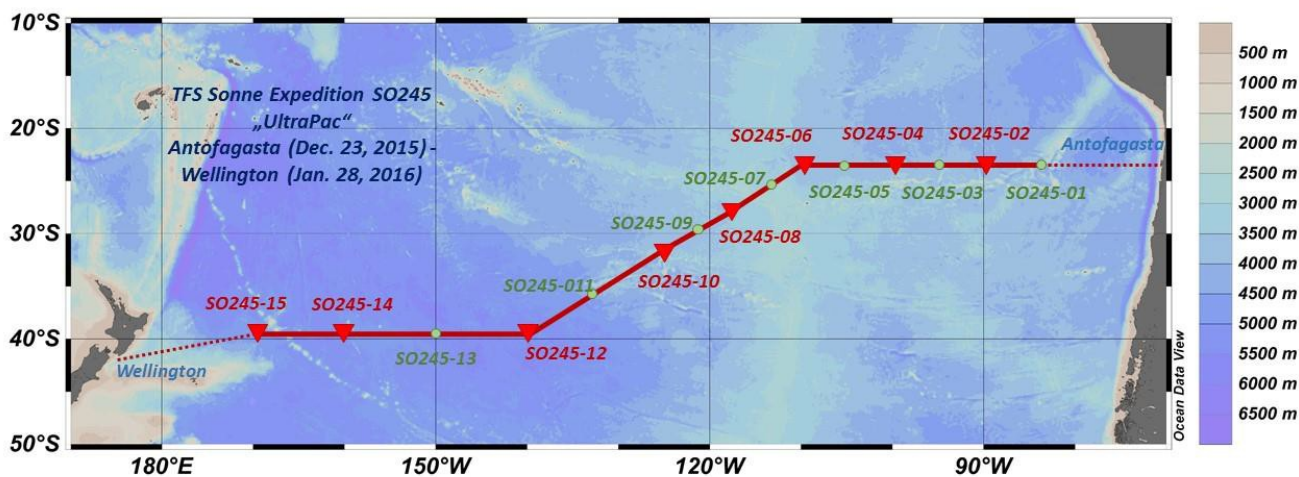


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Short Cruise Report TFS Sonne SO245

Antofagasta, Chile – Wellington, New Zealand
December 17, 2015 – January 28, 2016
Chief Scientist: Timothy G. Ferdelman
Captain: Lutz Mallon



Objectives

Due to its extreme remoteness from any continents, the surface waters of the South Pacific Subtropical Gyre (SPG) are the most oligotrophic in the global ocean, with the clearest waters and lowest sea surface chlorophyll a concentrations. Recent studies indicate that microbial nutrient and carbon cycling is especially adapted for these ultraoligotrophic waters, and SPG may be a significant region of nitrogen fixation. We conducted a cross-gyre transect to investigate the controls on nitrogen, phosphorus and organic carbon cycling, trace element isotope geochemistry, and microbial ecology in the water column and surface sediments at 8 main stations, and 7 intermediate stations. The transect proceeded east to west over three sections: a) 25°30' S along the northern side of the gyre from 84°33'W to 110°00'W, b) southwest to 39°S 140°W through the heart of the gyre, and c) further westward along 39°S to 170°W where we linked up with GeoTraces station GR11. Sampling included extensive CTD-Niskin bottle sampling casts throughout the water column, in situ pump deployments at all main stations, plankton net sampling, high-resolution pumpcast sampling of the surface 200 meters, optical properties profiling, and box and gravity coring of the sediments.

A special focus of the expedition was on process studies, using radio-labeled and stable isotope tracer experiments to experimentally examine biogeochemical and microbiological processes. Bacterial cell counts, identification of cells with high throughput fluorescent in situ hybridization (FISH), and onboard 16S rDNA tag sequencing was performed at near to real-time pace. Additional underway sampling of salinity, temperature, fluorescence, aerosol measurements, dust collection, surface bacterial counts, microplastics and bird observations were also made. Rare earth element and U-Th series isotope samples were obtained to address water mass provenance and particle fluxes.

Anthropogenic nutrient loading continues to impact sub-tropical gyres and the South Pacific Gyre may be the last, pristine gyre system in the world ocean, where ultra-oligotrophic (microbial) community function might be studied. UltraPac provides baseline data and understanding of the the chemical and microbiological structure and function of this vast, important but rarely studied ecosystem.

Narrative

On Wednesday the 16th of December, all scientific members of the SO245 *UltraPac* expedition to the South Pacific Gyre (SPG) arrived and boarded the *TFS Sonne* in Antofagasta, Chile. The scientific crew of 33 souls representing seven institutes and nine nationalities were ready embark on a trans-Pacific expedition to investigate the geochemistry, biology, microbiology, optical properties, molecular ecology and biogeochemistry of the Earth's largest and most ultra-oligotrophic gyre system.

