

A. Cruise narrative

1. Highlights

Cruise designation: RF13-06 and RF13-07 (WHP-P03W revisit)

a. EXPOCODE: 49UP20130619

b. Chief scientist: RF13-06 Kazuhiro NEMOTO (k-nemoto@met.kishou.go.jp)

RF13-07 Hitomi KAMIYA

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c. Ship name: R/V Ryofu Maru

d. Ports of call: RF13-06 Leg 1: Tokyo–Naha, Leg 2: Naha–Tokyo

RF13-07 Leg 1: Tokyo–Pohnpei, Leg 2: Pohnpei–Tokyo

e. Cruise dates: RF13-06 Leg 1: 19 June 2013–1 July 2013

RF13-06 Leg 2: 5 July 2013–24 July 2013

RF13-07 Leg 1: 31 July 2013–21 August 2013

RF13-07 Leg 2: 25 August 2013–18 September 2013

f. Floats and drifters deployed: RF13-06: 1 float and 2 drifters

RF13-07: 5 floats

2. Cruise Summary Information

RF13-06 and RF13-07 cruises were carried out during the period from June 19 to September 18, 2013. The observation line along approximately 24°N was observed by Scripps Institution of Oceanography (SIO), USA in 1985 and Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan in 2005–2006. These cruises were carried out as ‘WHP-P03’, which is a part of WOCE (World Ocean Circulation Experiment) Hydrographic Programme, CLIVAR (Climate Variability and Predictability Project) and GO-SHIP (Global Ocean Ship-based Hydrographic Investigations Program).

A total of 120 stations was 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), Teledyne Benthos altimeter (PSA-916D), and Teledyne RD Instruments L-ADCP (300kHz). Cruise track and station location are shown in Figure 1.

At each station, full-depth CTDO₂ (temperature, conductivity (salinity) and dissolved oxygen) profile 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 using a stainless steel bucket at each station. Sampling layer is designed as so-called staggered mesh as shown in Table 1 (Swift, 2010). The bottle depth diagram is shown in Figure 2.

Water samples were analyzed for salinity, dissolved oxygen, nutrients, dissolved inorganic carbon (DIC), total alkalinity (TA), pH, CFC-11, CFC-12 and phytopigment (chlorophyll-a and phaeopigments). Underway measurements of partial pressure of carbon dioxide ($p\text{CO}_2$), temperature, salinity, chlorophyll-a, subsurface current, bathymetry and meteorological parameters were conducted along the cruise track.

RF13-06

RF13-06 cruise was carried out during the period from June 19 to July 24, 2013. Before the observation at the first station, all watch standers were drilled in the method of sample drawing and CTD operations at the point (34°22'N, 138°30'E). At first, the cruise started from Stn.13 (28°42'N, 126°27'E; RF4757) and sailed south-eastward to Stn.26 (27°30'N, 128°15'E; RF4770). After observation of Stn.26 we observed from Stn.1 (30°14'N, 130°50'E; RF4771) to Stn.12 (28°35'N, 129°45'E; RF4782) and from Stn.27 (26°04'N, 127°55'E; RF4783) to Stn.31 (25°39'N, 128°34'E; RF4787). Leg 1 consisted of 31 stations. We finished Stn.31 on June 29. She called for Naha (Japan) on July 1 (Leg 1). She left Naha on July 5, we restarted observation from Stn.32 (25°39'N, 128°34'E; RF4788) that was same the station of Stn.31. Owing to the typhoon (T1307), after observation of Stn.45 (23°43'N,

133°00'E; RF4801), we sailed to Stn.63 (24°15'N, 143°38'E; RF4802). After observation of Stn.63, we sailed to westward, and observed from Stn.59 (24°14'N, 141°34'E; RF4803) to Stn.52 (24°15'N, 137°47'E; RF4810). We gave up at the station of Stn.52 and turned toward Tokyo (Japan). Leg 2 consisted of 23 stations. We arrived at Tokyo on July 24, 2013 (Leg 2).

One float and two drifting ocean data buoy were deployed along the cruise track. The information of deployed the float and the buoy are listed in Table 2a.

