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Short Cruise Report
RV Sonne, cruise SO298

Guayaquil (Ecuador) – Townsville (Australia)
April 14 – June 2 2023
Chief Scientist: Eric P. Achterberg
Captain: Tilo Birnbaum

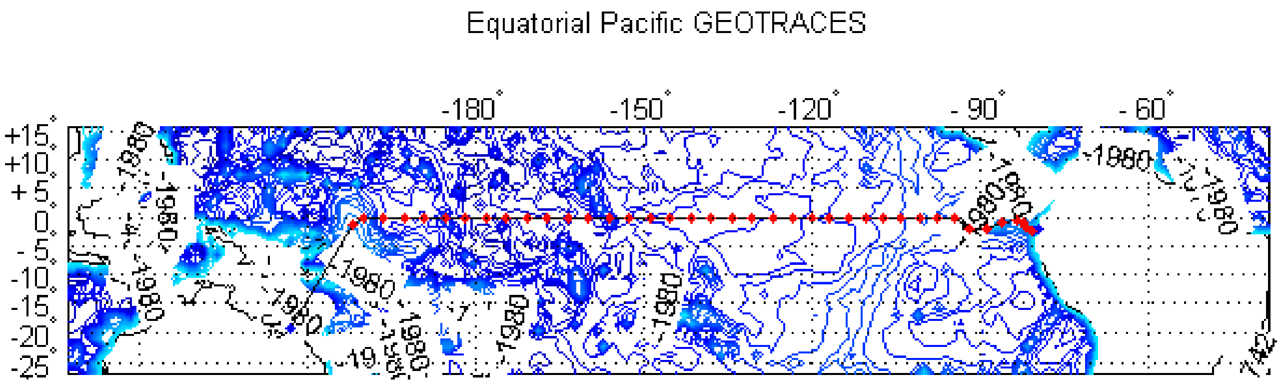

Fig. 1: Cruise track (black line) and stations locations (red dots) of RV SONNE cruise SO298

Objectives

The main **scientific aim** of the proposed work is to establish the distributions of trace elements and their isotopes (TEIs), quantify their sources from the four major ocean boundaries (rivers, atmosphere, exchange with sediments, ocean crust), and determine their biogeochemical cycling and relationships to large scale ocean circulation along a cruise track in the Equatorial Pacific Ocean (EPO).

The **major questions** that we will address on the proposed cruise are:

1. The EPO surface waters exhibits a transition from high nitrate low chlorophyll (HNLC) waters with probable iron (Fe) limitation in the east to oligotrophic conditions with low concentrations of nitrate and micronutrients (Fe, cobalt (Co), zinc (Zn)) in the west. What are the proximally limiting or co-limiting (micro)nutrients for surface ocean productivity along cruise track, and how do N_2 fixation rates and diazotrophic communities change?
2. The sources, sinks, and internal cycling of TEIs in the EPO are poorly understood despite the importance of this region for the global cycling of nutrients and carbon. Which processes control the fluxes, supplies and cycling of TEIs?
3. Seafloor spreading centres along the East Pacific Rise (EPR) are well-known, but the region near Papua New Guinea in the Western EPO also features hydrothermal activity and provide deep water Fe inputs. Are there notable hydrothermal Fe fluxes in the western EPO, and can we determine the length scales of the Fe plumes?
4. Are the Central American and Papua New Guinean shelf and slope systems important sources of Fe and other TEIs to the Pacific Ocean along our ocean section?
5. The zonal current systems form a prominent feature of the EPO. The Equatorial Undercurrent (EUC) is the dominant zonal current with respect to volume transport along the equator, transferring TEI-rich waters from the west EPO shelves eastwards along the equator, and supplying micronutrients following upwelling to surface waters in the EPO and Peruvian coastal regions. How large is the EUC TEI transport?
6. Intermediate and deep water masses in the Pacific upwell in the tropical Pacific, and therefore supply micronutrients to the EPO. The Fe/N ratios in these waters are likely below those required by phytoplankton communities in surface waters, but in terms of the total Fe supply to the surface ocean, these waters make a contribution to setting surface productivity.
7. Enhanced productivity in the EPO facilitates particle export from the surface to deeper ocean. Can we observe a zonal variation in carbon export and nutrient utilisation (Si, Ba isotopes) related to upwelling strength and supplied (micro)nutrients?
8. How does large scale ocean circulation affect the TEI distributions in surface and subsurface EPO water masses? Is the advection of intermediate depth water masses from the Southern Ocean reflected by their TEI distributions (including Nd isotopes, REEs)?

