# A. Cruise narrative

## Highlights

Cruise designation: RF22-05, RF22-06, RF22-07 (WHP-P09 revisit)

a. EXPOCODE: RF22-05 49UP20220727

RF22-06 49UP20220824

RF22-07 49UP20220929

b. Chief scientist: NAGAI Naoki

Atmospheric Environment and Ocean Division

Atmosphere and Ocean Department

Japan Meteorological Agency (JMA)

c. Ship name: R/V Ryofu Maru

d. Ports of call: RF22-05: Tokyo (Japan) – Tokyo (Japan)

RF22-06: Tokyo (Japan) – Tokyo (Japan)

RF22-07: Leg 1: Tokyo (Japan) – Kochi (Japan)

Leg 2: Kochi (Japan) – Tokyo (Japan)

e. Cruise dates (JST): RF22-05: 27 July 2022 – 20 August 2022

 RF22-06: 24 August 2022 – 17 September 2022

 RF22-07: Leg 1: 29 September 2022 – 19 October 2022

 Leg 2: 23 October 2022 – 2 November 2022

f. Principal Investigator (Contact person):

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## Cruise Summary

RF22-05, RF22-06 and RF22-07 cruises were carried out during the period from July 27 to November 2, 2022. The cruises started from the north of Papua New Guinea, and sailed towards north along approximately 137°E meridian. This line (WHP-P09) was observed by JMA in 1994 as WOCE (World Ocean Circulation Experiment) Hydrographic Programme and in 2010 and 2016 as CLIVAR (Climate Variability and Predictability Project) / GO-SHIP (Global Ocean Ship-based Hydrographic Investigations Program).

A total of 93 stations were occupied using a Sea-Bird Electronics (SBE) 36 position carousel equipped with 10-liter Niskin water sample bottles, a CTD system (SBE911plus) equipped with SBE35 deep ocean standards thermometer, JFE Advantech oxygen sensor (RINKO III), Valeport altimeter (VA500), and Teledyne RD Instruments L-ADCP (300kHz). To examine consistency of data, we carried out the observation repeatedly twice at stations of 4°30’N, 137°00’E (Stns.24 and 25) and 21°00’N, 137°00’E (Stns.61 and 62) at the cross points of each cruise. Station location and cruise track are shown in Figure A.1 (except Leg 2 at RF22-07).

At almost all station, full-depth CTDO2 (temperature, conductivity (salinity) and dissolved oxygen) profile were taken, and up to 36 water samples were taken and analyzed. Water samples were obtained from 10 dbar to approximately 10 m above the bottom. In addition, surface water was sampled by a stainless steel bucket at each station. Sampling layer is designed as so-called staggered mesh as shown in Table A.1 (*Swift*, 2010). The bottle depth diagram is shown in Figure A.2.

Water samples were analyzed for salinity, dissolved oxygen, nutrients, dissolved inorganic carbon (DIC), total alkalinity (TA), pH, CFCs (CFC-11, CFC-12, and CFC-113), SF6 and phytopigments (chlorophyll-a and phaeopigment). Underway measurements of partial pressure of carbon dioxide (*p*CO2), temperature, salinity, chlorophyll-*a*, subsurface current, bathymetry and meteorological parameters were conducted along the cruise track.

At RF22-05, R/V Ryofu Maru departed from Tokyo (Japan) on July 27, 2022. The hydrographic cast of CTDO2 was started at the first station (Stn.1 (2°20’S, 141°10’E; RF7041)) in the north of Papua New Guinea on August 5. RF22-05 consisted of 24 stations from Stn.1 to Stn.24 (4°30’N, 137°00’E; RF7064). Observation at Stn.24 was finished on August 13. She returned at Tokyo on August 20.

At RF22-06, she departed from Tokyo on August 24. The hydrographic cast of CTDO2 restarted at the same station (Stn.25 (4°30’N, 137°00’E; RF7066)) with the RF22-05 last station on August 30. RF22-06 consisted of 37 stations from Stn.25 to Stn.61 (21°00’N, 137°00’E; RF7102). Observation at Stn.61 was finished on September 12. She returned at Tokyo on September 17.

