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# Short Cruise Report

## SONNE SO292/2

### Nouméa (New Caledonia) – Dutch Harbor (USA)

### 24.06.2022 – 21.07.2022

**Chief Scientist: Dr. Walter Menapace**

**Captain: Oliver Meyer**

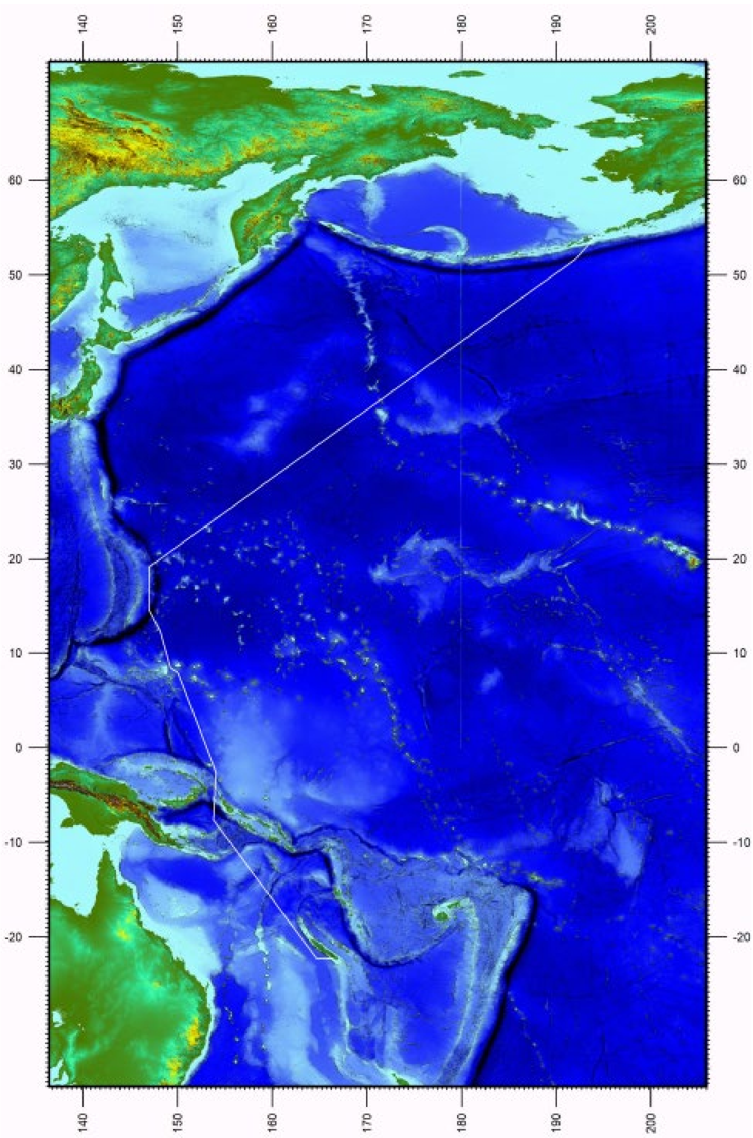


Fig. 1: Ship track of cruise SO292/2

## Objectives

The transit expedition SO292/2 was composed by two different projects: the main one with acronym "DeepBlue" and the secondary one with acronym "PORD", each one with diverse but compatible objectives.

*Objectives DeepBlue*
The main objective of DeepBlue was to investigate geodynamic processes and geochemical cycles in the Mariana Trench forearc, as this is a unique location worldwide for the possibility to study active subduction zone serpentinization through seafloor samples. Mud volcanoes (MVs), cold seep structures which are scattered on the forearc, are known features in the area and they have been proved to have a crucial role in recycling subducted sediments and even exhuming hydrated forearc mantle and subduction channel material to the seafloor. The nature of the emitted MVs sediments (mostly clast-rich dark blue serpentinite mud) and fluids (high pH and variable composition with increasing distance from the trench) allows to sample processes happening at depth into the subduction zone, up to ~19 km below seafloor. The samples collected with the RV Sonne on serpentinite MVs at varying distances from the trench will allow to characterize the fluid and solid end members of such extrusive products and shed some light on the serpentinization at depth in the forearc.

Previous expeditions have studied several Marianas MVs, but no sediments, rocks, or pore water samples have ever been recovered from MVs <50 km from the trench axis. The primary objective of SO292/2 was to fill this knowledge gap and thus:

i) characterize the spatial variability of slab fluids within the forearc environment as a means of tracing dehydration, decarbonization, and water-rock reactions in subduction and supra-subduction zone environments;
ii) investigate the metamorphic and tectonic evolution of this non-accretionary forearc region;
iii) explore the relationships between seismicity and seamount subduction vs. MV evolution.

