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Short Cruise Report
RV SONNE cruise SO290

Nouméa (New Caledonia) – Nouméa (New Caledonia)

15.04.2022 – 12.05.2022

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Captain: Oliver Meyer

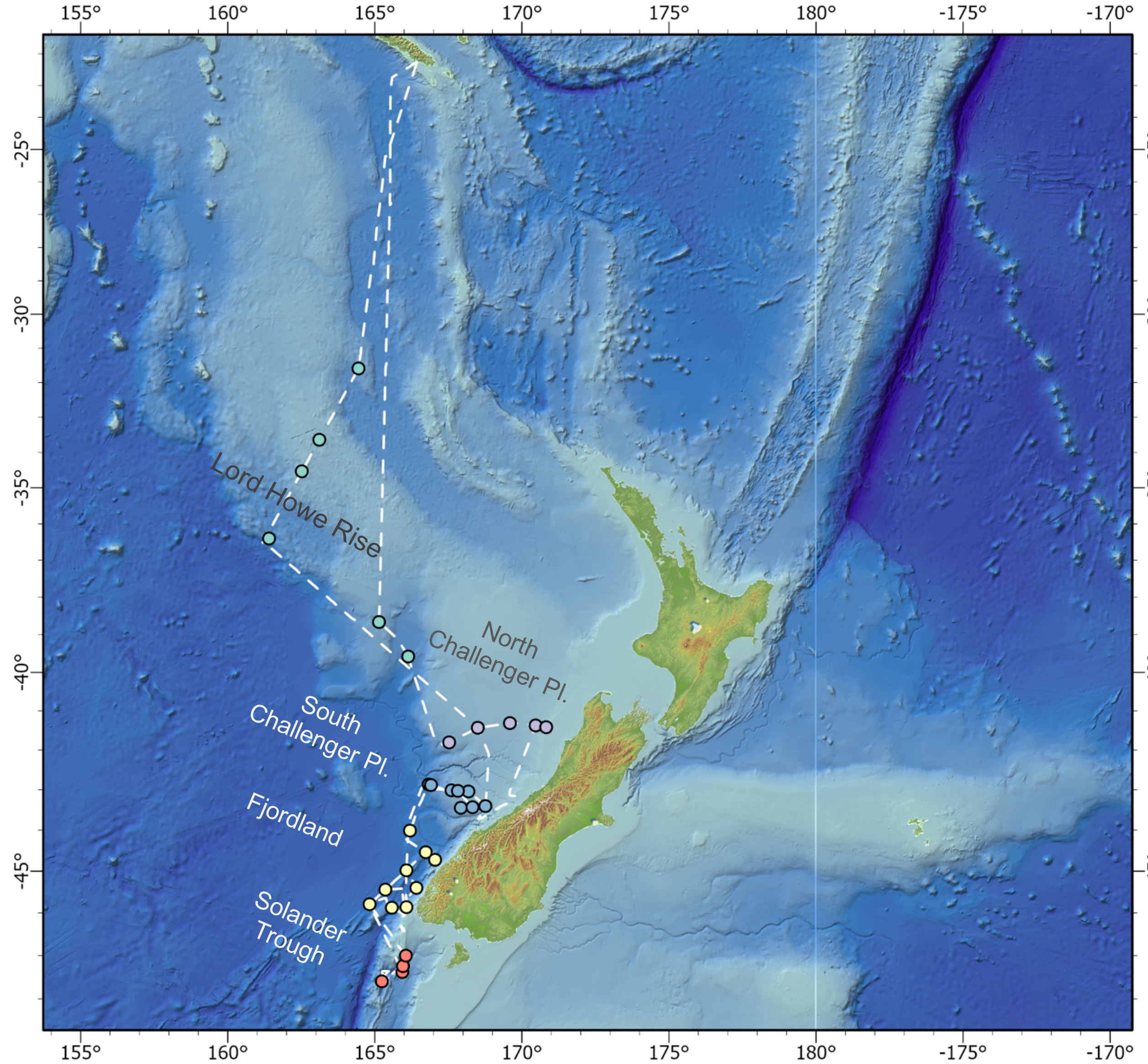

Figure 1: Map of cruise track and sampling stations of SO290, color-coded by working area.