We have the following **major goals** that we want to achieve for the proposed cruise:

- Obj 1. Determine the distribution, as well as the physical and chemical speciation of TEIs, including micronutrients (such as Cd, Co, Cu, Fe, Mn, Mo, Ni, V, Zn, Cr), non biologically essential elements (such as Al, Pb, Hg, Ti, Zr, Hf, Nb, U, W and REEs) and a range of isotope systems (including Pa/Th, Ra, Nd, Ba, Si, Pb, Fe, Cd) in high resolution full-depth profiles and along a continuous surface water section.
- Obj 2. Quantify the fluxes of these TEIs and micronutrients to the ocean from the four ocean boundaries: atmosphere, continent, ocean crust and sediments and assess the role of physical and chemical speciation of TEIs for their fluxes from the different sources.
- Obj 3. Assess, using chemical tracers and physical oceanography, the mixing and advection of these TEIs away from their sources into the ocean interior, and upwards into the surface ocean.
- Obj 4. Explore the relationship between macro- and micro-nutrient concentrations and fluxes, ocean productivity, particle and zooplankton distribution, metagenomic markers of particle export, nutrient utilization and limitation, diazotrophy, and nitrogen/carbon cycles.

Narrative

April 10-14, 2023- Scientists and technicians travelled from their home laboratories to Ecuador (Guayaquil) to join RV Sonne. A group of GEOMAR scientists and technicians

had travelled already on April 10 and 11 to arrive earlier in Guayaquil to unload containers and set up the equipment for the cruise. Unfortunately, the port of Guayaquil was not able to handle containers for the Sonne before the evening of April 12. Also all the airfreight was delivered late (April 13 and 14). All the cruise participants of SO298 were transferred to the vessel by bus in the morning of April 13. A total of 7 containers for SO298 were loaded plus the supplies containers for the cruise and also 6 containers for the GEOMAR ROV team (for cruise SO299). The GEOMAR trace metal clean winch container with a cable guiding deck block was installed, as were our clean container for sample filtration. The CTD sensors, UVP, nitrate sensor, lADCP and other instruments were installed on the GEOMAR stainless steel CTD frame. The cruise participants installed their laboratories. We sailed in the evening of April 14 with calm sea conditions in the coastal waters off Ecuador.

Fig. 2: Top: Winch with Kevlar conducting wire. Below: Deployment of titanium CTD frame. Photo E. Achterberg (top) and C. Rohleder (below).

April 14, 2023- The cruise started sampling surface waters from our trace metal clean tow fish for trace elements and biological variables at the first station in the coastal waters of Ecuador. This sampling activity using the tow fish continued until we reached the waters of Papua New Guinea (May 27). The surface waters were sampled for nitrogen fixation, nutrients and trace elements to establish the rates of nitrogen fixation, types of diazotrophs present (using nifH gene analysis), and the chemical environment of the diazotrophs. Nutrients and trace elements were sampled typically every 3 hours when steaming, and also upon arrival or departure at stations. The tow fish was deployed throughout the cruise and only taken out of the water for inspection once or twice.
The ship's ADCP, multibeam and TSG (underway T, S system) were functioning (until May 27) whilst the vessel was sailing. In addition, we sampled for aerosols (until May 27). The aerosol collector was placed on the top deck of the Sonne and filters changed every 72 h.

We have been deploying 2 different CTDs (titanium GEOMAR CTD, stainless steel GEOMAR CTD) and also a set of 7 in situ pumps. The titanium GEOMAR CTD is operated by a dedicated winch system with a Kevlar cable (Fig. 1), thereby preventing contamination of the samples during the sample collection. The deployments of the CTDs have been successful. The GEOMAR Stainless CTD did not function at station 1, but was fixed successfully and was functioning fine afterwards. The deployment of the in situ pumps was also very successful and greatly contributed to the success of the cruise.

At each station we sampled the full water column with the titanium GEOMAR CTD for contamination prone variables (Ti-CTD), and using the stainless steel GEOMAR CTD for less contamination prone variables, including isotopes like Nd and Th (SS-CTD). An additional SS-CTD (BIO-CTD) was deployed daily to about 300 m depth for collection of samples for biological variables. Biological rate experiments of di-nitrogen fixation were conducted using the water from the BIO-CTD (and also tow fish). Phytoplankton resource limitation experiments were conducted in the ship-board laboratory and also in incubation tanks on the aft deck.

We sampled a total of 39 stations on SO298, and 12 were so-called superstations. At the superstations, we deployed an additional SS-CTD for the collection of additional waters for isotope measurements. In addition, at the superstations we deployed 7 in situ pumps on the stainless steel wire of the SS-CTD. The pumps and SS-CTD deployment occurred simultaneously. The stainless steel wire of the Sonne was clean and released few particles. The freshwater rinsing system of the cable on the Sonne facilitated a clean CTD wire.