In order to answer these questions, the scientific program included the following approaches: a) sample sediments and rocks from active MVs using gravity coring and dredging; b) acquire hydrographic data (parasound and multibeam) on newly discovered MVs and active fluid emission features; c) obtain photo/video material with the OFOS to investigate macrofauna and ongoing biogeochemical processes on active MVs; d) deploy two p-T observatories to assess episodic emission of sediments and/or fluids (and their implication for the subduction dynamics) on key MVs.

While objectives i) and ii) can be achieved through onshore laboratory analyses of the samples collected during the SO292/2 expedition, objective iii) will only be completed after recovery of the long-term pressure and temperature in-situ observatories deployed on two MVs during a future expedition.

*Objectives PORD*
The primary goals of the PORD project were to obtain continuous reference data over oceans during the whole SO292/2 transit. The atmospheric data collected (aerosol, clouds and trace-gases) will offer needed references to satellite remote sensing from space. Since relatively sparse data are present over the Pacific, the SO292/2 data will also support global modeling in a wider sense. The simultaneous sampling, also by the vessel's standard meteorological instruments, will be applied (1) to explore accuracy and consistency from redundant data and (2) to establish from associations with observational data possible statistical relationships. In addition, the bathymetry collected during transit will be uploaded to the SEABED 2030 database.

## Narrative

All the scientific participants of expedition SO292/2 boarded the ship in the early morning of the 23rd of June, after being tested for COVID infection before their respective flight, on land in Nouméa, and upon setting foot on the ship. The testing continued during the following days, in order to minimize the chances of contagion. The containers for the SO292/2 and the subsequent expedition (SO293) arrived as soon as the ship docked, on the 21st, and were consequently loaded. Due to the deferred arrival of several pieces of luggage from both the scientific and the ship's crew, the departure has been delayed to 22:00 on the 24th.

During the transit to Working Area 1 (WA1) the meteorologists and the hydroacoustics team started collecting data as soon as the Sonne was in open waters, and the measurements stopped at the end of the SO292/2 expedition, just before reaching the arrival harbor in Alaska. The atmospheric data for the PORD project have then been gathered in a seamlessly continuous way during the whole expedition.

This first part of the transit lasted from 25.06 until 02.07, when we entered the Northern Mariana EEZ and started the scientific work of the DeepBlue project. In these first days the scientists, which were mostly new to the ship, had the chance to get acquainted with the life on board and had to participate to the mandatory safety drill simulating an abandon ship situation. Science also kept the SO292/2 participants busy; laboratories were prepared for the first "core on deck", science meetings were held daily in the conference room, and continuous multibeam and parasound profiles were taken during transit, in order to contribute to the DAM Underway Bathymetry project.

On 03.07 we reached the Southern Mariana forearc, the first of our two study areas (WA1). During the night we could extensively map the target MV situated between 6000 and 7000 mbsl. Taking advantage of the beautiful weather and the perfect sea conditions on Monday the 4th we deployed the gravity corer, in order to sample diverse morphological features on the MV. Unfortunately, the coring operations revealed more difficult than expected, with a low core retrieval. Nonetheless, we continued the scientific program with a dredge profile on the same target, which allowed us to collect a suite of different rock clasts from both lower and upper plate. Subsequently, we used the RV Sonne own OFOS (Ocean Seafloor Observation System) to image the MV, getting spectacular footage of a clasts-rich ocean seafloor, mudflow terraces, and brucite chimneys. This not only confirmed the mud volcanic nature of this feature, but also allowed us to select a proper site for the deployment of the long-term pressure and temperature (p-T) observatory we built at MARUM. The NCB Observatory was then safely released on the seafloor (05.07), with the purpose of monitoring the p-T parameters of the MV sediments in the years to come, until its future retrieval.

We then steamed away in the direction of our second working area (WA2), in the Northern Mariana Forearc, which we reached on the 6th of July. Here we focused our research on multiple seafloor structures. Several gravity cores have been done, coring known features (Pacman, Conical and Cerulean Springs), as well as two new structures, which were identified as MVs due to retrieval of blue serpentinite muds and clasts. These sample will be studied in order to determine the geochemical composition of the porewater, as well as the presence of microbial activity, in an effort to shed some light on the origin of the fluids and the life which they could fuel. Finally, we also managed to core a deep-sea basin in the forearc, which recovered the first turbidite record of the Mariana Forearc retrieved after the DSDP Leg 60 in 1982.

Two further OFOS dives were performed at Cerulean Springs (06.07) and Conical (08.07), with the latter returning spectacular images of carbonate chimneys, ferromanganese crusts and deep fractures scattered on the seafloor. Moreover, we deployed the dredge two more times on Pacman (07.07) and

Conical (09.07), getting a discrete amount of samples which will be driving further petrological studies once onshore. The site selected for the deployment of our second observatory was Cerulean Springs, as it has been identified in the past as the one with the highest fluid flow emission of the whole forearc. The second NCB observatory was also flawlessly deployed on the 07th of July, in a location chosen from the seafloor imagery of the OFOS dive.