Objectives

RV SONNE cruise SO290 'PaläoTaNZ' in the southeastern Tasman Sea had three main objectives: 1) the reconstruction of paleoceanographic and climatic changes in the southeastern Tasman Sea over the last glacial-interglacial cycles, 2) the reconstruction of the glacial history of the Southern Alps of New Zealand over the last glacial-interglacial cycles, and 3) the study of the hydrography and trace element and neodymium isotope composition of the water column with particular focus on the different water masses and the potential influence of element input through supply from New Zealand, dust, and/or bottom sediments. The Tasman Sea extends from mid to high southern latitudes in the Southwest Pacific, bordered to the East by the South Island of New Zealand and to the South by the Subtropical Front of the circum-Antarctic frontal system, that separates subtropical from subantarctic waters. The Tasman Sea receives Antarctic intermediate and bottom water masses formed in the Southern Ocean, and Pacific Deep Water from the North. The extended submarine Challenger Plateau makes this area one of few regions in the Southern Ocean, where depth transects of sediment cores can be collected. Additionally, the high amounts of terrigenous material supplied to the Tasman Sea from the glaciated Southern Alps of New Zealand as well as the dry basins in Australia make this a potentially viable region to reconstruct glacier changes and dust variations over the recent geologic past. The Tasman Sea is therefore an ideal area for the study of past changes in sea surface temperatures, ocean circulation, the glaciation history of New Zealand and dust input from Australia over past glacial-interglacial climate cycles and comparison with existing records from Antarctic ice cores.

Specific research questions related to the three overarching objectives are:

1.1: Did sea surface temperatures in the Tasman Sea change in parallel to temperature changes in Antarctica?
1.2: How did the intermediate and bottom water circulation change in the past?
1.3: Can changes in dust input be correlated with dust records from Antarctic ice cores and distal sediment cores from the South Pacific?
1.4: Which factors controlled bioproduction in the Tasman Sea?

2.1: Can dust inputs into the Tasman Sea be separated from glacier and river supplies from New Zealand and how did they change over glacial-interglacial cycles?
2.2: How are glacier and precipitation changes in New Zealand linked to sea surface temperatures in the Tasman Sea?

3.1: What are the rare earth element and Nd isotope signatures of Southern Ocean water masses close to their source and are these signatures modified by element inputs from New Zealand and/or Australia?

The depth and proximal to distal transects as well as the latitudinal distribution of the sediment cores collected during SO290 will allow us to address the questions related to objectives 1 and 2 using sedimentological, micropaleontological and geochemical methods. The water column samples collected at most stations cover all water masses and open ocean and more proximal stations are ideally suited to address objective 3.

Narrative

RV SONNE cruise SO290 started in Nouméa, New Caledonia, on Friday, April 15, at 16:00 local time (UTC+11). All scientists and crew had already boarded the ship on April 10 after being tested for Corona, but four of our five containers with scientific equipment were still on their way to Nouméa. This delay was due to difficulties in container transports globally related to the Corona pandemic. The containers arrived alongside SONNE on April 15 in the afternoon, were loaded and shortly after we departed Nouméa and started the transit to our working area in the southeastern Tasman Sea in the EEZ of New Zealand. The transit was used to unload the containers and set up the scientific equipment in the labs, and to get used to rough seas - the first storm with wind force of up to 8-9 Bf and wave heights >4 m was unfortunately traveling in the same direction as the SONNE.

On April 19 at 01:30 (local time in Nouméa), we arrived at our first station on a small extension of southern Lord Howe Rise with a water depth of 1649 m. The CTD, MUC and gravity corer (GC; recovery: 250 cm) were deployed and sampled. A biogeochemical ArgoFloat was deployed, followed by Secchi disc and Satlantic Profiler deployments (referred to as optical instruments or optics in the following) for the analysis of the light field of the upper ~200 m of the water column. Another station (SO290-2) was occupied in the late afternoon to early evening at a deep site (3127 m water depth) just east of the first station with the deployment of the MUC and GC.

