

P1W

I. Cruise Narrative

Tomowo Watanabe (National Research Institute of Far Seas Fisheries Laboratory)

The cruise was the first cruise of the R/V Kaiyo-Maruf of Japan Fisheries Agency in 1999 fiscal year and was planned to cover the western stations of the WHP-P1 revisit observation, which was a part of SAGE (Sub-Arctic Gyre Experiment). The purpose of the P1-revisit cruise was to detect the decadal change of the oceanographic structure from P1 cruise in 1985.

We departed from the Harumi pier of the Tokyo harbor at 13:46 JST on May 21, 1999. On the way to the first station of the WHP-P1 revisit, we did the CTD+RMS observation at 38.94N, 144.09E on May 22 for checking the conditions of equipments, and where we confirmed the techniques for water sampling from the Niskin bottles. The first station, P1_#1, was located at 42.98N, 145.45E where CTD+RMS observation began at 10:09 JST on May 23. After finishing the first observation, we sailed to southeastward along the original P1 observation line. In the daytime of the same day, we could occupied to the forth station. In the nighttime we found the many drifting nets of salmon fisheries in the course and we decided to skip 15 stations from the next. Taking the bypass route, we reached at the southernmost station P1_#20 located 39.69N, 147.93E, and where we restarted the P1-revisit observation. 15 CTD+RMS stations (P1_#20 - #37) and 3 XCTD stations (#21, #23, #25) were occupied along the P1 line off the Kurile Islands. The LADCP was changed at P01_#34. At P1_#35, a jellyfish entered the CTD sensor and brought the bad influence to the CTD data. Since we had to save the ship time, the second cast was not done. We reached to 47N at P01_#38 located 47.00N, 160.00E on May 28 and continued the P1 revisit cruises eastward along the 47N latitude line. The stations along the 47N line were basically the same to the original stations of P1 observation in 1985. We added the cross points with X13 and X14. The XCTD observations were also done at between CTD+RMS stations and 36 probes were launched. The CTD+RMS observation was favorable in general. Though we experienced the wire trouble at P01_#56 and the CTD sensor troubles at P01_#58, both troubles were fixed for short time and successfully recovered by the second cast. 34 CTD+RMS stations were occupied along the 47N line from P01_#38 to P01_#74 which was the easternmost station of the R/V Kaiyo-maruf cruise located 47.00N, 165.97W.

After finishing the CTD+RMS observation at P01_#74 on June 7, we changed the course and

started to the west to reoccupy the station P01_#35. We did 75 XBT observations on the course from 166W to 157E every 0.5-degree longitude by the request of the hydrographic division of Japan Meteorological Agency on SAGE. We left the last station CTD-RMS station P01_#35 at 12:00 JST June 11 and we turned the bow to Kushiro. We arrived in the Kushiro harbor on June 13.

The cruise succeeded to take oceanographic data with high accuracy by cooperation of many people. We believe that our dataset are valuable and effectively used for the climate study.

II. Cruise summary

1. Ship name

Kaiyo-maruf (Japan Fisheries Agency)

2. Cruise period

From 23 May 1999 to 6 June 1999

3. Observation

49 stations along WHP P1 from 148E to 172W

4. Chief Scientist

Tomowo Watanabe (Far Fisheries Laboratory, Japan Fisheries Agency):
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5. Observation Item and PI

CTD/DO	Masao Fukasawa (Tokai University): fksw@jamstec.go.jp Tomowo Watanabe (National Research Institute of Far Seas Fisheries Lab): wattom@affrc.go.jp Takahiko Kameda (National Research Institute of Far Seas Fisheries Laboratory)
Bottle Salinity	Ayako Nishina (Kagoshima University): nishina@fish.kagoshima-u.ac.jp
Bottle Oxygen	Ayako Nishina (Kagoshima University): nishina@fish.kagoshima-u.ac.jp
Nutrients	Chizuru Saitoh (Japan Marine Science and Technology Center): saitoc@jamstec.go.jp

CFC11,12,113	Yutaka Watanabe (National Institute for Resource and Environment): yywata@ees.hokudai.ac.jp
SF6	Yutaka Watanabe (National Institute for Resource and Environment): yywata@ees.hokudai.ac.jp
DIC, pH, TAlk	Tsuneo Ono (National Research Institute of Fisheries Laboratory): onot@jamstec.go.jp
delta 14C	Robert Key (Princeton University): key@Princeton.EDU Masao Fukasawa (Tokai University): fksw@jamstec.go.jp
delta 13C	Yutaka Watanabe (National Institute for Resource and Environment)*: yywata@ees.hokudai.ac.jp
Barium	Yoshihisa Kato (Tokai University): ykato@scc.u-tokai.ac.jp
Chlorophyll_a	Yoshimi Suzuki (Shizuoka University): ysuzu@shizuoka-u.ac.jp
Cu, Ni	Chizuru Saitoh (Japan Marine Science and Technology Center): saitoc@jamstec.go.jp

* Three samples were collected to be analyzed at three different institutes.

