. Some first-order predictions can be made from available distributions of nitrate and phosphate from the World Ocean Atlas. Historical observations of nitrate reveal generally replete levels along the transect up to 170°E. The eastern part of the transect passes through regions with >5 µM nitrate, and the presence of residual N is suggestive of (co-)limitation by another nutrient, and given the excess P, strongly indicates insufficient Fe.

Our bio-team with Zhongwei Yuan, Brandy Robinson, Ze Chen, Anne Imig and Jiaying Guo, are investigating the (micro-)nutrient controls on phytoplankton productivity. The team collects surface ocean waters and incubates the waters for a period of 48 h on deck under controlled light and temperature conditions, following the addition of N, P, Fe and combinations thereof. Various variables, including chlorophyll a are measured following the incubation period. Figure 3 shows the results of an incubation experiment, indicating changes in chlorophyll-a biomass, a pigment found in all phytoplankton, in response to supply of N, Fe, or N and Fe combined (N+Fe) after 48 hours. The experiment is conducted with surface water sample collected along the equator (station 17). The largest response is seen in response to Fe supply, suggesting Fe is approaching levels low enough to limit phytoplankton growth. Considering the enhanced nitrate (and phosphate) concentrations observed along the cruise track so far, because of the shallow EUC, this result was expected.

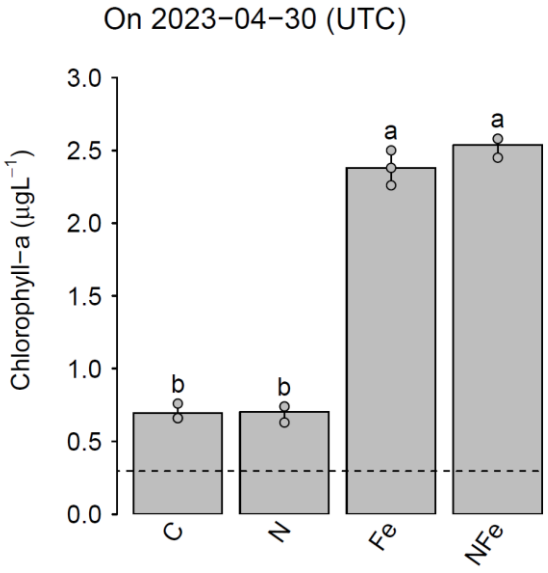
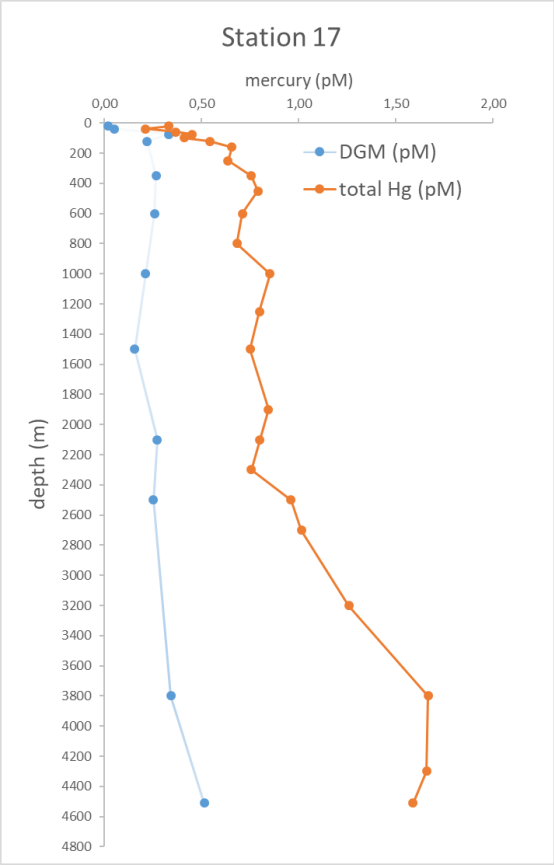


Figure 3. Changes in chlorophyll-a biomass, a pigment found in all phytoplankton, in response to supply of nitrogen (N), iron (Fe), or nitrogen and iron combined (N+Fe) after 48 hours. C is the control incubation. Experiment is conducted with surface water sample collected at station 17. The largest response is seen in response to Fe supply, indicating that Fe is approaching levels low enough to limit phytoplankton

Mercury observations: Mercury (Hg) is a natural but also a very toxic element, and the various chemical Hg species can have detrimental impacts on marine ecosystems. There is a lack of understanding of Hg sources, speciation, cycling, and distributions in marine systems. The atmospheric component dominates the global transport of Hg and has a significant influence on oceanic Hg fluxes. Natural sources of Hg include geologically active systems such as volcanoes and hydrothermal vents. Coal burning, cement manufacturing and other industrial practices form the majority of anthropogenic Hg emissions to the atmosphere and oceans, and these have persistently increased over the last 5 decades.

On cruise SO298, Kati Gosnell and Marco Ajmar perform an ocean basin wide study in the Equatorial Pacific Ocean to assess Hg sources, speciation and cycling in one of the remotest ocean regions on our planet. The analysis for total Hg and gaseous Hg concentrations on SO298 is conducted on board by Kati and Marco. The data is immediately available and is showing the importance of various sources along the section.



The Equatorial Pacific Ocean is host to many active seismic margins and hydrothermal vent fields and therefore subject to various natural Hg inputs. However, there is a paucity of Hg data for this region, and hence our understanding of Hg sources and behaviour is poorly constrained for this basin. Figure 4 shows an increased in total Hg concentrations with depth at station 17, with highest total dissolved Hg concentrations of 1.5 pM at about 4 km in waters of Antarctic origin (Lower Circumpolar Deep Waters). Dissolved gaseous Hg concentrations were also highest in the deep waters, up to 0.5 pM. There are indications of enhanced concentrations in the EUC at around 100 m depth.

RV Sonne at sea 0°S/175°E

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Figure 4. Preliminary data for total Hg and gaseous Hg at station 17 in the Equatorial Pacific Ocean. Data by Kati Gosnell and Marco Ajmar.