The scheduled sailing date was originally set for Thursday 17th of December. Unfortunately, and for reasons beyond our control and understanding, only a fraction of critical scientific and ship's spares had arrived in Antofagasta as of the expected sailing date. Furthermore, a service technician who was supposed to repair the malfunctioning liquid scintillation counter in the isotope container failed to appear, and a back-up brought by the NOC scientists suffered a catastrophic detector failure, thus severely constraining our plans for radio-isotope experiments. After nearly six days delay *Sonne* cleared the harbour entrance at 2 AM in the morning on the 23rd of December and the SO-245 *UltraPac Expedition* was truly underway.

We arrived at our first station SO245-01 on Christmas Day. We combined our first two planned shallow water stations (to 500 meter water depth) into one somewhat larger station (SO245-01) in order to test equipment and sampling protocols for the expedition. Furthermore, the station allowed us to estimate the influence of the Humboldt Upwelling region on the eastern boundary of the South Pacific Gyre.

With the first station behind us, we settled into a routine of mid-day intermediate stations followed by 40 - 42 hour main stations. The intermediate stations typically included two CTD-bottle casts through the deep Chl a maximum to 500 meters, a shallower CTD-bottle cast for collecting water for incubation experiments, a Go Flo bottle deployment and the UV and optical profiling program.

Main stations work typically commenced operations with short 15-25 nautical mile Parasound and Multibeam (EM 122) surveys of the area to evaluate seafloor bathymetry. The information was used to estimate CTD maximum depths as well as determine suitable site for later geological coring operations. Water column sampling included five to six CTD Niskin Bottle Rosette sampling over the entire water column. A Secchi Disk/Forel-Ule Ocean Color deployment was included with the UV and Optical Stalantic profiler program in order characterize ocean optical properties. Continuous flow pumpcast CTD, Go-Flo Bottles and Micronet deployments to 250 meters were made on a plastic coated cable run off the starboard stern of the ship. Eight McLane in situ Pumps via the CTD cable for the collection of particles for U-Th, rare earth element isotope distributions and microbial populations were deployed throughout the entire water column. Pump deployment time was set for six hours (except at Station SO245-15 where pumps were deployed for three hours over the upper 1250 m). At all eight main stations, the eight in situ pumps performed flawlessly, pumping 200 to 1500 liters of water at various depths. Overall we obtained 64 priceless filters sampled *in situ* from across the entire South Pacific that are now available for particulate bound isotope and molecular ecology studies.

The first CTD traces west of 84°W showed a 40 m surface mixed layer and a broad and distinct chlorophyll a maximum centered around 100 meter water depth (see Figure 1) Below the pycnocline, dissolved oxygen concentrations dropped to 20% saturation, reflecting the influence of the oxygen minimum zone that extends offshore from the South American continental margin. In the first week of January we had reached the first hinge point where we turned southwest from our transect along 23°30'S and headed into the heart of the SPG. The chlorophyll a maximum, the layer where most photosynthetic activity and organic carbon production occurs, deepened from 70 meters near our first sites closer to Chile to depths of 190 meters below the sea-surface in the latter stations SO245-04 to SO245-06 (100° to 110° W respectively). In the gyre the Chl a formed a thick layer of between 150 to 250 meters water depth. Even though the Chl a max deepens it's intensity as measured by the downcast CTD fluorescence remained constant along our 23°30' S east to west transect. Interestingly, bacterial cell counts and total organic carbon contents were greater above the chlorophyll peak.

Southwestward and towards the outer edge of the gyre beginning with Station SO245-11, chlorophyll contents began to shoal, with detectable fluorescence in the upper mixed 40 meters of water at Stations SO245-11 and SO245-12. Along the 39°S section, chlorophyll rich waters between the surface and 112 meters with a peak at around 55 meters, abundant diatoms on filters and micronet samples indicated that we were out of the oligotrophic gyre. Ongoing, bacterial cell counts, identification of cells with high throughput fluorescent in situ hybridization (FISH), and onboard 16S rDNA tag sequencing were also carried out onboard at a near to real-time pace by the MPI Molecular Ecology group. These onboard analysis yielded unique insights into the changing microbial community structure as we moved out of the gyre into more productive waters.