RF13-07

RF13-07 cruise was carried out during the period from July 31 to September 18, 2013. Before the observation at the first station, all watch standers were drilled in the method of sample drawing and CTD operations at the point (34°41'N, 139°51'E). We restarted observation from Stn.46 (24°14'N, 133°21'E; RF4812) on August 3 to Stn.51 (24°14'N, 137°49'E; RF4817) that was same the station of Stn.52, and from Stn.60 (24°15'N, 141°46'E; RF4818) and Stn.62 (24°15'N, 143°14'E; RF4820). We continued observation from Stn.64 (24°15'N, 143°39'E; RF4821) that was the same station of Stn.63. We sailed eastward and finished at Stn.89 (24°00'N, 164°59'E; RF4846) on August 15. Leg 1 consisted of 35 stations. She called for Pohnpei (Federated States of Micronesia) on August 21 (Leg 1). She left Pohnpei on August 25, 2013. The hydrographic cast of CTDO₂ was restarted at the same station (Stn.90 (24°00'N, 165°01'E; RF4847)) of Stn.89 on August 28. We observed eastward to Stn.108 (24°00'N, 179°00'E; RF4865), we turned northward and finished Stn.120 (29°58'N, 178°58'E; RF4877). Leg 2 consisted of 31 stations from Stn.90 to Stn.120. Stn.120 was finished on September 7. She arrived at Tokyo (Japan) on September 18, 2013 (Leg 2).

Five Argo floats were deployed along the cruise track. The information of deployed the float and the buoy are listed in Table 2b.

Location data of stations is shown in Table 3.

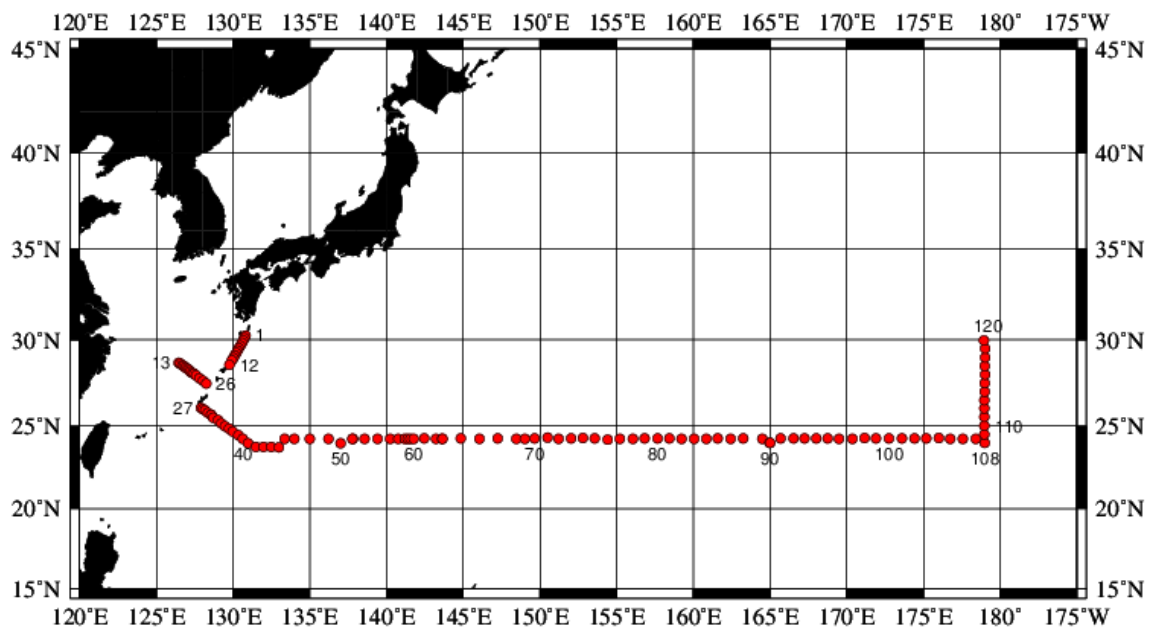


Figure 1. Cruise track of RF13-06 and RF13-07.