On the 9th of July we started the transit from WA2, which terminated with our arrival to Unalaska (Aleutian Islands). Meanwhile, the work on the samples collected in the working areas was still going on, with the scientists processing the cores and the dredge hauls material. In order to be able to use the samples in future publications, everything had to be thoroughly catalogued and stored adequately, with the corresponding metadata. We arrived on the 21st of July in Dutch Harbor (Unalaska), and disembarked the Sonne in the following days, since due to bad weather most of the flights to the Alaskan mainland were canceled.

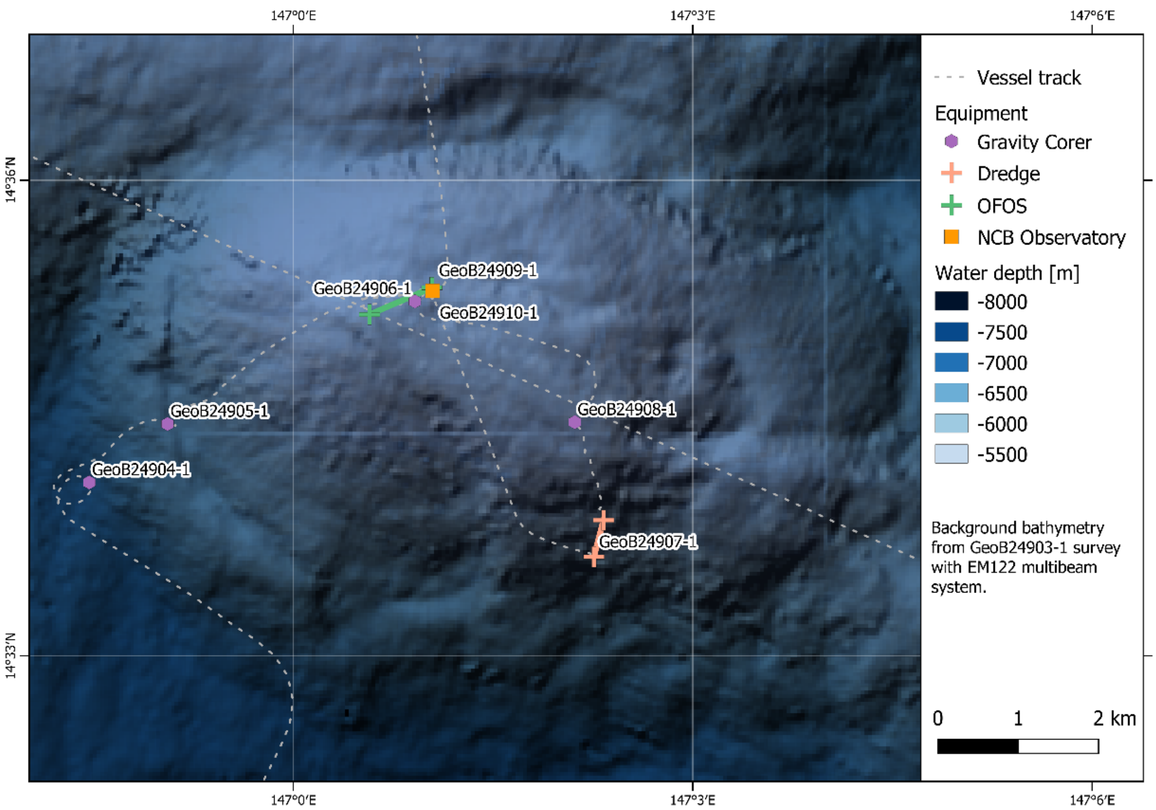

Figure 2: Overview of stations in the Unknown MV#1 in WA1.