The in situ pumps were used to collect particles for geochemical and biological investigations. Particulate Th isotopes (Th 234) obtained from the filters of the in situ pumps will be analysed. In addition, a Mn cartridge was placed on the in situ pumps, which allowed for the collection of long-lived Ra samples. We also sampled the Niskins from the SS-CTD for helium isotopes which we will use as a tracer of the hydrothermal fluid inputs to the ocean. Helium is a conservative tracer and allows us to follow the plume and determine the fluxes of elements.

The first station on April 15 (2023) was conducted in coastal waters of Ecuador with a water depth of just 110 m. The GEOMAR titanium CTD with OTE Niskin bottles worked well, but the stainless steel (SS) CTD GEOMAR CTD had problems with the Niskin bottle release mechanisms (carousel). The carousel was exchanged for the unit from the Sonne CTD and all worked well for the next 38 stations. The occupation of the first station was finished within about 1 hour.

The next 4 stations moved from the slope to the deep ocean, and were conducted in waters with depths of less than 2600 m, and therefore took only a few hours to complete. Also, the distance between the stations was relatively short with only a few hours steaming between stations, increasing to 12 hours by station 6. Therefore, the sampling and sample processing teams were very busy during the first days. After station 6, the steaming times between stations ranged between 19 and 22 hours, and the depths were about 3000 m or more, which allowed good time for sample handling and also sleep between stations. We had permission to sample in EEZ waters of Ecuador, but not in waters of the Ecuadorian National Park of the Galapagos Islands and the National park of Hermandad. Therefore we sailed south of the Galapagos, and reached the equator at station 8.

We sailed in international waters until the waters of Kiribati. Station distances were 3 to 4 degrees (longitude) along the cruise track. The region along the equator where our cruise track passed over the East Pacific Rise did not have any reported vent systems. We therefore did not attempt to sample specifically over a vent region, but kept our standard station distance. Sailing west from the East Pacific Rise, we kept our sampling stations at a 3 or 4 degrees distance along 0°0S. Station occupation along the equator continued until station 38 (May 26), following which we sailed southwest towards the waters of Papua New Guinea. We occupied station 39 in international waters at a short distance of about 10 miles from the EEZ of Papua New Guinea. Station 39 was a superstation, and we also conducted an additional BIO-CTD. As we did not have a formal signed permission to work in waters of Papua New Guinea, we stopped all the ship-based recording instruments, took the tow fish out of the water and stopped station occupation until the official issue of the research permits. In the end the permit did not arrive, and station 39 was our last station and we arrived in Townsville (Australia) on June 2. During the transit through the Coral Sea towards Australia we packed up and loaded our containers.

The cruise took place during a transition period of La Nina to El Nino. We already noticed this in the Ecuadorian region where surface waters were up to 2°C warmer than the previous year. Also, further to the west on the equator, the surface ocean temperatures were higher than in 2022. Along the equator we anticipated an east to west current which would move the ship along. However, we instead faced a west to east current of 2 to nearly 4 knots which impeded the ship's speed. Thanks to careful engine and speed management, we were able to make excellent progress along the cruise track. The west to east surface current only disappeared at about 170°W. The surface current was in fact the Equatorial Undercurrent which had shoaled, providing nutrient-rich waters to the surface ocean, with enhanced pCO_2. We assume that the shallow EUC was caused by the transition to El Nino.

The weather in the study area has been kind and we have not lost any station time as a result of poor weather.

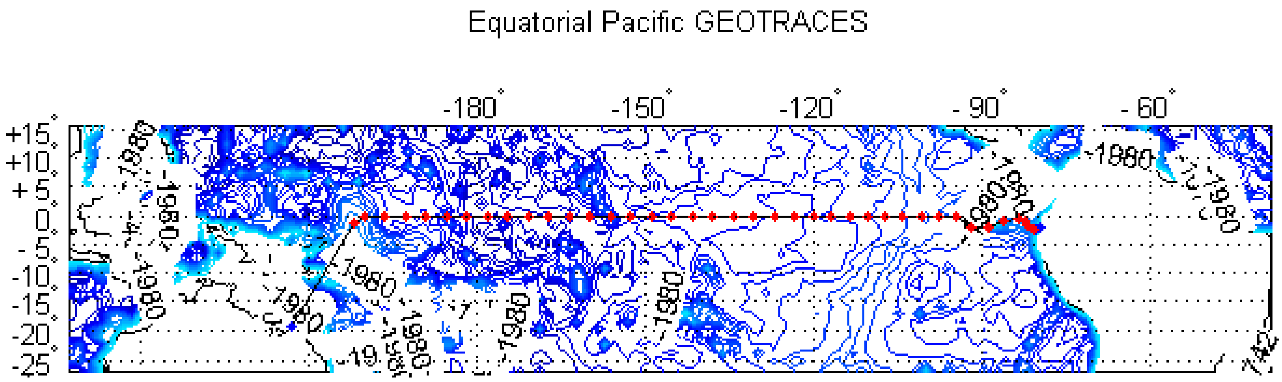

Fig. 3: Cruise track (black line) for SO298 with station locations as red.