Bottle Depth Diagram along P03

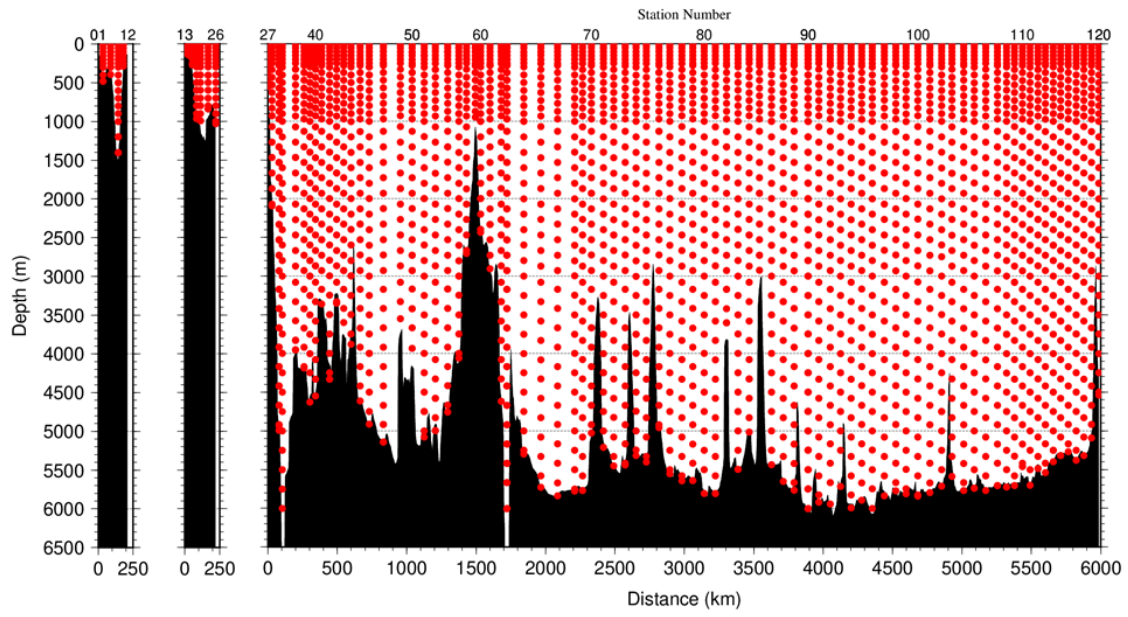


Figure 2. The bottle depth diagram for WHP-P03 revisit.

Table 1. The scheme of sampling layer in meters.

<i>Bottle count</i>	<i>scheme1</i>	<i>scheme2</i>	<i>scheme3</i>
<i>1</i>	10	10	10
<i>2</i>	50	50	50
<i>3</i>	100	100	100
<i>4</i>	150	150	150
<i>5</i>	200	200	200
<i>6</i>	250	250	250
<i>7</i>	300	330	280
<i>8</i>	400	430	370
<i>9</i>	500	530	470
<i>10</i>	600	630	570
<i>11</i>	700	730	670
<i>12</i>	800	830	770
<i>13</i>	900	930	870
<i>14</i>	1000	1070	970
<i>15</i>	1200	1270	1130
<i>16</i>	1400	1470	1330
<i>17</i>	1600	1670	1530
<i>18</i>	1800	1870	1730
<i>19</i>	2000	2070	1930
<i>20</i>	2200	2270	2130
<i>21</i>	2400	2470	2330
<i>22</i>	2600	2670	2530
<i>23</i>	2800	2870	2730
<i>24</i>	3000	3080	2930
<i>25</i>	3250	3330	3170
<i>26</i>	3500	3580	3420
<i>27</i>	3750	3830	3670
<i>28</i>	4000	4080	3920
<i>29</i>	4250	4330	4170
<i>30</i>	4500	4580	4420
<i>31</i>	4750	4830	4670
<i>32</i>	5000	5080	4920
<i>33</i>	5250	5330	5170
<i>34</i>	5500	5580	5420
<i>35</i>	5750	5830	5670
<i>36</i>	6000	6000	6000

Table 2a. Information of deployed float and buoy at RF13-06.

<i>Float WMO number</i>	<i>Date and Time (UTC) of Deployment</i>	<i>Position of deployment</i>		<i>PI</i>	
		<i>Latitude</i>	<i>Longitude</i>		
2902430	2013 July 9 01:32	23-42.54 N	132-56.59 E	JMA	APEX
<i>Buoy WMO number</i>	<i>Date and Time (UTC) of Deployment</i>	<i>Position of deployment</i>		<i>PI</i>	
		<i>Latitude</i>	<i>Longitude</i>		
21679	2013 June 25 01:32	28-42.30 N	126-27.04 E	JMA	YTSS-2100
21704	2013 July 6 00:42	25-32.74 N	128-44.72 E	JMA	YTSS-2100

APEX : Teledyne Webb Research (USA)

YTSS-2100: JVC KENWOOD Co., Japan

Table 2b. Information of deployed float and buoy at RF13-07.

