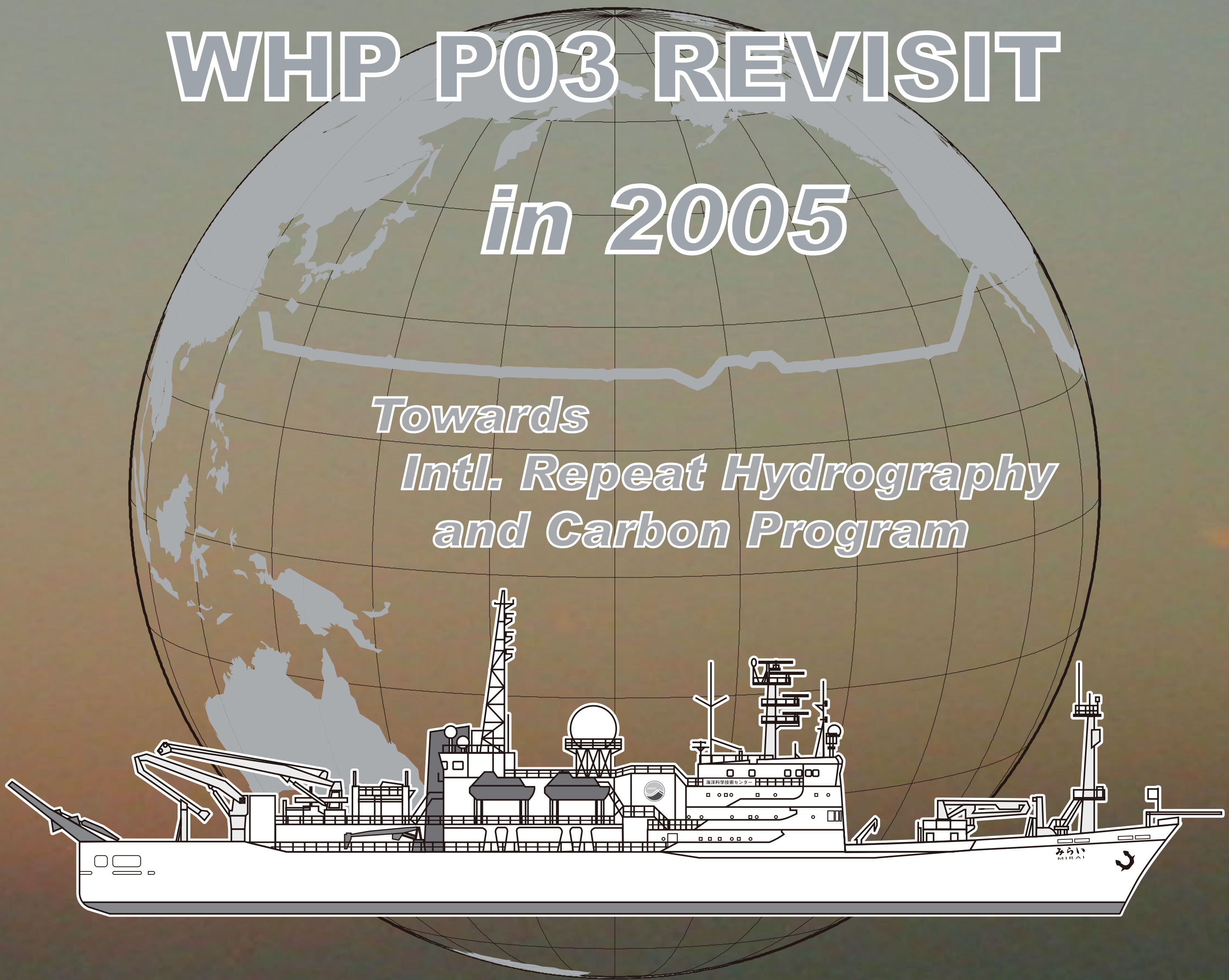
WHP P03 REVISIT DATA BOOK

Field Activity of JAMSTEC towards International Repeat Hydrography and Carbon Program



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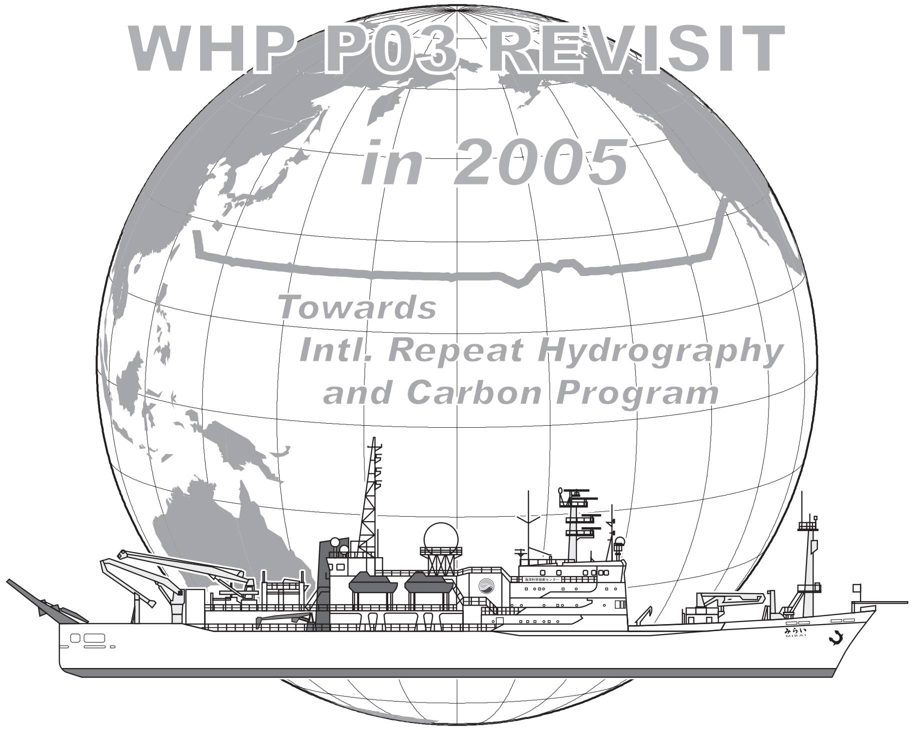
Edited by
Takeshi Kawano (JAMSTEC),
Hiroshi Uchida (JAMSTEC)



WHP P03 REVISIT DATA BOOK

December 27, 2007 Published
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Contents

Preface

Ocean General Circulation Observational Research Program of IORGC(1) / JAMSTEC(2) selected former WHP(3) line of P3 or P3-1985 as one of four repeat long lines in accordance with the mid-term objective of the program.

P3 line was occupied by US scientists with Dr. Dean Roemmich as the chief scientist in 1985 (They also occupied P1 line on the way back to the United States from Japan after P3 line cruise with Dr. Lynne Talley as the chief scientist) and was the first land-to-land line in the North Pacific along which sets of high quality hydrographic observations were carried out. The performances of P3 cruise were outstanding from various viewpoints compared to those of other historical hydrographic observations. It should be noted here that P3-1985 was the first complete zonal section in the North Pacific with a dense station distribution and high quality CTD measurements appropriate to estimate meridional ocean fluxes. Quite a few scientific results have been published. Most of these results have focused attention on the meridonal overturn structure of sea water mass and of dissolved materials fluxes induced by the overturn of sea water mass. Those scientific results have given a new viewpoint or concept toward ocean general circulation and strongly support the scientific needs of WOCE(4). Also data managing system in SIO(5), one of back offices of P3 observation, was recognized as an effective support to the global hydrography network in WOCE. In fact, the framework of data assembly center (DAC) during WOCE period and ongoing IRHCP(6) inherit a concept of data management system from SIO. If it were NOT for P3-1985, we might have to make an extraordinary effort to share and utilize hydrographic data for global climate study even now.

P3 revisit was carried out during the period from October 31, 2005 to January 30, 2006 following IRHCP under CLIVAR(7) and IOCCP(8). Therefore, the objectives of this revisit are 1) to investigate interannual and long-term variations in the ocean circulation and associated net property transports and their divergences, and 2) to quantify net changes in water mass inventories and renewal rate on seasonal to decadal time series, and to explore their relationships to estimate ocean transport divergences and air-sea exchanges. Beside these comprehensive objectives which are defined by IRHCP, one more objective was added to present revisit, that is to detect and evaluate changes in heat and material inventories of LCDW(9) together with other results from mooring observation across the Wake Island Deep Passage. This objective was the very reason why our program preferred P3 to P2.

Lastly, as noted before, we would heartily ask favors of all scientists to refer our data books of repeat hydrography including this issue as often as possible though those data sets can be accessed through web-sites of IORGC(10), JAMSTEC(11), IRHCP(12) and CDIAC(13),(14). No permission is required to reproduce those data books and CDs. Such references are the only proof that our repeat hydrography activity is closely connected to science and can keep our activity sustainable.

On Canadian Thanksgiving Day at Yokosuka

Masao Fukasawa
Director- General of IORGC/JAMSTEC,
Program Director of Ocean General Circulation Observational Program IORGC/JAMSTEC

(1) Institute of Observational Research for Global Change
(2) Japan Agency for Marine-Earth Science and Technology
(3) WOCE(4) Hydrographic Programme
(4) World Ocean Circulation Experiment
(5) Scripps Institution of Oceanography
(6) International Repeat Hydrography and Carbon Project
(7) Climate Variability and Predictability
(8) International Ocean Carbon Coordination Project
(9) Lower Circumpolar Deep Water
(10) http://www.jamstec.go.jp/iorgc/ocorp/data/post-woce.html
(11) http://www.jamstec.go.jp/mirai/index_eng.html
(12) http://cchdo.ucsd.edu/index.html
(13) Carbon Dioxide Analytical Center
(14) http://cdiac.ornl.gov/oceans/RepeatSections/repeat_map.html

1 Cruise Narrative

1.1 Highlight

GHPO Section Designation: P3

Expedition Designation: MR05-05

Chief Scientists and Affiliation:

Leg.1: ***Takeshi Kawano***

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Leg.3: ***Shuichi Watanabe***

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Ship: R/V MIRAI

Ports of Call: San Diego (U.S.A.) – Honolulu (U.S.A.) – Okinawa – Sekinehama

Cruise Dates: October 31, 2005 – January 30, 2006

Leg.1: October 31, 2005 – November 24, 2005
Leg.2: November 27, 2005 – January 17, 2006
Leg.3: January 20, 2006 – January 30, 2006

Number of Stations: 237 stations for CTD/Carousel Water Sampler

(Leg.1: 78, Leg.2: 129, Leg.3: 30)

Geographic boundaries: 124° 59.27' E - 117° 19.84' W

12° 43.32' N - 35°16.29' N

Floats and drifters deployed:

One Argo float was deployed.

Mooring deployed or recovered mooring:

Five mooring systems in the Wake Island Deep Channel were recovered during the period from December 14 to 16, 2005.

1.2 Cruise Summary

(1) Geographic boundaries

MR05-05 occupied stations along about 24°N, from 117°20' W to 124°59' E.

(2) Station occupied

A total of 237 stations (Leg.1: 78, Leg.2: 129, Leg.3: 30) were occupied using a Sea Bird Electronics 36 bottle carousel equipped with 12-liter Niskin X water sample bottles, a SBE911plus equipped with SBE35 deep ocean standards thermometer, SBE43 oxygen sensor, AANDERAA “optode” oxgen sensor and Benthos Inc. Altimeter and RDI Monitor ADCP. Cruise track and station location are shown in Figure 1.2.1.

(3) Sampling and measurements

Water samples were analyzed for salinity, oxygen, nutrients, CFC-11, -12, -113, total alkalinity, DIC, and pH. The sampling layers in dbar were 10, 50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1,000, 1,200, 1,400, 1,600, 1,800, 2,000, 2,200, 2,400, 2,600, 2,800, 3,000, 3,250, 3,500, 3,750, 4,000, 4,250, 4,500, 4,750, 5,000, 5,250, 5,500, 5,750 and bottom (minus 10 m). Samples for POM, ^{14}C, ^{13}C, ^{15}N, ^{137}Cs, N_2O, CH_4 and Bacteria were also collected at the selected stations. The bottle depth diagram is shown in Figure 1.2.2. Underway measurements of pCO_2, temperature, salinity, oxygen, surface current, bathymetry and meteorological parameters were conducted along the cruise track.

(4) Floats and Drifters deployed

One ARGO float was launched along the cruise track. The launched positions of the ARGO floats are listed in Table 1.2.1.

Table 1.2.1. Launched positions of the ARGO float.

Float S/N	ARGOS PTT ID	Date and Time of Reset (UTC)	Date and Time of Launch (UTC)	Location of Launch	CTD St. No.
2296	60094	07:32 Jan.,3	09:22 Jan, 3	24° 14.25’ N, 144° 12.65’ E	P03-291

(5) Moorings deployed or recovered

Five moorings for Wake Island passage Flux Experiment (WIFE) were recovered. Locations of the moorings are listed in Table 1.2.2.

Table 1.2.2. Location of the moorings determined by acoustic navigation system. Locations of WM2 and WM1 could not be determined by acoustic navigation system due to leaking of the transponder. Depth of each location is derived from multi narrow beam bathymetry data obtained in this cruise.

Station	Latitude	Longitude	Depth (m)
WM5	16° 26.18’ N	171° 33.21’ E	5,477
WM4	15° 31.19’ N	171° 14.69’ E	5,616
WM3	14° 34.14’ N	170° 55.21’ E	5,680
WM2	(13° 38.45’ N)	(170° 34.70’ E)	5,522
WM1	(12° 45.90’ N)	(170° 14.90’ E)	5,378

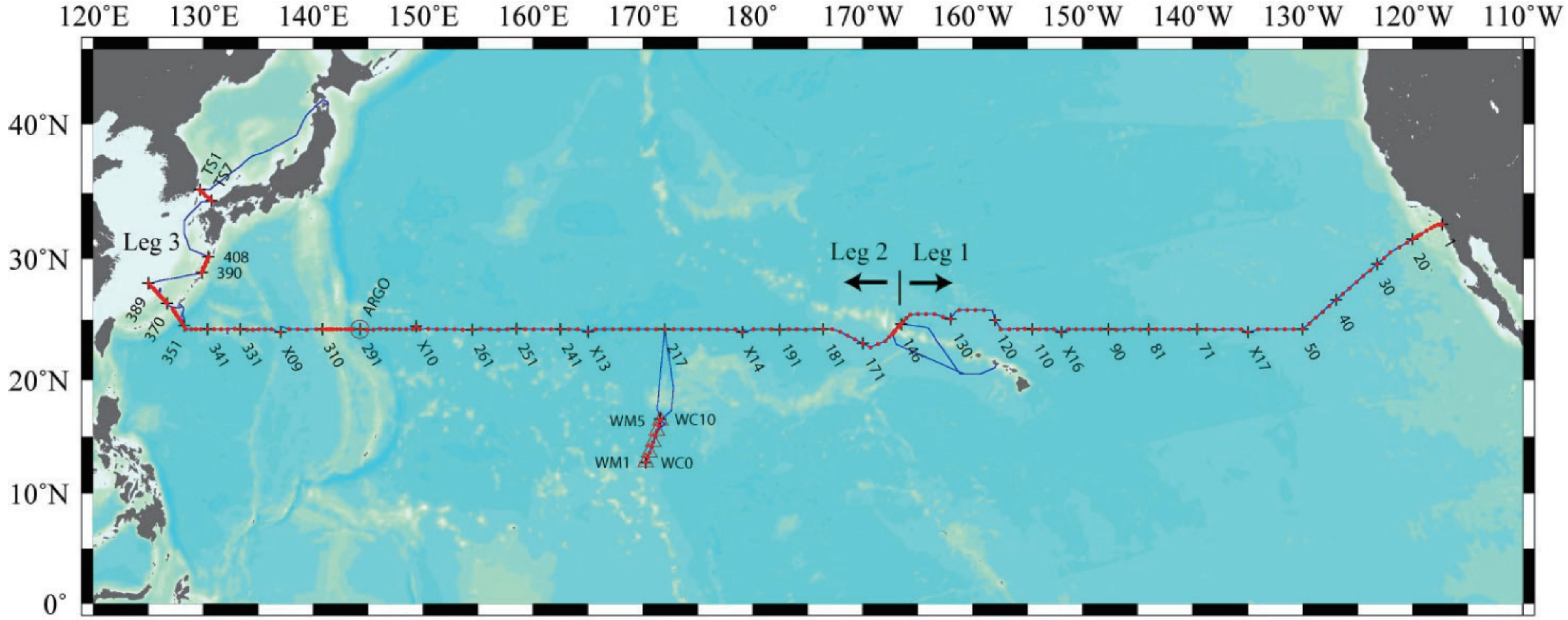

Figure 1.2.1. Cruise track.