At RF22-07, she departed from Tokyo on September 29. The hydrographic cast of CTDO2 restarted at same station (Stn.62 (21°00’N, 137°00’E; RF7104)) with the RF22-06 last station on October 3. Observations from Stn.62 to Stn.86 (32°00’N, 137°00’E; RF7128) were carried out in order from the south. After observation at Stn.86, she evacuated to Suruga Bay in Shizuoka (Japan) for avoiding high waves expected in the observation area. She restarted from Stn.93 (34°10’N, 137°00’E; RF7129) on the coast of Japan on October 15 and observed southward to Stn.87 (32°20’N, 137°00’E; RF7136). Observation at Stn.87 was finished on October 16. RF22-07 consisted of 32 stations from Stn.62 to Stn.93. She entered at Kochi on October 19 (Leg 1). At Leg 2, she departed from Kochi on October 23, and observed the pCO2 and the surface layer temperature in the south of Japan, returned at Tokyo on November 2. Location data of stations is shown in Table A.2.

Five Argo floats were deployed along the cruise track. The information of deployed the float is listed in Table A.3.

Figure A.1. Location of hydrographic stations and cruise track of RF22-05, RF22-06 and RF22-07. Circles indicate stations along WHP-09.

Figure A.2. The bottle depth diagram for WHP-P09 revisit.

Table A.1. The scheme of sampling layer in meters.

|  |  |  |
| --- | --- | --- |
|  | **North of 20°N (Stn.60–Stn.93)** | **South of 20°N (Stn.1–Stn.59)** |
| ***Bottle count*** | ***Scheme 1*** | ***Scheme 2*** | ***Scheme 3*** | ***Scheme 4*** | ***Scheme 5*** | ***Scheme 6*** |
| **1** | 10 | 10 | 10 | 10 | 10 | 10 |
| **2** | *25**50**75**100**125**150**200**250**300**400**500**600**700**800**900**1000**1200**1400**160050* | *25* | *25* | *25* | *25* | *25* |
| **3** | 50 | 50 | 50 | 50 | 50 | 50 |
| **4** | *75* | *75* | *75* | *75* | *75* | *75* |
| **5** | 100 | 100 | 100 | 100 | 100 | 100 |
| **6** | *125* | *125* | *125* | *125* | *125* | *125* |
| **7** | 150 | 150 | 150 | 150 | 150 | 150 |
| **8** | 200 | 200 | 200 | 200 | 200 | 200 |
| **9** | 250 | 250 | 250 | 250 | 250 | 250 |
| **10** | 300 | 330 | 280 | 300 | 330 | 280 |
| **11** | 400 | 430 | 370 | 350 | 380 | 320 |
| **12** | 500 | 530 | 470 | 400 | 430 | 370 |
| **13** | 600 | 630 | 570 | 450 | 480 | 420 |
| **14** | 700 | 730 | 670 | 500 | 530 | 470 |
| **15** | 800 | 830 | 770 | 600 | 630 | 570 |
| **16** | 900 | 930 | 870 | 700 | 730 | 670 |
| **17** | 1000 | 1070 | 970 | 800 | 830 | 770 |
| **18** | 1200 | 1270 | 1130 | 900 | 930 | 870 |
| **19** | 1400 | 1470 | 1330 | 1000 | 1070 | 970 |
| **20** | 1600 | 1670 | 1530 | 1200 | 1270 | 1130 |
| **21** | 1800 | 1870 | 1730 | 1400 | 1470 | 1330 |
| **22** | 2000 | 2070 | 1930 | 1600 | 1670 | 1530 |
| **23** | 2200 | 2270 | 2130 | 1800 | 1870 | 1730 |
| **24** | 2400 | 2470 | 2330 | 2000 | 2070 | 1930 |
| **25** | 2600 | 2670 | 2530 | 2200 | 2270 | 2130 |
| **26** | 2800 | 2870 | 2730 | 2400 | 2470 | 2330 |
| **27** | 3000 | 3080 | 2930 | 2600 | 2670 | 2530 |
| **28** | *3250* | *3330* | *3170* | *2800* | *2870* | *2730* |
| **29** | 3500 | 3580 | 3420 | 3000 | 3080 | 2930 |
| **30** | *3750* | *3830* | *3670* | *3250* | *3330* | *3170* |
| **31** | 4000 | 4080 | 3920 | 3500 | 3580 | 3420 |
| **32** | *4250* | *4330* | *4170* | *3750* | *3830* | *3670* |
| **33** | 4500 | 4580 | 4420 | 4000 | 4080 | 3920 |
| **34** | *4750* | *4830* | *4670* | *4250* | *4330* | *4170* |
| **35** | 5000 | 5080 | 4920 | 4500 | 4580 | 4420 |
| **36** | 5250 | 5330 | 5170 | 4750 | 4830 | 4670 |
| **37** | 5500 | 5580 | 5420 | 5000 | 5080 | 4920 |
| **38** | 5750 | 5830 | 5670 | 5250 | 5330 | 5170 |
| **39** | 6000 | 6000 | 6000 | 5500 | 5580 | 5420 |
| **40** |  |  |  | 5750 | 5830 | 5670 |
| **41** |  |  |  | 6000 | 6000 | 6000 |