On April 20 we entered the EEZ of New Zealand and started our work at the northern Challenger Plateau by deploying all devices at two stations (optics only at SO290-03) at 1600 m and 996 m water depth before traveling further east towards New Zealand while monitoring the bathymetry and sediment cover with Hydrosweep and Parasound. On April 21 in the morning, we changed the GC to the piston corer (PC) and sampled two stations with water depths of 914 m and 631 m. At SO290-05, all gear was deployed except for the Secchi disc and Satlantic Profiler (SO290-05, -06). One additional station at 285 m water depth (SO290-07) close to New Zealand was sampled in the evening using CTD and MUC. The latter came up with three broken tubes and only little, very sandy sediments. We therefore decided not to deploy a GC or PC at this station and instead traveled south to our next working area on the southern Challenger Plateau.

Due to increased wind force (8-9 Bf) and wave heights (≥4 m) in the following night and on April 22, station work was not possible and so we only surveyed the seafloor for potential sampling sites along a track parallel to the 12-nm-zone of New Zealand on the way to our South Challenger Plateau working area. In the morning of April 23, we surveyed a relatively thick sediment cover with high Parasound penetration and occupied two stations (SO290-08 and -09) at water depths of 925 m and 1143 m along a transect from close the 12 mile zone towards the west and towards deeper waters. We deployed CTD, MUC and GC at both stations and the optical instruments at SO290-08. Due to still high seas (wave heights ≥5 m), the deployment of the PC was not possible, so that we instead used it as gravity corer. Since bad weather conditions prevailed, we selected two other sites along the transect towards the west at water depths of 1383 m and 3129 m and deployed only a MUC at site SO290-10 on the same day and a CTD at 3:30 am on April 24, with the intention to revisit both stations towards the end of our cruise. In the night of April 24 to 25, we had to weather off another storm and used the time to transit southward, surveying the bathymetry and sediment cover at offshore locations in our next working area, Fjordland, and identified another site with a suitable Parasound profile suggesting a thick enough sediment cover for coring later during the cruise (see below, station SO290-25).

On April 25, we were able to occupy two stations proximal to New Zealand at 3291 m and 2539 m water depth (SO290-12, -13) using MUC and GC at both stations, and CTD at SO290-13 and optics at SO290-12 only. In the night from April 25 to 26, we revisited SO290-

12 on our transit to the south and deployed the CTD. Due to worsening wind and wave conditions off Fjordland and a good weather window forecast for our southern working area, the Solander Trough, for April 27, we transited southward on April 26, defying strong wind force (up to 9 Bf) and high seas (>5 m wave height) while surveying potential sampling areas along the way on a track offshore roughly parallel to the New Zealand coastline. Three potential sites were identified along our cruise track to the southwest that we decided to revisit after finishing our work in the south, and three sites were found in the Solander Trough.

On April 27, wind and waves had calmed down enough to allow station work in the Solander Trough working area and we occupied two stations (SO290-14 and -15). Overnight, we surveyed and mapped a small basin east of Solander Trough. On April 28, we deployed a MUC and GC at station SO290-16 (3648 m water depth) within this basin, revisited site SO290-14 (now SO290-17) to deploy a PC and then transited to a station at the northern end of Solander Trough, where a core was taken previously by the RV TANGAROA (TAN0803-09), and deployed MUC and GC at a water depth of 1655 m (SO290-18). This station completed our work in the Solander Trough.