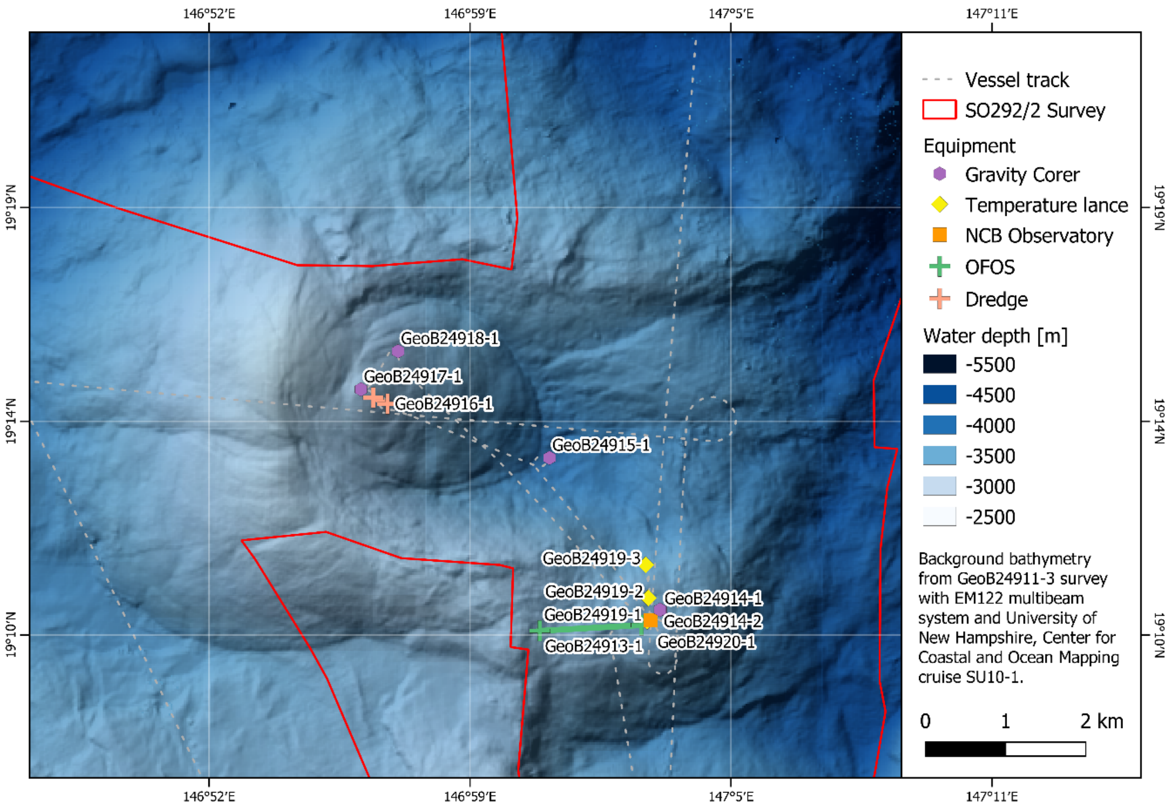


Figure 3: Overview of stations and bathymetric coverage on Pacman MV and Cerulean Springs (in WA2).