Scheme 1 to Scheme 3 are applied to the area north of 20°N, while Scheme 4 to Scheme 6 are applied to the area south of 20°N. At some deep stations over 36 layers, some layers shown in italic may be skipped.

Table A.2(a). Station lists of RF22-05 cruise. The ‘RF’ column indicates the JMA station identification number.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Station*** | ***Location*** |  | ***Station*** | ***Location*** |
| *Stn.* | *RF* | *Latitude* | *Longitude* |  | *Stn.* | *RF* | *Latitude* | *Longitude* |
| 1 | 7041 | 02-20.13 S | 141-09.15 E |  | 13 | 7053 | 02-11.50 N | 140-59.64 E |
| 2 | 7042 | 02-10.14 S | 141-29.08 E |  | 14 | 7054 | 02-16.10 N | 140-30.17 E |
| 3 | 7043 | 02-00.64 S | 141-59.04 E |  | 15 | 7055 | 02-23.44 N | 140-00.04 E |
| 4 | 7044 | 01-30.13 S | 141-59.32 E |  | 16 | 7056 | 02-29.21 N | 139-30.50 E |
| 5 | 7045 | 00-59.65 S | 141-58.62 E |  | 17 | 7057 | 02-35.79 N | 138-59.40 E |
| 6 | 7046 | 00-30.32 S | 141-58.70 E |  | 18 | 7058 | 02-40.99 N | 138-30.23 E |
| 7 | 7047 | 00-00.31 S | 141-59.37 E |  | 19 | 7059 | 02-47.67 N | 137-59.50 E |
| 8 | 7048 | 00-29.19 N | 141-58.95 E |  | 20 | 7060 | 02-54.57 N | 137-30.73 E |
| 9 | 7049 | 00-59.43 N | 141-59.48 E |  | 21 | 7061 | 03-00.56 N | 137-00.19 E |
| 10 | 7050 | 01-29.76 N | 141-59.82 E |  | 22 | 7062 | 03-30.53 N | 137-00.96 E |
| 11 | 7051 | 01-59.40 N | 142-00.44 E |  | 23 | 7063 | 04-00.55 N | 137-00.86 E |
| 12 | 7052 | 02-05.54 N | 141-30.24 E |  | 24 | 7064 | 04-30.80 N | 137-00.95 E |