III. Sample water salinity measurements

(1) Personal

Ayako Nishina (Kagoshima University)
Tomowo Watanabe (Fisheries Agency)
Masao Fukasawa (Tokai University)

(2) Objective

Calibration of salinity measured by CTD.

(3) Measured Parameter

Sample water salinity

(4) Instruments and Method

The salinity analysis was carried out by two Guildline Autosol salinometers model 8400B, which were modified by addition of an Ocean Science International peristaltic-type sample intake

pump. One salinometer was operated in an air-conditioned ship's laboratory and in a laboratory of Far Fisheries Laboratory JFA. The other one was operated also in an air-conditioned room at Kagoshima University.

i) Standard Sea Water

All salinometers were standardized using IAPSO Standard Seawater batch P133. Aspirated sea water was applied every salinometer at least for a full day, then each salinometer was standardized. Drifts of a salinometer were examined by SSW of P133 ampoule before and after the measurements for samples of one station. Drifts of all salinometer was so small that no re-standardization was needed.

ii) Salinity Sample Collection

The bottles in which the salinity samples are collected and stored are 250ml clear glass bottles with inner caps and outer screw caps. Each bottle was rinsed three times and filled with sample water. Salinity samples were stored in the same laboratory where the salinity measurement was made at least for 50 hours.

iii) Replicate Samples

Replicate samples were drawn from several Niskin bottles for each station. Standard deviation in the measurements of replicate samples was 0.0011 psu for 208 pairs of which flags were not 4.

IV. Sample Dissolved Oxygen Measurements

(1) Personel

Ayako Nishina (Kagoshima University)
Hiroyuki Nakajima (Tokai University)
Masao Fukasawa (Tokai University)

(2) Objective

To describe changes in DO transect between 1985 and 1999.

(3) Equipment and techniques

Bottle oxygen samples were taken in calibrated clear glass bottle of 100 ml capacity before other samples were drawn. To check and to allow corrections for change in capacity of the sample between the closure of the rosette bottle and fixing of the dissolved oxygen, the potential

temperature calculated from CTD results was used after a correction based on the measured temperature data. Analysis followed the whole bottle method. The thiosulfate titration was carried out in a controlled environmental laboratory maintained at temperature between 20 deg.C and 28deg.C. The normality of thiosulfate was set to be 0.05 when the reagents were made up, and checked their changes 7 times during a cruise. Replicate samples were taken from bottles of fixed number (2, 7, 12, 17, 22) on every cast ; usually these were included deepest bottle and DO minimum bottle.

The end point of titration was determined by a photometric method using ART-3/DO-1 manufactured by HIRAMA (Japan) which has an auto burette with 6 ml cylinder. Titration volume was always smaller than 3.5 ml and the smallest increment from the burette was 2.5 micro-liters.

The volume of oxygen dissolved in the water was converted to mass fraction by use of the factor 44.66 and an appropriate value of the density; corrections for the volume of oxygen added with reagents and for impurities in the manganese chloride were also made as described in the WOCE Manual of Operation and Methods (Culberson, 1991, WHPO 91-1).

(4) Reproducibility of measurement

During the cruise 1481 samples were taken including 167 of replicates. Statistics on the replicates are given in Table 1. These include both replicates and those taken from different bottles fired at the same depth but exclude bad measurement data.

Table 1: Statistics of replicates and duplicate obtained during the cruise

Number of replicates	Oxygen concentration umol/kg			
	mean difference	Std. dev	%mean	mean abstract diff.
167	0.00 $\mu mol / kg$	0.48 $\mu mol / kg$	0.29	0.39 $\mu mol / kg$

V. Carbonate species and Chemical transient tracers

(1) Personnel

Yutaka Watanabe (National Institute of Resource and Environment)
Tsuneo Ono (National Research Institute of Fisheries Laboratory)

Yoshiyuki Nakano (Hokkaido University)
Masahide Wakita (Hokkaido University)

(2) Objectives

Total dissolved inorganic carbon (DIC), titration Alkalinity (TA) and pH are the main parameters of oceanic carbon cycle, which owes significant importance recently for understanding of the fate of human-released CO₂. On the other hand, CFC11, CFC12, CFC113 and SF₆ as chemical transient tracers are very useful to clarify the water movement and/or the fate of human-released CO₂. If we observed the above parameters simultaneously, it will allow us to get more information about oceanic carbon cycle.