Acknowledgements

All the members of the SO298 GEOTRACES Equatorial Pacific team are very grateful to the BMBF, the German Research Fleet Coordination Centre at the Universität Hamburg, the shipping company BRIESE RESEARCH and LPL Projects + Logistics GmbH for providing their outstanding support to science and ship logistics, which made this cruise possible. We also like to sincerely thank the captain, officers and crew on the RV Sonne who did a fantastic job at facilitating our research and making our life as pleasant as possible on board.

Participant list

Surname	First name	Function	Institute
Achterberg	Eric	Chief Scientist. Lead scientific operations on cruise. Liaise with captain and officers. Chemical Oceanography.	GEOMAR, Germany
Steiner	Zvi	Scientist. Co-lead scientific operations on cruise. Will lead trace element and isotope sampling. Chemical Oceanography.	GEOMAR, Germany
Mutzberg	Andre	Nutrient analysis on board ship. Chemical Oceanography.	GEOMAR, Germany
Hollister	Adrienne	TEI sampling, collection and preservation of metal binding ligand samples. Chemical Oceanography.	Constructor Uni, Germany
Singh	Naman Deep	TEI sampling and analysis of dissolved Al on board ship Chemical Oceanography.	GEOMAR , Germany
Guo	Jinqiang	Particle characterisation Biogeochemical Oceanography.	GEOMAR, Germany
Franzen	Luisa Marie	Nd/Ba isotope Hiwi, Chemical Oceanography.	GEOMAR, Germany
Gosnell	Kathleen Joehr	TEI analysis. Will undertake sampling and analysis of Hg. Chemical Oceanography.	GEOMAR , Germany
Bauer	Elisabeth Johanna Clarissa	CTD work; sensor handling Chemical Oceanography.	GEOMAR , Germany
O'Sullivan	Edel Mary	TEI. Will undertake TEI sampling, major ions and F measurements. Chemical Oceanography.	GEOMAR, Germany
Theileis	Anton	Will undertake underwater camera observations. Biological Oceanography.	GEOMAR, Germany
Yuan	Zhongwei	Bioassay experiments. Biological Oceanography.	GEOMAR, Germany
Von Keitz	Tabea	Ra isotopes. Will assist with sampling and analysis of long-lived Ra isotopes. Hiwi. Chemical Oceanography.	GEOMAR, Germany
Liguori	Bianca	Isotope sampling. Paleao Oceanography.	GEOMAR, Germany
Löhr	Jannik	Will undertake sampling of CFCs. Chemical Oceanography.	GEOMAR, Germany
Evers	Florian	Winch Operation. Will undertake trace metal clean winch operations. Physical Oceanography	GEOMAR, Germany
Jasinski	Dominik	TEI sampling. Will organise and undertake sampling and analysis of trace elements. Chemical Oceanography.	GEOMAR, Germany
Chen	Xuegang	TEI sampling. Will conduct sampling and analysis of trace elements. Chemical Oceanography.	Zhejiang Uni, China
Chen	Ze	Nitrogen fixation rate measurements. Biological Oceanography.	GEOMAR, Germany
Blum	Lea Katharina	Helium sampling	GEOMAR, Germany
Van Horsten	Natasha	TEI sampling. Will conduct sampling and analysis of trace elements. Chemical Oceanography.	Constructor Uni, Germany

Guo	Yuping	TEI sampling. Will conduct sampling and analysis of trace elements. Chemical Oceanography.	GEONAR, Germany
Czeschel	Rena	CTD work; sensor handling Physical Oceanography.	GEOMAR, Germany
Müller	Mario	CTD work; sensor handling Physical Oceanography.	GEOMAR, Germany
Imig	Anne	TEI sampling. Will conduct sampling and analysis of ammonium. Chemical Oceanography.	GEOMAR, Germany
Battermann	Paul	Will assist with sampling of long-lived Ra isotopes. Chemical Oceanography.	GEOMAR, Germany
Robinson	Tierra-Brandy	Will conduct light measurements	GEOMAR, Germany
McKellar	Clara	CTD assistance	GEOMAR, Germany
Gammanpila	Anjala	Proteomic sampling	GEOMAR, Germany
Schäfer	Rieke	Carbonate chemistry measurements	PTB, Germany
Tselykh	Polina	TEI sampling, collection and preservation of metal binding ligand samples. Chemical Oceanography.	Constructor Uni, Germany
Norbisrath	Mona	Carbonate chemistry measurements	GEOMAR, Germany
Wang	Yu	Metagenomic sampling of water column	GEOMAR, Germany
Wittmers	Fabian	Metagenomic sampling of water column	GEOMAR, Germany
Guo	Jiaying	Bioassay experiments. Biological Oceanography.	University of Tasmania, Australia
Nicolas	Angele	TEI analysis. Will undertake sampling and analysis of Hg. Chemical Oceanography.	GEOMAR, Germany
Ajmar	Marco	TEI analysis. Will undertake sampling and analysis of ammonium. Chemical Oceanography.	GEOMAR, Germany