In the night to April 29, we transited to a deep offshore station of our Fjordland working area, where we had found promising sediment cover during our Parasound survey on the way south. Upon arrival at station SO290-19 (4374 m water depth) in the morning of April 29, we deployed CTD, MUC, PC and optical instruments. Unfortunately, the PC barrel was bend and the top of the core disturbed, but the remaining liners with sediments were recovered in good shape. On our way to the area just off Fjordland, we deployed another MUC and GC at 3711 m water depth in the evening (SO290-20). We used the night and next day for bathymetric and Parasound surveying and identified two sites off Fjordland for sampling. However, the next bad storm was moving in from the south and we transited northward on April 30 and returned south towards the first identified site in the night to May 1 to weather off the storm. This storm was the strongest we experienced, with wind gusts of 12-13 Bf, and hardly anybody was able to sleep this night. At noon on May 1, we were able to deploy the CTD followed by the MUC (SO290-21). For GC deployment, wind and waves were still too rough, so we decided to transit to our second Fjordland station (SO290-22) slightly further south and deploy the MUC in the evening. The night was spent surveying potential other coring sites in the south, but without success. On May 2, we deployed a GC at SO290-22 early in the morning and at SO290-21 in the late morning to early afternoon, before transiting towards the west to more offshore Fjordland stations to occupy a previously identified deep site using the GC on May 2 in the evening. On May 3 at 2 am, we arrived at another previously identified offshore Fjordland station (SO290-24; water depth 3348 m) and deployed the CTD followed by MUC and GC, before heading straight north. In the afternoon, we arrived at SO290-25 previously identified based on our Parasound and bathymetric surveys and deployed the GC around 6 pm, followed by MUC and CTD in the late evening. This station completed our work in the Fjordland working area.

Our next goal was now to complete the transect on the southern Challenger Plateau that we had to abandon earlier during the cruise because of bad weather conditions. On May 4 at 6 am, we arrived at station SO290-11, where we had only deployed a CTD. However, the sediment cover was not as good as we expected based on the previous Parasound profiles which were apparently not just disturbed by the poor weather conditions. We therefore continued up the slope towards the east and after about 1 hour found an appropriate site with a water depth of 2876 m. We deployed MUC, GC and optical instruments (SO290-26) and continued eastward towards New Zealand and shallower water depths. At the site of SO290-10, where MUC samples had already been taken, we deployed a GC in the afternoon (SO290-27, 1383 m water depth) and continued to station SO290-28 (1246 m) for the deployment of MUC and GC in the evening. At night, we surveyed a transect on the way to station MD06-2986, from which a Marion Dufresne core with very good age control and paleoceanographic records already exists. On May 5 in the early morning, CTD and MUC were deployed followed by a PC (SO290-29; 1439 m water depth, some 0.8 nm east of the MD core site). We occupied two additional stations on this day and along this depth transect (SO290-30 at 1131 m water depth and SO290-31 at 926 m water depth) with MUC, PC and optical instrument deployments (the latter only at SO290-30). Station SO290-31 was a reoccupation of SO290-08 with the goal to extend the existing GC by deploying a PC. This station completed our work on southern Challenger Plateau.

In the following night we transited northward across the Challenger Plateau, first roughly following the bathymetric contours with the aim to follow individual reflectors in the Parasound profiles and eventually connect the cores on the southern and northern Challenger Plateau. We also transited over another MD coring site (MD06-2989) that contains two dated tephra layers which we hope to link into our Parasound profiles and sediment cores from the region. We traveled into the working area of Lord Howe Rise and on May 7 arrived at the site of an old core taken in 1969 by US RV Eltanin (E39.75). However, due to poor positioning systems at that time, coordinates and water depth of this core did not match the actual situation in the area and we did not find appropriate sediment cover. Therefore, we transited upslope the Lord Howe Rise and identified a coring site at 36.4°S / 161.4°E and a water depth of 3101 m, where we deployed a GC in the late evening, followed by MUC and CTD at night. On May 8, we sampled two stations, SO290-33 at 1089 m and SO290-34 at 892 m water depth, using CTD and optical instruments at SO290-33 only and MUC and GC at both stations. One final station (SO290-35) was occupied by all instruments on northern Lord Howe Rise in the morning until early afternoon of May 9 at a water depth of 2127 m, completing our work on Lord Howe Rise and successfully concluding SO290.