Thus observing them together, and comparing the 1985 WOCE/WHP P01 data with our data, we tried to get the time change of carbonate species and water movement in the North Pacific subpolar region.

(3) Sampling and Methods

(a) DIC

Method: Extraction/Coulometry (Ono et al., 1998)
Analyzer: UIC CM5012 coulometer & KIMOTO EN-501 auto-coulometer
Standard: Primary standard grade Na₂CO₃ (Asahi grass Co.)
Precision: +/- 2.7 $\mu mol/kg$

Sub-samples were drawn into a 150 ml grass salinity bottle and closed after 5 seconds of overflow. Duplicate samples were taken on every station. All samples were stored under room temperature and analyzed within 12 hours after the sampling followed by a coulometric method (Ono et al., 1998). In some stations, measurement was also done by the automatic DIC measurement system by coulometry (KIMOTO EN-501, KIMOTO Electronic CO.). Two solutions of standard grade sodium carbonate were used as the primary standard. Two concentrations of the seawater standards containing a constant amount of DIC were made in laboratory as working standard in the cruise. The DIC content of this working standard was determined on board using the primary standard sodium carbonate solutions. The Certified Reference materials distributed by Scripps Institution of Oceanography was measured together with the measurement at several stations.

(b) TA

Method: Modified one-point method (Culberson et al., 1970)

Analyzer: Manual measurement

Standard: Primary standard grade Na₂CO₃ (Asahi grass Co.)

Precision: +/- 3.5 µmol/kg

Sub-samples were drawn into a 120 ml vial grass bottle. Duplicate samples were taken on every station. All samples were stored under room temperature and analyzed within 12 hours after the sampling followed by the modified one-point titration method of Culberson et al. (1970).

2l of 0.6N HCl solution was prepared and normality was calibrated against the primary standard sodium carbonate solutions. Calibration of pH probe was made by Tris and 2-Aminopyridine Buffers (Dickson, 1993). To correct the drift of glass electrode during the measurement of pH after titration, we measure the pH of acidified seawater which pH was controlled at 3.38 by adding HCl at interval of every 10 samples.

(c) pH

Method: Continuous-flow Spectrophotometric pH measurements (Clayton et al., 1993)

(The pH indicator is m-cresol purple)

Analyzer: Spectrophotometer: Spectro multi channel photo detector MCPD-2000 (Otsuka ELECTRONICS CO., LTD)

Standard: 2-amino-2-hydroxymethyl-1, 3-propanediol (tris) buffer in synthetic seawater

2-aminopyridine buffer in synthetic seawater (Dickson, Goyet, DOE, 1994)

Precision: +/- 0.002pH

Sub-samples were drawn into a 120 ml grass bottle. Duplicate samples were taken from surface water on every station. All samples were stored under room temperature and analyzed within 12 hours after the sampling followed by the modified Continuous-flow Spectrophotometric pH measurements (Clayton et. al., 1993)

(d) CFC11, CFC12 & CFC113

Method: Purged and trapped ECD-GC method (Bullister and Weiss, 1988)

Analyzer: ECD-GC (Hitachi 263-30E)

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.01 pmole/kg

Sub-samples were drawn into a 120 ml grass syringe. Duplicate samples were taken on every station. We used 30 ml as a sample. All samples were stored within 12 hours after the sampling followed by the modified purged and trapped ECD-GC method (Bullister and Weiss, 1988). We

measured water sample of 30 ml. All data were normalized to SIO '93 scale.

(e) SF₆

Method: Purged and trapped ECD-GC method (Law et al., 1994)

Analyzer: ECD-GC (Hitachi 5000A)

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.03 fmole/kg

Sub-samples were drawn into a 1200 ml grass bottle. We used 500 ml as a sample. All samples were stored within 12 hours after the sampling followed by the modified purged and trapped ECD-GC method (Law et al., 1994).

(4) Preliminary results

Measurements of DIC, TA, pH, CFC11, CFC12, CFC113 and SF₆ were made with the above precision. This was the first result of the east-west cross section where precise carbonate species and chemical transient tracers were simultaneously observed in the North Pacific subpolar region. We will try to get these detailed spatial distributions with the results of SAGE-P1revisit first leg by R/V Kaiyo-maru of Japan Fisheries Agency during May-June 1999. We also will do the time change of carbonate species and water movement by comparing the 1985 WOCE/WHP P01 data with our data in the future.