Table A.2(b). Same as Table A.2(a) but for RF22-06 cruise.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Station*** | ***Location*** |  | ***Station*** | ***Location*** |
| *Stn.* | *RF* | *Latitude* | *Longitude* |  | *Stn.* | *RF* | *Latitude* | *Longitude* |
| 25 | 7066 | 04-30.84 N | 137-01.30 E |  | 44 | 7085 | 12-29.79 N | 136-59.62E |
| 26 | 7067 | 05-01.47 N | 137-01.08 E |  | 45 | 7086 | 12-59.13 N | 137-00.42 E |
| 27 | 7068 | 05-30.42 N | 137-00.06 E |  | 46 | 7087 | 13-29.59 N | 136-59.71 E |
| 28 | 7069 | 06-00.32 N | 137-00.56 E |  | 47 | 7088 | 13-59.76 N | 136-59.36 E |
| 29 | 7070 | 06-30.58 N | 136-59.24 E |  | 48 | 7089 | 14-31.00 N | 136-59.91 E |
| 30 | 7071 | 07-00.63 N | 136-58.86 E |  | 49 | 7090 | 15-01.07 N | 137-00.41 E |
| 31 | 7072 | 07-19.80 N | 136-49.15 E |  | 50 | 7091 | 15-30.54 N | 136-59.32 E |
| 32 | 7073 | 07-30.13 N | 136-48.76 E |  | 51 | 7092 | 16-00.19 N | 136-58.59 E |
| 33 | 7074 | 07-39.71 N | 136-49.44 E |  | 52 | 7093 | 16-30.50 N | 136-58.55 E |
| 34 | 7075 | 08-00.18 N | 136-58.93 E |  | 53 | 7094 | 17-01.83 N | 137-00.22 E |
| 35 | 7076 | 08-19.91 N | 136-59.77 E |  | 54 | 7095 | 17-30.97 N | 137-00.14 E |
| 36 | 7077 | 08-40.49 N | 136-59.19 E |  | 55 | 7096 | 18-01.11 N | 137-00.10 E |
| 37 | 7078 | 09-00.28 N | 136-59.51 E |  | 56 | 7097 | 18-30.24 N | 136-59.50 E |
| 38 | 7079 | 09-29.99 N | 136-59.32 E |  | 57 | 7098 | 19-00.30 N | 137-00.14 E |
| 39 | 7080 | 09-59.93 N | 136-59.43 E |  | 58 | 7099 | 19-30.01 N | 137-00.87 E |
| 40 | 7081 | 10-29.14 N | 136-59.68 E |  | 59 | 7100 | 19-59.90 N | 137-00.62 E |
| 41 | 7082 | 10-59.88 N | 136-58.72 E |  | 60 | 7101 | 20-30.45 N | 136-59.92 E |
| 42 | 7083 | 11-29.81 N | 136-59.23 E |  | 61 | 7102 | 21-00.13 N | 137-00.88 E |
| 43 | 7084 | 12-00.68 N | 136-59.21 E |  |  |  |  |  |