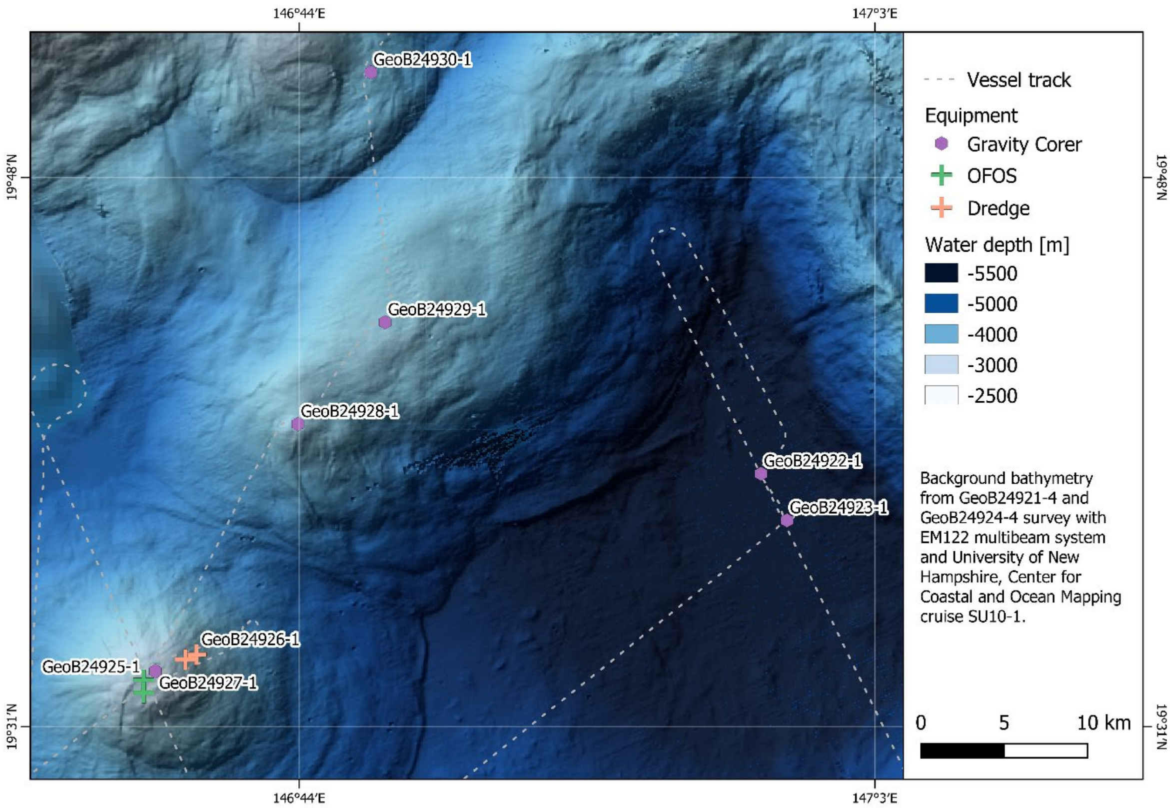


Figure 4: Detailed map of stations on a deep-sea Basin, Conical MV and two newly discovered MVs (Unknown MV#2 and Unknown MV#3 in WA2).

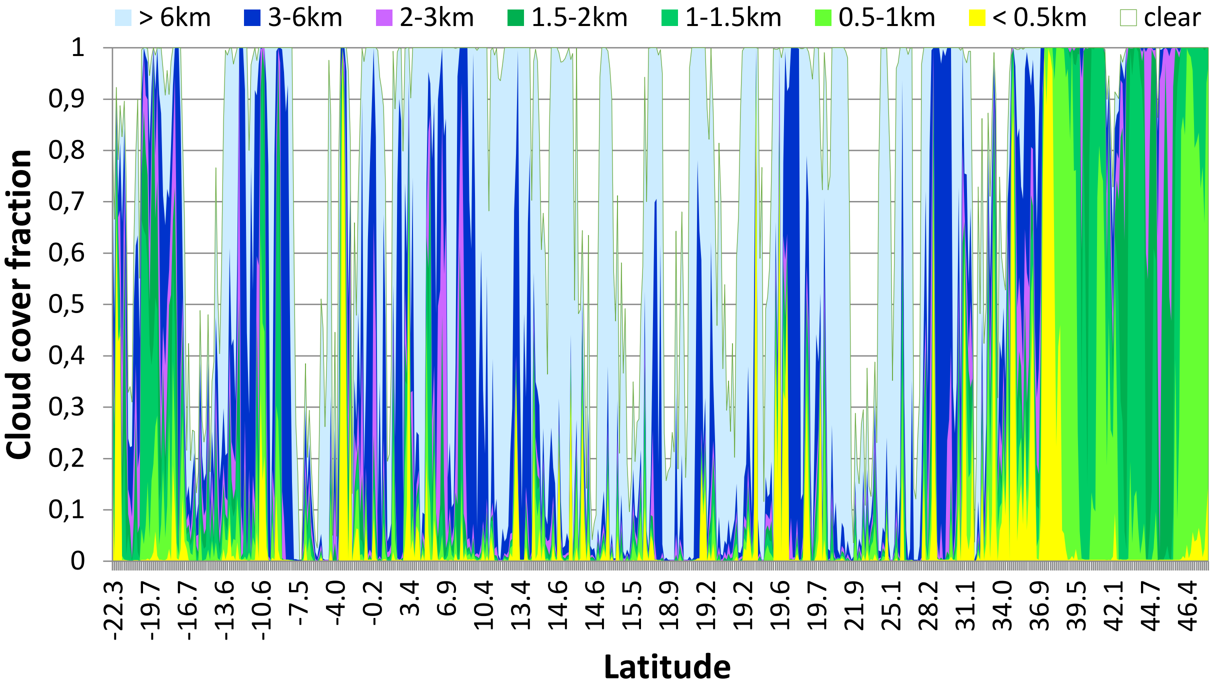


Figure 5: SO292-2 timeseries of hourly averages for cloud-base altitude range fractional coverage. Cloud-free fractions are indicated by absence of color.

## Acknowledgements


All participants of Expedition SO292/2 thank in addition to New Caledonia and Micronesia the US Department of State and the US Fish and Wildlife Service in particular for the permission of research in the Northern Marianas EEZ and in the Marianas Trench Marine National Monument area. The captain and crew of R/V SONNE are thanked for their support, which contributed to the success of the expedition. Particular gratitude goes also to the PTJ, the German Research Fleet Coordination Centre (LDF) and the shipping company Briese Research for the tremendous support they have provided.