VI. Carbon Isotope Ratios in dissolved inorganic carbon ($\Delta^{14}\text{C}$)

(1) Personnel

Masao Fukasawa (Tokai University): collecting sample

Robert Key (Princeton University): analyzing sample

(2) Objective

To add new data to the historical P1 database and to estimate the ocean up-take rate of the anthropogenic carbon together with the CFCs data.

(3) Sample collection

Sampling stations of ¹⁴C are planned to be every five degrees except the western boundary area. Samples were collected from depth using 12 liter Niskin bottles. Sampling glass bottles of c.a. 500ml were baked at 450 degree C for tow hours after dipped into 1 N of HCl solution. After baking, each bottle was capped with an aluminum foil until the sampling on the shipboard. The

seawater sample was siphoned into the glass bottle with enough seawater to fill the glass. Immediately after the collection, about 10 ml of seawater was removed from the bottle and poisoned by 1 ml of saturated HgCl₂ solution. The bottle was put a screwed plastic cap on and sealed with butyl tape. Then the bottle was put in a wooden container.

295 samples were collected from 12 stations.

(4) Sample measurements

All samples were sent to Dr. Robert Key of Princeton University to be analyzed.

VII. CTD measurement

(1) Personnel

- Masao Fukasawa (Tokai University)
- Tomowo Watanabe (National Research Institute of Far Seas Fisheries Laboratory)
- Tkahiko Kameda (National Research Institute of Far Seas Fisheries Laboratory)

(2) Objective

To detect long term changes in the T-S stratification along P1 transect between 1985 and 1999.

(3) Apparatus

Body and Circuit

Sea-Bird CTD9 s/n 09P13830-0429

Sensors

- Temperature sensor: 2109
- Conductivity sensor: 041723,042256
- Pressure sensor: Digiquartz 410k-105 s/n 59935
- DO sensor: s/n 130207, Beckman s/n 7-05-19

(3) Sensor calibration

(3)-1 Temperature sensor

Temperature sensor was calibrated before and after the cruise on 3 Apr. 99 and 29 Jun. 99, respectively at Sea-Bird Electronics. Post-cruise residuals defined as differences between the bath temperature and the instrument temperature

were checked at eleven temperature points of -1.4108, 1.0995, 4.5914, 8.1890, 11.6230, 15.1795, 18.6833, 22.1824, 25.7416. 29.1567 and 32.6894 ITS-90 degree C. The largest sensor drift during the period from the pre-cruise calibration to the post-cruise calibration was found to be 0.00003 deg C at around 1.0995 deg C. On the other hand, the absolute temperature difference between the bath and the instrument temperature was found to be largest as 0.0007deg C at around 15.1770 deg C using coefficients decided at the time of pre-cruise.

Consequently, if define the accuracy of the sensor as the sum of the drift and the absolute temperature difference at eleven bath temperature, the result can be expressed as follows;

bath temp (deg C)	ambiguity (deg C)
-1.41	0.00004
1.01	0.00007
4.59	0.00001
8.19	0.00006
11.62	0.00002
15.18	0.00008
18.68	0.00005
22.18	0.00004
25.74	0.00002
29.16	0.00004
32.69	0.00003

It must be noted that these numbers shows the accuracy of the CTD temperature measurement at its worst case.

(3)-2 Conductivity sensors

Sensor 042256 was used before the stations 54. At station 54 the sensor was replaced with 041723. Sensor of 041723 was calibrated at Sea-Bird Electronics on 6 Apr. 99 and 29 Jun. 99 just before and after the cruise. The sensor of 042256 was calibrated on 3 Apr. 99 and 29 Jun. 99 just before and after the cruise. For both of sensors, no severe non-linear response was detected which may affect the in-situ calibration of CTD salinity using the bottle salinity.

(3)-3 Pressure sensor

Pressure sensor was calibrated at the time of the purchase in May 96 and after this cruise on 7 Jul. 99. Calibration was carried out on six pressure values from 14 psia to 10000 psia. Any apparent hysteresis was found. Coefficients were decided so as to make the real pressure value and the CTD out put value are linear with the slope of 1 and the inter-sect of 0 at the time of newly equipped. Using the same coefficients, the slope value and intersect value were found to be shifted to 1.00003 and -1.38 psi or -0.954 db.

The linearity of calibration line was so good that the largest offset of -0.23 db was found at around 2000 psi.