Stationlist SO298

ISP= in situ pumps on GEOMAR SS-CTD. CTD used: GEOMAR stainless steel CTD (SS-CTD) and GEOMAR stainless steel CTD for biology (Bio-CTD), GEOMAR Ultra Clean Titanium CTD for geochemistry (Ti-CTD). Super denotes Superstations with a ISP deployment.

Station	Device Operation	Event Date and Time	Event Comment	Latitude	Longitude	Seafloor Depth (m)
1	SO298_0_Underway-1		2023/05/26 22:35:45	01° 21.224' S	157° 51.805' E	0.000
0	SO298_0_Underway-2		2023/05/26 22:36:04	01° 21.224' S	157° 51.805' E	0.000
0	SO298_0_Underway-3	EM122	2023/05/26 22:36:19	01° 21.223' S	157° 51.804' E	0.000
1	SO298_0_Underway-4	EM710	2023/04/15 12:00:47	02° 30.000' S	080° 59.999' W	104.200
1	SO298_1-1	Ti-CTD	2023/04/15 12:39:28	02° 29.995' S	080° 59.995' W	105.000
1	SO298_1-2	CTD Karussel defekt. Stationsabbruch	2023/04/15 14:58:23	02° 29.993' S	080° 59.993' W	107.810
2	SO298_0_Underway-6	Fisch zu Wasser	2023/04/15 15:02:52	02° 29.990' S	080° 59.995' W	106.550
2	SO298_2-1	SS-CTD	2023/04/15 22:08:26	01° 47.792' S	081° 54.139' W	1705.460
2	SO298_2-2	Ti-CTD	2023/04/15 22:47:25	01° 47.824' S	081° 54.119' W	1709.850
2	SO298_2-3	SS-CTD	2023/04/16 00:57:02	01° 47.818' S	081° 54.110' W	1710.670
3	SO298_3-1	SS-CTD	2023/04/16 07:55:27	01° 08.213' S	082° 27.255' W	1576.010
3	SO298_3-2	Ti-CTD	2023/04/16 09:17:30	01° 08.350' S	082° 27.242' W	1480.490
3 Super	SO298_3-3	ISP	2023/04/16 10:39:03	01° 08.348' S	082° 27.247' W	1479.160
4	SO298_4-1	Bio-CTD	2023/04/16 23:21:32	00° 34.092' S	083° 43.653' W	2643.360
4	SO298_4-2	Ti-CTD	2023/04/16 23:50:38	00° 34.172' S	083° 43.630' W	2646.320
4	SO298_4-3	SS-CTD	2023/04/17 02:03:13	00° 34.187' S	083° 43.587' W	2636.870
5	SO298_5-1	Ti-CTD	2023/04/17 19:29:23	01° 06.000' S	086° 06.038' W	2108.860
5	SO298_5-2	SS-CTD	2023/04/17 21:20:04	01° 06.002' S	086° 06.001' W	2107.230
6	SO298_6-1	bio CTD	2023/04/18 17:53:10	01° 59.959' S	088° 59.948' W	3102.290
6	SO298_6-2	Ti-CTD	2023/04/18 18:30:32	01° 59.961' S	088° 59.943' W	3102.310
6	SO298_6-3	CTD-SS	2023/04/18 20:52:00	01° 59.853' S	089° 00.030' W	3104.040
7 Super	SO298_7-1	ISP	2023/04/19 18:17:14	02° 00.093' S	092° 05.859' W	3308.060
7	SO298_7-2	Ti-CTD	2023/04/19 21:39:00	02° 00.319' S	092° 05.926' W	3304.230
7	SO298_7-3	SS-CTD	2023/04/20 00:03:02	02° 00.354' S	092° 05.902' W	3308.390