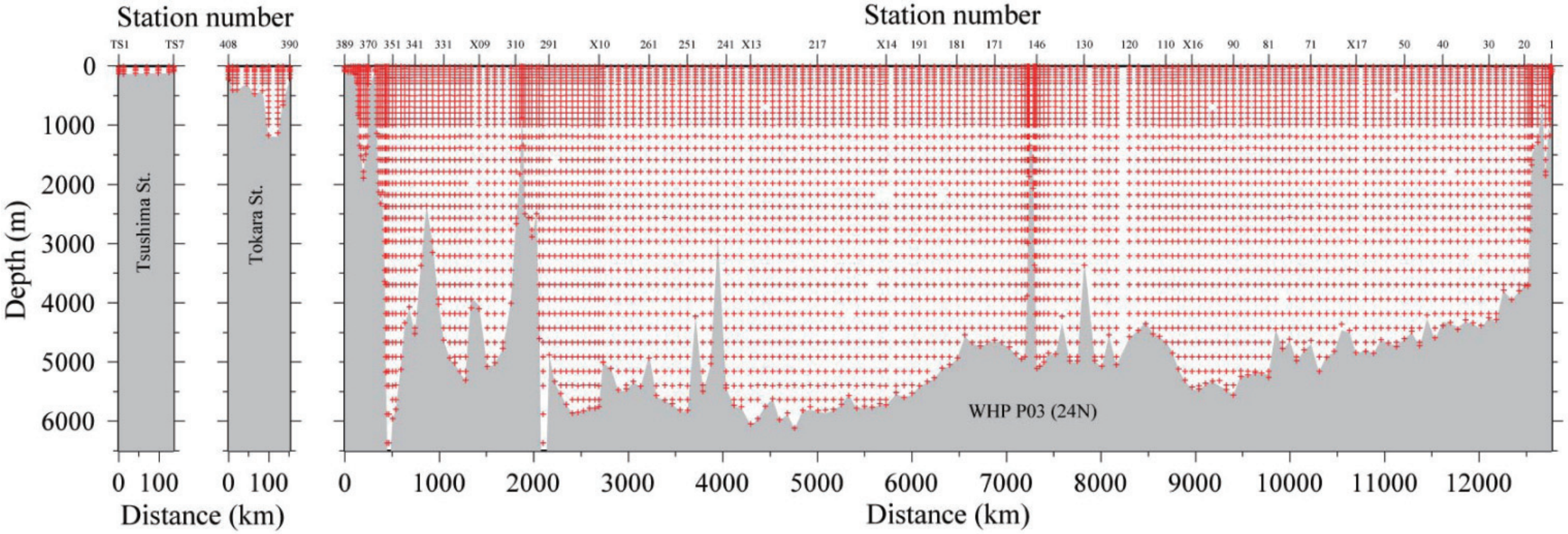

Figure 1.2.2. Bottle depth diagram.

1.3 List of Principal Investigator and Person in Charge on the Ship

The principal investigator (PI) and the person in charge responsible for major parameters measured on the cruise are listed in Table 1.3.1.

Table 1.3.1(a). List of Principal Investigator and Person in Charge on the ship for Leg.1.

Item	Principal Investigator	Person in Charge on the Ship
Underway		
ADCP	Yasushi Yoshikawa (JAMSTEC) yoshikaway@jamstec.go.jp	Soichiro Sueyoshi (GODI)
Bathymetry	Takeshi Matsumoto (Univ. Ryukyus) tak@sci.u-ryukyu.ac.jp	Soichiro Sueyoshi (GODI)
Meteorology	Kunio Yoneyama (JAMSTEC) yoneyamak@jamstec.go.jp	Soichiro Sueyoshi (GODI)
T-S	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Takuya Shiozaki (MWJ)
pCO$_2$	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Minoru Kamata (MWJ)
Hydrography		
CTDO	Hiroshi Uchida (JAMSTEC) huchida@jamstec.go.jp	Kentaro Oyama (MWJ)
Salinity	Takeshi Kawano (JAMSTEC) kawanot@jamstec.go.jp	Fujio Kobayashi (MWJ)
Oxygen	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Takayoshi Seike (MWJ)
Nutrients	Michio Aoyama (MRI) maoyama@mri-jma.go.jp	Kenichiro Sato (MWJ)
DIC	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Minoru Kamata (MWJ)
Alkalinity	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Taeko Ohama (MWJ)
pH	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Taeko Ohama (MWJ)
CFCs	Kenichi Sasaki (JAMSTEC) ksasaki@jamstec.go.jp	Hideki Yamamoto (MWJ)
LADCP	Shinya Kouketsu (JAMSTEC) skouketsu@jamstec.go.jp	Shinya Kouketsu (JAMSTEC)
Δ^{14}C & δ^{13}C	Yuichiro Kumamoto (JAMSTEC) kumamotoy@jamstec.go.jp	Takeshi Kawano (JAMSTEC)
^{137}Cs & Pu	Michio Aoyama (MRI) maoyama@mri-jma.go.jp)	Takeshi Kawano (JAMSTEC)
CH$_4$ etc.	NaohiroYoshida (TITECH) naoyoshi@depe.titech.ac.jp	Osamu Yoshida (TITEC)

GODI: Global Ocean Development Inc.

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

MRI: Meteorological Research Institute, Japan Meteorological Agency

MWJ: Marine Works Japan. LTD

TITECH: Tokyo Institute of Technology

Univ. Ryukyus: University of the Ryukyus

Table 1.3.1(b). List of Principal Investigator and Person in Charge on the ship for Leg.2.

Item	Principal Investigator	Person in Charge on the Ship
Underway		
ADCP	Yasushi Yoshikawa (JAMSTEC) yoshikaway@jamstec.go.jp	Shinya Okumura (GODI)
Bathymetry	Takeshi Matsumoto (Univ. Ryukyus) tak@sci.u-ryukyu.ac.jp	Shinya Okumura (GODI)
Meteorology	Kunio Yoneyama (JAMSTEC) yoneyamak@jamstec.go.jp	Yasutaka Imai (GODI)
T-S	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Kimiko Nishijima (MWJ)
pCO_2	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Mikio Kitada (MWJ)
Hydrography		
CTDO	Hiroshi Uchida (JAMSTEC) huchida@jamstec.go.jp	Satoshi Ozawa (MWJ)
Salinity	Takeshi Kawano (JAMSTEC) kawanot@jamstec.go.jp	Fujio Kobayashi (MWJ)
Oxygen	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Takayoshi Seike (MWJ)
Nutrients	Michio Aoyama (MRI) maoyama@mri-jma.go.jp	Junko Hamanaka (MWJ)
DIC	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Mikio Kitada (MWJ)
Alkalinity	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Fuyuki Shibata (MWJ)
pH	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Fuyuki Shibata (MWJ)
CFCs	Kenichi Sasaki (JAMSTEC) ksasaki@jamstec.go.jp	Katsunori Sagishima (MWJ)
LADCP	Shinya Kouketsu (JAMSTEC) skouketsu@jamstec.go.jp	Hiroshi Uchida (JAMSTEC)
$\Delta^{14}C$ & $\delta^{13}C$	Yuichiro Kumamoto (JAMSTEC) kumamotoy@jamstec.go.jp	Yuichiro Kumamoto (JAMSTEC)
^{137}Cs & Pu	Michio Aoyama (MRI) maoyama@mri-jma.go.jp)	Akihiko Murata (JAMSTEC)
CH_4 etc.	NaohiroYoshida (TITECH) naoyoshi@depe.titech.ac.jp	Narin Boontanon (TITECH)
Floats, Drifters		
Argo float	Nobuyuki Shikama (JAMSTEC) nshikama@jamstec.go.jp	Satoshi Ozawa (MWJ)
Mooring	Hiroshi Uchida (JAMSTEC) huchida@jamstec.go.jp	Satoshi Ozawa (MWJ)

GODI: Global Ocean Development Inc.

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

MRI: Meteorological Research Institute, Japan Meteorological Agency

MWJ: Marine Works Japan. LTD

TITECH: Tokyo Institute of Technology

Univ. Ryukyus: University of the Ryukyus

Table 1.3.1(c). List of Principal Investigator and Person in Charge on the ship for Leg.3

Item	Principal Investigator	Person in Charge on the Ship
Underway		
ADCP	Yasushi Yoshikawa (JAMSTEC) yoshikaway@jamstec.go.jp	Katsuhisa Maeno (GODI)
Bathymetry	Takeshi Matsumoto (Univ. Ryukyus) tak@sci.u-ryukyu.ac.jp	Katsuhisa Maeno (GODI)
Meteorology	Kunio Yoneyama (JAMSTEC) yoneyamak@jamstec.go.jp	Katsuhisa Maeno (GODI)
T-S	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Takuhei Shiozaki (MWJ)
pCO_2	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Masaki Moro (MWJ)
Bacteria	Masaaki Tamayama (JAMES) tamayamam@kuramae.ne.jp	Masaaki Tamayama (JAMES)
Hydrography		
CTDO	Hiroshi Uchida (JAMSTEC) huchida@jamstec.go.jp	Kentaro Oyama (MWJ)
Salinity	Takeshi Kawano (JAMSTEC) kawanot@jamstec.go.jp	Naoko Takahashi (MWJ)
Oxygen	Yuichiro Kumamoto (JAMSTEC) kumamoto@jamstec.go.jp	Kimiko Nishijima (MWJ)
Nutrients	Michio Aoyama (MRI) maoyama@mri-jma.go.jp	Junko Hamanaka (MWJ)
DIC	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Masaki Moro (MWJ)
Alkalinity	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Taeko Ohama (MWJ)
pH	Akihiko Murata (JAMSTEC) akihiko.murata@jamstec.go.jp	Taeko Ohama (MWJ)
CFCs	Kenichi Sasaki (JAMSTEC) ksasaki@jamstec.go.jp	Hideki Yamamoto (MWJ)
LADCP	Shinya Kouketsu (JAMSTEC) skouketsu@jamstec.go.jp	Shinya Kouketsu (JAMSTEC)
$\Delta^{14}C$ & $\delta^{13}C$	Yuichiro Kumamoto (JAMSTEC) kumamotoy@jamstec.go.jp	Yuichiro Kumamoto (JAMSTEC)
CH_4 etc.	NaohiroYoshida (TITECH) naoyoshi@depe.titech.ac.jp	Narin Boontanon (TITECH)

GODI: Global Ocean Development Inc.

JAMES: Japan Macro-Engineers' Society

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

MRI: Meteorological Research Institute, Japan Meteorological Agency

MWJ: Marine Works Japan. LTD

TITECH: Tokyo Institute of Technology

Univ. Ryukyus: University of the Ryukyus

1.4 Scientific Program and Methods

(1) Objectives of MR05-05 cruise project

It is well known that the oceans play a central role in determining global climate. However, heat and material transports in the oceans and their temporal changes have not yet been sufficiently quantified. Therefore, the global climate change is not understood satisfactorily. The purposes of this research are to evaluate transports of heat and materials such as carbon and nutrients in the North Pacific and to detect their long term changes and basin-scale biogeochemical changes since the 1990s.

This cruise is a reoccupation of the hydrographic section called 'WHP-P3', which was once observed by an ocean science group of USA in 1985 and later the observation data were included in the data set of the World

Ocean Circulation Experiment (WOCE: 1990-2002) Hydrographic Programme (WHP). We will compare physical and chemical properties along section WHP-P3 with those obtained in 1985 to detect and evaluate long term changes in the marine environment of the North Pacific.

Reoccupations of the WOCE hydrographic sections are now in progress by international cooperation among ocean science communities, in the framework of CLIVAR (Climate Variability and Predictability) as part of World Climate Research Programme (WCRP) and IOCCP (International Ocean Carbon Coordination Project). Our research is planned as a contribution to these international projects supported by WMO, ICSU/SCOR, and UNESCO/IOC.

The other objectives of this cruise are as follows:

1) to observe surface meteorological and hydrogical parameters as a basic data of meteorology and oceangraphy,
2) to observe sea bottom topography, gravity and magnetic fields along the cruise track for understanding the dynamics of ocean plate and accompanying geophysical activities,
3) to contribute to establishment of data base for model validation,
4) ARGO sensor calibration and its deployment in the western Pacific,
5) Calibration and recovery of mooring sensors in the Wake Island Passage.

(2) Cruise overview

MR05-05 cruise was carried out during the period from October 31, 2005 to January 30, 2006. The cruise started from the coast near San Diego and sailed towards west along approximately 24°N. This line was observed in 1985 as a part of WOCE Hydrographic Programme. A total of 237 stations were observed. At each station, full-depth CTD profile and up to 36 water samples were taken and analyzed. Water samples were obtained from fixed layers with 12-liter Niskin bottles attached to 36-position SBE carousel water sampler. The layers were 10, 50, 100, 150, 200, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1,000, 1,200, 1,400, 1,600, 1,800, 2,000, 2,200, 2,400, 2,600, 2,800, 3,000, 3,250, 3,500, 3,750, 4,000, 4,250, 4,500, 4,750, 5,000, 5,250, 5,500, 5,750 dbar and approximately 10 dbar above the bottom. The scientists of JAMSTEC and Meteorological Research Institute and the technicians of Marine Works Japan. LTD (MWJ) were responsible for analyzing water sample for salinity, dissolved oxygen, nutrients, CFCs, total carbon contents, alkalinity, and pH. They also contributed to sampling for total organic carbon, radiocarbon and so on. A scientist of Japan Macro-Engineers' Society joined Leg.3 of the cruise for the research on Colon Bacillus and General Bacteria. The scientists of Tokyo Institute of Technology joined the cruise for their research on chemical oceanography. A scientist from University of the Ryukyus was a principal investigator for geological parameters (topography, geo-magnetic field and gravity). The technicians of Global Ocean Development Inc. (GODI) had responsibility for a part of underway measurements such as current velocity by Acoustic Doppler Current Profiler (ADCP) geological parameters (topography, geo-magnetic field and gravity), and meteorological parameters. One ARGO floats prepared by JAMSTEC was launched by MWJ technicians and the ship crew.

(3) Cruise narrative

R/V MIRAI departed San Diego (U.S.A) on October 31, 2005. She called for Honolulu (U.S.A.) on November 24, 2005 (Leg.1). She left Honolulu on November 27, 2005 for Okinawa (Japan) and arrived at Nakagusuku (Okinawa, Japan) on January 17, 2006 (Leg.2). For Leg.3, she departed from Nakagusuku on January 20, 2006 and arrived at Sekinehama on January 30, 2006. All watchstanders were drilled in the method of sample drawing before the first station. We observed 237 stations along approximately 24°N, namely WHP P3.

1.5 Major Problems and Goals not Achieved

(1) Position Changed

a) Leg.1

Positions of stations 120, 122, 124, 126 and 128 were changed from (158°16.2'W, 24°15.7'N), (159°0.5'W, 24°14.5'N), (159°46.8'W, 24°28.1'N), (160°31.9'W, 24°40.2'N) and (161°15.4'W, 24°53.6'N) to (158°00'W, 25°00'N), (159°0.5'W, 25°50'N), (159°46.8'W, 25°50'N), (160°31.9'W, 24°50'N) and (161°15.4'W, 25°50'N), respectively, to avoid entering the training area of U. S. Navy.

b) Leg.2

The position of Station 155 was changed from (24°10.00'N, 167°06.40'W) to (24°08.82'N, 167°07.96'W). This is because the value of the water depth (2,006 m) at the original position recorded in the SUM file of WHP-P3 in 1985 was largely different from our value (800 m) at Station 155, whose position was accurately determined by modern GPS system. In addition to that, the original position of Station 155 was so unnaturally distributed against adjacent stations on the WHP-P3 section in 1985 that we could guess its position incorrect or inaccurate. Dr. Roemmich's (Chief scientist of WHP-P3 in 1985) reply to our enquiry on this matter is "It would seem that the ship was positioned correctly in between Stations 154 and 157, but the recorded position was erroneously taken from the dead reckoning Satnav computer".

The postion of Station X09 (the crossover station with WHP-P09) was changed from (24°30.2'N, 136°59.1'E) to (23°59.22'N, 136°59.60'E) because a fishery boat was operating longline fishing at the planning position when R/V MIRAI reached there on January 6, 2006.

c) Leg.3

None of the station positions was changed. However, TS3 was shifted about 0.3 nm from its planning position because a lot of fishing boats were in operation.

