Trace Metals ('GEOTRACES' Project) Group Voyage Report

1. General Introduction

The Southern Ocean and overlying atmosphere have a profound influence on regional and global climate, sea level, biogeochemical cycles, and marine biological productivity. However, present-day models used for forecasts and projections have large and persistent biases in the region, especially for trace element biogeochemistry.

The primary productivity of the Southern Ocean is driven by the supply and recycling of the trace element iron (Fe). Iron can be supplied by multiple distinct mechanisms within this region and rapid recycling can often further boost ocean productivity. The availability of Fe in the Southern Ocean is expected to increase with increases in atmospheric supply, changes in ocean circulation, and increased ice melt associated with changes in climate, yet repeat observations suitable for assessing rates of change remain sparse. Iron supply drives summer phytoplankton blooms that supply energy to food webs, provide carbon for export to the deep sea, and are the main producers of atmospheric biogases.

2. Overall aim and hypothesis

The aim of MISO was to improve our understanding of how the Southern Ocean region influences the Earth system and use this knowledge to improve models. Within this context, GEOTRACES section(s) GS05 aimed to characterise dissolved and particulate trace metal distributions, metal speciation (i.e., iron and copper), and other trace elements and isotopes (TEIs, see **Table 3** for more info on all the sampled parameters) along the GO-SHIP repeat hydrographic line I9S in the entire water column, for the first time. The same parameters were also measured at repeat superstations of the international GEOTRACES program from the southern end of GO-SHIP lines SR3 (140°E) and P11 (150°E), as well as an unnamed section along 132°E. The GEOTRACES team collected whole water-depth samples along the transects, with a focus on gathering high-depth resolution samples at 13 superstations and 4 multi-day process stations. These high-resolution super- and process-stations are crucial for monitoring the intricate dynamics of metal biogeochemistry, enabling researchers to track the fluxes of particulate and dissolved metal pools, allowing investigation into key processes such as metal regeneration and scavenging, organic ligand release, authigenic metal production, and biological uptake and recycling in both the upper and mesopelagic ocean layers. Super-stations were strategically located at oceanographic fronts and other points of interest, such as glaciers and hydrothermal inputs. Meanwhile, process-stations were dynamically selected in real-time based on tracking phytoplankton blooms using satellite-derived ocean chlorophyll-a data. Additionally, samples for TEIs in marine aerosols and precipitation were also taken.

3. GEOTRACES Objectives

GS05 helped address MISO science questions by completing the following objectives:

- Collect TEI samples at 1° latitude intervals along previously sampled GO-SHIP lines SR3 (140°E), P11 (150°E), an un-named section along 132°E and the entirety of the GO-SHIP line I9S (for the first time).
- Collect TEI samples in the particulate phase at super-stations and process-stations along the above-mentioned lines.
- Collect aerosol (weekly-fortnightly) and rainwater (event driven) samples using the ship's dedicated air intake system and a rainwater sampler, respectively.

- Collect samples for radiogenic isotopes and nitrogen isotopes at select depths from the ship's 36-bottle CTD rosette at super-stations and process-stations.

4. Science Team

The sea-going GEOTRACES Science Team (**Table 1**) is comprised of experienced GEOTRACES researchers and seagoing scientists, as well as students. The inclusion of students reflects the groups commitment to training the next generation of marine biogeochemical scientists. The Team was also supported shoreside by IMAS researchers Prof Andrew Bowie (MISO PI) and Dr Thomas Holmes who were unable to go to sea on this occasion.

Table 1: GEOTRACES Team

Name	Affiliation	Position
Dr Scott Meyerink	AAPP	Team leader
Dr Rebecca Zitoun	IMOS/UTAS/GEOMAR	Co-Team leader
Dr Tom Williams	ACEAS	Postdoctoral Researcher
Christopher Traill	AAPP	PhD student
Knut Heinatz	UTAS	PhD student
McKeira Cumming	UTAS	Volunteer student

The GEOTRACES Science Team also collected samples for various national research groups and international collaborators (**Table 2**), underscoring the group's dedication to strengthening long-term collaborations with scientists both nationally and internationally, and emphasizing the group's dedication to fostering expertise and knowledge transfer within the wider scientific community. This collaborative effort is instrumental in advancing our understanding of how chemical and biological processes in the surface ocean respond to climate change. It serves as a prime example of the profound impact that collective teamwork can have in expanding the frontiers of knowledge and discovery in science.

Table 2: List of Collaborators (not on board)

Name	Affiliation	Country
Prof Michael Ellwood	Australian National University	Australia
Assoc Prof Randie Bundy	University of Washington	USA
Dr Sarah Fawcett	University of Cape Town.	South Africa
Prof Sylvia Sander	GEOMAR – Helmholtz Centre of Ocean Research	Germany
Jennifer Powell	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia
Prof. Zanna Chase	University of Tasmania (UTAS)	Australia
Dr. Taryn Noble	University of Tasmania (UTAS)	Australia

5. Voyage Sampling Plan

The GEOTRACES team collected both aqueous (marine and atmospheric), and particulate (atmospheric and marine) samples for the measurement and analysis of trace elements and isotopes (TEIs), radiogenic isotopes (Th, Nd, U, Pb), ligands, and siderophores. A comprehensive list of all the parameters collected can be found below (**Table 3**). Samples collected cover almost all parameters from the GEOTRACES science plan **(Table 4).**

Table 3: List of parameters sampled.

Parameter	Collected by	Responsible for analysis and data management
Dissolved Metals	TM Rosette	Andrew Bowie, Scott Meyerink
Cu isotopes	TM Rosette	Michael Ellwood
Cd, Fe, Zn isotopes	TM Rosette	Michael Ellwood
Pb isotopes	TM Rosette	Taryn Noble
U isotopes	TM Rosette	Taryn Noble
Cu ligands	TM Rosette	Clément Astruc Delor
Fe ligands	TM Rosette	Talitha Nelson
Siderophores	TM Rosette	Thomas Holmes, Randie Bundy
Ca and Mg	TM Rosette	Michael Ellwood
Total Hg	TM Rosette	Rebecca Zitoun
N isotopes	CTD Rosette	Sarah Fawcett
REE	CTD Rosette	Taryn Noble, Zanna Chase
Radiogenic isotopes (Th, Nd)	CTD Rosette	Taryn Noble, Zanna Chase
Particulate trace metals	Insitu Pumps	Andrew Bowie
Labile particulate trace metals	Insitu Pumps	Andrew Bowie
Trace metal isotopes	Insitu Pumps	Michael Ellwood
Radiogenic isotopes	Insitu Pumps	Taryn Noble, Zanna Chase
Fe mineralogy	Insitu Pumps	Taryn Noble, Andrew Bowie
CHN	Insitu Pumps	Lavy Ratnarajah
Trace Metals, Soluble Ions	Rainwater Sampler	Andrew Bowie, Scott Meyerink
Trace Metals, Soluble Ions	Aerosol Sampler Manifold	Andrew Bowie, Scott Meyerink

Sampling for dissolved and particulate samples was conducted using an autonomous 12 bottle (12 L, Teflon coated Ocean Test Equipment (OTE) externally-closing water sampling bottles with outer springs) trace metal-clean rosette (TMR), a 36 bottle (12 L, Niskin bottles) standard CTD, and 8 in-situ pumps (ISPs, McLane). At super-stations GS05-30/31 and GS05-35/36 (**Table 5**), intercalibration samples were collected at every depth for dissolved metals, following the GEOTRACES protocol to ensure globally-consistent data quality. Additionally, at station GS05-30/31 at 1206 dbar depth and at GS05-35/36 at 3000 dbar depth, 5x1 L intercalibration samples were also collected for Pb analysis. Further, at stations GS05-05 and GS05-15, 2 pre-cleaned 50 L HDPE containers were filled with filtered surface seawater. These containers are designated to serve as internal standards at the IMAS clean laboratories (University of Tasmania). Two shallow TMR deployments were also conducted down to 500 m depth in the northern section of the I9S line (i.e., between station GS05-57 and GS05-58). Each deployment was done by another shift (PM shift: Scott, Tom, Knut; AM shift: Rebecca, Christopher, McKeira). For these deployments (i.e., quality control stations), all bottles were closed at 100 m to assess the cleanliness of the Niskin bottles and the sampling procedure of each team.