8	**SO298_8-1**	**bio-CTD**	**2023/04/20 21:55:41**	**00° 00.064' N**	**094° 34.756' W**	**3351.780**
8	**SO298_8-2**	**Ti-CTD**	**2023/04/20 22:39:25**	**00° 00.078' N**	**094° 34.656' W**	**3346.130**
8	**SO298_8-3**	**SS-CTD**	**2023/04/21 01:08:21**	**00° 00.074' N**	**094° 34.519' W**	**3335.400**
9	**SO298_9-1**	**Ti-CTD**	**2023/04/21 23:08:18**	**00° 00.010' S**	**097° 46.827' W**	**3304.460**
9	**SO298_9-2**	**SS-CTD**	**2023/04/22 01:22:19**	**00° 00.003' S**	**097° 46.830' W**	**3308.250**
10	**SO298_10-1**	**bio-CTD**	**2023/04/22 23:32:00**	**00° 00.003' S**	**100° 58.172' W**	**3240.770**
10	**SO298_10-2**	**Ti CTD**	**2023/04/23 00:07:35**	**00° 00.001' S**	**100° 57.945' W**	**3242.400**
10	**SO298_10-3**	**SS-CTD**	**2023/04/23 02:29:19**	**00° 00.260' S**	**100° 56.842' W**	**3228.350**
11 Super	**SO298_11-1**	**ISP**	**2023/04/24 02:17:18**	**00° 00.010' S**	**104° 10.171' W**	**3510.170**
11	**SO298_11-2**	**Ti-CTD**	**2023/04/24 05:42:26**	**00° 00.020' N**	**104° 08.968' W**	**3422.920**
11	**SO298_11-3**	**SS-CTD**	**2023/04/24 08:15:17**	**00° 00.042' N**	**104° 07.552' W**	**3388.030**
12	**SO298_12-1**	**bio-CTD**	**2023/04/25 07:38:35**	**00° 00.031' N**	**107° 21.492' W**	**3653.770**
12	**SO298_12-2**	**Ti-CTD**	**2023/04/25 08:12:11**	**00° 00.009' N**	**107° 21.188' W**	**3683.440**
12	**SO298_12-3**	**SS-CTD**	**2023/04/25 10:46:53**	**00° 00.006' N**	**107° 19.834' W**	**3673.690**
13	**SO298_13-1**	**Ti-CTD**	**2023/04/26 09:03:57**	**00° 00.075' N**	**110° 32.994' W**	**3786.610**
13	**SO298_13-2**	**SS-CTD**	**2023/04/26 11:42:03**	**00° 00.037' N**	**110° 32.419' W**	**3804.230**
14	**SO298_14-1**	**bio-CTD**	**2023/04/27 09:48:51**	**00° 00.023' S**	**113° 45.075' W**	**4183.390**
14	**SO298_14-2**	**Ti-CTD**	**2023/04/27 10:17:21**	**00° 00.098' S**	**113° 44.620' W**	**4178.260**
14	**SO298_14-3**	**SS-CTD**	**2023/04/27 13:19:00**	**00° 00.234' S**	**113° 43.927' W**	**4163.480**
15	**SO298_15-1**	**SS-CTD**	**2023/04/28 11:40:55**	**00° 00.000' S**	**116° 56.357' W**	**4134.900**
15	**SO298_15-2**	**Ti-CTD**	**2023/04/28 14:19:56**	**00° 00.001' N**	**116° 56.110' W**	**4132.470**
15 Super	**SO298_15-3**	**ISP**	**2023/04/28 17:20:01**	**00° 00.004' N**	**116° 55.529' W**	**4114.580**
16	**SO298_16-1**	**bio CTD**	**2023/04/29 16:15:04**	**00° 00.007' N**	**120° 08.247' W**	**4698.530**
16	**SO298_16-2**	**Ti CTD**	**2023/04/29 16:46:52**	**00° 00.042' S**	**120° 08.002' W**	**4160.160**
16	**SO298_16-3**	**SS CTD**	**2023/04/29 19:39:52**	**00° 00.240' S**	**120° 06.714' W**	**4199.800**
17	**SO298_17-1**	**Ti CTD**	**2023/04/30 19:05:06**	**00° 00.003' S**	**123° 29.668' W**	**4526.050**
17	**SO298_17-2**	**SS-CTD**	**2023/04/30 22:05:38**	**00° 00.001' N**	**123° 29.529' W**	**4527.280**
18 Super	**SO298_18-1**	**ISP**	**2023/05/01 23:18:40**	**00° 00.006' S**	**127° 09.014' W**	**4545.400**
18	**SO298_18-2**	**Ti-CTD**	**2023/05/02 02:25:20**	**00° 00.274' S**	**127° 08.312' W**	**4444.440**