Acknowledgements

Due to the Corona pandemic and related strains in the travel and container transportation sectors, preparations for the cruise were particularly challenging. The fact that everything worked out eventually so that we could carry out the cruise, is the result of the excellent support of the German Research Fleet Coordination Centre at the University of Hamburg, the shipping company Briese, the Project Management Jülich (PtJ), the logistics company LPL Projects and Logistics GmbH and the agent in Nouméa. We gratefully acknowledge the help of the German Embassy in Wellington, New Zealand, and thank the Government and the Environmental Protection Authority of New Zealand for granting permission for our work within the EEZ of New Zealand. We thank captain Oliver Meyer and his crew for the smooth workflow onboard, their flexibility with respect to station timing, and the competent deployment of the gravity and piston corers (and smaller gear). We are further particularly grateful to Dirk Nürnberg (GEOMAR) for lending us the GEOMAR piston corer and equipment container for the cruise. The cruise and scientific work was funded by the Federal Ministry of Education and Research (BMBF) through grants 03G0290NA A and B to ICBM and AWI.

Participants

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Institutes:

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AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung
IOW	Leibniz-Institut für Ostseeforschung Warnemünde
LDEO	Lamont-Doherty Earth Observatory of Columbia University (USA)
U Otago	University of Otago, Dunedin (NZ)
U Birmingh.	University of Birmingham (UK)

Stationsliste

Station	Cast	Gear	Date	Time at depth (UTC)	Latitude (deg/min)	Longitude (deg/min)	Water Depth EM122 (m)
SO290-1	1	CTD	18.04.22	15:28	38° 40.004' S	165° 08.675' E	1650
SO290-1	2	CTD	18.04.22	16:38	38° 39.996' S	165° 08.672' E	1646
SO290-1	3	MUC	18.04.22	18:17	38° 39.995' S	165° 08.678' E	1645
SO290-1	4	GC	18.04.22	19:38	38° 39.996' S	165° 08.668' E	1649
SO290-1	5	FLOAT	18.04.22	20:35	38° 40.002' S	165° 08.668' E	1651
SO290-1	6	LIOP	18.04.22	21:06	38° 40.321' S	165° 09.895' E	1649
SO290-2	1	GC	19.04.22	06:39	39° 35.107' S	166° 07.906' E	3127
SO290-2	2	MUC	19.04.22	08:43	39° 35.115' S	166° 07.898' E	3128
SO290-3	1	CTD	19.04.22	22:24	41° 48.049' S	167° 31.639' E	1601
SO290-3	2	MUC	19.04.22	23:41	41° 48.045' S	167° 31.635' E	1601