Trace metal clean aerosol (weekly-fortnightly) and rainwater (event-driven) samples were collected using the ship's dedicated air intake system, and a specialized rain sampler that was strategically mounted on the 5th deck at the bow of the *RV* Investigator. Near real-time analyses of iron was made at sea using a Flow Injection Analysis System (FIA) to ascertain the cleanliness of the TMR before commencing voyage sampling along the main transect lines.

Table 4: List of key parameters for GEOTRACES ocean sections from the GEOTRACES science plan (SCOR Working Group, 2007).

Key Parameter	**Examples of use**
Trace elements	
Fe	Essential micronutrient
Al	Tracer of Fe inputs (from mineral dust and elsewhere)
Zn	Micronutrient – potentially toxic at high concentrations
Mn	Tracer of Fe inputs and redox cycling
Cd	Essential micronutrient; palaeoproxy for nutrient content of waters
Cu	Micronutrient, potentially toxic at high concentrations
Stable isotopes	
$\delta^{15}N$	Modern palaeoproxy for nitrate cycling
$\delta^{13}C$	Modern palaeoproxy for nutrient content and ocean circulation
Radioactive isotopes	
^{230}Th	Constant flux monitor in sediments; tracer of modern ocean circulation and particle scavenging
^{231}Pa	Palaeoproxy for circulation and productivity; tracer of modern particle processes
Radiogenic isotopes	
Pb isotopes	Tracer of natural and contaminant sources to the ocean
Nd isotopes	Tracer of natural sources of TEI's to the ocean
Other parameters	
Stored sample	To allow future work
Particles	Transport vector for many TEIs
Aerosols	Essential source of TEIs to the surface ocean

6. Voyage Station Plan

Sampling commenced at the Southern Ocean Time series (SOTS) to collect a TMR profile for dissolved TEIs and to add to the expanding TEI data available from SOTS repeat voyages. The MISO voyage then moved onto repeat sections at 150°E (P11), 140°E (SR3), and 132°E (**Figure 1; Table 5**). Following completion of the 150°E line, an opportunity arose where sampling could take place in and around the Mertz Glacier Polyna (a key region for formation of Antarctic Bottom Water precursor water masses). Subsequently, 3 super-stations near the Mertz Glacier tongue, in the vicinity of the Adelie Depression, were sampled for TEI's, siderophores, ligands, Pb isotopes, radiogenic isotopes (Th/Nd), and particles. Upon completion of the repeat sections at 150°E, 140°E, and 132°E, an integrated transect was completed at I9S (~115°E) as part of the GEOTRACES campaign (GS05 section). Sufficient time also permitted the deployment of 2 TMRs along the Leeuwin Current during the transit

back to Fremantle. In total 65 stations were sampled. One station located at 66.5°S on the 150°E transect, as well as 5 stations (which include 3 GS05 stations) at the start of the I9S transect had to be omitted due to sea ice coverage in the area. Station GS05-11 was not sampled for dissolved metals due to a failure in the TMR rechargeable battery pack and station GS05-ISP2 was not sampled due to ice getting caught in ISP lines.

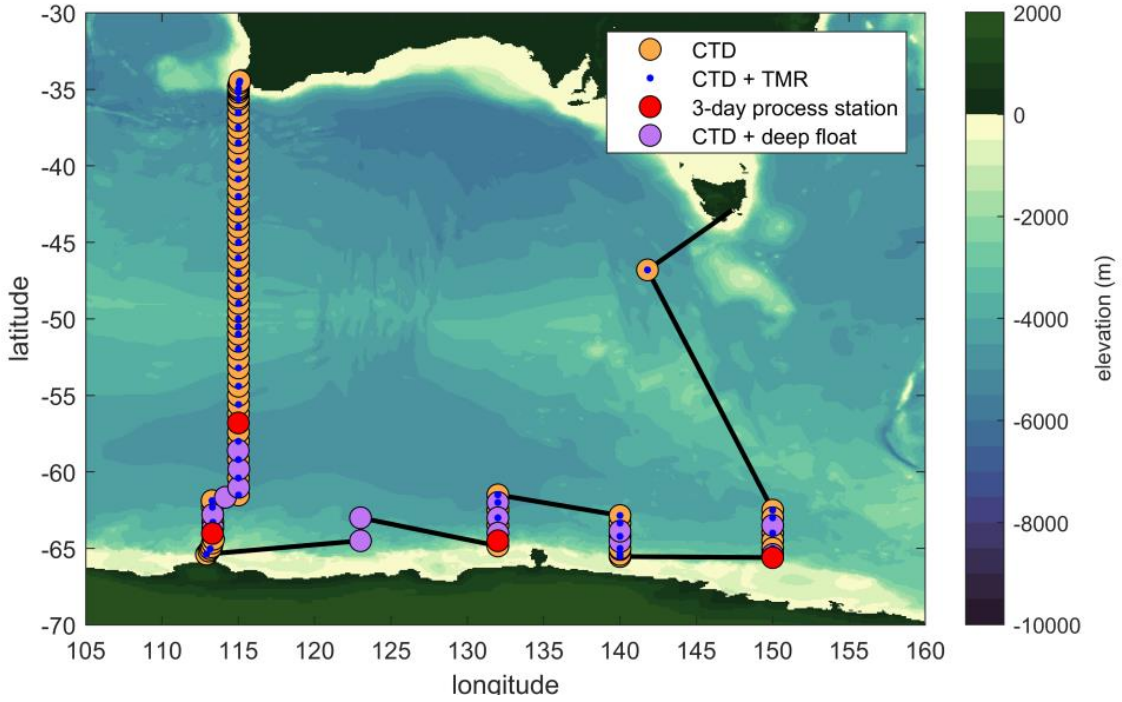

Figure 1: Cruise track

TMR deployments followed the standard CTD deployments in order to pre-define specific depth intervals at key features such as the mixed layer, deep chlorophyll maximum, oxygen minimum, temperature minimum, salinity minimum, and salinity maximum etc. All TMR deployments varied, ranging from regular full-depth TMR stations to shallow TMR stations focusing on sampling the uppermost 1500 m water column for dissolved trace metals. Super- and process-stations typically involved two TMR deployments for high-resolution sampling, unless bad weather prohibited this procedure, then only one full-depth profile was collected. Each TMR deployment at the super- and process stations consisted of a shallow TMR down to 1500 m and a deep TMR from 1000 m to near the ocean floor, with 2-3 crossover samples taken at the same depth to ensure data consistency. Both TMR's were then sampled for the entire suite of parameters (**Table 3**). To allow sufficient time for filtering, ISPs were deployed to 1500 m between the two TMR deployments. At process stations, the TMR was also deployed to 200 m to collect water for the incubation work conducted by the BioGeoSCAPES Team.

Table 5: List of TMR and ISP Stations. Super- and process stations are highlighted in grey, while intercalibration and quality control stations are highlighted in yellow and green, respectively. BioGeoSCAPES TMRs are highlighted in blue. DTM: dissolved trace metals.