<i>Float WMO number</i>	<i>Date and Time (UTC) of Deployment</i>	<i>Position of deployment</i>		<i>PI</i>	
		<i>Latitude</i>	<i>Longitude</i>		
2902453	2013 August 12 05:30	24-16.70 N	157-39.46 E	JAMSTEC	ARVOR
2902461	2013 August 29 21:59	24-16.84 N	168-02.16 E	JAMSTEC	ARVOR
2902462	2013 August 31 20:45	24-18.38 N	172-47.57 E	JAMSTEC	ARVOR
2902463	2013 September 2 11:45	24-16.08 N	176-47.13 E	JAMSTEC	ARVOR
2902464	2013 September 3 10:20	24-00.89 N	178-59.85 E	JAMSTEC	ARVOR

ARVOR : nke Instrumentation (France)

Table 3a. Station data of RF13-06 cruise. The 'RF' column indicates the JMA station identification number.

<i>EXPCODE</i>	<i>Leg</i>	<i>Station</i>		<i>Position</i>	
		<i>Stn.</i>	<i>RF</i>	<i>Latitude</i>	<i>Longitude</i>
1	1	1	4771	30-14.47 N	130-50.26 E
1	1	2	4772	30-05.87 N	130-44.66 E
1	1	3	4773	29-58.18 N	130-40.29 E
1	1	4	4774	29-48.88 N	130-34.72 E
1	1	5	4775	29-40.04 N	130-28.82 E
1	1	6	4776	29-32.26 N	130-23.37 E
1	1	7	4777	29-23.21 N	130-17.82 E
1	1	8	4778	29-15.26 N	130-12.34 E
1	1	9	4779	29-06.58 N	130-06.60 E
1	1	10	4780	28-58.18 N	130-01.36 E
1	1	11	4781	28-50.25 N	129-55.28 E
1	1	12	4782	28-35.19 N	129-45.09 E
1	1	13	4757	28-42.01 N	126-26.87 E
1	1	14	4758	28-38.37 N	126-34.13 E
1	1	15	4759	28-33.26 N	126-41.28 E
1	1	16	4760	28-29.59 N	126-48.44 E
1	1	17	4761	28-24.62 N	126-54.41 E
1	1	18	4762	28-21.11 N	127-01.79 E
1	1	19	4763	28-16.09 N	127-08.65 E
1	1	20	4764	28-10.72 N	127-14.80 E
1	1	21	4765	28-06.17 N	127-21.50 E
1	1	22	4766	28-02.56 N	127-28.39 E
1	1	23	4767	27-57.76 N	127-34.77 E
1	1	24	4768	27-48.18 N	127-48.09 E
1	1	25	4769	27-38.76 N	128-02.00 E
1	1	26	4770	27-30.08 N	128-15.29 E
1	1	27	4783	26-04.15 N	127-54.85 E
1	1	28	4784	26-00.11 N	128-02.11 E
1	1	29	4785	25-54.71 N	128-09.77 E
1	1	30	4786	25-47.16 N	128-21.45 E
1	1	31	4787	25-39.13 N	128-33.96 E
2	2	32	4788	25-38.74 N	128-33.71 E
2	2	33	4789	25-29.81 N	128-43.41 E
2	2	34	4790	25-20.88 N	129-00.74 E
2	2	35	4791	25-09.31 N	129-14.70 E

Table 3a. Continue.

<i>EXPCODE</i>	<i>Leg</i>	<i>Station</i>		<i>Position</i>	
<i>sub number</i>		<i>Stn.</i>	<i>RF</i>	<i>Latitude</i>	<i>Longitude</i>
2	2	36	4792	24-59.45 N	129-29.38 E
2	2	37	4793	24-50.65 N	129-44.33 E
2	2	38	4794	24-40.71 N	129-58.82 E
2	2	39	4795	24-28.09 N	130-19.53 E
2	2	40	4796	24-14.71 N	130-38.28 E
2	2	41	4797	23-59.02 N	130-58.98 E
2	2	42	4798	23-45.49 N	131-28.65 E
2	2	43	4799	23-45.05 N	131-59.11 E
2	2	44	4800	23-45.30 N	132-29.45 E
2	2	45	4801	23-43.71 N	133-00.00 E
2	2	52	4810	24-14.55 N	137-47.36 E
2	2	53	4809	24-15.12 N	138-33.99 E
2	2	54	4808	24-14.40 N	139-26.01 E
2	2	55	4807	24-13.83 N	140-14.17 E
2	2	56	4806	24-14.62 N	140-46.37 E
2	2	57	4805	24-14.60 N	141-11.02 E
2	2	58	4804	24-14.47 N	141-23.34 E
2	2	59	4803	24-14.07 N	141-33.75 E
2	2	63	4802	24-15.23 N	143-37.66 E