SO290-3	3	GC	20.04.22	00:55	41° 48.050' S	167° 31.643' E	1601
SO290-3	4	LIOP	20.04.22	01:35	41° 48.051' S	167° 31.639' E	1601
SO290-3	5	LIOP	20.04.22	01:42	41° 48.041' S	167° 31.640' E	1601
SO290-4	1	GC	20.04.22	06:33	41° 26.132' S	168° 30.310' E	996
SO290-4	2	MUC	20.04.22	07:33	41° 26.131' S	168° 30.314' E	995
SO290-4	3	CTD	20.04.22	08:43	41° 26.093' S	168° 30.662' E	995
SO290-5	1	CTD	20.04.22	17:42	41° 18.463' S	169° 36.073' E	912
SO290-5	2	MUC	20.04.22	18:43	41° 18.466' S	169° 36.065' E	912
SO290-5	3	PC	20.04.22	23:04	41° 18.469' S	169° 36.066' E	914
SO290-6	1	PC	21.04.22	04:35	41° 22.424' S	170° 28.684' E	631
SO290-7	1	CTD	21.04.22	07:09	41° 25.478' S	170° 49.614' E	285
SO290-7	2	MUC	21.04.22	07:43	41° 25.474' S	170° 49.612' E	285
SO290-6	2	CTD	21.04.22	10:15	41° 22.433' S	170° 28.684' E	629
SO290-6	3	MUC	21.04.22	11:06	41° 22.439' S	170° 28.682' E	629
SO290-8	1	CTD	22.04.22	22:14	43° 24.362' S	168° 46.087' E	928
SO290-8	2	MUC	22.04.22	23:18	43° 24.354' S	168° 46.079' E	926
SO290-8	3	GC	23.04.22	00:08	43° 24.361' S	168° 46.084' E	925
SO290-8	4	LIOP	23.04.22	00:41	43° 24.360' S	168° 46.085' E	928
SO290-8	5	LIOP	23.04.22	00:45	43° 24.370' S	168° 46.072' E	924
SO290-9	1	GC	23.04.22	04:37	43° 02.393' S	168° 10.996' E	1143
SO290-9	2	MUC	23.04.22	05:36	43° 02.397' S	168° 11.002' E	1142
SO290-9	3	CTD	23.04.22	06:48	43° 02.426' S	168° 10.814' E	1144
SO290-10	1	MUC	23.04.22	11:09	43° 00.557' S	167° 36.110' E	1383
SO290-11	1	CTD	23.04.22	16:27	42° 52.374' S	166° 49.837' E	3129
SO290-12	1	MUC	25.04.22	00:25	44° 32.320' S	166° 43.509' E	3289
SO290-12	2	GC	25.04.22	02:27	44° 32.316' S	166° 43.503' E	3291
SO290-12	3	LIOP	25.04.22	03:30	44° 32.318' S	166° 43.510' E	3292
SO290-12	4	LIOP	25.04.22	03:36	44° 32.320' S	166° 43.493' E	3290
SO290-13	1	GC	25.04.22	06:56	44° 43.792' S	167° 02.734' E	2539
SO290-13	2	MUC	25.04.22	08:37	44° 43.801' S	167° 02.735' E	2544
SO290-13	3	CTD	25.04.22	10:40	44° 43.935' S	167° 02.567' E	2539
SO290-12	5	CTD	25.04.22	16:17	44° 32.284' S	166° 43.533' E	3290
SO290-14	1	MUC	27.04.22	00:09	47° 14.739' S	165° 57.573' E	2246
SO290-14	2	GC	27.04.22	01:41	47° 14.740' S	165° 57.580' E	2245
SO290-14	3	LIOP	27.04.22	02:30	47° 14.746' S	165° 57.575' E	2249
SO290-14	4	LIOP	27.04.22	02:36	47° 14.746' S	165° 57.575' E	2248
SO290-15	1	GC	27.04.22	05:20	47° 22.605' S	165° 56.735' E	2520
SO290-15	2	MUC	27.04.22	07:00	47° 22.605' S	165° 56.736' E	2525
SO290-15	3	CTD	27.04.22	08:53	47° 22.700' S	165° 56.662' E	2533