Approximately halfway through the expedition we also crossed the East Pacific Rise, the impressive north-south range that divides the South Pacific Ocean seafloor into eastward and westward moving ocean crust. In doing so we also crossed the *Biosope* Expedition transect (from Tahiti to Valparaiso, Chile, 2004) and reoccupied the “GYR4” station of the *Biosope* expedition at our intermediate Station SO245-07. Due to various time-saving measures and the excellent 13 knot sailing speeds of the *Sonne*, we decided to pursue our original plans to address diurnal variation in the microbial populations at gyre station(SO245-08). The extra 12 hours of station time included four extra high resolution CTD-bottle casts through the upper 250 meters of water throughout the night of January 6 throughout the following day, where sun-driven peroxide production throughout the upper water column was documented. A small boat foray was also launched to obtain uncontaminated surface seawater trace element samples away from the boat.

Box coring operations were successful at all eight main stations; gravity coring less so. At SO245-02 box coring yielded a thin 20 cm layer of brown clays overlying a stiff carbonate layer at SO245-02. At the next main SO245-04 we recovered excellent box and gravity cores containing fine brown clays of 50 and 375 cm length respectively. The box core at Site SO245-10 returned with pebble sized manganese nodules scattered randomly across the surface, whereas the box cores at SO245-12 though SO245-15 were covered with 3-7 cm diameter manganese nodules. Cores and sediment samples were processed and stored for curation at the MARUM GeoB Core Repository in Bremen.

The *UltraPac* expedition was generally blessed with good weather. Only at Station SO245-11 did the weather and sea-state take a turn for the worse. Long period swells and wave heights of up to 5 m and winds from the south slowed transit speeds to 11 knots and caused some deployments to be cancelled. Although we had gained considerable time over the initial science plan with increased ship speeds and shortened station times, the loss of days at the beginning of the cruise and the uncertain weather situation in latitudes south of 40°S led us to move the last main and intermediate stations northwards along 39°S. At Station SO245-15 we were still able to link up with a *GeoTraces* north-south transect station (GR12). As the *UltraPac* expedition is listed as a *GeoTraces* Data Compliance and Process Expedition, we were pleased to have adequate time to sample this site, especially for the rare earth element and U-Th isotope studies.

On January 25, the last coring operations were completed and at 06:00 we turned our course for Wellington, marking the end of our approximately 4600 nautical mile scientific transect through the South Pacific Subtropical Gyre. After fifteen stations and nearly 200 sampling events over fifteen and one-half days of station time, laboratory operations ceased on the evening of January 26th. Final packing of airfreight and six containers of laboratory equipment and samples on January 28, 2016 in Wellington Harbor, concluded the shipboard activities the *TFS Sonne UltraPac Expedition SO245*.