Date	Station	Latitude (Start)	Longitude (Start)	Max depth (dbar)	Deployed instruments	Parameters sampled	Remarks
06/01/2024	TMR_01	- 46° 39.9588'	142° 39.9675'	4191	TMR	11xDTM, 11xPb,	Deep-TMR SOTS test deployment
10/01/2024	TMR_02	- 62° 30.1933'	149° 59.4987'	3896	TMR	11xDTM,11xPb	Deep TMR
11/01/2024	TMR_03	- 63° 0.5416'	149° 59.6850'	3830	TMR	11xDTM, 11xPb	Deep TMR

11/01/2024	TMR_04	- 63° 59.9350'	150° 0.2912'	3624	TMR	11xDTM, 11xPb	Deep TMR
12/01/2024	TMR_05	- 65° 0.5941'	149° 59.9032'	3266	TMR	12xDTM, 5xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 12xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Super-station 1: Shallow Super TMR
13/01/2024	ISP_01				ISP	6 Supor filters, 6 QMA filters	Super-station 1:
13/01/2024	TMR_06	- 65° 1.0992'	149° 59.3351'	3252	TMR	12xDTM, 4xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 12xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Super-station 1: Deep Super TMR
13/01/2024	TMR_07	- 65° 20.0233'	150° 0.0429'	2941	TMR	12xDTM, 12xPb	Deep TMR
14/01/2024	TMR_08	- 66° 27.0098'	144° 57.5342'	403	TMR	12xDTM, 12xPb, 8xCu ligands, 8xFe ligands, 12xCu isotopes, 20xCd isotopes, 5xsiderophores, 12xHg, 12xCa/Mg	Super-station 2 Mertz 1: Super TMR
14/01/2024	ISP_02	- 66° 27.0098'	144° 57.5342'	403	ISP	6 Supor filters, 6 QMA filters	Super-station 2 Mertz 1
15/01/2024	TMR_09	- 66° 42.3045'	144° 11.3933'	859	TMR	12xDTM, 12xPb, 8xCu ligands, 8xFe ligands, 12xCu isotopes, 20xCd isotopes, 5xsiderophores, 12xHg, 12xCa/Mg	Super-station 3 Mertz 2: Super TMR
15/01/2024	ISP_03	- 66° 42.3045'	144° 11.3933'	859	ISP	6 Supor filters, 6 QMA filters	Super-station 3 Mertz 2
15/01/2024	TMR_10	- 67° 0.1331'	145° 0.8399'	1120	TMR	12xDTM, 12xPb, 8xCu ligands, 8xFe ligands, 12xCu isotopes, 20xCd isotopes, 5xsiderophores, 12xHg, 12xCa/Mg	Super-station 4 Mertz 3: Super TMR
15/01/2024	ISP_04	- 67° 0.1331'	145° 0.8399'	1120	ISP	6 Supor filters, 6 QMA filters	Super-station 4 Mertz 3
20/01/2024	TMR_MBP_01	- 65° 23.8446'	139° 59.9607'	70	TMR		Bio-TMR
21/01/2024	TMR_11	- 65° 23.9573'	140° 0.0224'	2415	TMR	12xDTM, 12xPb+U, 8xCu ligands, 8xFe ligands, 12xCu isotopes, 16xCd isotopes, 4xsiderophores, 8xHg, 8xCa/Mg	Process-Station12: Deep Super TMR
21/01/2024	ISP_05	- 65° 23.9573'	140° 0.0224'	2415	ISP	8 Supor filters, 6 QMA filters	Process-Station 1:
21/01/2024	TMR_12	- 65° 0.0753'	140° 0.4815'	2680	TMR	12xDTM, 12xPb+U	Deep TMR
22/01/2024	TMR_13	- 65° 13.2165'	140° 0.4688'	3290	TMR	11xDTM, 11xPb+U	Deep TMR
23/01/2024	TMR_14	- 63° 22.1928'	139° 57.6892'	3700	TMR	12xDTM, 12xPb+U	Deep TMR
23/01/2024	TMR_15	- 62° 51.8561'	140° 0.2462'	3214	TMR	12xDTM, 12xPb+U	Deep TMR
24/01/2024	TMR_16	- 61° 59.9716'	131° 59.7455'	4481	TMR	11xDTM, 11xPb+U	Deep TMR
25/01/2024	TMR_17	- 63° 0.2462'	131° 59.1130'	4301	TMR	12xDTM, 12xPb+U	Deep TMR
26/01/2024	TMR_18	- 64° 0.1314'	131° 59.6024'	3175	TMR	11xDTM, 11xPb+U, 8xCu ligands, 9xFe ligands, 8xCu isotopes, 9xCd isotopes	Deep Extra TMR
28/01/2024	TMR_MBP_02	- 64° 31.1310'	132° 6.5007'	100	TMR		Bio TMR
28/01/2024	TMR_19	- 64° 31.0727'	132° 6.4748'	1320	TMR	12xDTM, 12xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 8xHg, 8xCa/Mg	Process-station 2: Shallow Super TMR

28/01/2024	ISP_06	- 64° 31.0727'	132° 6.4748'	1320	ISP	8 Supor filters, 6 QMA filters	Process-station 2
29/01/2024	TMR_20	- 64° 50.0972'	131° 59.6544'	950	TMR	12xDTM, 12xPb	Deep TMR
01/02/2024	TMR_21	- 64° 26.3336'	113° 52.8523'	2551	TMR	12xDTM	Deep TMR
01/02/2024	TMR_22	- 64° 20.4971'	113° 22.1750'	2460	TMR	12xDTM, 10xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Super-station 5: Shallow Super TMR
02/02/2024	ISP_07	- 64° 20.4111'	113° 22.6217'	1500	ISP	8 Supor filters, 6 QMA filters	Super-station 5
02/02/2024	TMR_23	- 63° 39.1656'	113° 18.4664'	3270	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Super-station 5: Shallow Super TMR
02/02/2024	TMR_24	- 64° 19.2509'	113° 22.1277'	2360	TMR	12xDTM	Shallow TMR
02/02/2024	TMR_25	- 63° 39.1656'	113° 18.4664'	3271	TMR	12xDTM	Shallow TMR
04/02/2024	TMR_26	- 61° 52.8829'	113° 16.6247'	1450	TMR	12xDTM, 5xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 14xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Process-station 3: Shallow Super TMR
04/02/2024	ISP_08	- 61° 52.8829'	113° 16.6247'	1500	ISP	8 Supor filters, 5 QMA filters	Process-station 3
04/02/2024	TMR_27	- 61° 52.8829'	113° 16.6247'	415	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Process-station 3: Deep Super TMR
05/02/2024	TMR_MBP_03	- 61° 57.6829'	113° 31.6304'	110	TMR		Bio TMR
03/02/2024	TMR_28	- 62° 47.0536'	113° 18.5994'	3827	TMR	12xDTM	Deep TMR
06/02/2024	TMR_29	- 61° 30.8831'	115° 0.6998'	1360	TMR	12xDTM	Shallow TMR
07/02/2024	TMR_30	- 59° 12.0917'	115° 0.1415'	1150	TMR	12xDTM, 6xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 14xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Super-station 6: Shallow Super TMR
07/02/2024	ISP_09	- 59° 12.6589'	115° 1.9181'	1500	ISP	8 Supor filters, 6 QMA filters	Super-station 6
07/02/2024	TMR_31	- 59° 12.7933'	115° 5.6467'	4500	TMR	12xDTM, 9xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Super-station 6: Deep Super TMR
08/02/2024	TMR_32	- 57° 59.9603'	114° 59.6745'	4571	TMR	12xDTM	Deep TMR
09/02/2024	TMR_33	- 56° 48.5047'	114° 58.7425'	4350	TMR	12xDTM, 10xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Super-station 7: Deep Super TMR
09/02/2024	ISP_10	- 56° 48.7667'	114° 58.8750'	1500	ISP	8 Supor filters, 6 QMA filters	Super-station 7
12/02/2024	TMR_34	- 55° 35.8598'	115° 0.1806'		TMR	12xDTM	Deep TMR
15/02/2024	TMR_MBP_04	- 54° 21.6532'	115° 0.2832'		TMR		Bio TMR
15/02/2024	TMR_35	- 54° 23.3035'	115° 1.0271'	1460	TMR	12xDTM, 9xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 14xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Process-station 2: Shallow Super TMR