**List of participants**

| # | Name | Task | Institute |
|---|---|---|---|
| 1. | Walter Menapace | Chief Scientist | MARUM / U-IBK |
| 2. | Timo Fleischmann | In-situ Observatories/Coring | MARUM |
| 3. | Sophia Stavrakoudis | In-situ Observatories/Heat Flow | MARUM - HiWi |
| 4. | Stefan Kinne | Atmospheric Measurements | MPI |
| 5. | Steffen Dörner | Atmospheric Measurements | MPI |
| 6. | Bianca Lauster | Atmospheric Measurements | MPI |
| 7. | Cornelia V. Kieckebusch | Atmospheric Measurements | MPI |
| 8. | Amber Henningsen | Hydroacoustics | MARUM - HiWi |
| 9. | Mona Lütjens | Hydroacoustics | HCU |
| 10. | Gavin Dmello | Hydroacoustics | MARUM - HiWi |
| 11. | Meret Felgendreher | Hydroacoustics | MARUM - HiWi |
| 12. | Shuhui Xu | Gas sampling | MARUM |
| 13. | Anna Krug | Biology | MARUM - HiWi |
| 14. | Peter Matzerath | Fluid Geochemistry | MARUM - HiWi |
| 15. | Antonia Witzleb | Fluid Geochemistry | MARUM - HiWi |
| 16. | Pauline Cornard | Sedimentology | U-IBK |
| 17. | Nele Behrendt | Sedimentology | MARUM |
| 18. | Dominik Zawadzki | Sedimentology | U-SZ |
| 19. | Junli Zhang | Cores / samples Curator | MARUM |
| 20. | Yuji Ichiyama | Petrology | CHIBA |
| 21. | Shun Takamizawa | Petrology | CHIBA |
| 22. | Palash Kumawat | Petrology | MARUM - HiWi |

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**Stations list**

GeoB Number: Curation number of the MARUM core repository

Abbreviations: SBE/ParaS/ADCP = Ship-mounted Multibeam/Parasound/ADCP systems; XSV = expendable sound velocimeter; GC = Gravity Corer; DRG = Chain-bag Dredge; OFOS = Ocean Floor Observation System; Observatory = p-T in-situ Observatory; TL = Temperature Lance; CO/CC/Ceilo/MAXDOAS = atmospheric measurements.

NOTE: Date/Time/LAT/LONG/Water Depth are relative to either start of the operation (for SBE/ParaS/ADCP, XSV) or seafloor conditions (GC, DRG, OFOS, Observatory, TL)