(2) Misfiring and mistrip

The carousel water sampler misfired at the following stations:

Leg.1: 33, 51 and 116
Leg.2: X14, 201, 203, 217, 231, 322 and 351_2
Leg.3: None

Through the bottle data QC, mistrips were detected at the following stations:

Leg.1: 38
Leg.2: 185, WC2, WC5, 289, 357 and 351_2
Leg.3: 380

(3) CTD sensor replacement

During Leg.2, we encountered several problems (drift, shift, noise) in CTD sensors and replaced them after the following stations:

Station X14: primary and secondary conductivity sensors
Station WC8: primary oxygen sensor
Station 285: secondary oxygen sensor

(4) Interruption of sequential occupations due to gale and bad sea condition

At Station 353 above the Ryukyu Trench, the first CTD cast was hindered due to bad weather and sea conditions. Since the prolonged gale was predicted around the area, we abandoned the original plan for sequential occupations of the P3 stations from east to west, reached the west end station (Station 369), and re-started the observation from west to east toward Station 351, where sections were connected with the second CTD cast. Station 351 was occupied twice in Leg.2.

The CTD observation in the East China Sea was suspended at Station 384 due to bad sea condition lasting for about half day. The observation was restarted at Station 382.

1.6 List of Participants

The members of the scientific party are listed in Table 1.6.1 to 1.6.3 along with their main tasks on the cruise.

Table 1.6.1. List of cruise participants in Leg.1.

Name	Main tasks	Affiliation
Ayako Fujii	CH_4, N_2O, ^{15}N	TITECH
Go Haruta	Water Sampling	MWJ
Hiroyuki Hayashi	CTD	MWJ
Akihito Hirai	Laser Ladar, Infrared Radiometer	Chiba Univ.
Tetsuya Inaba	Water Sampling	MWJ
Yoshiko Ishikawa	Carbon Items	MWJ
Minoru Kamata	Carbon Items	MWJ
Takeshi Kawano	Chief Scientist, Salinity	IORGC/JAMSTEC
Mikio Kitada	Carbon Items	MWJ
Fujio Kobayashi	Salinity	MWJ
Shinya Kouketsu	LADCP, ADCP	IORGC/JAMSTEC
Katsuhisa Maeno	Meteorology, Geology	GODI
Junji Matsushita	Nutrients	MWJ
Takami Mori	Water Sampling	MWJ
Norio Nagahama	Meteorology, Geology	GODI
Yoshifumi Noiri	Water Sampling	MWJ
Taeko Ohama	Carbon Items	MWJ
Miwa Okino	Water Sampling	MWJ
Kosuke Okudaira	Water Sampling	MWJ
Kentaro Oyama	CTD	MWJ
Satoshi Ozawa	Chief Technologist, Water Sampling	MWJ
Kenichi Sasaki	CFCs	MIO/JAMSTEC
Kenichiro Sato	Nutrients	MWJ
Takayoshi Seike	LADCP, DO	MWJ
Takuhei Siozaki	DO, Thermosalinograph	MWJ
Yuichi Sonoyama	CFCs	MWJ
Soichiro Sueyoshi	Meteorology, Geology	GODI
Nobuhiko Tahara	Water Sampling	MWJ
Tomoyuki Takamori	CTD	MWJ
Asumi Takeuchi	Water Sampling	MWJ
Ayumi Takeuchi	Nutrients	MWJ
Tatsuya Tanaka	Salinity	MWJ
Hiroshi Uchida	Water Sampling, CTD	IORGC/JAMSTEC
Hiroki Ushiromura	CTD	MWJ
Masahide Wakita	CFCs	MIO/JAMSTEC
Keisuke Wataki	DO, Thermosalinograph	MWJ
Hideki Yamamoto	CFCs	MWJ
Osamu Yoshida	CH_4, N_2O, ^{15}N	TITECH
Atsushi Yoshimura	Water Sampling	MWJ

Chiba Univ.:	Chiba University
GODI:	Global Ocean Development Inc.
MWJ:	Marine Works Japan. LTD
JAMSTEC:	Japan Agency for Marine-Earth Science and Technology
IORGC:	Institute of Observational Research for Global Change
MIO:	Mutsu Institute for Oceanography
TITECH:	Tokyo Institute of Technology

Table 1.6.2. List of cruise participants in Leg.2.

Name	Main tasks	Affiliation
Eiji Abe	Laser Radar, Infrared Radiometer	Chiba Univ.
Narin Boontanon	CH_4, N_2O, ^{15}N	TITECH
Masanori Enoki	CFCs	MWJ
Ami Fujiwara	Water Sampling	MWJ
Junko Hamanaka	Nutrients	MWJ
Yasushi Hashimoto	Water Sampling	MWJ
Ei Hatakeyama	Carbon Items	MWJ
Miyo Ikeda	Water Sampling	MWJ
Yasutaka Imai	Meteorology, Geology, ADCP	GODI
Ikuo Kaneko	Chief Scientist, LADCP	IORGC/JAMSTEC
Mikio Kitada	Carbon Items	MWJ
Fujio Kobayashi	Salinity	MWJ
Misato Koide	Water Sampling	MWJ
Hiroshi Komura	Water Sampling	MWJ
Yuichiro Kumamoto	Water Sampling, DO	IORGC/JAMSTEC
Kohei Miura	Nutrients	MWJ
Takami Mori	Water Sampling	MWJ
Masaki Moro	Carbon Items	MWJ
Akihiko Murata	Chief Scientist, Carbon Items	IORGC/JAMSTEC
Akinori Murata	CTD, Water Sampling	MWJ
Kimiko Nishijima	DO, Thermosalinograph	MWJ
Ryo Ohyama	Meteorology, Geology, ADCP	GODI
Shinya Okumura	Meteorology, Geology, ADCP	GODI
Asako Onda	Water Sampling	MWJ
Satoshi Ozawa	CTD, Argo Float	MWJ
Katsunori Sagishima	CFCs	MWJ
Kenichi Sasaki	CFCs	MIO/JAMSTEC
Kenichiro Sato	Water Sampling	MWJ
Takayoshi Seike	DO	MWJ
Fuyuki Shibata	Chief Technologist, Carbon Items	MWJ
Naoko Takahashi	Salinity	MWJ
Tomoyuki Takamori	CTD, Water Sampling	MWJ
Ayumi Takeuchi	Nutrients	MWJ
Shinsuke Toyoda	CTD, Water Sampling	MWJ
Hiroshi Uchida	LADCP, Mooring, CTD	IORGC/JAMSTEC
Hirokatsu Uno	CTD	MWJ
Hiroki Ushiromura	CTD, Water Sampling	MWJ
Keisuke Wataki	CFCs	MWJ

Chiba Univ.:	Chiba University
GODI:	Global Ocean Development Inc.
MWJ:	Marine Works Japan. LTD
JAMSTEC:	Japan Agency for Marine-Earth Science and Technology
IORGC:	Institute of Observational Research for Global Change
MIO:	Mutsu Institute for Oceanography
TITECH:	Tokyo Institute of Technology

Table 1.6.3. List of cruise participants in Leg.3.

Name	Main tasks	Affiliation
Yukiko Aoyagi	Water Sampling	MWJ
Narin Boontanon	CH_4, N_2O, ^{15}N	TITECH
Masanori Enoki	CFCs	MWJ
Ami Fujiwara	Water Sampling	MWJ
Chusei Fujiwara	Laser Radar, Infrared Radiometer	GODI
Yoko Fukuda	Water Sampling	MWJ
Junko Hamanaka	Nutrients	MWJ
Miyo Ikeda	Water Sampling	MWJ
Yoshiko Ishikawa	Carbon Items	MWJ
Minoru Kamata	Chief Technologist, Carbon Items	MWJ
Misato Koide	Water Sampling	MWJ
Shinya Koketsu	LADCP, ADCP, Bathymetry	IORGC/JAMSTEC
Yuichiro Kumamoto	Water Sampling, DO	IORGC/JAMSTEC
Hiroshi Komura	Water Sampling	MWJ
Masaaki Maekawa	Water Sampling	MWJ
Katsuhisa Maeno	Meteorology, Geology, ADCP	GODI
Junji Matsushita	Nutrients	MWJ
Hiroshi Matsunaga	CTD	MWJ
Kohei Miura	Nutrients	MWJ
Masaki Moro	Carbon Items	MWJ
Kimiko Nishijima	DO	MWJ
Tomohide Noguchi	CTD, Water Sampling	MWJ
Taeko Ohama	Carbon Items	MWJ
Asako Onda	Water Sampling	MWJ
Kentaro Oyama	CTD	MWJ
Ryo Ohyama	Meteorology, Geology, ADCP	GODI
Takuhei Shiozaki	DO	MWJ
Yuichi Sonoyama	CFCs	MWJ
Naoko Takahashi	Salinity	MWJ
Masaaki Tamayama	Bacteria	JAMES
Tatsuya Tanaka	Salinity	MWJ
Hiroshi Uchida	Water Sampling, CTD	IORGC/JAMSTEC
Masahide Wakita	CFCs	MIO/JAMSTEC
Shuichi Watanabe	Chief Scientist, LADCP, Water Sampling	MIO/JAMSTEC
Makito Yokota	CTD, Water Sampling	MWJ
Hideki Yamamoto	CFCs	MWJ

GODI: Global Ocean Development Inc.

MWJ: Marine Works Japan. LTD

JAMES: Japan Macro-Engineers' Society

JAMSTEC: Japan Agency for Marine-Earth Science and Technology

IORGC: Institute of Observational Research for Global Change

MIO: Mutsu Institute for Oceanography

TITECH: Tokyo Institute of Technology

2 Underway Measurement

2.1 Navigation and Bathymetry

June 28, 2007

2.1.1 Navigation

(1) Personnel

Souichiro Sueyoshi	***(GODI)***
Katsuhisa Maeno	***(GODI)***
Norio Nagahama	***(GODI)***
Yasutaka Imai	***(GODI)***
Shinya Okumura	***(GODI)***
Ryo Ohyama	***(GODI)***

(2) Overview of the equipment

The Ship's position was measured by navigation system, made by Sena Co. Ltd, Japan. The system has two 12-channel GPS receivers (Leica MX9400N) and two 9-channel GPS receivers (Trimble DS-4000). GPS antennas located at Navigation deck, offset to starboard and portside, respectively. We switched them to choose better state of receiving when the number of the available GPS satellites decreased or HDOP increased. The system also integrates gyro heading (Tokimec TG-6000), log speed (Furuno DS-30) and other navigation devices data on HP workstation. The workstation keeps accurate time using GPS Time server (Datum Tymserv2100) via NTP (Network Time Protocol). Navigation data was recorded as "SOJ" data every 60 seconds.

(3) Data period

Leg.1: 16:50, 31 October 2005 to 18:40, 24 November 2005 (UTC)

Leg.2: 19:00, 27 November 2005 to 01:10, 17 January 2006 (UTC)

Leg.3: 23:50, 19 January 2006 to 00:00, 30 January 2006 (UTC)

2.1.2 Bathymetry

(1) Personnel

Takeshi Matsumoto	***(Univ. of the Ryukyus) Principal Investigator / Not on-board:***
Souichiro Sueyoshi	***(GODI)***
Katsuhisa Maeno	***(GODI)***
Norio Nagahama	***(GODI)***
Yasutaka Imai	***(GODI)***
Shinya Okumura	***(GODI)***
Ryo Ohyama	***(GODI)***

(2) Overview of the equipments

R/V MIRAI equipped a Multi Narrow Beam Echo Sounding system (MNBES), SEABEAM 2112.004 (SeaBeam Instruments Inc.) The main objective of MNBES survey is collecting continuous bathymetry data along ship's track to make a contribution to geological and geophysical investigations and global datasets. Data interval along ship's track was max 17 seconds at 6,000 m. To obtain accurate sound velocity profile of water column for ray-path correction of acoustic multibeam, we used Surface Sound Velocimeter (SSV) data for the surface (6.2 m) sound velocity, and the sound velocity profile of the deeper depths was calculated using temperature and salinity profiles from the nearest CTD data by the equation in Mackenzie (1981).

System configuration and performance of SEABEAM 2112.004,

Frequency:	12 kHz
Transmit beam width:	2 degree
Transmit power:	20 kW
Transmit pulse length:	3 to 20 msec.
Depth range:	100 to 11,000 m

Beam spacing:	1 degree athwartships
Swath width:	150 degree (max) 120 degree to 4,500 m 100 degree to 6,000 m 90 degree to 11,000 m
Depth accuracy:	Within < 0.5% of depth or +/-1m, whichever is greater, over the entire swath. (Nadir beam has greater accuracy; typically within < 0.2% of depth or +/-1m, whichever is greater)

(3) Data Period

Bathymetric survey was carried out along the CTD observation line during the cruise

Leg.1: P03-001c on 31 Oct 2005 to P03-146 on 22 Oct. 2005
Leg.2: P03-146 on 30 Nov 2005 to P03-351 on 15 Jan 2006
Leg.3: P03-370 on 20 Jan 2006 to TS-1 on 26 Jan 2006.

(4) Data processing

(4.1) Editing for the navigation data

Erroneous navigation data are manually removed (by using “mbnavedit” module of the mbsystem) and linearly interpolated.

(4.2) Sound velocity correction

The continuous bathymetry data are split into small areas around each CTD station. For each small area, the bathymetry data are corrected using a sound velocity profile calculated from the CTD data in the area. The equation of Mackenzie (1981) is used for calculating sound velocity. The data processing is carried out using “ mbbath” module of the mbsystem

(4.3) Gridding

Gridding for the bathymetry data is carried out using the HIPS software version 5.4 (CARIS, Canada). Firstly, the bathymetry data during a turn, speed up or down are removed using swath editor and subset editor. A spike noise of each swath data is also removed. Then the bathymetry data are gridded by “Interpolate” function of the software with the following parameters.

Matrix size: 5 x 5
Number of nearneighbors: 16

Reference

Mackenzie, K.V. (1981): Nine-term equation for the sound speed in the oceans, J. Acoust. Soc. Am., 70 (3), pp 807-812.

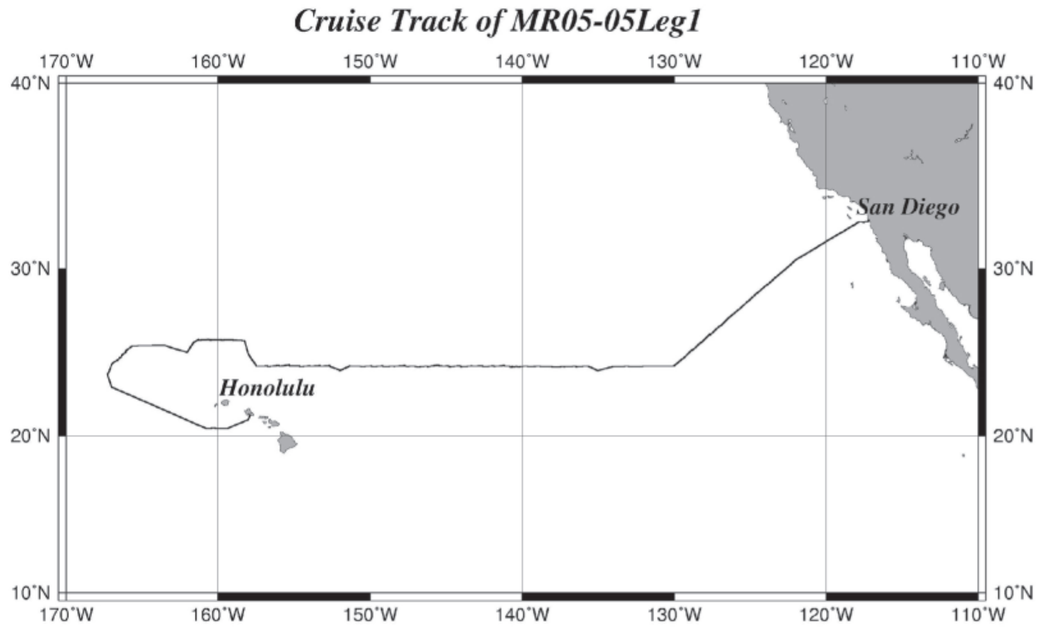

Figure 2.1.1-1. Cruise Track of MR05-05 Leg.1.