18	**SO298_18-3**	**SS-CTD**	**2023/05/02 05:20:11**	**00° 00.341' S**	**127° 08.136' W**	**4408.100**
19	**SO298_19-1**	**Bio CTD**	**2023/05/03 06:30:04**	**00° 00.000' S**	**130° 47.653' W**	**4493.140**
19	**SO298_19-2**	**Ti-CTD**	**2023/05/03 07:02:38**	**00° 00.025' S**	**130° 47.339' W**	**4465.330**
19	**SO298_19-3**	**SS-CTD**	**2023/05/03 10:00:19**	**00° 00.125' S**	**130° 46.879' W**	**4450.920**
20	**SO298_20-1**	**Ti-CTD**	**2023/05/04 11:10:33**	**00° 00.121' N**	**134° 27.100' W**	**4100.530**
20	**SO298_20-2**	**SS-CTD**	**2023/05/04 14:04:26**	**00° 00.149' N**	**134° 26.707' W**	**4081.930**
21	**SO298_21-1**	**SS-CTD**	**2023/05/05 14:56:13**	**00° 00.010' N**	**138° 06.131' W**	**4279.290**
21	**SO298_21-2**	**Ti-CTD**	**2023/05/05 17:38:50**	**00° 00.004' S**	**138° 05.912' W**	**4525.050**
21 Super	**SO298_21-3**	**ISP**	**2023/05/05 20:33:41**	**00° 00.001' S**	**138° 05.605' W**	**4270.890**
22	**SO298_22-1**	**bio-CTD**	**2023/05/06 21:37:36**	**00° 00.014' S**	**141° 45.006' W**	**4332.430**
22	**SO298_22-2**	**Ti-CTD**	**2023/05/06 22:05:51**	**00° 00.178' S**	**141° 44.553' W**	**4341.320**
22	**SO298_22-3**	**SS-CTD**	**2023/05/07 01:05:11**	**00° 00.338' S**	**141° 44.120' W**	**4350.100**
23	**SO298_23-1**	**Ti-CTD**	**2023/05/08 02:26:02**	**00° 00.004' S**	**145° 24.003' W**	**4343.020**
23	**SO298_23-2**	**SS-CTD**	**2023/05/08 05:19:00**	**00° 00.183' S**	**145° 23.505' W**	**4328.900**
24	**SO298_24-1**	**bio CTD**	**2023/05/09 05:24:52**	**00° 00.003' N**	**149° 02.941' W**	**4576.730**
24	**SO298_24-2**	**Ti-CTD**	**2023/05/09 05:55:05**	**00° 00.005' N**	**149° 02.858' W**	**4580.750**
24	**SO298_24-3**	**SS-CTD**	**2023/05/09 09:06:45**	**00° 00.006' N**	**149° 02.802' W**	**4577.060**
25	**SO298_25-2**	**Ti-CTD**	**2023/05/10 12:17:01**	**00° 00.005' N**	**152° 41.928' W**	**4536.540**
25 Super	**SO298_25-3**	**ISP**	**2023/05/10 15:24:30**	**00° 00.044' N**	**152° 41.581' W**	**4532.220**
26	**SO298_26-1**	**Bio-CTD**	**2023/05/11 16:03:55**	**00° 00.037' S**	**156° 21.121' W**	**3295.380**
26	**SO298_26-2**	**Ti-CTD**	**2023/05/11 16:34:09**	**00° 00.043' S**	**156° 20.940' W**	**3332.080**
26	**SO298_26-3**	**SS-CTD**	**2023/05/11 18:54:38**	**00° 00.041' S**	**156° 20.762' W**	**3430.820**
27	**SO298_27-2**	**SS-CTD**	**2023/05/12 18:04:05**	**00° 00.009' S**	**160° 00.002' W**	**5160.000**
27	**SO298_27-3**	**Ti-CTD**	**2023/05/12 21:20:52**	**00° 00.002' N**	**159° 59.997' W**	**5158.370**
27	**SO298_27-1**	**bio-CTD**	**2023/05/13 00:54:07**	**00° 00.003' S**	**159° 59.996' W**	**5159.150**
28 Super	**SO298_28-1**	**ISP**	**2023/05/13 22:07:07**	**00° 00.002' N**	**163° 38.992' W**	**4843.190**
28	**SO298_28-2**	**Ti-CTD**	**2023/05/14 01:02:19**	**00° 00.237' N**	**163° 38.580' W**	**4923.120**
28	**SO298_28-3**	**SS-CTD**	**2023/05/14 04:30:36**	**00° 00.231' N**	**163° 38.558' W**	**4925.080**
29	**SO298_29-1**	**bio-CTD**	**2023/05/15 04:27:32**	**00° 00.001' S**	**167° 18.097' W**	**4739.570**