15/02/2024	ISP_11	- 54° 23.3035'	115° 1.0271'	1460	ISP	8 Supor filters, 6 QMA filters	Process-station 2
15/02/2024	TMR_36	- 54° 23.3035'	115° 1.0271'	4160	TMR	12xDTM, 10xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Process-station 2: Deep Super TMR
16/02/2024	TMR_37	- 53° 12.8114'	115° 0.7190'	3983	TMR	12xDTM	Shallow TMR
16/02/2024	TMR_38	- 51° 58.9204'	115° 0.0060'	3632	TMR	12xDTM	Deep TMR
17/02/2024	TMR_39	- 51° 0.6157'	114° 59.7944'	3915	TMR	12xDTM	Deep TMR
18/02/2024	TMR_40	- 50° 29.4701'	115° 0.0683'	1236	TMR	12xDTM, 6xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 14xCd isotopes, 5xsiderophores, 8xHg, 8xCa/Mg	Super-Shallow TMR
18/02/2024	TMR_41	- 50° 29.7958'	115° 0.5327'	2905	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg	Super-Deep TMR
18/02/2024	ISP_12	- 50° 30.2773'	115° 1.2297'	2900	ISP	8 Supor filters, 6 QMA filters	ISP
18/02/2024	TMR_42	- 50° 0.3321'	115° 3.7190'	3832	TMR	12x DTM and 1x 20L Carboy	Deep TMR
19/02/2024	TMR_MBP_05	- 49° 30.8124'	115° 3.3060'	70	TMR	5x 20L Carboys for Biology	Bio-cast
19/02/2024	TMR_43	- 48° 59.1646'	115° 2.6586'	3860	TMR	12x DTM and 1x 20L Carboy	Deep TMR
20/02/2024	TMR_44	- 48° 0.1087'	115° 0.0095'	1640	TMR	12xDTM	Shallow TMR
20/02/2024	TMR_45	- 47° 0.4370'	115° 1.0251'	3835	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xHg, 8xCa/Mg (No siderophores or isotopes)	Super-Shallow TMR
21/02/2024	TMR_46	- 46° 59.6067'	114° 59.9328'	3790	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xHg, 8xCa/Mg (No siderophores or isotopes)	Super-Deep TMR
20/02/2024	ISP_13	- 47° 0.4940'	115° 1.8081'	1545	ISP	8 Supor filters, 6 QMA filters	ISP
21/02/2024	TMR_47	- 46° 1.6571'	115° 0.1578'	1610	TMR	12xDTM	Shallow TMR
22/02/2024	TMR_48	- 45° 0.7901'	115° 0.5912'	4300	TMR	12xDTM	Deep TMR
23/02/2024	TMR_49	- 43° 59.5875'	114° 59.8702'	4331	TMR	12xDTM	Deep TMR
23/02/2024	TMR_50	- 42° 59.7956'	114° 59.2831'	4332	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCu isotopes, 8xCd isotopes, 3xsiderophores, 8xHg, 8xCa/Mg, 12x intercalibrations samples	Shallow Super TMR
24/02/2024	TMR_51	- 42° 59.9606'	114° 59.5949'	4250	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xHg, 8xCa/Mg (No siderophores or isotopes) 12x intercalibration samples	Deep Super TMR
23/02/2024	ISP_14	- 42° 59.9324'	114° 59.4936'	1750	ISP	8 Supor filters, 6 QMA filters	ISP

25/02/2024	TMR_52	- 42° 0.2879'	115° 0.2324'	1550	TMR	12xDTM	Shallow TMR
25/02/2024	TMR_53	-40° 51.9027'	114° 59.9737	4666	TMR	12xDTM	Deep TMR
26/02/2024	TMR_54	- 39° 41.9537'	115° 0.1382'	1550	TMR	12xDTM	Shallow TMR
26/02/2024	TMR_55	- 38° 30.0072	115° 0.0267'	1410	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCa/Mg	Super Shallow TMR
27/02/2024	TMR_56	- 38° 30.3614'	115° 1.4853'	4520	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCa/Mg (no siderophores or isotopes)	Super Deep TMR
27/02/2024	ISP_15	- 38° 30.2405	115°0.9537	1790	ISP	8 Supor filters, 6 QMA filters	ISP
28/02/2024	TMR_57	- 37° 30.3193'	115° 0.0307'	1476	TMR	12xDTM	Shallow TMR
28/02/2024	QC_01	- 37° 2.2700'	114° 59.8595'	500	TMR	12xDTM	Shallow quality control TMR
28/02/2024	TMR_58	- 36° 31.7386'	114° 59.8383'	5016	TMR	12xDTM	Deep TMR
29/02/2024	QC_02	- 36° ' 32.8040	114° 58.7244'	500	TMR	24xDTM	Shallow quality control TMR
29/02/2024	TMR_59	- 35° 38.9849'	115° 0.0630	1505	TMR	12xDTM	Shallow TMR
01/03/2024	TMR_60	- 35° 11.9234	114° 59.9765	1440	TMR	12xDTM, 8xPb, 8xCu ligands, 8xFe ligands, 8xCa/Mg	Super Shallow TMR
02/03/2024	ISP_16	- 35° 12.0634	115° 0.3965	1410	ISP	8 Supor filters, 6 QMA filters	ISP
02/03/2024	TMR_61	- 34° 57.0535'	115° 0.5623'	162	TMR	9xDTM	Shallow TMR
02/03/2024	TMR_62	- 34° 35.8304'	115° 3.0528'	82	TMR	6x DTM	Shallow TMR
02/03/2024	TMR_63	- 34° 27.4723'	115° 5.4509'	41	TMR	4x DTM	Shallow TMR
02/03/2024	TMR_64	- 35° 10.1257'	114° 12.7334'	3450	TMR	12 x DTM	Deep TMR
04/03/24	TMR_65	- 32° 39.5327	114° 9.6086'	2391	TMR	11x DTM, 8x Pb	Deep TMR

Dissolved trace metal samples were taken at each TMR station, while multiple other samples were collected (TEIs, Pb/Pb+U, stable isotopes, ligands, siderophores) only from pre-selected stations and depths (**see Table 5**) for both national and international collaborators. Radiogenics, REE, and N-isotopes were collected from the standard CTD using trace metal clean techniques, targeting the same stations and depths as sampled with the TMR for comparison (see **Table 6**). ISPs were deployed at super- and process-stations, reaching depths of up to 2900 m. The deployment depth of the pumps was determined by key features in the water column and the sample depth targeted by the TMR (see **Table 7**).

7. Sampling and Analysis Processes

The GEOTRACES team collected over 3000 samples over the course of the MISO voyage, representing multiple analytes and the interests of several research groups (**Table 3**). All samples were collected following protocols documented in the GEOTRACES cookbook (Cutter et al., 2017). Dissolved samples were collected using an autonomous 12 Bottle Trace Metal Clean Rosette (TMR) **(Figure 2)** and filtered using clean techniques under laminar flow (HEPA filters) in a specially designed clean container (**Figure 2**).