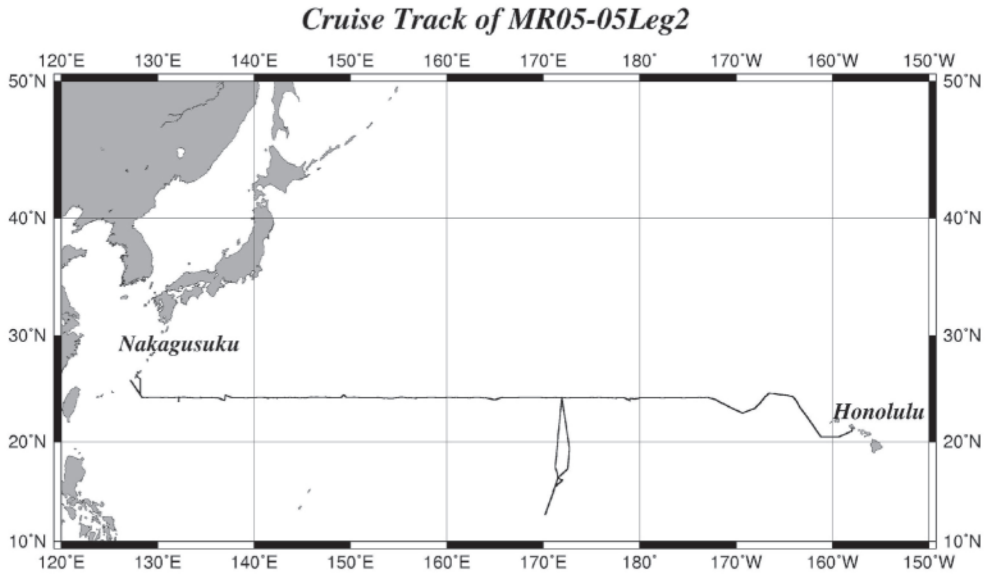

Figure 2.1.1-2. Cruise Track of MR05-05 Leg.2.

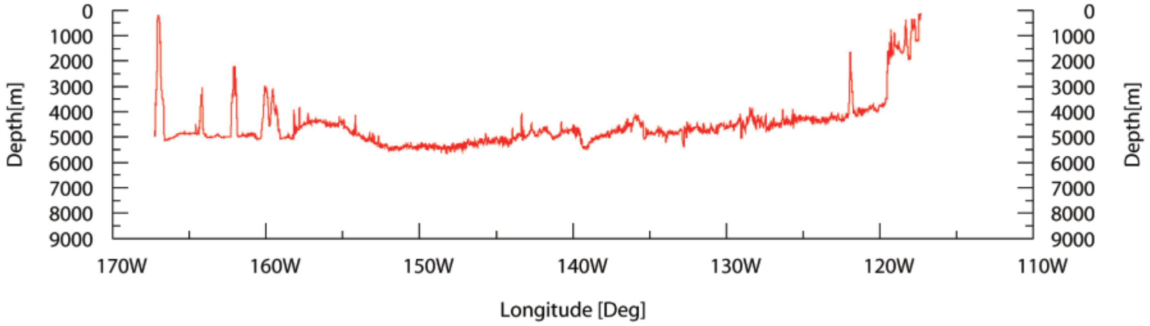

Figure 2.1.2-1. Depth profile of CTD line MR05-05 Leg.1.

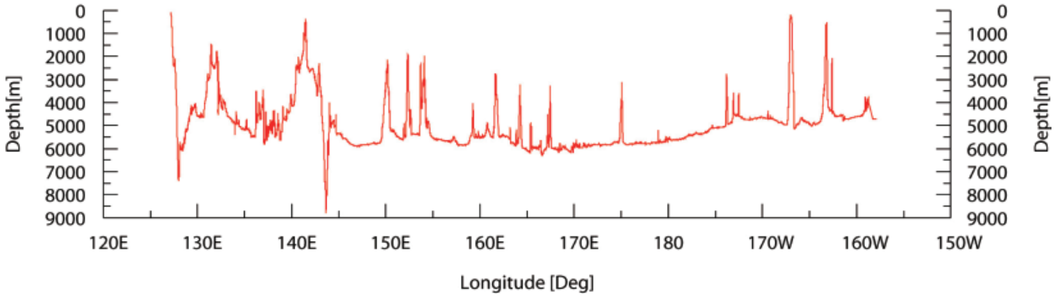

Figure 2.1.2-2. Depth profile of CTD line MR05-05 Leg.2.

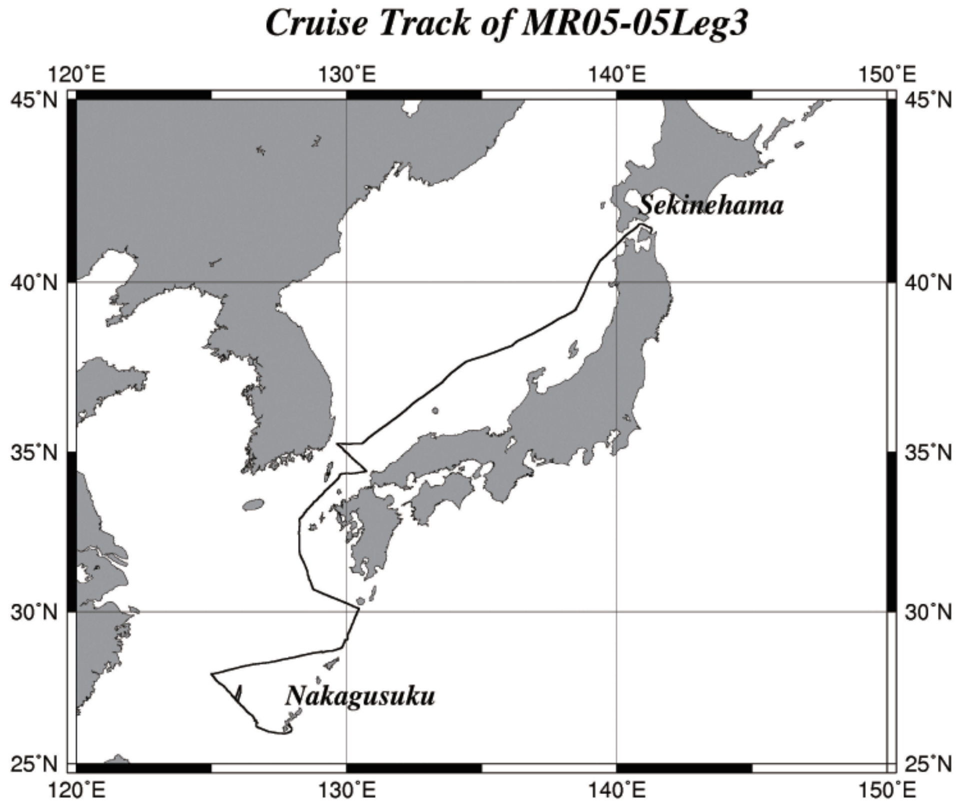

Figure 2.1.1-3. Cruise Track of MR05-05 Leg.3.

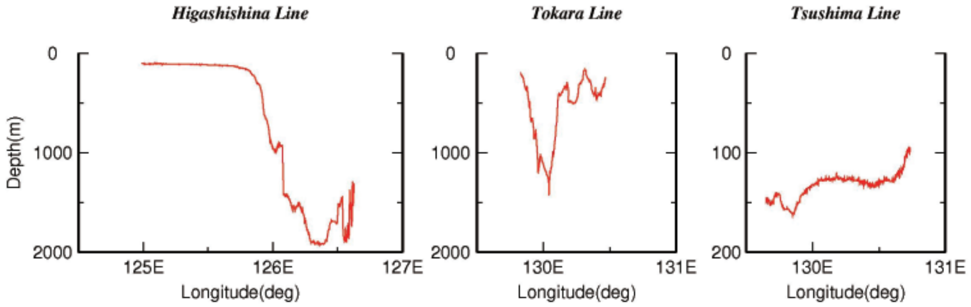

Figure 2.1.2-3. Depth profile of CTD line MR05-05 Leg.3.

2.1.3 Sea surface gravity

(1) Personnel

Takeshi Matsumoto	*(Univ. of the Ryukyus) Principal Investigator / Not on-board:*
Souichiro Sueyoshi	*(GODI)*
Katsuhisa Maeno	*(GODI)*
Norio Nagahama	*(GODI)*
Yasutaka Imai	*(GODI)*
Shinya Okumura	*(GODI)*
Ryo Ohyama	*(GODI)*

(2) Introduction

Marine gravity is an important parameter in geophysics and geodesy. We collected gravity data at the sea surface during the MR05-05 Leg.1 cruise from 31 Oct. 2005 to 24 Nov. 2005, Leg.2 cruise from 27 Nov. 2005 to 17 Jan. 2006, Leg.3 cruise from 20 Jan. 2006 to 30 Jan. 2006.

(3) Parameters

Relative Gravity [mGal]

(4) Data Acquisition

We have measured relative gravity using LaCoste and Romberg air-sea gravity system II (Micro-G LaCoste, Inc.) during this cruise. To convert the relative gravity to absolute one, we measured gravity, using portable gravity meter (Scintrex gravity meter CG-3M), at Honolulu and Nakagusuku and Sekinehama as reference points.

(5) Preliminary Results

Absolute gravity is shown in Table 2.1.3.

Table 2.1.3. Absolute gravity table MR05-05 cruise.

No.	Date	UTC	Port	Absolute Gravity (mGal)	Sea Level (cm)	Draft (cm)	Gravity at Sensor*[1] (mGal)	L&R*[2] (mGal)
1	2005/Oct/31	14:23	SanDiego	-	240	636	-	11853.79
2	2005/Nov/25	21:59	Honolulu	978927.57	154	655	978928.10	11266.15
3	2006/Jan/19	02:41	Nakagusuku[*3]	979114.12	219	610	979114.83	11456.52
4	2006/Jan/19	23:03	Nakagusuku[*3]	979114.12	237	605	979114.88	11456.67
5	2006/Feb/1	00:52	Sekinehama	980371.95	286	625	980372.87	12719.15

*1: Gravity at Sensor= Absolute Gravity + Sea Level*0.3086/100 + (Draft-530)/100*0.0431

*2: LaCoste and Romberg air-sea gravity system II

*3: It was measured at June 20, 2003.

(6) Data Archives

Gravity data obtained during this cruise will be submitted to the JAMSTEC Data Management Division, and will be archived there.

(7) Remarks

1. We did not collect data from 18 Nov. 2005 18:55UTC to 19:10UTC, due to reboot of the meter.
2. Long Accelerometer did not work properly from 31 Oct. 2005 to 18 Nov. 19:10. Therefore, Gravity, VCC and AL were not correct value.

2.1.4 On-board geomagnetic measurement

(1) Personnel

Takeshi Matsumoto	***(Univ. of the Ryukyus) Principal Investigator / Not on-board:***
Souichiro Sueyoshi	***(GODI)***
Katsuhisa Maeno	***(GODI)***
Norio Nagahama	***(GODI)***
Yasutaka Imai	***(GODI)***
Shinya Okumura	***(GODI)***
Ryo Ohyama	***(GODI)***

(2) Introduction

Measurement of geomagnetic field on the sea is required for the interpretation of marine magnetic anomaly caused by magnetization in the upper crust. We measured geomagnetic field using a three-component magnetometer during the MR05-05 Leg.1 cruise from 31 Oct. 2005 to 24 Nov. 2005, Leg.2 cruise from 27 Nov. 2005 to 17 Jan. 2006, and Leg.3 cruise from 20 Jan. 2006 to 30 Jan. 2006.

(3) Method

A shipboard three-component magnetometer system (Tierra Tecnica SFG1214) is equipped on-board R/V MIRAI. Three-axis flux-gate sensors with ring-cored coils are fixed on the fore mast. Outputs of the sensors are digitized by a 20-bit A/D converter (1 nT/LSB), and sampled at 8 times per second. Ship's heading, pitch and roll are measured utilizing a ring-laser gyro installed for controlling attitude of a Doppler radar. Ship's position (GPS) and speed data are taken from LAN every second.

(4) Data Archives

Magnetic field data obtained during this cruise will be submitted to the JAMSTEC Data Management Division, and will be archived there.

(5) Remarks

We collected the data for calibration during the following period by ‘figure-eight’ turn.

11 Oct. 2005 00:00 – 00:23 (Leg.1)

08 Dec. 2005 05:58 – 06:22 (Leg.2)

01 Jan. 2006 03:55 – 04:21 (Leg.2)

28 Jan. 2006 08:25 – 08:50 (Leg.3)

2.2 Surface Meteorological Observation

June 15, 2007

(1) Personnel

Kunio Yoneyama	***(JAMSTEC)***
Souichiro Sueyoshi	***(GODI)***
Katsuhisa Maeno	***(GODI)***
Norio Nagahama	***(GODI)***
Yasutaka Imai	***(GODI)***
Shinya Okumura	***(GODI)***
Ryo Ohyama	***(GODI)***

(2) Objective

As a basic dataset that describes weather conditions during the cruise, surface meteorological observation was continuously conducted.

(3) Methods

There are two different surface meteorological observation systems on the R/V MIRAI. One is the MIRAI surface meteorological measurement station (SMET), and the other is the Shipboard Oceanographic and Atmospheric Radiation (SOAR) system.

Instruments of SMET and its data used here are listed in Table 2.2.1. All SMET data were collected and processed by KOAC-7800 weather data processor manufactured by Koshin Denki, Japan. Note that although SMET contains rain gauge, anemometer and radiometers in their system, we adopted those data from not SMET but SOAR due to the following reasons; 1) Since SMET rain gauge is located near the base of the mast, the location possibly affect on the accuracy of the capture rate of the gauge, 2) SOAR's anemometer has better starting threshold wind speed (1 m/sec) comparing to SMET's anemometer (2 m/sec), and 3) SMET's radiometers record data with 10 W/m^2 unit, while SOAR records 1 W/m^2 unit.

SOAR system was designed and constructed by the Brookhaven National Laboratory (BNL), USA, for an accurate measurement of solar radiation on the ship. Details of SOAR can be found at http://www.gim.bnl.gov/soar/. SOAR consists of 1) Portable Radiation Package (PRP) that measures short and long wave downwelling radiation, 2) Zeno meteorological system that measures pressure, air temperature, relative humidity, wind speed/direction, and rainfall, and 3) Scientific Computer System (SCS) developed by the National Oceanic and Atmospheric Administration (NOAA), USA, for data collection, management, real-time monitoring, and so on. Information on sensors used here is listed in Table 2.2.2.

Table 2.2.1. Instruments and locations of SMET.

Sensor	Parameter	Manufacturer / type	Location / height from sea level
Thermometer[*1]	air temperature relative humidity	Vaisala, Finland / HMP45A	compass deck[*2] / 21 m
Thermometer	sea temperature	Koshin Denki, Japan / RFN1-0	4th deck / -5 m
Barometer	pressure	Setra Systems Inc., USA / 370	captain deck / 13 m

[*1] Gill aspirated radiation shield 43408 made by R. M. Young, USA is attached.

[*2] There are two thermometers at starboard and port sides.

Table 2.2.2. Instruments and locations of SOAR.

Sensor	Parameter	Manufacturer / type	Location / height from sea level
Anemometer	wind speed/direction	R. M. Young, USA / 05106	foremast / 25 m
Rain gauge	rainfall accumulation	R. M. Young, USA / 50202	foremast / 24 m
Radiometer	short wave radiation	Eppley, USA / PSP	foremast / 25 m
	long wave radiation	Eppley, USA / PIR	foremast / 25 m

(4) Data processing and data format

All raw data were recorded every 6 seconds. Datasets produced here are 1-minute mean values (time stamp at the beginning of the average). They are simple mean of 8 samples (10 samples minus maximum/minimum values) to exclude singular values. Liner interpolation onto missing values was applied only when their interval was less than 5 minutes.

Since the thermometers are equipped on both starboard/port sides on the deck, we used air temperature/relative humidity data taken at upwind side. Dew point temperature was produced from relative humidity and air temperature data.

No adjustment to sea level values is applied except pressure data.

Data are stored as ASCII format and contains following parameters.

Time in UTC expressed as YYYYMMDDHHMM, time in Julian day (1.0000 = January 1, 0000Z), longitude (°E), latitude (°N), pressure (hPa), air temperature (°C), dew point temperature (°C), relative humidity (%), sea surface temperature (°C), zonal wind component (m/sec), meridional wind component (m/sec), precipitation (mm/hr), downwelling shortwave radiation (W/m^2), and downwelling longwave radiation (W/m^2).

Missing values are expressed as “9999”.

(5) Data Quality

To ensure the data quality, each sensor was calibrated as follows. Since there is a possibility for fine time resolution data sets to have some noises caused (generated) by turbulence, it is recommended to filter them out (ex. hourly mean) from this 1-minute mean data sets depending on the scientific purpose.

T/RH sensor:

Temperature and humidity probes were calibrated before/after the cruise by the manufacturer. Certificated accuracy of T/RH sensors are better than ± 0.2°C and ± 2%, respectively.

We also checked T/RH values using another calibrated portable T/RH sensor (Vaisala, HMP45A) before and after the cruise. The results are,

Temperature (°C)

Mean difference between T (SMET) and T (portable) is

0.0±0.6 (°C) at port side, -0.3±0.3 (°C) at starboard side.