Table A.2(c). Same as Table A.2(a) but for RF22-07 cruise.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Station*** | ***Location*** |  | ***Station*** | ***Location*** |
| *Stn.* | *RF* | *Latitude* | *Longitude* |  | *Stn.* | *RF* | *Latitude* | *Longitude* |
| 62 | 7104 | 20-58.77 N | 136-59.83 E |  | 78 | 7120 | 28-59.50 N | 137-00.25 E |
| 63 | 7105 | 21-29.28 N | 136-59.23 E |  | 79 | 7121 | 29-28.73 N | 137-09.88 E |
| 64 | 7106 | 22-00.24 N | 137-19.80 E |  | 80 | 7122 | 30-00.02 N | 137-01.17 E |
| 65 | 7107 | 22-29.79 N | 137-19.12 E |  | 81 | 7123 | 30-20.41 N | 137-01.66 E |
| 66 | 7108 | 22-59.46 N | 137-19.00 E |  | 82 | 7124 | 30-40.80 N | 137-00.92 E |
| 67 | 7109 | 23-29.33 N | 136-59.47 E |  | 83 | 7125 | 31-00.60 N | 137-00.89 E |
| 68 | 7110 | 23-59.83 N | 136-59.22 E |  | 84 | 7126 | 31-18.37 N | 137-00.51 E |
| 69 | 7111 | 24-30.90 N | 136-59.26 E |  | 85 | 7127 | 31-40.52 N | 137-02.13 E |
| 70 | 7112 | 24-59.01 N | 136-59.41 E |  | 86 | 7128 | 31-59.88 N | 137-00.27 E |
| 71 | 7113 | 25-29.33 N | 137-01.01 E |  | 87 | 7135 | 32-18.85 N | 137-00.19 E |
| 72 | 7114 | 25-58.35 N | 137-00.90 E |  | 88 | 7134 | 32-39.22 N | 136-59.16 E |
| 73 | 7115 | 26-29.23 N | 137-01.76 E |  | 89 | 7133 | 32-59.08 N | 136-58.87 E |
| 74 | 7116 | 26-58.04 N | 137-00.96 E |  | 90 | 7132 | 33-19.81 N | 136-58.23 E |
| 75 | 7117 | 27-28.52 N | 137-01.12 E |  | 91 | 7131 | 33-42.00 N | 137-00.05 E |
| 76 | 7118 | 27-59.29 N | 137-00.39 E |  | 92 | 7130 | 34-00.51 N | 137-01.03 E |
| 77 | 7119 | 28-29.67 N | 136-59.61 E |  | 93 | 7129 | 34-10.07 N | 137-00.78 E |

Table A.3. Information of deployed float.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Float*** | ***Date and Time*** | ***Position of deployment*** | ***PI*** | ***Manufacturer*** |
| ***WMO number*** | ***of Deployment (UTC)*** | *Latitude* | *Longitude* |  |  |
| 5905872 | September 4, 202200:27 | 9-59.83 N | 136-58.85 E | JAMSTEC | APEX |
| 2903708 | September 11, 202202:18 | 20-01.60 N | 137-03.39 E | JMA | ARVOR |
| 2903712 | October 7, 202210:31 | 27-57.75 N | 137-00.04 E | JMA | ARVOR |
| 2903714 | October 9, 202206:37 | 30-00.04 N | 137-02.38 E | JMA | ARVOR |
| 2903716 | October 11, 202203:38 | 31-59.68 N | 137-01.45 E | JMA | ARVOR |

ARVOR: NKE Instrumentation (France)

APEX: Teledyne Webb Research (USA)

## List of Principal Investigators for Measurements

The principal investigators for each parameter are listed in Table A.4.

|  |
| --- |
| Table A.4. List of principal investigators for each parameter. |
| Hydrography | CTDO2 | MURAKAMI Kiyoshi |
|  | Salinity | MURAKAMI Kiyoshi |
|  | Dissolve oxygen | KITAGAWA Takahiro |
|  | Nutrients | KITAGAWA Takahiro |
|  | Phytopigments | KITAGAWA Takahiro |
|  | DIC | ENYO Kazutaka |
|  | TA | ENYO Kazutaka |
|  | pH | ENYO Kazutaka |
|  | CFCs | ENYO Kazutaka |
|  | SF6 | ENYO Kazutaka |
|  | LADCP | MURAKAMI Kiyoshi |
| Underway | Meteorology | NAGAI Naoki |
|  | Thermo-Salinograph | ENYO Kazutaka |
|  | *p*CO2 | ENYO Kazutaka |
|  | Chlorophyll *a* | KITAGAWA Takahiro |
|  | ADCP | MURAKAMI Kiyoshi |
|  | Bathymetry | MURAKAMI Kiyoshi |
| Float | JMA | NAKAMURA Tetsuya |
|  | JAMSTEC  | HOSODA Shigeki |

***Reference***

Swift, J. H. (2010): Reference-quality water sample data: Notes on acquisition, record keeping, and evaluation. *IOCCP Report No.****14****, ICPO Pub. 134, 2010 ver.1*