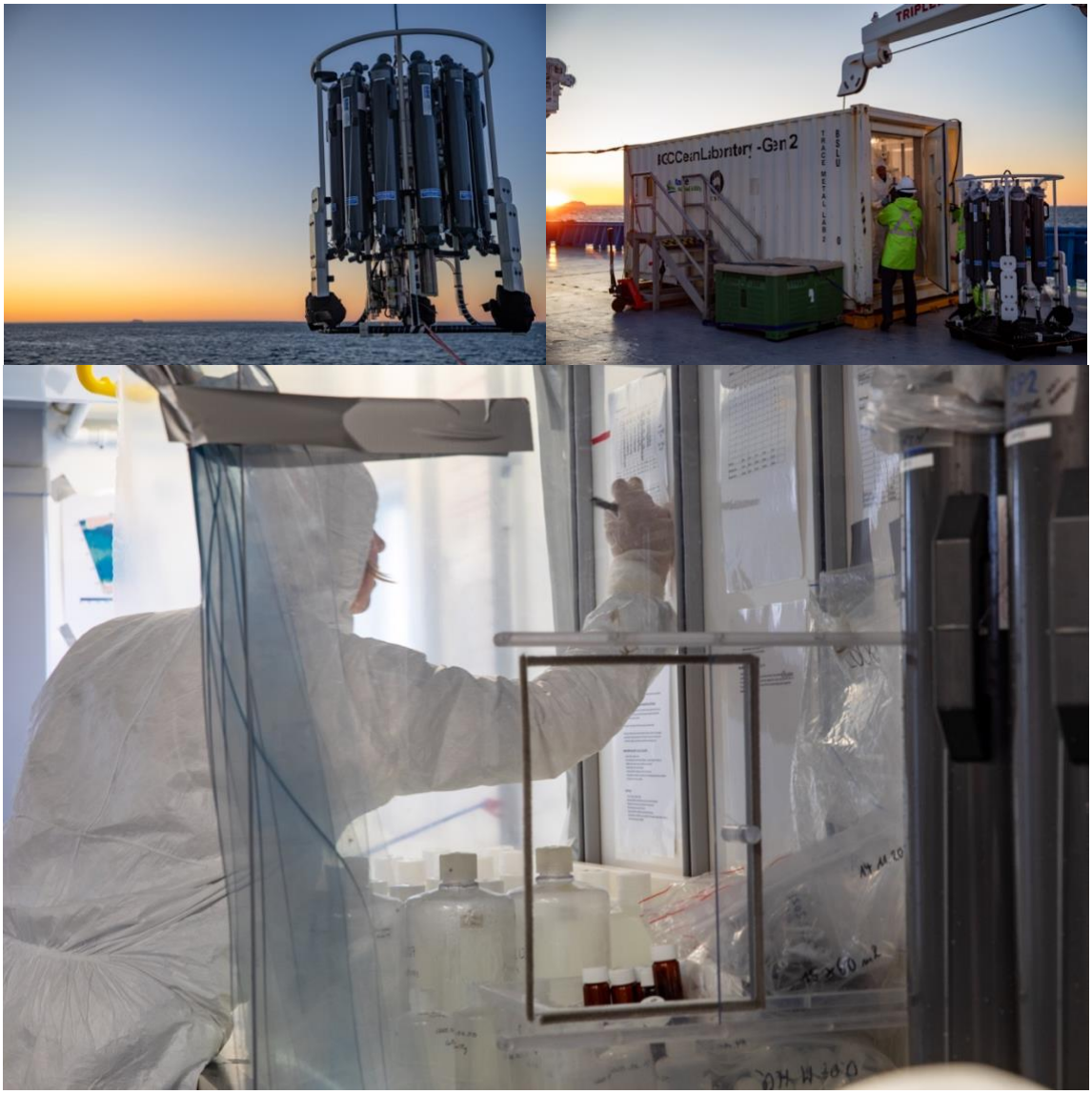

Figure 2: Pictures of the autonomous 12 Bottle Trace Metal Clean Rosette (TMR), and the outside and inside of the TM clean container.

Particulate samples were collected using 6 Dual Head, and 2 single head Mclane® in-situ pumps (ISP's) at selected stations and depths **(Figure 3)**. 18 of the 14 ISP filter heads contained two back-to-back paired pre-cleaned Supor filters for particulate trace metal, isotopes, radiogenics, iron mineralogy, and iron leaching work, and 6 ISP filter heads contained pre-combusted QMA filters for CHN analysis. Filters were doubled up to provide an effective filtration pore size of approximately 0.4 micron.

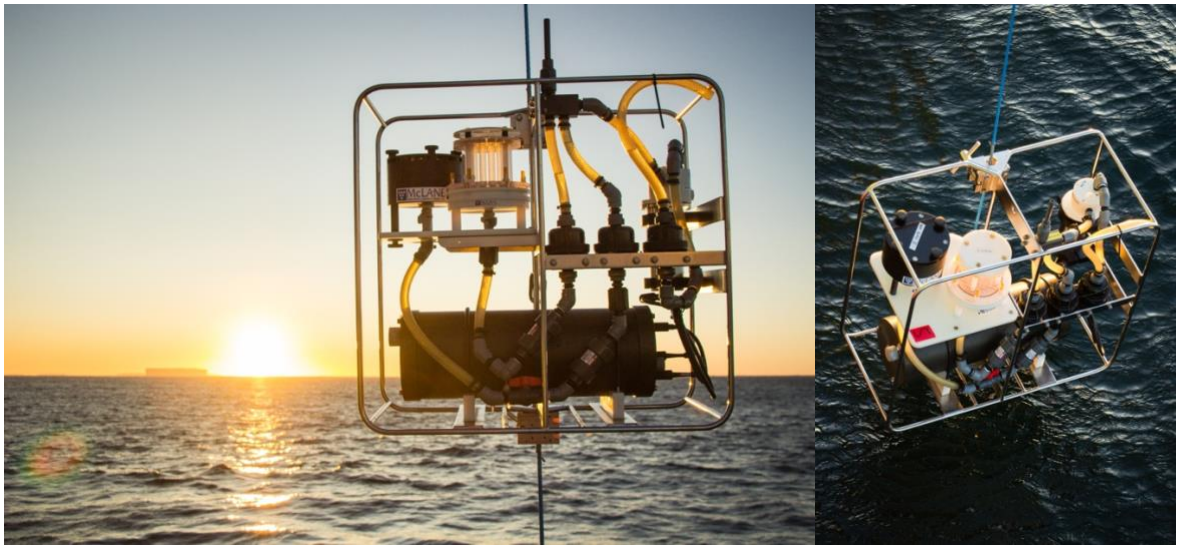

Figure 3: Pictures of Dual Head Mclane® insitu pump (ISP).

In addition to the collection of aqueous and particulate samples, 5 sets of duplicate samples for aerosols were also collected using the ships dedicated air-intake system and aerosol sampling manifold (**Figure 4, Table 9**), as well as 2 rainwater samples using the trace metal clean rainwater collector on deck 5 (**Figure 5, Table 10**).

Analysis of trace metals and radiogenic isotopes will take place in the IMAS laboratories at the University of Tasmania (UTAS) in collaboration with the GEOTRACES program. Stable isotopes will be processed and analyzed at the Australian National University by Michael Ellwood. Ligands offer insights into Fe and Cu cycling in the ocean and will be processed and analyzed at the University of Tasmania (UTAS). Siderophores (specific Fe-binding ligands) will be analyzed at the University of Washington in conjunction with Randie Bundy. Total Hg samples will be analyzed at GEOMAR in Sylvia Sander's research group in conjunction with Jennifer Powell (CSIRO). N isotopes will be measured at the University of Cape Town by Sarah Fawcett.

8. Trace Metal Clean Rosette (TMR) Sampling

Prior to the initiation of sampling we did a 'cleaning' TMR caste at the 2000 m isobath. Water collected at 100m and approximately 100 mL of distilled acid was added to each Niskin bottle. The bottles were left to clean overnight, before a second 'rinsing' caste at the 2000 m isobath was completed. The water from each Niskin bottle then underwent a cleanliness test by direct iron (Fe) analysis on the automated Flow Injection Analyzer (FIA). We had problems with the FIA which are outlined in section 14, so results were only indicative. Relative peak intensities between samples and calibrants on the FIA indicated sub-nano-molar concentrations of Fe in the Niskin Bottles indicating they were clean and ready for deployment and sampling. Before each deployment, the SeaRam was programmed to close the Niskin bottles at pre-defined depths during the up-cast. After each deployment, the Rosette frame and sensors were cleaned with freshwater (except when outside temperature dropped below 0°C), and the data from the SeaRam and USBL (Ultra-Short Baseline acoustic positioning system) were offloaded. The frame contained calibrated sensors for various measurements (pressure, temperature, conductivity and salinity). Refer to **Table 5** for numbers of samples collected.