Relative Humidity (%)

Mean difference between RH (SMET) and RH (portable) is

2±2 (%) at port side, 3±1 (%) at starboard side.

Pressure sensor:

Using calibrated portable barometer (Vaisala, Finland / PTB220, certificated accuracy is better than ± 0.1 hPa), pressure sensor was checked before/after the cruise. Mean difference of SMET pressure sensor and portable sensor is -0.1±0.3 hPa.

Anemometer:

Using digital tester (Hioki, Japan / 3805), pre-cruise calibration was conducted by the GODI.

Pre-cruise calibration date: Sep. 7, 2005

Starting threshold wind speed: 0.9 m/sec for clockwise

0.9 m/sec for counter-clockwise

Wind direction check: better than ± 2°

Set value	6	36	64	96	126	156	185	215	244	275	306	336
Measured value	6	30	68	97	127	156	186	216	245	275	306	337
Difference	0	0	-4	-1	-1	0	-1	-1	-1	0	0	-1

Precipitation:

Before the cruise, we put water into the rain gauge to check their linearity between the indicated values and the water amount input. Expected accuracy is better than ±1 mm corresponding to the sensor's specification. The results are as follows, and data were corrected using this relationship.

	Leg.1	Leg.2	Leg.3
minimum input water volume (cc)	0.0	0.0	0.0
minimum measured value (mm)	0.9	2.1	0.7
maximum input water volume (cc)	509.8	514.3	510.3
maximum measured value (mm)	51.6	52.7	51.5

Radiation sensors:

Short wave and long wave radiometers were calibrated by the manufacturer, Remote Measurement and Research Company, USA, prior to the cruise.

(6) Data periods

Leg.1 1200 UTC, October 31, 2005 - 1830 UTC, November 24, 2005

* SST data is available from 0000 UTC, November 2, 2005.

Leg.2 1900 UTC, November 27, 2005 - 0000 UTC, January 17, 2006

* SST data is available between 0400 UTC, November 29, 2005 - 0500 UTC, January 15, 2006

Leg.3 2350 UTC, January 19, 2006 - 2300 UTC, January 29, 2006

* SST is available until 0000 UTC, January 28, 2006.

(7) Point of contact

Kunio Yoneyama (yoneyamak@jamstec.go.jp)
IORGC / JAMSTEC, 2-15, Natsushima, Yokosuka 237-0061, Japan

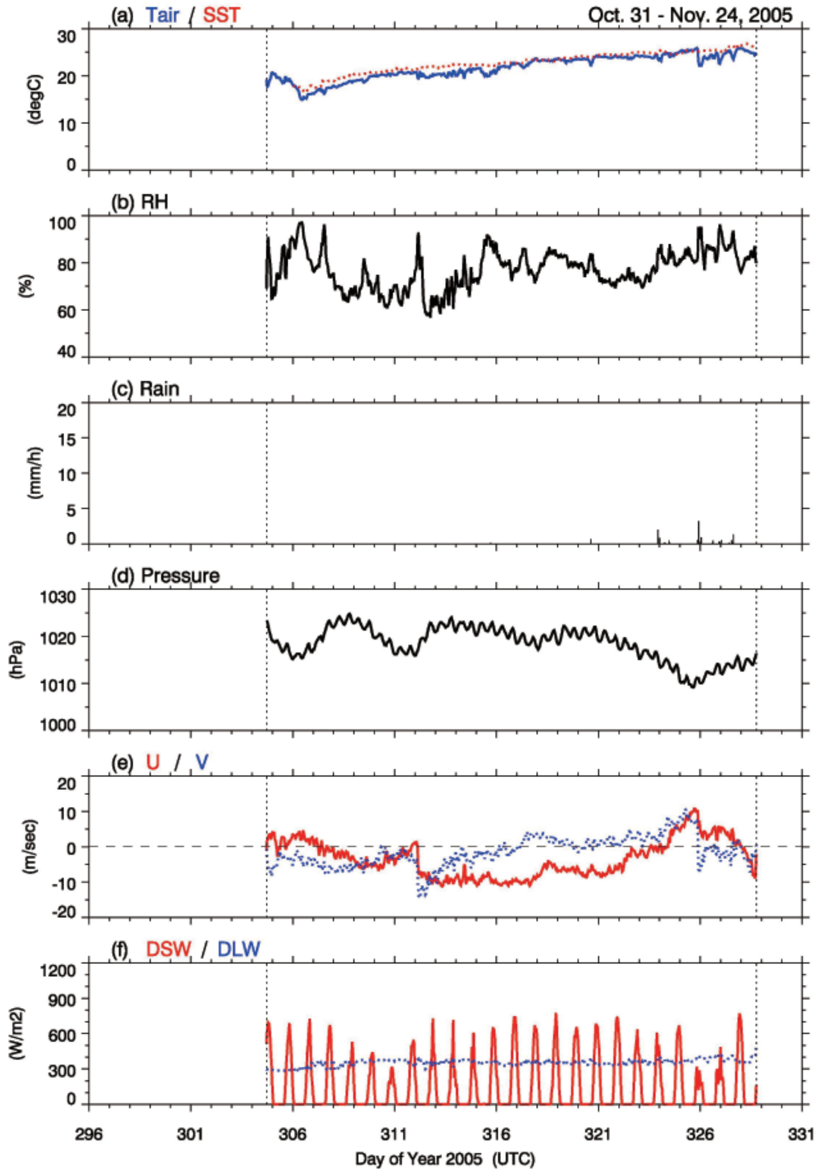

Figure 2.2.1. Time series of (a) air and sea surface temperature, (b) relative humidity, (c) precipitation, (d) pressure, (e) zonal and meridional wind components, and (e) short and long wave radiation. Day 304 corresponds to October 31, 2005.

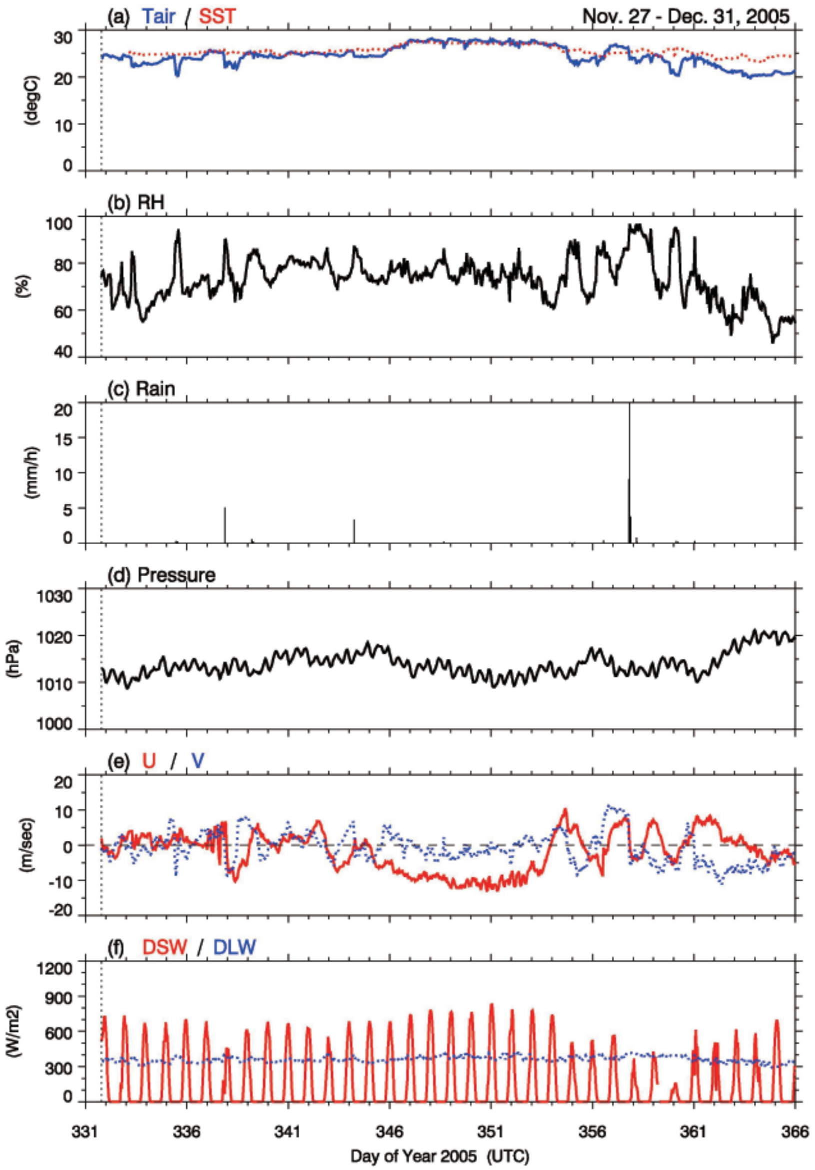

Figure 2.2.1. (continued)

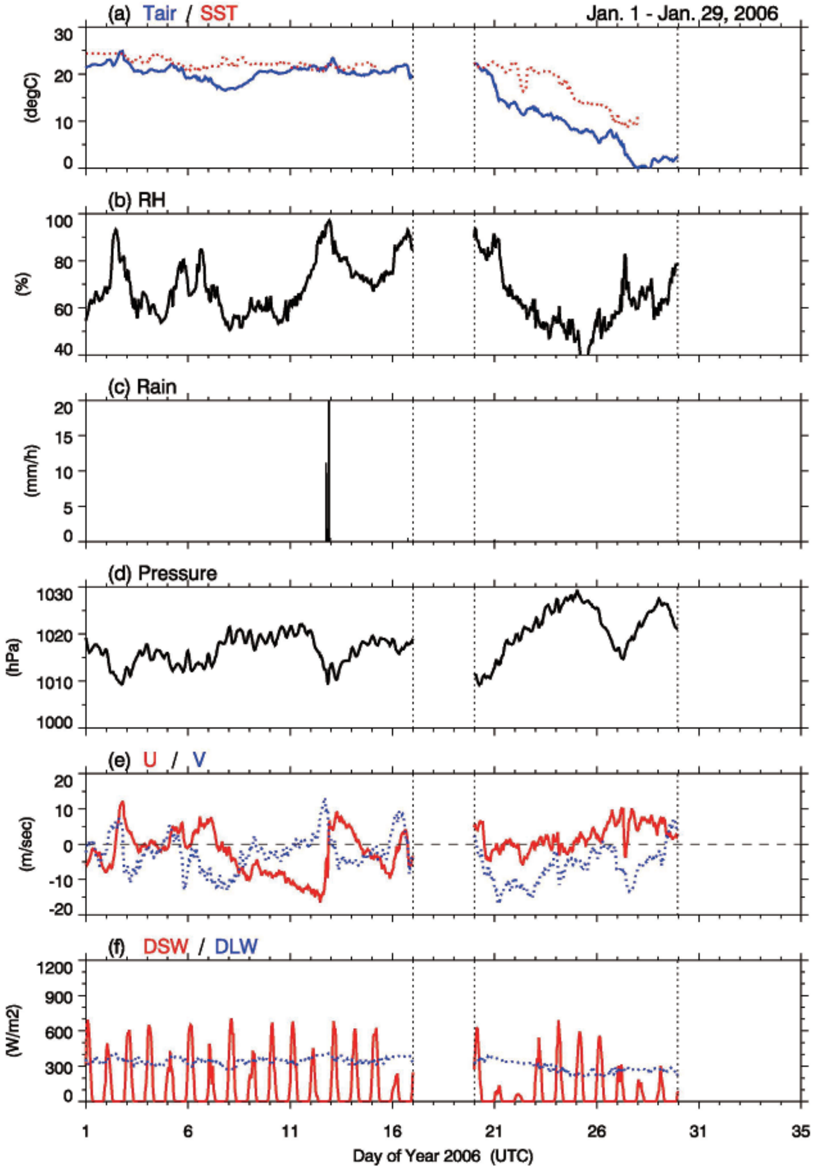

Figure 2.2.1. (continued)

2.3 Thermo-salinograph and related measurements

May 2, 2007

(1) Personnel

Yuichiro Kumamoto	***(JAMSTEC)***
Takeshi Kawano	***(JAMSTEC)***
Takuhei Shiozaki	***(MWJ)***
Keisuke Wataki	***(MWJ)***
Kimiko Nishijima	***(MWJ)***
Takayoshi Seike	***(MWJ)***
Osamu Yoshida	***(Tokyo Institute of Technology)***

(2) Objective

Our purpose is to measure salinity, temperature, dissolved oxygen, fluorescence, and particle size and number in near-sea surface water during MR05-05 cruise.

(3) Methods

The Continuous Sea Surface Water Monitoring System (Nippon Kaiyo Co. Ltd.), including the thermo-salinograph, has six kinds of sensors and can automatically measure salinity, temperature, dissolved oxygen, fluorescence and particle size and number in near-sea surface water every one minute. This system is located in the sea surface monitoring laboratory on R/V MIRAI and connected to shipboard LAN system. Measured data, time, and location of the ship were displayed on a monitor and then stored in a data management PC (IBM NetVista 6826-CBJ).

Near-surface water was continuously pumped from a depth of about 4 m to the laboratory and flowed into the system through a vinyl-chloride pipe. The flow rate of the surface seawater was controlled by several valves and adjusted to 12 L/min. except for a fluorometer (about 0.3 L/min.). The flow rate was measured by two flow meters.

During this cruise, the data management PC had a trouble in data acquisition of dissolved oxygen and particle counting and sizing. Thus, we connected another computer (IBM ThinkPad T41) to the system for those data storage.

Specifications of the each sensor in this system are listed below.

a) Temperature and salinity sensors*

SEACAT THERMOSALINOGRAPH

Model:	SBE-21, SEA-BIRD ELECTRONICS, INC.	
Serial number:	2118859-3126	
Measurement range:	Temperature -5 to +35°C,	Salinity 0 to 6.5 S m^{-1}
Accuracy:	Temperature 0.01°C 6month^{-1},	Salinity 0.001 S m^{-1} month^{-1}
Resolution:	Temperatures 0.001°C,	Salinity0.0001 S m^{-1}

b) Bottom of ship thermometer

Model:	SBE 3S, SEA-BIRD ELECTRONICS, INC.
Serial number:	032607
Measurement range:	-5 to +35°C
Resolution:	±0.001°C
Stability:	0.002°C year^{-1}

c) Dissolved oxygen sensor

Model:	2127A, HACH ULTRA ANALYTICS JAPAN, INC.
Serial number:	47477
Measurement range:	0 to 14 ppm
Accuracy:	±1% at 5°C of correction range
Stability:	1% month^{-1}

d) Fluorometer

Model:	10-AU-005, TURNER DESIGNS
Serial number:	5562 FRXX
Detection limit:	5 ppt or less for chlorophyll a
Stability:	0.5% month-1 of full scale

e) Particle Size sensor

Model:	P-05, Nippon Kaiyo LTD.
Serial number:	P5024

Measurement range: 0.2681 mm to 6.666 mm
Accuracy: ±10% of range
Reproducibility: ±5%
Stability: 5% $week^{-1}$

f) Flow meter

Model: EMARG2W, Aichi Watch Electronics LTD.
Serial number: 8672
Measurement range: 0 to 30 l min^{-1}
Accuracy: ±1%
Stability: ±1% day^{-1}

*During the past cruises, an antifoulant (antibiotic) device including TBTO (tributyltin oxide) was attached to the salinity sensor to control growth of aquatic organisms in electronic conductivity sensors. TBTO is an endocrine disrupting chemical and restricted its use in the environments by Japanese law. Consequently, we did not use the antifoulant device during this cruise. After Leg.2, we found biogenic stains on both temperature and salinity sensors that had not been found at the end of Leg.1 cruise (Photo 2.3.1). Although effectiveness of the antibiotic device is uncertain, the biogenic stains found on the sensors suggest that the device should should have been attached to the sensors for longer than one month during the cruises.

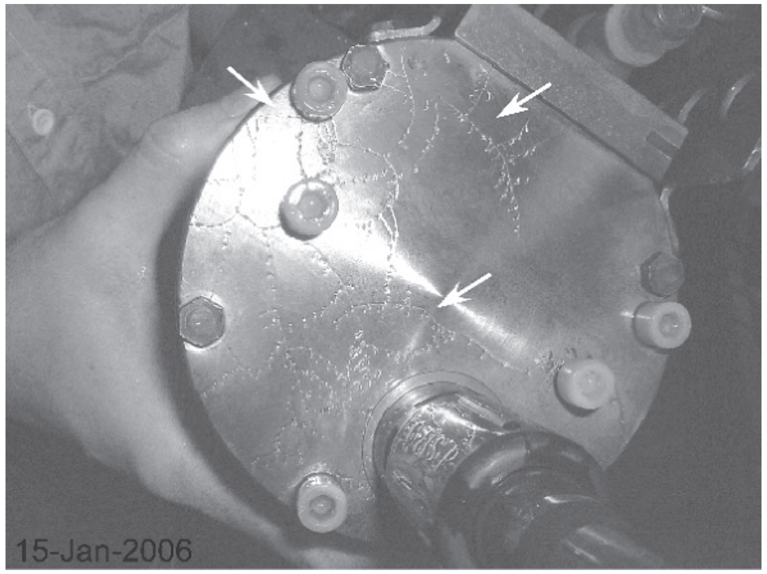

Photo 2.3.1.