(3)-4 DO sensor

DO sensor was calibrated on 7 Jul. 1999 after the cruise. Before the cruise, the sensor was calibrated on 17 Dec. 1997. Though changes in coefficient values were large, the response of the sensor was good enough for post-cruise calibration using results of the titration of bottle water.

(4) Data calibration

(4)-1 Temperature

Residual which was detected at post-cruise sensor calibration at 14 temperature points were interpolated and added to the CTD out put. The largest value of 0.00007deg.C was added to the CTD out put of 1.0995 IPTS-68.

(4)-2 Salinity

Bottle salinity values of which flags were 2 were used for the salinity calibration. Differences between CTD salinity and bottle salinity were minimized using the least square method against the pressure. Linear calibration equations were estimated for depths shallower than 1000db and deeper than 1000db, respectively. The calibration equation for deeper data was estimated first. The calibration value at 1000db was calculated and used as a fix point for the calibration for shallower data. As the result, two calibration equations which were connected to each other at 1000db were decided for every station. CTD salinity was re-produced using these equations. Standard deviation from the bottle salinity at each station is as follows;

stn	cast	SD(0-1000)	SD(1000-bottom)
		PSS-78	PSS-78
1	1	4.6181239e-003	N/A

2	1	1.4421889e-002	N/A
3	1	4.4185086e-003	N/A
4	1	4.2680562e-003	2.1874343e-004
20	1	3.8094293e-003	6.8252835e-004
22	1	2.8298779e-003	6.6035513e-004
24	1	1.7978313e-003	6.3866350e-004
26	1	1.8037580e-003	1.5259117e-003
27	1	1.9352809e-003	5.1124454e-004
28	1	2.1721584e-003	1.5042862e-003
29	1	1.2927151e-003	1.4045676e-003
30	1	2.1852552e-003	5.6407853e-004
31	1	1.6322545e-003	1.5007146e-003
32	1	2.2444854e-003	1.2699376e-003
33	1	2.5252833e-003	6.4161291e-004
34	1	1.5195429e-003	1.2669956e-003
35	1	N/A	N/A
36	1	1.4124021e-003	1.0463125e-003
37	1	1.6730462e-003	5.9182014e-004
38	1	1.0860671e-003	3.8176772e-004
39	1	1.4468418e-003	4.1070157e-004
40	1	1.9508624e-003	4.0846259e-004
41	1	1.1322033e-003	5.4830744e-004
X13	1	1.1533325e-003	5.5110814e-004
44	1	2.5624161e-003	9.8279168e-004
45	1	1.2238404e-003	2.3456222e-004
46	1	2.5344814e-003	8.9530163e-004
47	1	1.4346796e-003	1.2657885e-003
48	1	1.6048432e-003	6.9112603e-004
50	1	2.1409360e-003	4.1719428e-004
51	1	1.2464234e-003	9.7123702e-004
52	1	2.0123110e-003	5.5598393e-004

53	1	1.8584236e-003	1.3536450e-003
54	1	2.0292922e-003	5.2621502e-004
55	1	9.4859231e-004	7.0931218e-004
56	1	1.6160037e-003	3.4954619e-004
57	1	1.0671158e-003	7.6074263e-004
58	1	1.6572174e-003	7.6170433e-004
59	1	1.6213917e-003	4.9963344e-004
X14	1	1.9148849e-003	5.9706077e-004
62	1	1.9565395e-003	5.6959306e-004
63	1	1.2508871e-003	5.6891581e-004
64	1	1.5835605e-003	8.8598186e-004
65	1	2.0835625e-003	5.0560941e-004
66	1	1.2284561e-003	4.7343619e-004
67	1	2.1126449e-003	1.5229159e-003
68	1	1.8909090e-003	4.5770846e-004
69	1	4.8606318e-004	7.2303315e-004
70	1	1.6047963e-003	6.9342843e-004
71	1	1.9905149e-003	3.2169472e-004
72	1	2.0370839e-003	3.7782415e-004
73	1	1.1440231e-003	3.4743448e-004
74	1	1.5586888e-003	2.4118045e-004
35	2	1.3240061e-003	9.9363923e-004

calibration are crosschecked now.

As for the traceability of SSW P-133, was -14/10000 psu to Mantyla's value. Aoyama et al. (2002) also reported -17/10000, -14/10000, -12/10000 for P133. It must be noted that data calibration did not include the traceability.

(4)-3 Pressure

CTD outputs were re-produced using coefficients noted above.

(4)-4 Oxygen

Not yet. There seems to be a systematic error between bottle DO data of Kaiyo-maru cruise and Mirai cruise which can be attributed to the different analyzing method. Preliminary results of data