continued

Station	Cast	Gear	Date	Time at depth (UTC)	Latitude (deg/min)	Longitude (deg/min)	Water Depth EM122 (m)
SO290-16	1	MUC	27.04.22	21:37	47° 35.818' S	165° 13.927' E	3650
SO290-16	2	GC	27.04.22	23:53	47° 35.814' S	165° 13.915' E	3648
SO290-16	3	LIOP	28.04.22	01:00	47° 35.819' S	165° 13.920' E	3647
SO290-16	4	LIOP	28.04.22	01:07	47° 35.824' S	165° 13.903' E	3647
SO290-17	1	PC	28.04.22	05:36	47° 14.744' S	165° 57.573' E	2248
SO290-18	1	MUC	28.04.22	09:00	47° 00.039' S	166° 03.586' E	1654
SO290-18	2	GC	28.04.22	10:19	47° 00.038' S	166° 03.592' E	1655
SO290-19	1	CTD	28.04.22	19:12	45° 47.832' S	164° 49.505' E	4375
SO290-19	2	MUC	28.04.22	22:13	45° 47.830' S	164° 49.500' E	4374
SO290-19	3	PC	29.04.22	01:24	45° 47.829' S	164° 49.500' E	4374
SO290-19	4	LIOP	29.04.22	03:17	45° 47.832' S	164° 49.498' E	4373
SO290-19	5	LIOP	29.04.22	03:26	45° 47.808' S	164° 49.485' E	4374
SO290-20	1	GC	29.04.22	10:03	45° 52.157' S	165° 35.271' E	3711
SO290-20	2	MUC	29.04.22	12:19	45° 52.157' S	165° 35.270' E	3700
SO290-21	1	CTD	01.05.22	02:41	45° 23.863' S	166° 24.534' E	3260
SO290-21	2	MUC	01.05.22	05:00	45° 23.863' S	166° 24.532' E	3259
SO290-22	1	MUC	01.05.22	10:06	45° 51.356' S	166° 04.019' E	1464
SO290-22	2	GC	01.05.22	19:41	45° 51.361' S	166° 04.020' E	1461
SO290-21	3	GC	02.05.22	00:52	45° 23.865' S	166° 24.539' E	3263
SO290-23	1	GC	02.05.22	07:30	45° 26.587' S	165° 21.777' E	4422
SO290-24	1	CTD	02.05.22	15:07	44° 58.578' S	166° 04.533' E	3348
SO290-24	2	MUC	02.05.22	17:30	44° 58.585' S	166° 04.523' E	3355
SO290-24	3	GC	02.05.22	20:22	44° 58.583' S	166° 04.522' E	3347
SO290-25	1	MUC	03.05.22	05:24	44° 00.809' S	166° 11.303' E	3983
SO290-25	2	GC	03.05.22	07:49	44° 00.816' S	166° 11.308' E	3982
SO290-25	3	CTD	03.05.22	10:49	44° 00.861' S	166° 11.073' E	3983
SO290-26	1	MUC	03.05.22	21:13	42° 53.306' S	166° 55.107' E	2876
SO290-26	2	GC	03.05.22	23:05	42° 53.309' S	166° 55.113' E	2878
SO290-26	3	LIOP	04.05.22	00:13	42° 53.304' S	166° 55.110' E	2879
SO290-26	4	LIOP	04.05.22	00:21	42° 53.313' S	166° 55.094' E	2878
SO290-27	1	GC	04.05.22	04:38	43° 00.552' S	167° 36.109' E	1384
SO290-28	1	GC	04.05.22	06:56	43° 01.319' S	167° 48.997' E	1246
SO290-28	2	MUC	04.05.22	07:54	43° 01.318' S	167° 49.002' E	1245
SO290-29	1	CTD	04.05.22	18:15	43° 26.868' S	167° 55.136' E	1437
SO290-29	2	MUC	04.05.22	19:40	43° 26.873' S	167° 55.129' E	1437
SO290-29	3	PC	04.05.22	21:17	43° 26.874' S	167° 55.134' E	1439
SO290-30	1	MUC	05.05.22	00:15	43° 25.949' S	168° 18.834' E	1133
SO290-30	2	PC	05.05.22	01:30	43° 25.950' S	168° 18.830' E	1131
SO290-30	3	LIOP	05.05.22	02:16	43° 25.945' S	168° 18.825' E	1131
SO290-30	4	LIOP	05.05.22	02:23	43° 25.949' S	168° 18.827' E	1132
SO290-31	1	PC	05.05.22	05:31	43° 24.363' S	168° 46.089' E	926
SO290-32	1	GC	07.05.22	09:19	36° 24.390' S	161° 24.071' E	3101
SO290-32	2	MUC	07.05.22	11:18	36° 24.384' S	161° 24.060' E	3100
SO290-32	3	CTD	07.05.22	13:37	36° 24.039' S	161° 23.911' E	3090
SO290-33	1	MUC	08.05.22	01:39	34° 32.254' S	162° 31.409' E	1089
SO290-33	2	GC	08.05.22	02:30	34° 32.257' S	162° 31.418' E	1089
SO290-33	3	LIOP	08.05.22	03:10	34° 32.253' S	162° 31.407' E	1091
SO290-33	4	LIOP	08.05.22	03:16	34° 32.252' S	162° 31.410' E	1090
SO290-33	5	CTD	08.05.22	04:25	34° 32.099' S	162° 31.369' E	1089
SO290-34	1	GC	08.05.22	10:29	33° 38.679' S	163° 06.813' E	892
SO290-35	1	CTD	08.05.22	22:16	31° 34.953' S	164° 27.052' E	2125
SO290-35	2	GC	08.05.22	23:59	31° 34.959' S	164° 27.055' E	2127
SO290-35	3	MUC	09.05.22	01:24	31° 34.957' S	164° 27.055' E	2133
SO290-35	4	LIOP	09.05.22	02:12	31° 34.962' S	164° 27.057' E	2127