(4) Measurements

Periods of measurement, maintenance, and problems during MR05-05 are listed in Table 2.3.1.

Table 2.3.1. Events list of the thermo-salinograph.

Date [UTC]	Time [UTC]	Event	Remarks
31-Oct-05	18:13	All measurements started.	Leg.1 start
11-Nov-05	02:45 ~ 03:46	The fluorescence measurement stopped for cell cleaning.	
23-Nov-05	22:57	All measurements stopped.	Leg.1 end
29-Nov-05	06:53	All measurements started.	Leg.2 start
14-Dec-05	20:23 ~ 21:50	The fluorescence measurement stopped for cell cleaning.	
15-Jan-06	05:12	All measurements stopped.	Leg.2 end
20-Jan-06	04:32	All measurements started.	Leg.3 start
25-Jan-06	05:48 ~ 07:14	Failure of data storage for T, S, Flu, location due to the PC troubles.	
26-Jan-06	07:58 ~ 09:04 09:13 ~ 09:39	Failure of data storage for T, S, Flu, location due to the PC troubles.	
26-Jan-06	09:13 ~ 09:28	Failure of data storage for oxygen and particle size due to the PC troubles.	
27-Jan-06	23:27	All measurements stopped.	Leg.3 end

(5) Calibrations

i. Comparison with bottle data

We collected the surface seawater samples approximately twice a day from the outlet equipped in the middle of water line of the system for salinity sensor calibration. 250 ml brown grass bottle with plastic inner stopper and screw cap was used to collect the samples. The sample bottles were stored in the sea surface monitoring laboratory. The samples were measured using the Guildline 8400B at the end of each leg after all measurements of hydrocast bottle samples. The measurement technique was almost same as that for bottle salinity measurement. The results are shown in Table 2.3.2 and JAMSTEC MIRAI DATA web;

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg1/EPCS/MR0505_leg1_cor_info_eng.html,

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg2/EPCS/MR0505_leg2_cor_info_eng.html,

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg3/EPCS/MR0505_leg3_cor_info_eng.html.

In order to calibrate the fluorescence sensor, Tokyo Institute of Technology group collected the surface seawater at the noon and about 4 hours after the sunset for measuring chlorophyll-a. 500 ml of the seawater sample was gently filtrated by low vacuum pressure (<15 cmHg) through Whatman GF/F filter (diameter 25 mm) in a dark room. The filter was immediately transferred into 7 ml of N,N-dimethylformamide (DMF) and then the bottle of DMF was stored at –20°C under dark condition to extract chlorophyll-a for more than 24 hours. Concentrations of chlorophyll-a were measured by a fluorometer (10-AU-005, TURNER DESIGNS) that was previously calibrated against a pure chlorophyll-a (Sigma chemical Co.). We carried out "Non-acidification method " (Welschmeyer, 1994) for chlorophyll-a measurements. The results of the measurements are shown in Table 2.3.3.

Sensors for dissolved oxygen and particle size were not calibrated against bottle data.

ii. Sensor calibrations

The sensors for temperature and salinity were calibrated before and after the cruise in order to evaluated the measurement drifts during the cruise. The results of the calibrations are available through JAMSTEC MIRAI DATA Web as above.

2.3.6 Date archive

Quality controlled data of temperature, salinity, and dissolved oxygen can be downloaded from JAMSTEC MIRAI DATA Web;

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg1/EPCS/MR0505_1_qced_data.html,

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg2/EPCS/MR0505_2_qced_data.html,

http://www.jamstec.go.jp/mirai/2005/MR05-05_leg3/EPCS/MR0505_3_qced_data.html.

Data of fluorescence and particle size and number are also available through the web page.

Table 2.3.2. Comparison of the sensor salinity and the bottle salinity.

Date [UTC]	Time [UTC]	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Quality Flag for bottle salinity
2-Nov-05	6:50	33.5700	33.5695	2
3-Nov-05	8:22	33.1737	33.1713	2
4-Nov-05	6:13	33.6508	33.6571	3
5-Nov-05	5:17	34.2141	34.2115	2
6-Nov-05	8:26	34.5818	34.5795	2
7-Nov-05	8:00	34.8829	34.8789	2
8-Nov-05	7:46	35.0396	35.0376	2
9-Nov-05	5:59	35.2435	35.2407	2
10-Nov-05	7:10	35.1329	35.1297	2
11-Nov-05	2:40	35.1480	35.1459	2
12-Nov-05	8:16	35.1758	35.1731	2
13-Nov-05	8:21	35.2669	35.2644	2
14-Nov-05	10:58	35.3217	35.3188	2
15-Nov-05	8:14	35.3293	35.3255	2

Table 2.3.2. (continued)

Date [UTC]	Time [UTC]	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Quality Flag for bottle salinity
16-Nov-05	8:27	35.0564	35.0519	2
17-Nov-05	7:00	35.2159	35.2122	2
18-Nov-05	10:12	35.3360	35.3320	2
18-Nov-05	22:25	35.3442	35.3403	2
19-Nov-05	8:52	35.3532	35.3484	2
19-Nov-05	21:20	35.3188	35.3158	2
20-Nov-05	11:25	35.3493	35.3466	2
20-Nov-05	23:29	35.3597	35.3548	2
21-Nov-05	12:05	35.1876	35.1860	2
21-Nov-05	18:09	35.2402	35.2369	2
29-Nov-05	20:08	35.2438	35.2462	2
29-Nov-05	23:17	35.1937	35.1943	2
30-Nov-05	15:46	35.2185	35.2217	2
1-Dec-05	1:25	35.2297	35.2325	2
1-Dec-05	14:25	35.2561	35.2590	2
2-Dec-05	8:07	35.2581	35.2605	2
2-Dec-05	13:21	35.2560	35.2573	2
3-Dec-05	0:41	35.1905	35.1972	2
3-Dec-05	15:12	35.1715	35.1738	2
4-Dec-05	0:44	35.2197	35.2220	2
4-Dec-05	13:59	35.2867	35.2874	2
5-Dec-05	0:47	35.3573	35.3594	2
5-Dec-05	13:36	35.2448	35.2460	2
6-Dec-05	1:25	35.2640	35.2658	2
6-Dec-05	13:33	35.2607	35.2663	2
7-Dec-05	1:00	35.2957	35.2981	2
7-Dec-05	13:28	35.3609	35.3635	2
8-Dec-05	1:00	35.3706	35.3732	2
9-Dec-05	1:38	35.3573	35.3590	2
9-Dec-05	9:02	35.3492	35.3494	2
9-Dec-05	14:28	35.3398	35.3414	2
10-Dec-05	1:56	35.3514	35.3536	2
10-Dec-05	14:25	35.2974	35.2998	2
11-Dec-05	2:10	35.2485	35.2508	2
11-Dec-05	14:30	35.2312	35.2333	2
12-Dec-05	2:18	35.2767	35.2751	2
12-Dec-05	19:46	34.9113	34.9100	2
13-Dec-05	5:32	34.8525	34.8533	2
13-Dec-05	20:55	34.8668	34.8662	2
14-Dec-05	9:51	34.8070	34.8062	2
14-Dec-05	21:32	34.8108	34.8095	2
15-Dec-05	13:57	34.7460	34.7482	2
15-Dec-05	20:08	34.7251	34.7255	2
16-Dec-05	13:48	34.7450	34.7477	2
16-Dec-05	18:51	34.7879	34.7876	2
17-Dec-05	1:58	34.7641	34.7631	2

Table 2.3.2. (continued)

Date [UTC]	Time [UTC]	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Quality Flag for bottle salinity
17-Dec-05	14:40	34.7886	34.7886	2
18-Dec-05	11:02	34.7928	34.7894	2
18-Dec-05	14:27	34.8002	34.8000	2
19-Dec-05	8:39	34.8347	34.8312	2
19-Dec-05	21:15	35.0004	35.0000	2
20-Dec-05	2:25	34.9669	34.9672	2
21-Dec-05	10:24	35.2600	35.2600	2
21-Dec-05	15:05	35.3098	35.3092	2
22-Dec-05	10:32	35.2453	35.2428	2
22-Dec-05	15:32	35.1821	35.1809	2
23-Dec-05	5:49	35.2539	35.2529	2
23-Dec-05	15:20	35.2687	35.2681	2
24-Dec-05	4:17	35.1506	35.1516	2
24-Dec-05	15:21	35.1108	35.1093	2
25-Dec-05	3:02	35.1697	35.1665	2
25-Dec-05	15:17	35.0202	35.0187	2
26-Dec-05	3:56	34.9861	34.9841	2
26-Dec-05	15:30	35.0344	35.0326	2
27-Dec-05	3:16	35.1956	35.1938	2
27-Dec-05	15:19	35.0220	35.0204	2
28-Dec-05	3:23	35.0168	35.0160	2
28-Dec-05	15:25	35.1121	35.1052	2
29-Dec-05	3:17	35.1368	35.1358	2
29-Dec-05	15:40	34.8900	34.8895	2
30-Dec-05	4:15	34.9790	34.9782	2
30-Dec-05	15:31	35.0010	35.0015	2
31-Dec-05	4:26	34.9686	34.9685	2
01-Jan-06	5:45	34.9579	34.9565	2
01-Jan-06	15:39	34.9594	34.9580	2
02-Jan-06	6:23	34.9835	34.9818	2
02-Jan-06	15:29	34.9401	34.9392	2
02-Jan-06	17:25	34.9542	34.9542	2
03-Jan-06	13:12	34.8194	34.8195	2
03-Jan-06	17:53	34.8762	34.8715	2
04-Jan-06	5:14	34.7966	34.7961	2
04-Jan-06	17:30	34.8093	34.8091	2
05-Jan-06	6:43	34.8998	34.8989	2
05-Jan-06	17:38	34.9090	34.9085	2
06-Jan-06	6:47	34.8450	34.8434	2
06-Jan-06	17:51	34.8190	34.8180	2
07-Jan-06	7:59	34.8109	34.8101	2
07-Jan-06	17:42	34.6597	34.6584	2
08-Jan-06	8:01	34.7983	34.7971	2
08-Jan-06	18:20	34.6684	34.6674	2
09-Jan-06	20:46	34.7581	34.7569	2
10-Jan-06	13:37	34.7615	34.7667	2
10-Jan-06	17:45	34.6906	34.6897	2

Table 2.3.2. (continued)

Date [UTC]	Time [UTC]	Sensor salinity [PSS-78]	Bottle salinity [PSS-78]	Quality Flag for bottle salinity
11-Jan-06	6:11	34.8660	34.8650	2
11-Jan-06	17:47	34.7070	34.7076	2
12-Jan-06	8:57	34.7660	34.7654	2
12-Jan-06	17:34	34.7228	34.7217	2
13-Jan-06	6:46	34.7033	34.7006	2
13-Jan-06	17:37	34.7052	34.7038	2
14-Jan-06	7:31	34.6351	34.6353	2
14-Jan-06	17:44	34.6562	34.6549	2
20-Jan-06	5:50	34.7968	34.7928	2
20-Jan-06	18:35	34.6766	34.6693	2
21-Jan-06	5:36	34.6326	34.6265	2
21-Jan-06	17:57	34.5974	34.5979	2
22-Jan-06	5:46	34.5873	34.5817	2
22-Jan-06	17:20	34.6853	34.6788	2
23-Jan-06	5:42	34.7726	34.7714	2
23-Jan-06	18:06	34.6577	34.6525	2
24-Jan-06	5:44	34.6295	34.6273	2
24-Jan-06	18:07	34.6144	34.6033	2
25-Jan-06	5:46	34.5806	34.5724	2
25-Jan-06	17:52	34.5397	34.5399	2
26-Jan-06	5:41	34.5224	34.5162	2
26-Jan-06	18:14	34.2362	34.2482	2

Table 2.3.3. Comparison of sensor fluorescence and bottle chlorophyll-a.

Date [UTC]	Time [UTC]	Sensor Fluorescence	Chlorophyll-a (μg/L)
1-Nov-05	6:20	15.791	0.37
1-Nov-05	20:00	15.266	0.44
2-Nov-05	6:03	16.915	0.30
2-Nov-05	20:29	14.017	0.17
3-Nov-05	6:02	14.768	0.13
3-Nov-05	20:13	13.192	0.12
4-Nov-05	6:13	13.394	0.08
4-Nov-05	20:05	12.899	0.08
5-Nov-05	6:00	12.971	0.08
5-Nov-05	20:08	12.469	0.10
6-Nov-05	6:11	13.063	0.09
6-Nov-05	20:08	12.755	0.12
7-Nov-05	6:03	13.085	0.10
7-Nov-05	20:59	12.587	0.08
8-Nov-05	7:05	12.750	0.10
8-Nov-05	21:15	12.280	0.12
9-Nov-05	7:10	12.815	0.12
9-Nov-05	23:34	12.659	0.15
10-Nov-05	7:19	12.784	0.13
10-Nov-05	21:08	12.427	0.12
11-Nov-05	7:19	13.846	0.12
11-Nov-05	22:10	12.609	0.12
12-Nov-05	8:10	13.467	0.13

Table 2.3.3. (continued)

Date [UTC]	Time [UTC]	Sensor Fluorescence	Chlorophyll-a (μg/L)
12-Nov-05	22:08	12.914	0.11
13-Nov-05	8:33	13.169	0.10
13-Nov-05	22:10	12.733	0.11
14-Nov-05	8:12	13.103	0.10
14-Nov-05	22:00	12.639	0.12
15-Nov-05	8:12	12.977	0.11
15-Nov-05	22:03	12.357	0.08
16-Nov-05	9:22	12.768	0.09
16-Nov-05	22:00	12.361	0.09
17-Nov-05	8:07	12.623	0.11
17-Nov-05	22:35	12.353	0.11
18-Nov-05	8:25	12.652	0.12
18-Nov-05	22:15	12.260	0.11
19-Nov-05	8:52	12.803	0.08
19-Nov-05	22:10	12.305	0.08
20-Nov-05	8:06	12.589	0.08
20-Nov-05	22:15	12.542	0.09
21-Nov-05	8:10	13.062	0.12
21-Nov-05	22:15	12.828	0.13
21-Nov-05	22:15	12.828	0.13
22-Nov-05	8:11	13.125	0.16
22-Nov-05	22:10	13.035	0.15
22-Nov-05	22:10	13.035	0.18
29-Nov-05	23:27	13.936	0.14
30-Nov-05	9:00	13.722	0.14
30-Nov-05	9:00	13.722	0.15
30-Nov-05	23:22	12.934	0.13
30-Nov-05	23:22	12.934	0.13
01-Dec-05	9:01	13.479	0.12
02-Dec-05	1:45	13.153	0.13
02-Dec-05	10:08	13.229	0.08
02-Dec-05	10:08	13.229	0.08
02-Dec-05	23:50	12.193	0.10
02-Dec-05	23:50	12.193	0.10
03-Dec-05	9:01	12.679	0.08
03-Dec-05	23:29	12.356	0.14
04-Dec-05	9:00	12.600	0.12
04-Dec-05	9:00	12.600	0.12
04-Dec-05	23:28	11.957	0.10
04-Dec-05	23:28	11.957	0.10
05-Dec-05	9:39	12.214	0.10
06-Dec-05	2:01	11.869	0.09
06-Dec-05	8:56	11.974	0.08
06-Dec-05	8:56	11.974	0.08
07-Dec-05	0:22	11.713	0.09
07-Dec-05	0:22	11.713	0.09
07-Dec-05	9:01	11.932	0.07

Table 2.3.3. (continued)