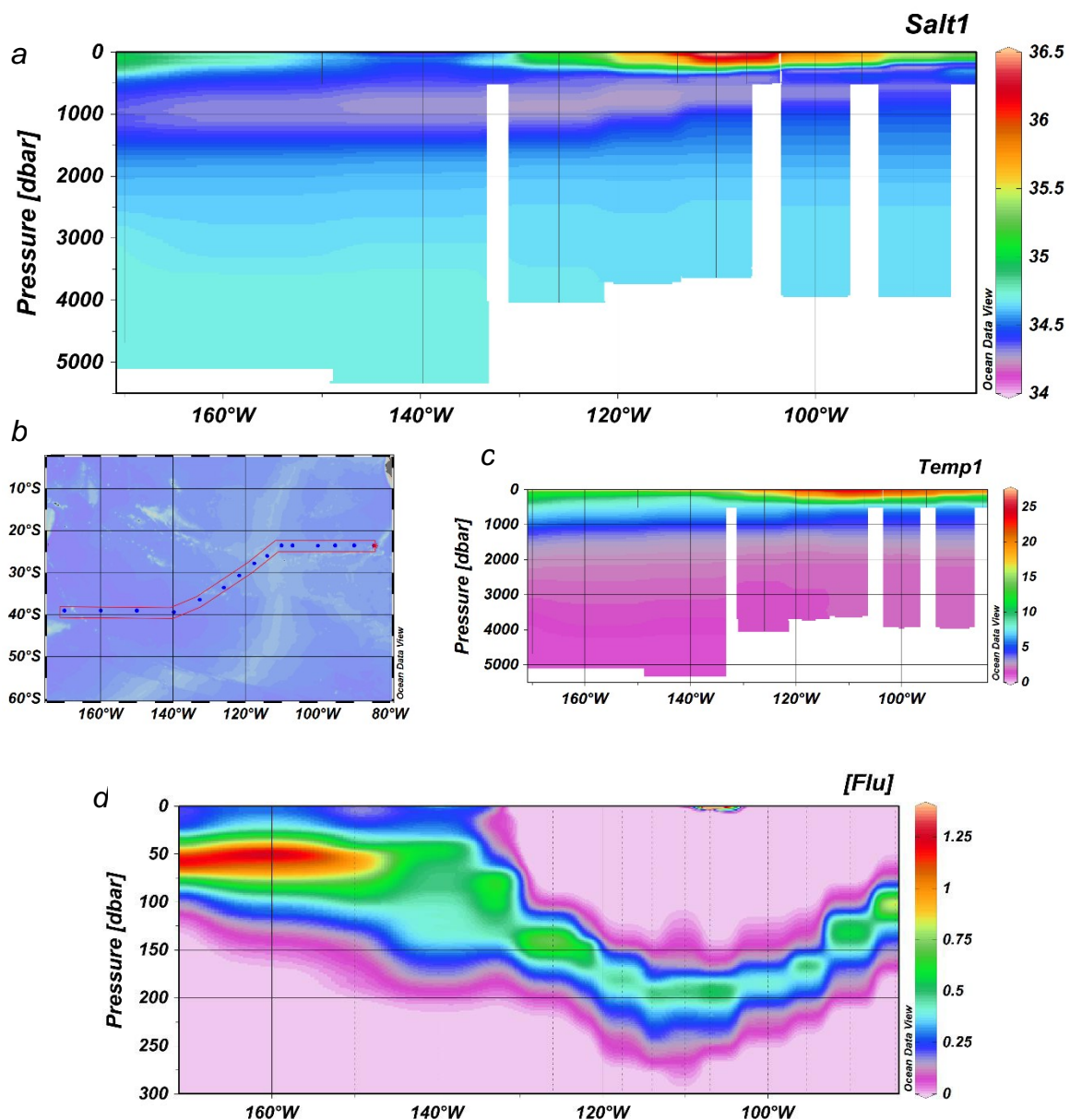


Figure 1 CTD derived parameters mapped out over the transect from *TFS Sonne SO245 UltraPac* expedition: a) salinity (units ppt), b) cruise track, c) temperature (units, °C), and d) fluorescence as measure of chlorophyll a content (units $\mu\text{g chl a kg}^{-1}$ seawater).

Acknowledgements

We would like to express our sincere thanks to Captain Lutz Mallon and his crew for the ever-present and always friendly support of our research activities. We thank all the shore-based technicians, administrative personnel and scientists, especially U. Tietjen, K. Imhoff, S. Lilienthal, H. Wojack, T. Wilkop, A. Heinrichsdorff and P. von Dassow, who helped make this this expedition happen. The German Federal Ministry of Education and Research (BMBF) generously provided the main funding for this expedition. Contributions also came from: the Max Planck Society (Germany), the German State of Lower Saxony, the National Environmental Research Council of Great Britain, the Science Foundation of Ireland, the European Regional Development Fund and the US National Science Foundation.

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Station List

Station	Start Date / Time UTC	End Date / Time UTC	Latitude	Longitude	Depth (m)
SO245-01	25.12.2015 18:03:30	26.12.2015 04:39:09	23° 30,190' S	84° 33,745' W	2764
SO245-02	27.12.2015 03:29:18	28.12.2015 18:42:21	23° 30,010' S	89° 55,807' W	3900
SO245-03	29.12.2015 18:03:03	29.12.2015 22:08:03	23° 29,964' S	95° 17,718' W	3772
SO245-04	30.12.2015 19:03:26	01.01.2016 09:09:12	23° 30,007' S	100° 0,005' W	3880
SO245-05	02.01.2016 14:30:32	02.01.2016 19:18:56	23° 30,013' S	106° 59,917' W	3878
SO245-06	03.01.2016 09:21:27	05.01.2016 02:30:10	23° 30,006' S	110° 2,968' W	3613
SO245-07	05.01.2016 22:20:33	06.01.2016 03:50:42	25° 57,856' S	114° 1,099' W	2940
SO245-08	06.01.2016 21:40:53	08.01.2016 23:56:02	27° 44,456' S	117° 37,131' W	3698
SO245-09	09.01.2016 21:02:00	10.01.2016 01:17:57	30° 37,897' S	121° 45,803' W	3780
SO245-10	11.01.2016 01:10:25	12.01.2016 16:07:49	33° 30,011' S	125° 59,972' W	4016
SO245-11	13.01.2016 22:07:05	14.01.2016 03:58:18	36° 21,736' S	132° 40,500' W	5069
SO245-12	15.01.2016 10:40:02	17.01.2016 06:16:27	39° 18,569' S	139° 48,565' W	5310
SO245-13	18.01.2016 15:52:03	18.01.2016 22:39:02	38° 59,889' S	149° 59,980' W	5481
SO245-14	20.01.2016 07:00:00	22.01.2016 01:12:48	39° 0,000' S	159° 56,182' W	4981
SO245-15	23.01.2016 09:24:10	24.01.2016 16:17:50	39° 1,694' S	169° 58,286' W	4612