29	**SO298_29-2**	**Ti-CTD**	**2023/05/15 04:57:27**	**00° 00.003' N**	**167° 18.103' W**	**4739.570**
29	**SO298_29-3**	**SS-CTD**	**2023/05/15 08:10:18**	**00° 00.006' S**	**167° 18.097' W**	**4741.500**
30	**SO298_30-1**	**SS-CTD**	**2023/05/16 11:49:37**	**00° 00.019' N**	**170° 56.805' W**	**5366.860**
30	**SO298_30-2**	**Ti-CTD**	**2023/05/16 11:50:02**	**00° 00.019' N**	**170° 56.805' W**	**5372.650**
30 Super	**SO298_30-3**	**ISP**	**2023/05/16 15:32:04**	**00° 00.030' N**	**170° 56.824' W**	**5371.520**
31	**SO298_31-1**	**bio-CTD**	**2023/05/17 15:55:01**	**00° 00.016' N**	**174° 36.203' W**	**5677.880**
31	**SO298_31-2**	**Ti-CTD**	**2023/05/17 16:40:12**	**00° 00.015' N**	**174° 36.202' W**	**5425.620**
31	**SO298_31-3**	**SS-CTD**	**2023/05/17 20:20:47**	**00° 00.012' N**	**174° 36.176' W**	**5426.890**
32	**SO298_32-1**	**Ti-CTD**	**2023/05/18 19:46:35**	**00° 00.020' S**	**178° 15.135' W**	**4926.690**
32	**SO298_32-2**	**SS-CTD**	**2023/05/18 23:06:05**	**00° 00.021' S**	**178° 15.138' W**	**4965.720**
33	**SO298_33-1**	**bio CTD**	**2023/05/19 22:24:38**	**00° 00.001' N**	**178° 06.009' E**	**5399.750**
33	**SO298_33-2**	**Ti-CTD**	**2023/05/19 22:52:26**	**00° 00.009' N**	**178° 05.995' E**	**5399.520**
33	**SO298_33-3**	**SS-CTD**	**2023/05/20 02:26:28**	**00° 00.008' N**	**178° 05.994' E**	**5401.000**
34 Super	**SO298_34-1**	**ISP**	**2023/05/21 01:54:28**	**00° 00.061' N**	**174° 26.970' E**	**4759.790**
34	**SO298_34-2**	**Ti-CTD**	**2023/05/21 05:01:05**	**00° 00.060' N**	**174° 26.973' E**	**4761.030**
34	**SO298_34-3**	**SS-CDT**	**2023/05/21 08:13:40**	**00° 00.067' N**	**174° 26.994' E**	**4762.530**
35	**SO298_35-1**	**bio-CTD**	**2023/05/22 07:13:26**	**00° 00.012' S**	**170° 47.884' E**	**4562.420**
35	**SO298_35-2**	**Ti-CTD**	**2023/05/22 07:41:05**	**00° 00.011' S**	**170° 47.879' E**	**4559.270**
35	**SO298_35-3**	**SS-CTD**	**2023/05/22 10:51:31**	**00° 00.010' S**	**170° 47.881' E**	**4568.460**
36	**SO298_36-1**	**bio CTD**	**2023/05/23 10:40:10**	**00° 00.136' S**	**167° 09.129' E**	**4338.600**
36	**SO298_36-2**	**Ti-CTD**	**2023/05/23 11:08:03**	**00° 00.138' S**	**167° 09.131' E**	**4339.590**
36	**SO298_36-3**	**SS-CTD**	**2023/05/23 14:35:28**	**00° 00.141' S**	**167° 09.130' E**	**4339.890**
37	**SO298_37-1**	**SS-CTD**	**2023/05/24 14:03:43**	**00° 00.015' S**	**163° 30.040' E**	**4447.750**
37	**SO298_37-2**	**Ti-CTD**	**2023/05/24 16:54:24**	**00° 00.004' S**	**163° 30.031' E**	**4448.570**
37 Super	**SO298_37-3**	**ISP**	**2023/05/24 19:54:10**	**00° 00.005' S**	**163° 30.030' E**	**4447.100**
38	**SO298_38-1**	**bio-CTD**	**2023/05/25 18:51:33**	**00° 00.004' S**	**160° 00.020' E**	**2816.530**
38	**SO298_38-2**	**Ti-CTD**	**2023/05/25 19:31:30**	**00° 00.004' S**	**160° 00.021' E**	**2815.090**
38	**SO298_38-3**	**SS-CTD**	**2023/05/25 21:29:18**	**00° 00.012' S**	**160° 00.014' E**	**2816.260**
39	**SO298_39-1**	**SS-CTD**	**2023/05/26 13:56:59**	**01° 21.363' S**	**157° 51.216' E**	**1868.720**

39	**SO298_39-2**	**Ti-CTD**	**2023/05/26 15:22:26**	**01° 21.357' S**	**157° 51.220' E**	**1868.440**
39 Super	**SO298_39-3**	**ISP**	**2023/05/26 16:47:11**	**01° 21.368' S**	**157° 51.212' E**	**1868.890**
39	**SO298_39-4**	**bio-CTD**	**2023/05/26 20:50:28**	**01° 21.231' S**	**157° 51.668' E**	**1876.640**