Date [UTC]	Time [UTC]	Sensor Fluorescence	Chlorophyll a (μg/L)
07-Dec-05	23:41	11.669	0.08
08-Dec-05	8:47	11.884	0.07
08-Dec-05	8:47	11.884	0.07
09-Dec-05	1:05	11.760	0.08
09-Dec-05	1:05	11.760	0.08
09-Dec-05	10:07	12.234	0.08
10-Dec-05	0:59	11.767	0.12
10-Dec-05	10:05	12.198	0.08
10-Dec-05	10:05	12.198	0.08
11-Dec-05	1:18	11.926	0.08
11-Dec-05	1:18	11.926	0.08
11-Dec-05	10:09	12.172	0.07
21-Dec-05	2:21	11.858	0.09
21-Dec-05	12:12	12.124	0.09
21-Dec-05	12:12	12.124	0.08
22-Dec-05	1:38	12.132	0.08
22-Dec-05	1:38	12.132	0.08
22-Dec-05	11:58	12.556	0.10
23-Dec-05	1:38	12.560	0.11
23-Dec-05	12:20	12.649	0.10
23-Dec-05	12:20	12.649	0.10
24-Dec-05	1:31	13.030	0.09
24-Dec-05	1:31	13.030	0.09
24-Dec-05	12:39	13.108	0.10
25-Dec-05	2:08	13.015	0.09
25-Dec-05	11:17	13.893	0.09
26-Dec-05	1:23	13.137	0.12
26-Dec-05	1:23	13.137	0.12
26-Dec-05	10:35	13.459	0.12
27-Dec-05	1:34	13.209	0.14
27-Dec-05	11:51	13.308	0.11
27-Dec-05	11:51	13.308	0.12
28-Dec-05	1:42	13.408	0.11
28-Dec-05	1:42	13.408	0.11
28-Dec-05	10:53	14.309	0.13
29-Dec-05	1:47	13.215	0.13
29-Dec-05	11:08	13.639	0.10
29-Dec-05	11:08	13.639	0.09
30-Dec-05	1:35	13.246	0.14
30-Dec-05	1:35	13.246	0.13
30-Dec-05	11:12	14.087	0.13
31-Dec-05	1:42	12.956	0.13
31-Dec-05	10:57	13.773	0.15
31-Dec-05	10:57	13.773	0.15
02-Jan-06	2:44	12.987	0.15
02-Jan-06	2:44	12.987	0.15
02-Jan-06	13:07	13.275	0.13

Table 2.3.3. (continued)

Date [UTC]	Time [UTC]	Sensor Fluorescence	Chlorophyll a (μg/L)
03-Jan-06	3:29	12.960	0.10
03-Jan-06	13:46	13.116	0.10
03-Jan-06	13:46	13.116	0.10
04-Jan-06	3:20	13.127	0.12
04-Jan-06	3:20	13.127	0.12
04-Jan-06	12:22	13.009	0.12
05-Jan-06	3:37	13.136	0.10
05-Jan-06	14:03	13.950	0.13
05-Jan-06	14:03	13.950	0.13
06-Jan-06	3:40	13.146	0.22
06-Jan-06	12:25	14.240	0.25
07-Jan-06	3:40	13.948	0.25
07-Jan-06	12:30	14.208	0.27
07-Jan-06	12:30	14.208	0.26
08-Jan-06	3:40	13.427	0.27
08-Jan-06	3:40	13.427	0.27
08-Jan-06	13:02	13.625	0.25
10-Jan-06	13:10	13.954	0.25
11-Jan-06	3:40	13.387	0.23
11-Jan-06	3:40	13.387	0.23
11-Jan-06	13:34	14.446	0.45
11-Jan-06	13:34	14.446	0.44
12-Jan-06	3:20	15.650	0.74
12-Jan-06	14:34	15.012	0.48
12-Jan-06	14:34	15.012	0.49
13-Jan-06	3:18	14.052	0.54
13-Jan-06	3:18	14.052	0.55
13-Jan-06	13:22	14.403	0.35
14-Jan-06	3:43	14.164	0.44
14-Jan-06	13:53	14.134	0.36
14-Jan-06	13:53	14.134	0.37
15-Jan-06	3:40	13.333	0.24
15-Jan-06	3:40	13.333	0.25
20-Jan-06	13:27	15.864	0.18
20-Jan-06	13:27	15.864	0.18
21-Jan-06	4:56	19.848	1.57
21-Jan-06	4:56	19.848	1.62
21-Jan-06	13:10	21.013	2.40
22-Jan-06	3:47	19.055	1.54
22-Jan-06	13:18	18.849	0.49
22-Jan-06	13:18	18.849	0.48
23-Jan-06	2:43	14.727	0.33
23-Jan-06	2:43	14.727	0.32
23-Jan-06	12:34	16.606	0.47
24-Jan-06	3:42	16.021	0.63
24-Jan-06	12:36	19.706	0.83
24-Jan-06	12:36	19.706	0.88

Table 2.3.3. (continued)

Date [UTC]	Time [UTC]	Sensor Fluorescence	Chlorophyll a (μg/L)
25-Jan-06	3:45	20.538	2.20
25-Jan-06	3:45	20.538	2.16
25-Jan-06	13:22	25.41	3.02
26-Jan-06	6:17	21.289	1.34
26-Jan-06	14:03	23.116	0.56
26-Jan-06	14:03	23.116	0.55

2.4 Underway pCO_2

July 4, 2007

(1) Personnel

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(2) Introduction

Concentrations of CO_2 in the atmosphere are currently increasing at a rate of 1.5 ppmv y^{-1} due to human activities such as burning of fossil fuels, deforestation, cement production, and so on. It is an urgent task to estimate as accurately as possible the absorption capacity of the ocean against the increasing atmospheric CO_2, as well as to clarify the mechanism of the CO_2 absorption, because the magnitude of the predicted global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In the P3 revist cruise, we aimed to quantify how much anthropogenic CO_2 is absorbed in the surface ocean of the North Pacific. For the purpose, we measured pCO_2 (partial pressures of CO_2) in the atmosphere and in the surface seawater.

(3) Apparatus and shipboard measurement

Continuous underway measurements of atmospheric and surface seawater pCO_2 were made with the CO_2 measuring system (Nippon ANS, Ltd) installed in the R/V MIRAI of JAMSTEC. The system comprises of a non-dispersive infrared gas analyzer (NDIR; BINOS® model 4.1, Fisher-Rosemount), an air-circulation module and a showerhead-type equilibrator. To measure concentrations (mole fraction) of CO_2 in dry air (xCO_2a), air sampled from the bow of the ship (approx. 30 m above the sea level) was introduced into the NDIR through a dehydrating route with an electric dehumidifier (kept at ~2°C), a Perma Pure dryer (GL Sciences Inc.), and a chemical desiccant ($Mg(ClO_4)_2$). The flow rate of the air was 500 ml min^{-1}. To measure surface seawater concentrations of CO_2 in dry air (xCO_2s), the air equilibrated with seawater within the equilibrator was introduced into the NDIR through the same flow route as the dehydrated air used in measuring xCO_2a. The flow rate of the equilibrated air was 600 – 800 ml min^{-1}. The seawater was taken by a pump from the intake placed at the approximately 4.5 m below the sea surface. The flow rate of seawater in the equilibrator was 500 – 800 ml min^{-1}.

The CO_2 measuring system was set to repeat the measurement cycle such as 4 kinds of CO_2 standard gases (Table 2.4.1), xCO_2a (twice), xCO_2s (7 times). This measuring system was run automatically throughout the cruise by a PC control.

(4) Quality control

Concentrations of CO_2 of the standard gases are listed in Table 2.4.1, which were calibrated by JAMSTEC primary standard gases. The CO_2 concentrations of the primary standard gases were calibrated by C.D. Keeling of the Scripps Institution of Oceanography, La Jolla, CA, USA.

Since differences in concentrations of the standard gases between before and after the cruise were acceptable (< 0.1 ppmv), the averaged concentrations (Table 2.4.1) were adopted for the subsequent calculations.

In actual shipboard observations, the signals of NDIR usually reveal trends. The trends were adjusted linearly using the signals of the standard gases analyzed before and after the sample measurements.

Effects of water temperature increased between the inlet of surface seawater and the equilibrator on xCO_2s were adjusted based on Gordon and Jones (1973), although the temperature increases were slight, being ~ 0.3°C.

We checked values of xCO_2a and xCO_2s by examining the signals of the NDIR on recorder charts, and by plotting the xCO_2a and xCO_2s as a function of sequential day, longitude, sea surface temperature and sea surface salinity.

Reference

Gordon, L. I. and L. B. Jones (1973) The effect of temperature on carbon dioxide partial pressure in seawater. *Mar. Chem.*, **1**, 317-322.

Table 2.4.1. Concentrations of CO_2 standard gases used in the P3 revisit cruise.

Cylinder no.	Concentrations (ppmv)
CQB17639	262.94
CQB17638	320.42
CQB17637	381.04
CQB17636	420.76

2.5 Acoustic Doppler Current Profiler

September 3, 2007

(1) Personnel

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(2) Instrument and method

The instrument used was an RDI 76.8 kHz unit, hull-mounted on the centerline and approximately 23 m aft of the bow at the water line. The firmware version was 5.59 and the data acquisition software was RDI VMDAS Version. 1.4. Operation was made from the first CTD station to the last CTD station. The instrument was used in water-tracking mode during the most of operations, recording each ping raw data in 8 m x 90 bin from about 23 m to 735 m in depth. Typical sampling interval was 3.5 seconds. Bottom track mode was added in the northernmost shallow water region. GPS gave navigation data. Two kinds of compass data were recorded. One compass was the ship's gyrocompass, which is connected the ADCP system directory, and its data were stored with the ADCP data. Current field based on the gyrocompass was used to check the operation and the performance on board. Another compass used was Inertial Navigation Unit (INU), DRU-H, Honeywell Inc. Its accuracy is 1.0 mile (about 0.056 degree) and had already set on zero bias before the beginning of the cruise. The INU compass data were stored independently and combined with the ADCP data after the cruise.

(3) Performance and quick view of the ADCP data on board

The performance of the ADCP instrument was almost good throughout the cruise: on streaming, profiles usually reached about 600 m (1609038 pings of all 2656345 pings). Profiles were sometimes rather bad on CTD station. The profiles did not reach so far, from 200 m to 500 m and the ADCP signal was typically weak at about 350 m in depth. It is probably due to babbles from the bow-thruster.

We processed the ADCP data in this cruise on board as described below. ADCP-coordinate velocities were converted to the earth-coordinate velocities using the ship's heading, roll and pitch data form the INU. The earth-coordinate currents were obtained by subtracting ship velocities from the earth-coordinate velocities. The ship velocities were obtained from the moving distances for 5 minites, which were measured by GPS data. The noise of the GPS position data was filtered out by 15-sec running mean. The errors of the estimated ship velocities are within 10 cm/s.

After this cruise the parameters of the misalignment and the scale factor would be evaluated by using the bottom track data obtained both in this cruise and in the engineering test cruise made just before this cruise.

(4) Data Processing

Corrections of the misalignment and the scale factor were made after the cruise using the bottom track data. The bottom track data used was obtained during the engineering test cruise carried out just before the P3_revisit cruise. The misalignment angle calculated was 0.15 degree and the scale factor was 0.975. Criteria for the correlation less than 64 and error velocity more than 20 mm/s are removed here. Therefore the error is estimated at 20 mm/s.

Raw data are filtered using the median filter on every 3 minutes. There are about 90 data in one ensemble. Time series of upper 200 m average flow for about 3 hours are calculated using the 3 minutes sub set. The continuity of the series on streaming between the CTD sites is examined. The standard deviation on the CTD sites is 56 mm/s. and that on streaming between the CTD sites is 47 mm/s. The qualitites of data on CTD sites and on streaming is not so different. The mismatch between the ship velocity obtained from the GPS and water column velocity of ADCP was found when the ship was accelerated and/or decelerated. To avoid the effect of the acceleration, we process the data only when standard deviation of ship velocity for three minutes is less than 10 cm/s. In the next step, we averaged the subset at each CTD station. Each mean profile is calculated with depth correction using the CTD data. Vertical grids are put on every 10 m.

(5) Data Structure

The record structure of the data set A, where file name is 'ADCP_A', is described below. The file consists of 239 profiles in the CTD sites. Each profile consists of header and data. The header has three lines representing analyzed site, date and time, and position. The data has 67 layers in which depth, zonal velocity, meridional velocity, and vetical velocity of each grid are stored. Unit of depth is in meter. Unit of flow is in m/s. On the CTD station, the CTD station name (e.g. '143_1') is recorded as the analyzed site in the header. Mean time and position were calculated and recorded using the ADCP profiles during the CTD operation was made. The '99.999' in the data represents no available data stored.

[data structure of the data set A]

Line 1: header 1
    Column 1: cruise code
    Column 2: analyzed site
Line 2: header 2
    date
Line 3: header 3
    Column 1: longitude (degree E)
    Column 2: latitude (degree N)
Line 4-70: flow data in each depth level
    Column 1: depth (m)
    Column 2: zonal velocity (m/s)
    Column 3: meridional velocity (m/s)
    Column 4: vertical velocity (m/s)

Flow data processed in every three minutes are stored in the data set B, where the file name is ' ADCP_B'. The data structure is the same as that of the data set B, except for the analyzed site in the header 1.

[data structure of the data set B: every 3 minutes]

Line 1: header 1
    Column 1: cruise code
    Column 2: sequatial record number
Line 2: header 2
    date
Line 3: header 3
    Column 1: longitude (degree E)
    Column 2: latitude (degree N)
Line 4-38: flow data in each depth level
    Column 1: depth (m)
    Column 2: zonal velocity (m/s)
    Column 3: meridional velocity (m/s)
    Column 4: vertical velocity (m/s)

3 Hydrographic Measurement Techniques and Calibrations

3.1 CTD/O_2 Measurements

May 2, 2007

(1) Personnel

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Makito Yokota	***(MWJ)***

(2) Winch arrangements

The CTD package was deployed by using 4.5 Ton Traction Winch System (Dynacon, Inc., Bryan, Texas, USA), which was installed on the R/V MIRAI in April 2001. The CTD Traction Winch System with the Heave Compensation Systems (Dynacon, Inc.) is designed to reduce cable stress resulting from load variation caused by wave or vessel motion. The system was operated passively by providing a nodding boom crane that moves up or down in response to line tension variations. Primary system components include a complete CTD Traction Winch System with up to 10 km of 9.53 mm armored cable (Ocean Cable and Communications Co., Yokohama, Kanagawa, Japan), a cable rocker and Electro-Hydraulic Power Unit, a nodding-boom crane assembly, two hydraulic cylinders and two hydraulic oil/nitrogen accumulators mounted within a single frame assembly. The system also contains related electronic hardware interface and a heave compensation computer control program.

(3) Overview of the equipment

The CTD system, SBE 911plus system (Sea-Bird Electronics, Inc., Bellevue, Washington, USA), is a real time data system with the CTD data transmitted from a SBE 9plus underwater unit via a conducting cable to the SBE 11plus deck unit. The SBE 11plus deck unit is a rack-mountable interface which supplies DC power to underwater unit, decodes serial data stream, formats data under microprocessor control, and passes the data to a companion computer. The serial data from the underwater unit is sent to the deck unit in RS-232 NRZ format using a 34,560 Hz carrier-modulated differential-phase-shift-keying (DPSK) telemetry link. The deck unit decodes the serial data and sends them to a personal computer to display, at the same time, to storage in a disk file using SBE SEASOFT software.

The SBE 911plus system acquires data from primary, secondary and auxiliary sensors in the form of binary numbers corresponding to the frequency or the voltage outputs from those sensors at 24 samples per second. The calculations required to convert raw data to engineering units of the parameters are performed by the SBE SEASOFT in real-time. The same calculations can be carried out after the observation using data stored in a disk file.

The SBE 911plus system controls 36-position SBE 32 Carousel Water Sampler. The Carousel accepts 12-litre water sample bottles. Bottles are fired through the RS-232C modem connector on the back of the SBE 11plus deck unit while acquiring real time data. The 12-litre Niskin-X water sample bottle (General Oceanics, Inc., Miami, Florida, USA) is equipped externally with two stainless steel springs. The external springs are ideal for applications such as trace metal analysis because the inside of the sampler is free from contaminants from springs.

SBE's temperature (SBE 3) and conductivity (SBE 4) sensor modules were used with the SBE 9plus underwater unit fixed by a single clamp and "L" bracket to the lower end cap. The conductivity cell entrance is co-planar with the tip of the temperature sensor's protective steel sheath. The pressure sensor is mounted in the main housing of the underwater unit and is ported to outside through the oil-filled plastic capillary tube. A compact, modular unit consisting of a centrifugal pump head and a brushless DC ball bearing motor contained in an aluminum underwater housing pump (SBE 5T) flushes water through sensor tubing at a constant rate independent of the CTD's motion. Motor speed and pumping rate (3,000 rpm) remain nearly constant over the entire input voltage range of 12-18 volts DC. Flow speed of pumped water in standard TC duct is about 2.4 m/s. SBE's dissolved oxygen sensor (SBE 43) was placed between the conductivity sensor module and the pump. Auxiliary sensors, Deep Ocean Standards Thermometer (SBE 35), altimeter (PSA-916T; Teledyne Benthos, Inc., North Falmous, Massachusetts, USA) and oxygen optode (Oxygen Optode 3830; Aanderaa Data Instruments AS, Bergen, Norway) were also used with the SBE 9plus underwater unit. The SBE 35 position in regard to the SBE 3 is shown in Figure 3.1.1.