| GeoB Nr. | Ship Station | Gear Type | Name/Area | LAT | | | LONG | | | Time (UTC) | Date | WD (mbsl) | Recovery (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ° | min | Dir | ° | min | Dir | | | | |
| GeoB24901-1 | SO292/2_1 | SBE | New Caledonian EEZ To WA1 | 22 | 21.354 | S | 166 | 5.351 | E | 13:13 | 24.06.2022 | 1988 | / |
| GeoB24901-2 | SO292/2_1 | ADCP | New Caledonian EEZ To WA1 | 22 | 21.354 | S | 166 | 5.351 | E | 13:13 | 24.06.2022 | 1988 | / |
| GeoB24901-3 | SO292/2_1 | ParaS | New Caledonian EEZ To WA1 | 22 | 21.354 | S | 166 | 5.351 | E | 13:13 | 24.06.2022 | 1988 | / |
| GeoB24901-4 | SO292/2_1 | XSV | Underway XSV | 16 | 49.262 | S | 160 | 53.745 | E | 04:35 | 26.06.2022 | 4479 | / |
| GeoB24901-5 | SO292/2_1 | SBE | New Caledonian EEZ To WA1 | 4 | 50.275 | S | 153 | 50.540 | E | 03:18 | 29.06.2022 | | / |
| GeoB24901-6 | SO292/2_1 | BUCKET | New Caledonian EEZ To WA1 | 1 | 5.786 | S | 153 | 49.764 | E | 09:00 | 30.06.2022 | | / |
| GeoB24902-1 | SO292/2_2 | XSV | Underway XSV | 13 | 20.165 | N | 147 | 48.819 | E | 06:00 | 03.07.2022 | 5170 | / |
| GeoB24903-1 | SO292/2_3 | SBE | Mapping Potential MV#1 | 14 | 15.426 | N | 147 | 2.121 | E | 12:11 | 03.07.2022 | 7465 | / |
| GeoB24903-2 | SO292/2_3 | ParaS | Mapping Potential MV#1 | 14 | 15.426 | N | 147 | 2.121 | E | 12:11 | 03.07.2022 | 7465 | / |
| GeoB24904-1 | SO292/2_4 | GC | Potential MV#1 - Background | 14 | 33.805 | N | 146 | 58.476 | E | 22:27 | 03.07.2022 | 7085 | 168 |
| GeoB24905-1 | SO292/2_5 | GC | Potential MV#1 - W Flank | 14 | 34.180 | N | 146 | 59.104 | E | 03:16 | 04.07.2022 | 6619 | 0 |
| GeoB24906-1 | SO292/2_6 | GC | Potential MV#1 - Summit | 14 | 35.091 | N | 147 | 0.947 | E | 07:21 | 04.07.2022 | 5857 | 0 |
| GeoB24907-1 | SO292/2_7 | DRG | Potential MV#1 - S Flank | 14 | 33.249 | N | 147 | 2.257 | E | 12:16 | 04.07.2022 | 6464 | / |
| GeoB24908-1 | SO292/2_8 | GC | Potential MV#1 - E Flank | 14 | 34.313 | N | 147 | 2.157 | E | 18:17 | 04.07.2022 | 5985 | 0 |
| GeoB24909-1 | SO292/2_9 | OFOS | Potential MV#1 - Summit | 14 | 35.215 | N | 147 | 1.040 | E | 00:17 | 05.07.2022 | 5969 | / |
| GeoB24910-1 | SO292/2_10 | Observatory | NCB Observatory_Potential MV #1 | 14 | 35.089 | N | 147 | 1.036 | E | 08:40 | 05.07.2022 | 5977 | / |
| GeoB24911-1 | SO292/2_11 | SBE | Transit between WA1-WA2 | 14 | 35.770 | N | 147 | 1.110 | E | 10:45 | 05.07.2022 | 5965 | / |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GeoB24911-2 | SO292/2_11 | ParaS | Transit between WA1-WA2 | 14 | 35.770 | N | 147 | 1.110 | E | 10:45 | 05.07.2022 | 5965 | / |
| GeoB24911-3 | SO292/2_11 | SBE | Transit between WA1-WA2 | 18 | 57.003 | N | 146 | 56.998 | E | 10:45 | 06.07.2022 | 3150 | / |
| GeoB24911-4 | SO292/2_11 | ParaS | Transit between WA1-WA2 | 18 | 57.003 | N | 146 | 56.998 | E | 10:45 | 06.07.2022 | 3150 | / |
| GeoB24912-1 | SO292/2_12 | XSV | Underway XSV | 17 | 47.244 | N | 147 | 5.858 | E | 03:00 | 06.07.2022 | 3880 | / |
| GeoB24913-1 | SO292/2_13 | OFOS | Cerulean Springs | 19 | 9.692 | N | 147 | 1.993 | E | 19:39 | 06.07.2022 | 3445 | / |
| GeoB24914-1 | SO292/2_14 | GC | Cerulean Springs | 19 | 10.091 | N | 147 | 3.014 | E | 01:18 | 07.07.2022 | 3462 | 0 |
| GeoB24914-2 | SO292/2_14 | GC | Cerulean Springs | 19 | 10.094 | N | 147 | 2.999 | E | 03:36 | 07.07.2022 | 3465 | 200 |
| GeoB24915-1 | SO292/2_15 | GC | Pacman - Background | 19 | 13.570 | N | 147 | 0.393 | E | 06:52 | 07.07.2022 | 4208 | 0 |
| GeoB24916-1 | SO292/2_16 | DRG | Pacman - E Flank | 19 | 14.795 | N | 146 | 56.598 | E | 09:55 | 07.07.2022 | 3127 | / |
| GeoB24917-1 | SO292/2_17 | GC | Pacman - Summit | 19 | 15.099 | N | 146 | 55.964 | E | 13:51 | 07.07.2022 | 2997 | 165 |
| GeoB24918-1 | SO292/2_18 | GC | Pacman - N Flank | 19 | 15.880 | N | 146 | 56.779 | E | 16:21 | 07.07.2022 | 3176 | 69 |