Dissolved Metal Sampling

For dissolved metals, samples were filtered over a 0.2 μm PES Acropak filter (Pall) directly from the Niskin bottles into 125 mL pre-cleaned LDPE bottles after rinsing the empty bottles

4x with sample seawater. Samples were then acidified to ~1.8 pH immediately after filtration using ultra clean HCl (SEASTAR Baseline®, using 2 µl of HCl per ml of seawater) and stored in plastic containers for later shore-based laboratory analysis at the University of Tasmania. It is crucial to note that the trace metal intercalibration samples, as well as all samples collected from station GS05-57 onwards, were not acidified due to the unavailability of acid. These samples were stored in a cool environment at 4ºC and will undergo acidification upon return to the home-laboratory. The analysis will be done using an offline SeaFAST preconcentrating system coupled with a High-Resolution Sector Field Inductively Coupled Plasma Mass Spectrometer (HR-ICP-MS) (Wuttig et al., 2019).

Total Hg Sampling

Pre-cleaned borosilicate bottles (~60 mL) were filled with filtered seawater (0.2 µm, PES Acropak) for total Hg after rinsing the empty bottles 3x with sample seawater. After sampling, the samples were acidified with quartz-distilled HCl to a final concentration of 0.004 M. Subsequently, Samples were double-bagged in ziplog bags and kept in cold conditions in the dark until analysis in the shore-based laboratory at GEOMAR, Germany, using a standard Brooks Rand mercury system. This research will be conducted in collaboration with Prof Sylvia Sander (GEOMAR) and Jennifer Powell at CSIRO.

Pb and U isotope Sampling

Samples for Pb analysis were taken from selected depths at deep TMR deployments at super- and process -tations, and from all TMR deployments at SOTS and along 150°E, 140°E and 131°E transects. Seawater samples were filtered (0.2 µm) as per the dissolved trace metals and collected in acid-cleaned 1L LDPE containers, after rinsing the empty bottles 3x with sample seawater, before acidification to pH <2.0 with twice-distilled HCl. Samples were double bagged in zip-lock bags and stored for shore-based analysis by collaborators Dr. Taryn Noble and Prof. Zanna Chase at the University of Tasmania, Australia. A total of 93 larger, 2L samples were taken for analysis of U alongside Pb, from deployments along 140°E and 131°E transects, for shore-based analysis by collaborators Dr. Taryn Noble and Prof. Zanna Chase at the University of Tasmania, Australia.

Cu, and Cd-Fe-Zn isotope Sampling

Samples for Cu isotope analysis and Cd-Zn-Fe isotope analysis were collected from 8-16 depths at super- and process-stations. Seawater samples were filtered (0.2 µm) and collected in acid-cleaned 1L LDPE containers after rinsing the empty bottles 3x with sample seawater. Surface samples for Cd-Zn-Fe isotope analysis were taken in volumes of at least 2L. Samples were then double bagged in zip-lock bags and stored for shore-based analysis by collaborator Prof Micheal Ellwood at the Australian National University, Australia.

Cu and Fe ligand Sampling

Samples for ligand analysis were taken at 8-16 depths at selected station, filtered in the clean container (0.2 µm filtered), and collected in acid-cleaned 500 mL LPDE bottles for Cu and 250 mL LDPE bottles for Fe after rinsing the empty bottles 3x with sample seawater. Samples were then double bagged and stored frozen at - 20 degrees Celsius in the dark. Ligand samples will be processes at the University of Tasmania using competitive ligand exchange -cathodic stripping voltammetry (CLE-CSV) with Salicylaldoxime (SA) as competing ligands (Thompson et al., 2014; Abualhaija and van den Berg, 2014).

Siderophore Sampling

Siderophore samples were taken at 8-16 depths per station, filtered in the clean container (0.2 μm filtered), and collected in acid-cleaned 2L polycarbonate bottles after rinsing the empty bottles 3x with sample seawater. Samples were then double bagged and stored frozen at - 20 degrees Celsius in the dark for later analysis at the University of Washington using High-Performance Liquid Chromatography−Inductively Coupled Plasma-Mass Spectrometry (Boiteau et al., 2013). This research will be conducted in collaboration with Assoc Prof Randie Bundy at the University of Washington.

Ca/Mg sampling

Samples for Ca/Mg analysis were collected from every TMR deployment, filtered (0.2 μm), and collected in acid-cleaned 500 mL LDPE containers, after rinsing the empty bottles 3x with sample seawater. Samples were then double bagged in zip-lock bags and stored for shore-based analysis by collaborator Prof Michael Ellwood at the Australian National University, Australia.

9. Conductivity, Temperature Depth (CTD) Sampling

A Conductivity, Temperature, Depth (CTD) sampler consisting of 36x12L Niskin bottles was employed for the collection of physical and hydrographical parameters and water samples throughout MISO/GS05. Niskins were tested for leaks at the start of the voyage. The CTD was deployed in Storm Bay, Tasmania, with all bottles fired at the same depth. Nutrients were analysed to check for contamination and/or leaking of seawater.

Table 6: List of sampled CTD stations. Samples taken for Th/Nd, N-isotopes, and REE.

Date	Station	Latitude (Start)	Longitude (Start)	Ocean depth (dbar)	# Samples (REE, Th/Nd)	# Samples (N-isotopes)
06/01/24	CTD_002	-46° 39.959	142°39.956	4224	12	-
10/01/24	CTD_003	-62° 30.134	149°59.693	3890	-	30
11/01/24	CTD_004	-63° 0.3656	149°49.8373	3817	-	26
11/01/24	CTD_006	-63° 9.9474	150° 0.2652	3621	-	28
12/01/24	CTD_007	-64° 30.1197	150° 0.4519	3470	13	-
12/01/24	CTD_008	-65° 0.7565	149° 59.7424	3263	11	20
13/01/24	CTD_009	-65° 20.3303	150° 1.3494	2929	6	21
14/01/24	CTD_010	-66° 28.5811	144° 56.7724	419	8	18
15/01/24	CTD_011	-66° 42.0022	144° 11.5713	856	6	20
15/01/24	CTD_012	-67° 0.1085	145° 0.131	1141	10	18
20/01/24	CTD_016	-65° 23.9681	139° 59.9978	2341	9	23
21/01/24	CTD_017	-65° 0.0593	140° 0.4577	2671	2	24
22/01/24	CTD_019	-64° 13.2094	140° 0.4609	3527	10	22
23/01/24	CTD_021	-63° 21.0488	140° 0.2478	3779	-	24
23/01/24	CTD_022	-62° 51.4852	140° 0.0552	3213	9	20
24/01/24	CTD_023	-62° 0.005	132° 0.140	4480	11	20
25/01/24	CTD_025	-63° 0.084	132° 0.107	4300	12	19
27/01/24	CTD_027	-64° 0.0605	131° 59.9180	3239	-	23
26/01/24	CTD_028	-64.521149	132.051285	1524	10	20
28/01/24	CTD_030	-64° 50.4166	131° 59.6507	971	-	13
30/01/24	CTD_031	-63° 0.0665	122° 59.926	4018	2	-
30/01/24	CTD_032	-64° 28.9003	122° 59.6972	3023	3	-
31/01/24	CTD_033	-64° 26.5180	113° 52.6396	2552	-	27
01/02/24	CTD_034	-64° 20.4100	113° 22.4714	3385	9	20
02/02/24	CTD_036	-63° 38.3744	113° 19.4861	3270	-	20
03/02/24	CTD_038	-62° 46.8979	113° 18.0829	3828	-	20
03/02/24	CTD_040	-61.879865	113.279682	4189	10	18
05/02/24	CTD_044	-61° 30.576	115° 0.718	4343	-	20
06/02/24	CTD_046	-60° 23.952	115° 0.208	4461	-	20