Table 3b. Station data of RF13-07 cruise. The 'RF' column indicates the JMA station identification number.

<i>EXPCODE</i>	<i>Leg</i>	<i>Station</i>		<i>Position</i>	
<i>sub number</i>		<i>Stn.</i>	<i>RF</i>	<i>Latitude</i>	<i>Longitude</i>
3	1	46	4812	24-13.57 N	133-21.00 E
3	1	47	4813	24-14.06 N	133-59.75 E
3	1	48	4814	24-15.17 N	134-59.94 E
3	1	49	4815	24-15.03 N	136-12.54 E
3	1	50	4816	23-59.27 N	137-00.24 E
3	1	51	4817	24-14.25 N	137-48.60 E
3	1	60	4818	24-15.40 N	141-45.91 E
3	1	61	4819	24-15.84 N	142-26.98 E
3	1	62	4820	24-15.32 N	143-13.93 E
3	1	64	4821	24-15.11 N	143-38.58 E
3	1	65	4822	24-15.63 N	144-50.93 E

Table 3b. Continue.

<i>EXPOCODE</i>	<i>Leg</i>	<i>Station</i>		<i>Position</i>	
		<i>Stn.</i>	<i>RF</i>	<i>Latitude</i>	<i>Longitude</i>
3	1	66	4823	24-14.65 N	146-03.68 E
3	1	67	4824	24-15.78 N	147-15.35 E
3	1	68	4825	24-15.50 N	148-28.09 E
3	1	69	4826	24-14.47 N	149-01.46 E
3	1	70	4827	24-16.36 N	149-39.23 E
3	1	71	4828	24-17.59 N	150-30.54 E
3	1	72	4829	24-14.47 N	151-14.05 E
3	1	73	4830	24-16.08 N	152-02.72 E
3	1	74	4831	24-16.71 N	152-49.03 E
3	1	75	4832	24-16.19 N	153-33.69 E
3	1	76	4833	24-10.97 N	154-26.25 E
3	1	77	4834	24-14.91 N	155-12.52 E
3	1	78	4835	24-14.85 N	156-03.86 E
3	1	79	4836	24-15.89 N	156-50.46 E
3	1	80	4837	24-15.92 N	157-39.77 E
3	1	81	4838	24-15.76 N	158-27.00 E
3	1	82	4839	24-14.67 N	159-14.71 E
3	1	83	4840	24-14.30 N	160-04.14 E
3	1	84	4841	24-14.98 N	160-50.69 E
3	1	85	4842	24-15.82 N	161-35.29 E
3	1	86	4843	24-15.13 N	162-26.54 E
3	1	87	4844	24-15.55 N	163-16.16 E
3	1	88	4845	24-15.36 N	164-03.30 E
3	1	89	4846	24-00.15 N	164-59.37 E
4	2	90	4847	24-00.48 N	165-00.85 E
4	2	91	4848	24-15.67 N	165-42.12 E
4	2	92	4849	24-16.16 N	166-31.51 E
4	2	93	4850	24-15.57 N	167-15.59 E
4	2	94	4851	24-15.88 N	168-00.59 E
4	2	95	4852	24-15.95 N	168-46.09 E
4	2	96	4853	24-14.85 N	169-30.85 E
4	2	97	4854	24-14.74 N	170-21.82 E
4	2	98	4855	24-16.58 N	171-10.76 E
4	2	99	4856	24-15.76 N	171-55.30 E
4	2	100	4857	24-16.08 N	172-44.98 E
4	2	101	4858	24-15.52 N	173-36.53 E

Table 3b. Continue.