| GeoB24919-1 | SO292/2_19 | TL | T measurement_Cerulean Springs | 19 | 9.910 | N | 147 | 2.739 | E | 19:45 | 07.07.2022 | 3487 | / |
| GeoB24919-2 | SO292/2_19 | TL | T measurement_Cerulean Springs | 19 | 10.433 | N | 147 | 2.763 | E | 21:13 | 07.07.2022 | 3442 | / |
| GeoB24919-3 | SO292/2_19 | TL | T measurement_Cerulean Springs | 19 | 11.178 | N | 147 | 2.706 | E | 23:05 | 07.07.2022 | 3684 | / |
| GeoB24920-1 | SO292/2_20 | Observatory | NCB Observatory_Cerulean Springs | 19 | 9.943 | N | 147 | 2.797 | E | 02:32 | 08.07.2022 | 3458 | / |
| GeoB24921-1 | SO292/2_21 | ParaS | Underway Mapping | 19 | 9.325 | N | 147 | 2.727 | E | 03:50 | 08.07.2022 | 3426 | / |
| GeoB24921-2 | SO292/2_21 | SBE | Underway Mapping | 19 | 9.325 | N | 147 | 2.727 | E | 03:50 | 08.07.2022 | 3426 | / |
| GeoB24921-3 | SO292/2_21 | ParaS | Mapping Basin | 19 | 29.049 | N | 147 | 4.086 | E | 05:40 | 08.07.2022 | 4772 | / |
| GeoB24921-4 | SO292/2_21 | SBE | Mapping Basin | 19 | 29.049 | N | 147 | 4.086 | E | 05:40 | 08.07.2022 | 4772 | / |
| GeoB24922-1 | SO292/2_22 | GC | Basin E Conical | 19 | 38.921 | N | 146 | 58.909 | E | 10:23 | 08.07.2022 | 5938 | 525 |
| GeoB24923-1 | SO292/2_23 | GC | Basin E Conical | 19 | 37.452 | N | 146 | 59.776 | E | 14:26 | 08.07.2022 | 5939 | 536 |
| GeoB24924-1 | SO292/2_24 | ParaS | Mapping Unknown MVs | 19 | 37.438 | N | 146 | 59.768 | E | 16:29 | 08.07.2022 | 5950 | / |
| GeoB24924-2 | SO292/2_24 | SBE | Mapping Unknown MVs | 19 | 37.438 | N | 146 | 59.768 | E | 16:29 | 08.07.2022 | 5950 | / |
| GeoB24924-3 | SO292/2_24 | ParaS | Mapping Unknown MVs | 19 | 25.432 | N | 146 | 42.525 | E | 18:31 | 08.07.2022 | 4744 | / |
| GeoB24924-4 | SO292/2_24 | SBE | Mapping Unknown MVs | 19 | 25.432 | N | 146 | 42.525 | E | 18:31 | 08.07.2022 | 4744 | / |
| GeoB24925-1 | SO292/2_25 | OFOS | Conical - W Flank | 19 | 32.628 | N | 146 | 39.328 | E | 01:02 | 08.07.2022 | 3093 | / |
| GeoB24926-1 | SO292/2_26 | DRG | Conical - E Flank | 19 | 34.452 | N | 146 | 42.546 | E | 06:55 | 09.07.2022 | 4136 | / |
| GeoB24927-1 | SO292/2_27 | GC | Conical Summit | 19 | 32.899 | N | 146 | 39.439 | E | 11:04 | 09.07.2022 | 3080 | 0 |
| GeoB24928-1 | SO292/2_28 | GC | Unknown MV#2 Summit | 19 | 40.423 | N | 146 | 44.043 | E | 14:04 | 09.07.2022 | 3358 | 188 |
| GeoB24929-1 | SO292/2_29 | GC | Unknown MV#2 Flank | 19 | 43.560 | N | 146 | 46.830 | E | 16:52 | 09.07.2022 | 3446 | 361 |
| GeoB24930-1 | SO292/2_30 | GC | Unknown MV#3 Flank | 19 | 51.098 | N | 146 | 46.400 | E | 20:00 | 09.07.2022 | 3710 | 272 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GeoB24931-1 | SO292/2_31 | SBE | WA#2 To Alaskan EEZ | 19 | 40.446 | N | 146 | 44.126 | E | 15:16 | 09.07.2022 | 3398 | / |
| GeoB24931-2 | SO292/2_31 | ParaS | WA#2 To Alaskan EEZ | 19 | 40.446 | N | 146 | 44.126 | E | 15:16 | 09.07.2022 | 3398 | / |
| GeoB24931-3 | SO292/2_31 | ADCP | WA#2 To Alaskan EEZ | 19 | 58.553 | N | 146 | 51.838 | E | 22:11 | 09.07.2022 | 3859 | / |
| GeoB24931-4 | SO292/2_31 | SBE | WA#2 To Alaskan EEZ | 19 | 58.553 | N | 146 | 51.838 | E | 22:11 | 09.07.2022 | 3859 | / |
| GeoB24932-1 | SO292/2_32 | XSV | Underway XSV | 32 | 17.610 | N | 156 | 26.874 | E | 02:03 | 13.07.2022 | 4238 | / |
| GeoB24933-1 | SO292/2_33 | XSV | Underway XSV | 44 | 44.708 | N | 172 | 50.746 | E | 18:15 | 16.07.2022 | 5870 | / |
| GeoB24934-1 | SO292/2_34 | CO | New Caledonian EEZ To Alaskan EEZ | / | | | | | | | | | |
| GeoB24934-2 | SO292/2_34 | CC | New Caledonian EEZ To Alaskan EEZ | / | | | | | | | | | |
| GeoB24934-3 | SO292/2_34 | Ceilo | New Caledonian EEZ To Alaskan EEZ | / | | | | | | | | | |
| GeoB24934-4 | SO292/2_34 | MAXDOAS | New Caledonian EEZ To Alaskan EEZ | / | | | | | | | | | |