07/02/24	CTD_048	-59° 12.8070	115° 1.3480	4527	10	20
08/02/24	CTD_050	-57° 59.7355	114° 59.850	4573	-	20
09/02/24	CTD_052	-56° 48.4719	114° 58.7855	4530	11	20
12/02/24	CTD_054	-55° 35.945	115° 0.322	4605	-	20
14/02/24	CTD_056	-54° 23.1698	115° 1.0446	4132	11	19
15/02/24	CTD_059	-53° 12.595	115° 0.7565	3979	-	20
16/02/24	CTD_061	-51° 58.800	115° 0.112	3629	-	18
17/02/24	CTD_063	-51° 0.0905	114° 59.9738	3969	-	20
17/02/24	CTD_064	-50° 29.491	115° 0.059	3141	11	20
18/02/24	CTD_065	-49° 54.406	115° 0.124	3895	-	20
19/02/24	CTD_067	-48° 59.411	115° 1.271	3957	-	20
19/02/24	CTD_069	-48° 0.1101	115° 0.0133	3649	-	20
20/02/24	CTD_071	-47° 0.7675	115° 1.5605	3870	12	20
21/02/24	CTD_073	-46° 1.159	114° 59.862	4114	-	20
22/02/24	CTD_075	-45° 0.020	115° 0.716	4235	-	20
23/02/23	CTD_077	-43° 59.3315	115° 0.0785	4342	-	20
23/02/24	CTD_079	-43° 29.9946	115° 0.1391	4311	12	18
24/02/24	CTD_081	-42° 0.110	114° 0.160	4526	-	20
24/02/24	CTD_083	-40° 52.225	115° 0.072	4652	-	20
25/02/24	CTD_085	-39° 41.9924	115° 0.0689	4759	-	20
26/02/24	CTD_087	-38° 30.0579	115° 0.2558	4782	12	20
28/02/24	CTD_089	-37° 30.2934	115° 0.0179	5264	-	20
28/02/24	CTD_091	-36° 31.8293	114° 59.1668	5236	-	20
01/03/24	CTD_093	-35° 38.7836	115° 0.4160	5113	-	20
01/03/24	CTD_095	-35° 29.978	115° 0.372	1488	8	20
01/03/24	CTD_097	-34° 57.0248	115° 0.5971	209	-	10
02/03/24	CTD_100	-34° 27.562	115° 5.3871	51	-	5
02/03/24	CTD_101	-35° 10.5458	114° 12.9410	3344	-	24

Radiogenic isotope (Th, Nd) sampling

Large (10L) samples were taken from the CTD for measurement of radiogenic isotopes (Th and Nd), from all super- and process-stations, as well as several stations along transects at 150°E, 140°E, 132°E, and during transit from 132°E to the start of I9S. Up to 12 depths were taken for analyses. Opportunistic sampling was also carried out within the Mertz Polynya region. Samples were filtered (0.2 μm) and collected in acid-cleaned 10L LPDE jerry cans. AcroPak filters were used, attached to acid-cleaned tubing. Samples were subsequently acidified to pH <2.0 using twice distilled HCl. Samples were left to stand for approximately 6-12 hours following acidification, and pH tested. Samples with pH >2.0 were then further acidified, and pH re-checked. Ship blanks were taken using 10L jerry cans filled with the ships Milli-Q water, with a filter left attached in the CTD room for the length of time taken to filter a regular sample. Blanks were acidified and treated identically to samples. Samples were taken to the University of Tasmania for measurement by collaborators Dr. Taryn Noble and Prof. Zanna Chase.

Rare Earth Element (REE) concentrations

Small (125 mL) REE samples were collected from the same Niskin bottles from which radiogenic isotopes samples were collected. Samples were filtered (0.2 μm) and collected in acid-cleaned 125 mL LPDE bottles. Samples were subsequently acidified to pH <2.0 using twice distilled HCl. Samples were taken to the University of Tasmania for measurement by collaborator Dr. Taryn Noble.

10. In situ Pump (ISP) Sampling

6 dual-head and 2 single-head Mclane® in-situ pumps were utilized for collecting particulate samples at super and process stations during the MISO/GS05 expedition. Before deployment, the ISPs were programmed with a pump time of 2 hours and a pump rate of 7000 mL/min (Dual Head pumps) and 4000 mL/min (single head pumps). Alkaline batteries were checked, flow meter data was recorded, and filter heads were assembled in a clean container and mounted on the pumps. A total of 8 filter heads were loaded with two pre-cleaned back-to-back paired 0.8 µm Supor filters (Pall), while 6 filter heads were loaded with two pre-combusted back-to-back paired 0.8 µm QMA filters (Pall) sitting on a 150 µm nylon support mesh. This gave an effective pore size of approximately 0.45 µm. All filters and filter holders were acid leached prior to use according to methods recommended in the GEOTRACES cookbook (Cutter et al., 2017). The first ISP was then mounted on the wire 10 m from the bottom weight and USBL, with the wire-out used to target nominal depths during deployment. The remaining pumps were mounted on the wire at the desired depth following the previous TMR deployment. Upon retrieval, the flow meter volumes were recorded, pump data was offloaded, and any water that remaining water in the pump was drained through the filters. Pump heads were then covered with ziplog bags and transferred into the clean container for processing. The ISPs were rinsed with freshwater after each deployment, except when outside temperature dropped below 0°C. In the clean container, filter heads were disassembled and left to dry under a laminar flow hood before subsampling the filters for various analyses, including CHN. Subsamples were obtained by cutting 13 mm and 47 mm replicate punches from the QMA and Supor filters. The subsamples were then stored in labeled petri dishes and transferred to the -20°C freezer. Afterwards, the filter screens were rinsed with Milli-Q and left to dry before the next deployment. Process filter blanks were also taken by loading the filters into the filter heads and deploying the ISPs without pumping. Filter blanks were processed and analyzed as regular samples, and thus functioned as full seawater process blanks.

Table 7: ISP sampling depth information

Station	Depth Pump 1 (m)	Depth Pump 2 (m)	Depth Pump 3 (m)	Depth Pump 4 (m)	Depth Pump 5 (m)	Depth Pump 6 (m)	Depth Pump 7 (m)	Depth Pump 8 (m)
GS05_ISP01	30	50	100	200	500	1000	-	-
GS05_ISP02	30	50	75	150	250	370	-	-
GS05_ISP03	15	27	75	400	650	750	-	-
GS05_ISP04	20	60	310	575	790	1050	-	-
GS05_ISP05	20	50	100	600	1400	1700	2000	2300
GS05_ISP06	20	35	85	145	405	510	1050	1200
GS05_ISP07	20	45	100	205	500	1100	1200	1500
GS05_ISP08	20	40	80	280	450	950	1200	1410
GS05_ISP09	20	65	125	345	505	990	1380	1780
GS05_ISP10	30	55	70	180	260	510	1110	1600
GS05_ISP11	30*	40*	90	125	285	580	920	1470
GS05_ISP12	20	75	120	600	1000	1900	2510	2900
GS05_ISP13	25	55	80	155	500	735	1050	1535
GS05_ISP14	15	57	85	205	505	705	1125	1740
GS05_ISP15	15	77	200	350	490	850	1400	1780
GS05_ISP16	25	50	100	240	400	750	1250	1400

*pump failed

11. Aerosol Sampling Manifold

Significant problems were encountered during the sample collecting of aerosols over the course of the voyage (see **Section 14** – issues encountered with equipment). Samples were collected on acid clean Whatman 41 cellulose filters (pore size 20 µm) using a trace metal clean aerosol sampling manifold (**Figure 4**) connected to the ships dedicated aerosol sampling system. The

pumps were connected to the ships sector-control, so sampling only took place when the ship was going into a headwind (see **Table 8** for more info on sampling settings). When flow readings exceeded 100 m^3 or more for both channels, the filters were changed over.

Table 8: Aerosol Sector Control Settings

Averaging duration	10 seconds
Port bearing limit	290º
Starboard bearing limit	70º
Windspeed min	4.3 Knots
Windspeed max	80 Knots
Black carbon concentration min	-10.0 ng mg^{-3}
Blank carbon concentration limit	5.0 ng mg^{-3}

Samples taken are shown in **Table 9.** Two sets of procedural blanks were taken, i.e., one at the beginning of the voyage and one at the end.