<i>EXPOCODE</i>	<i>Leg</i>	<i>Station</i>		<i>Position</i>	
		<i>sub number</i>	<i>Stn.</i>	<i>RF</i>	<i>Latitude</i>
4	2	102	4859	24-16.26 N	174-25.87 E
4	2	103	4860	24-16.23 N	175-10.65 E
4	2	104	4861	24-16.94 N	175-59.98 E
4	2	105	4862	24-15.37 N	176-45.70 E
4	2	106	4863	24-14.52 N	177-35.05 E
4	2	107	4864	24-15.14 N	178-24.54 E
4	2	108	4865	24-00.31 N	179-00.35 E
4	2	109	4866	24-30.64 N	178-58.68 E
4	2	110	4867	25-01.28 N	178-58.69 E
4	2	111	4868	25-31.64 N	178-59.31 E
4	2	112	4869	26-01.69 N	178-59.23 E
4	2	113	4870	26-30.91 N	178-58.88 E
4	2	114	4871	27-01.13 N	178-59.51 E
4	2	115	4872	27-30.64 N	179-00.24 E
4	2	116	4873	27-59.88 N	179-00.67 E
4	2	117	4874	28-30.42 N	178-59.89 E
4	2	118	4875	29-00.36 N	179-01.84 E
4	2	119	4876	29-29.78 N	179-01.18 E
4	2	120	4877	29-58.17 N	178-57.70 E

List of Principal Investigators for all Measurements

The principal investigator (PI) and the person in charge responsible for major parameters measured on the cruise are listed in Table 4a (RF13-06) and Table 4b (RF13-07).

Table 4a. List of principal investigator and the person in charge on the ship for RF13-06.

Item	Principal Investigator (PI)	Person in charge on the ship
<i>Hydrography</i>		
CTDO ₂ / LADCP	Toshiya NAKANO	Tomoyuki KITAMURA
Salinity	Toshiya NAKANO	Sho HIBINO
Dissolve oxygen	Toshiya NAKANO	Takashi MIYAO
Nutrients	Toshiya NAKANO	Sonoki IWANO
Phytopigment	Toshiya NAKANO	Naoshi KUBO
DIC	Toshiya NAKANO	Kyoichi KAWAHARA
Total Alkalinity	Toshiya NAKANO	Kyoichi KAWAHARA
pH	Toshiya NAKANO	Kyoichi KAWAHARA
CFCs	Toshiya NAKANO	Akira WADA

Underway

Meteorology	Toshiya NAKANO	Kazuhiro NEMOTO
Thermo-Salinograph	Toshiya NAKANO	Kyoichi KAWAHARA
pCO ₂	Toshiya NAKANO	Kyoichi KAWAHARA
Chlorophyll-a	Toshiya NAKANO	Naoshi KUBO
ADCP	Toshiya NAKANO	Tomoyuki KITAMURA
Bathymetry	Toshiya NAKANO	Tomoyuki KITAMURA

Float and Buoy

Argo float (JMA)	Kazuhiro NEMOTO	Kazuhiro NEMOTO
Buoy (JMA)	Kazuhiro NEMOTO	Kazuhiro NEMOTO

Table 4b. List of principal investigator and the person in charge on the ship for RF13-07.

Item	Principal Investigator (PI)	Person in charge on the ship
<u>Hydrography</u>		
CTDO ₂ / LADCP	Toshiya NAKANO	Kiyoshi MURAKAMI
Salinity	Toshiya NAKANO	Keizo SHUTTA
Dissolve oxygen	Toshiya NAKANO	Hiroyuki FUJIWARA
Nutrients	Toshiya NAKANO	Chihiro KAWAMURA
Phytopigment	Toshiya NAKANO	Tomohiro UEHARA
DIC	Toshiya NAKANO	Shu SAITO
Total Alkalinity	Toshiya NAKANO	Shu SAITO
pH	Toshiya NAKANO	Shu SAITO
CFCs	Toshiya NAKANO	Etsuro ONO
<u>Underway</u>		
Meteorology	Toshiya NAKANO	Hitomi KAMIYA
Thermo-Salinograph	Toshiya NAKANO	Shu SAITO
pCO ₂	Toshiya NAKANO	Shu SAITO
Chlorophyll-a	Toshiya NAKANO	Tomohiro UEHARA
ADCP	Toshiya NAKANO	Keizo SHUTTA
Bathymetry	Toshiya NAKANO	Keizo SHUTTA
<u>Float</u>		
Argo float (JAMSTEC)	Shigeki HOSODA	Hitomi KAMIYA

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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*