Table 9: Aerosol sampling information

Entry	Aerosol Number	Total volume (m3)	Start Date_Time (UTC)	Start Latitude	Start Longitude	End Date_Time (UTC)	End Latitude	End Longitude
1	Aero #1	120.4739	05/01/2024_03:37	-43.575	147.344	14/01/24_10:20	-66.5	145.087
	Aero #2	117.2894						
2	Aero #3	159.301	22/01/2024_12:21	-66.5	145.087	02/02/2023_01:30	-63.606	113.331
	Aero #4	136.814						
3	Aero #5	123.729	08/02/2024_14:38	-57.782	115	15/02/2024_1300	-53.809	115.014
	Aero #6	98.997						
4	Aero #7	138.327	15/02/2024_13:00	-53.809	115.014	22/02/2024_10:51	-48.002	115.000
	Aero #8	101.746						
5	Aero #9	138.143	22/02/2024_10:51	-48.002	115.000	29/02/24_16:43	-36.014	115.000
	Aero #10	101.746						

Figure 4: Aerosol sampling manifold in forward aerosol lab.

12. Rainwater Sampling

Rainwater was collected from the Deck 5 rainwater sampler (**Figure 5**) during significant precipitation events, such as heavy rain and snow. Although, two Rainwater samples were initially collected, due to heavy tailwinds, exhaust particles were observed in the funnel and the first sample. To address this issue, efforts were made to clean the funnel, and subsequently, precipitation samples were collected following a significant snow event (see **Table 10**).

Table 10: Aerosol sampling information

Entry	Start Date Time (UTC)	Start Latitude	Start Longitude	Volume Collected
RW Cover off	11/01/2024_19:53	- 63° 59.9957'	150° 0.0941'	-
RW Cover on	12/01/2024_04:02	- 64° 30.0109'	150° 0.0282'	100 mL
RW Cover off	12/01/2024 _06:53	- 64° 31.5760'	149° 59.9977'	-
RW Cover on	12/01/2024 _07:53	- 64° 40.6204'	149° 59.9960'	-
RW Cover off	18/01/2024 _10:15	- 65° 23.7138'	140° 0.0049'	400 mL
RW Cover on	19/01/2024_15:14	- 65° 25.3853'	140° 6.0452'	-

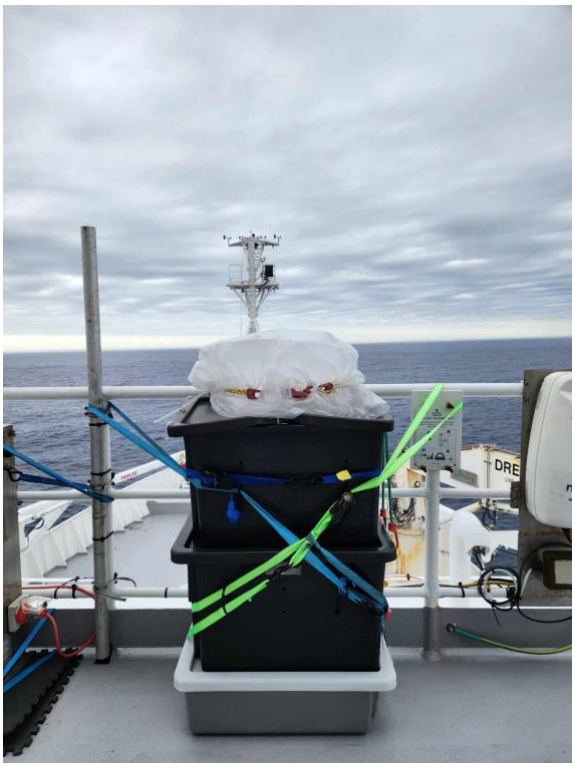

Figure 5. Rainwater/Precipitation catcher

13. Bongo Nets

Zooplankton graze on phytoplankton and release excess ingested material via excretion and egestion of faecal pellets. To date, very little is known about how zooplankton link primary production of phytoplankton with the cycling and export of iron and carbon. By collecting zooplankton samples for trace metal analyses, we will improve our understanding of how zooplankton-mediated iron recycling affects ocean productivity and carbon export in a changing climate.

In total, we deployed 13 bongo nets at each super and process station during the cruise, except at the 2nd process station (132E - Site 6) due to bad weather. The net was towed for 15 minutes at a depth of 70 metres to collect different zooplankton taxa such as krill, pteropods, copepods, amphipods and more. In total, we successfully collected over 160 samples to be analysed in the home laboratory for community structure and trace metal analysis.

Figure 6: Zooplankton sampling during the MISO voyage on board the RV Investigator.

14. Data Management

All raw and processed data from the project will be stored on the IMAS Data Portal and the CSIRO Data Access Portal for secured back-up and is available to collaborators on request upon completion of analysis. After suitable quality control, the metal data will be submitted in the final project year to the GEOTRACES International Data Management Centre (www.bodc.ac.uk/geotraces/) and included in the GEOTRACES Intermediate Data Products. The IMAS team have an excellent track record of submitting data from GEOTRACES to international databases. Two years after submission or upon publication (whichever comes sooner), data will become publicly available.

15. Issues encountered with equipment during the voyage

Unfortunately, we encountered several issues with the equipment, i.e., FIA, ISPs, TMR, and aerosol manifold, over the course of the voyage. See the details below.

- ***Flow Injection Analysis System (FIA)*** **-** We encountered difficulties obtaining reproducible data from the FIA, likely due to column saturation, while checking the cleanliness of the Niskin bottles. As a result, we had to rely on relative absorbances to assess the cleanliness of the bottles. Absorbances became reproducible only after significant flushing of the column. This process was adequate to ensure that Niskins from the TMR were free from contamination and sufficiently clean for sample collection.

- ***TMR and ISPs*** **-** The MNF protocol for operating the TMR and ISP's states that they should be rinsed with fresh water following deployment. However, we encountered issues when temperatures dropped below zero. In such conditions, we found that the bottles would not fire on the TMR due to the trigger mechanism being frozen, and the lines in the ISP's froze up, preventing the pumping mechanism to work. We recommend that future teams operating in freezing conditions avoid rinsing the equipment with fresh water until they reach warmer temperatures. We followed this procedure until we reached warmer regions along the I9S line.

- ***Aerosol manifold -*** We had significant problems with aerosol sampling throughout the voyage as a result of a problem with the aerosol filter manifold. One of the lines was drawing significant amounts of particles, likely rust or soot (see **Figure 6**), into the filter and filter housing. After significant troubleshooting, we found that the line did not extend far enough into the manifold. Unfortunately, the discovered was made after all acid washed lines and filter housings we brought were significantly contaminated. We recommend that prior to any voyage, the aerosol sampling manifold undergoes thorough cleaning and inspection before sensitive equipment is connected to it. Southern Ocean aerosols are notoriously difficult to collect due to the relatively low particle content of the overlying air masses. Therefore, any future re-design of the manifold should also include an option for a pair of Hi-volume lines that capable of collecting particles under trace metal clean conditions.

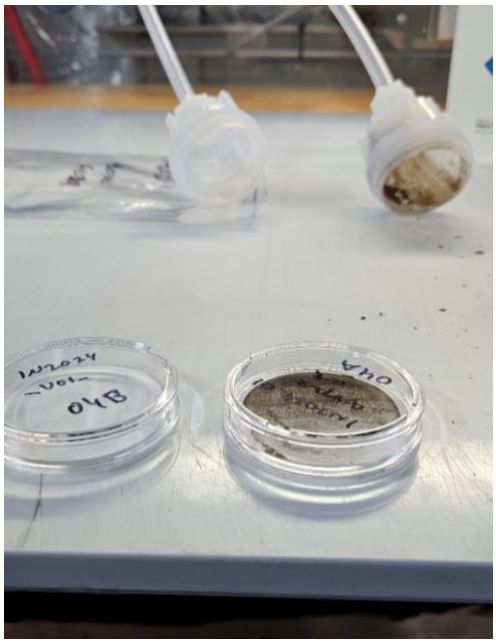

Figure 6: Contamination of aerosol sampling equipment from faulty manifold.

16. References

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