It is known that the CTD temperature data is influenced by motion (pitching and rolling) of the CTD package. In order to reduce the motion of the CTD package, a heavy stainless frame (total weight of the CTD package without sea water in the bottles is about 1,000 kg) was used and an aluminum plate (54 × 90 cm) was attached to the frame (Figure 3.1.1).

[Summary of the system used in this cruise]

Deck unit:
    SBE 11plus, S/N 0344
Under water unit:
    SBE 9plus, S/N 79511 (Pressure sensor: S/N 0677)
Temperature sensor:
    SBE 3, S/N 1464 (Leg.1: primary)
    SBE 3plus, S/N 4216 (Leg.1: secondary, Leg.2, 3: primary)
    SBE 3, S/N 1525 (Leg.2, 3: secondary)
Conductivity sensor:
    SBE 4, S/N 1203 (Leg.1: primary)
    SBE 4, S/N 2854 (Leg.1: secondary)
    SBE 4, S/N 3124 (Leg.2: primary from 146_2 to 197_1)
    SBE 4, S/N 3036 (Leg.2: secondary from 146_2 to 197_1)
    SBE 4, S/N 2854 (Leg.2, 3: primary from X14_1 to TS_1)
    SBE 4, S/N 3116 (Leg.2, 3: secondary from X14_1 to TS_1)
Oxygen sensor:
    SBE 43, S/N 0391 (Leg.1: primary, Leg.2: primary from 146_2 to WC7)
    SBE 43, S/N 0488 (Leg.1: secondary)
    SBE 43, S/N 0390 (Leg.2, 3: primary from WC8 to TS1)
    SBE 43, S/N 0394 (Leg.2: secondary from 146_2 to 283_1, Leg.3: secondary)
    SBE 43, S/N 0205 (Leg.2: secondary from 285_1 to 351_2)
    Oxygen Optode 3830, S/N 612 (Leg.1, 2, 3: pilot)
Pump:
    SBE 5T, S/N 3293 (Leg.1: primary)
    SBE 5T, S/N 3118 (Leg.1: secondary)
    SBE 5T, S/N 0984 (Leg.2, 3: primary)
    SBE 5T, S/N 2627 (Leg.2, 3: secondary)
Altimeter:
    PSA-916T, S/N 1100 (Leg.1)
    PSA-916T, S/N 1157 (Leg.2, 3)
Deep Ocean Standards Thermometer:

SBE 35, S/N 0022 (Leg.1, 2)

SBE 35, S/N 0045 (Leg.3)

Carousel Water Sampler:

SBE 32, S/N 0391 (Leg.1, 2, 3)

Water sample bottle:

12-litre Niskin-X (no TEFLON coating)

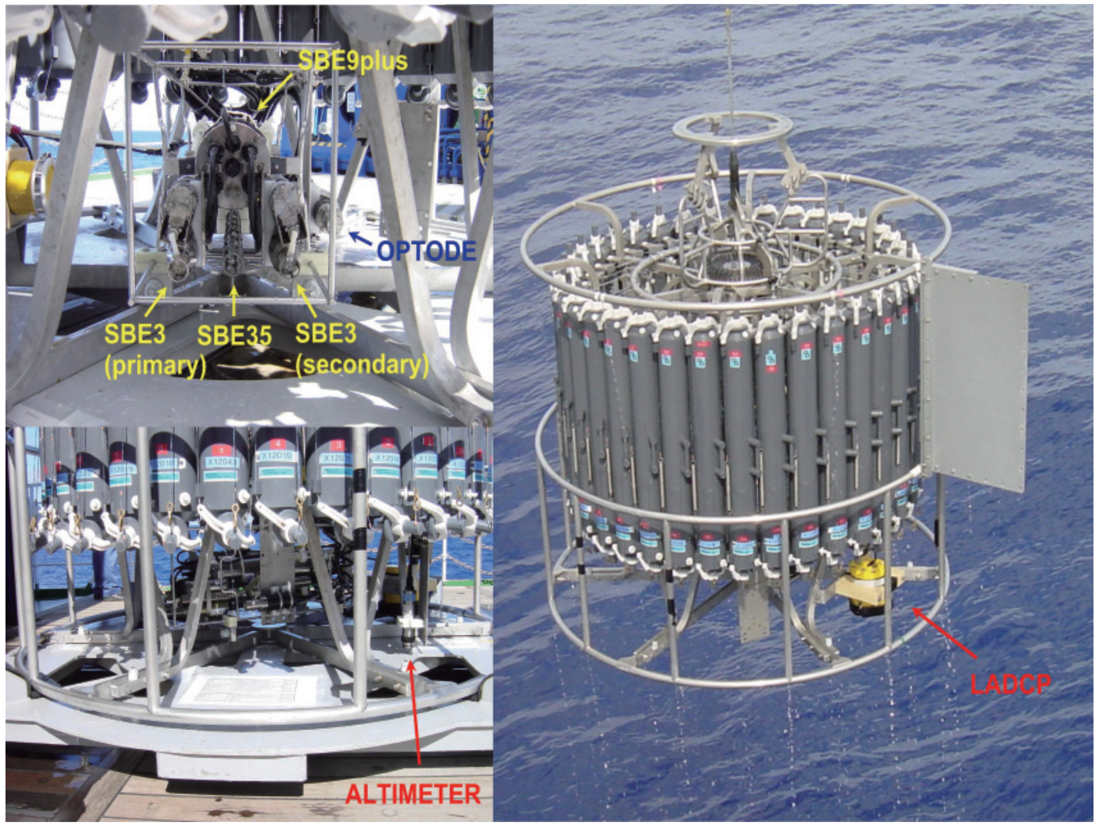


Figure 3.1.1. The CTD package (right) and the SBE 35 position in regard to the SBE 3 temperature sensors (left).

(4) Pre-cruise calibration

(4.1) Pressure

The Paroscientific series 4000 Digiquartz high pressure transducer (Paroscientific, Inc., Redmond, Washington, USA) uses a quartz crystal resonator whose frequency of oscillation varies with pressure induced stress with 0.01 per million of resolution over the absolute pressure range of 0 to 15,000 psia (0 to 10,332 dbar). Also, a quartz crystal temperature signal is used to compensate for a wide range of temperature changes at the time of an observation. The pressure sensor (MODEL 415K-187) has a nominal accuracy of 0.015% FS (1.5 dbar), typical stability of 0.0015% FS/month (0.15 dbar/month), and resolution of 0.001% FS (0.1 dbar).

Pre-cruise sensor calibrations were performed at SBE, Inc. The following coefficients were used in the SEASOFT:

S/N 0677, 2 July 2002

$c_1 = -62072.94$

$c_2 = -1.176956$

$c_3 = 1.954420e-02$

$d_1 = 0.027386$

$d_2 = 0.0$

$t_1 = 30.05031$

$t_2 = -4.744833e-04$

$t_3 = 3.757590e-06$

$t_4 = 3.810700e-09$

$t_5 = 0.0$

Pressure coefficients are first formulated into

$$c = c_1 + c_2 \times U + c_3 \times U^2$$

$$d = d_1 + d_2 \times U$$

$$t_0 = t_1 + t_2 \times U + t_3 \times U^2 + t_4 \times U^3 + t_5 \times U^4$$

where U is temperature in degrees Celsius. The pressure temperature, U, is determined according to

$$U\ (°C) = M \times (12\ \text{bit pressure temperature compensation word}) - B$$

The following coefficients were used in SEASOFT:

S/N 0677

$M = 0.0128041$

$B = -9.324136$

(in the underwater unit system configuration sheet dated on 22 February 2002)

Finally, pressure is computed as

$$P\ (\text{psi}) = c \times [1 - (t_0^2 / t^2)] \times \{1 - d \times [1 - (t_0^2 / t^2)]\}$$

where t is pressure period (μsec). Since the pressure sensor measures the absolute value, it inherently includes atmospheric pressure (about 14.7 psi). SEASOFT subtracts 14.7 psi from computed pressure above automatically.

Pressure sensor calibrations against a dead-weight piston gauge (Model 480DA, S/N 23906; Bundenberg Gauge Co. Ltd., Irlam, Manchester, UK) are performed at JAMSTEC, Yokosuka, Kanagawa, Japan by Marine Works Japan. LTD (MWJ), Yokohama, Kanagawa, Japan, usually once in a year in order to monitor sensor time drift and linearity. The pressure sensor drift is known to be primarily an offset drift at all pressures rather than a change of span slope. The pressure sensor hysterisis is typically 0.2 dbar. The following coefficients for the sensor drift correction were also used in SEASOFT:

S/N 0677, 8 September 2005

slope = 0.9998495

offset = −0.49595

The drift-corrected pressure is computed as

Drift-corrected pressure (dbar) = slope × (computed pressure in dbar) + offset

Result of the pressure sensor calibration against the dead-weight piston gauge is shown in Figure 3.1.2. Time drift of the pressure sensor based on the offset and the slope of the calibrations is also shown in Figure 3.1.3.

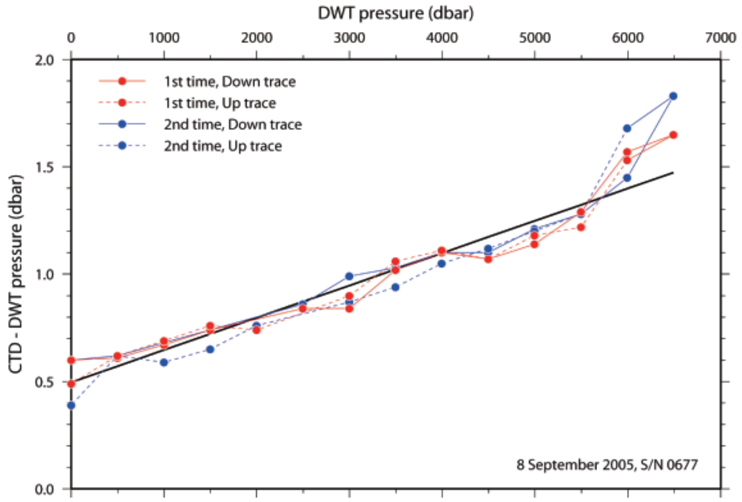


Figure 3.1.2. The residual pressures between the dead-weight piston gauge and the CTD pressure. The calibration line (black line) is also shown.

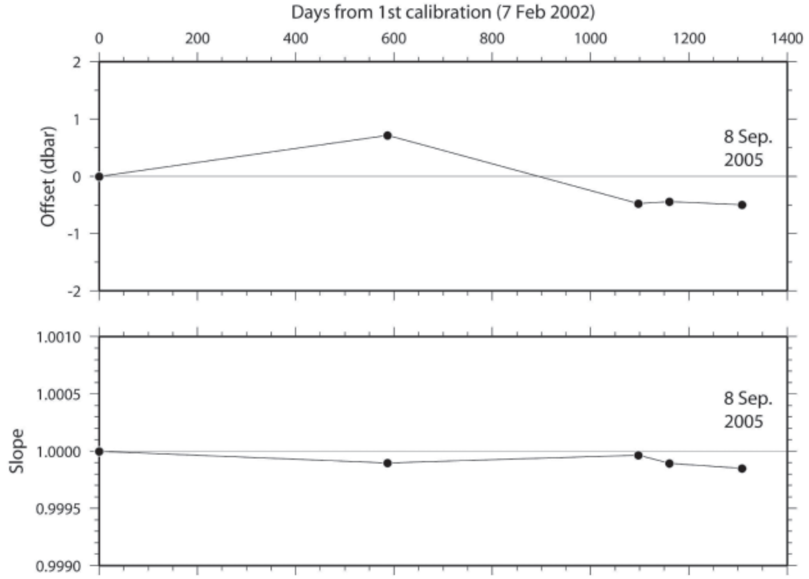


Figure 3.1.3. Pressure sensor time drift of offset (upper panel) and slope (lower panel) based on laboratory calibrations.

(4.2) Temperature (SBE 3)

The temperature sensing element is a glass-coated thermistor bead in a stainless steel tube, providing a pressure-free measurement at depths up to 10,500 (6,800) meters by titanium (aluminum) housing. The sensor output frequency ranges from approximately 5 to 13 kHz corresponding to temperature from –5 to 35°C. The output frequency is inversely proportional to the square root of the thermistor resistance, which controls the output of a patented Wien Bridge circuit. The thermistor resistance is exponentially related to temperature. The SBE 3 thermometer has a nominal accuracy of 1 mK, typical stability of 0.2 mK/month, and resolution of 0.2 mK at 24 samples per second. The premium temperature sensor, SBE 3plus, is a more rigorously tested and calibrated version of standard temperature sensor (SBE 3). A sensor is designated as an SBE 3plus only after demonstrating drift of less than 1 mK during a six-month screening period. In addition, the time response is carefully measured and verified to be 0.065 ± 0.010 seconds.

Pre-cruise sensor calibrations were performed at SBE, Inc. The following coefficients were used in SEASOFT:

S/N 1464 (Leg.1: primary), 14 September 2005

$g = 4.84384166e{-03}$

$h = 6.80721378e{-04}$

$i = 2.69562893e{-05}$

$j = 2.12657768e{-06}$

$f_0 = 1000.000$

S/N 4216 (Leg.1: secondary, Leg.2 and 3: primary), 20 September 2005

$g = 4.35983643e{-03}$

$h = 6.46128037e{-04}$

$i = 2.28907910e{-05}$

$j = 1.94862297e{-06}$

$f_0 = 1000.000$

S/N 1525 (Leg.2 and 3: secondary), 14 September 2005

$g = 4.84604175e{-03}$

$h = 6.75287460e{-04}$

$i = 2.65140918e{-05}$

$j = 2.12921574e{-06}$

$f_0 = 1000.000$

Temperature (ITS-90) is computed according to

Temperature (ITS-90) =

$$1 / \{g + h \times [\ln(f_0 / f)] + i \times [\ln^2(f_0 / f)] + j \times [\ln^3(f_0 / f)]\} - 273.15$$

where f is the instrument frequency (kHz).

Time drift of the SBE 3 temperature sensors based on the laboratory calibrations is shown in Figure 3.1.4.

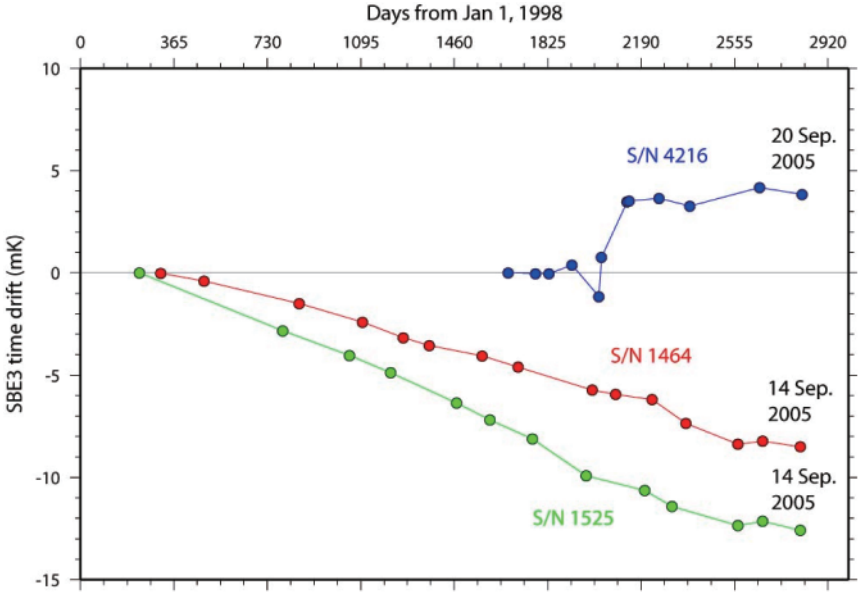


Figure 3.1.4. Time drift of SBE 3 temperature sensors based on laboratory calibrations.

(4.3) Conductivity (SBE 4)

The flow-through conductivity sensing element is a glass tube (cell) with three platinum electrodes to provide in-situ measurements at depths up to 10,500 meters. The impedance between the center and the end electrodes is determined by the cell geometry and the specific conductance of the fluid within the cell. The conductivity cell composes a Wien Bridge circuit with other electric elements of which frequency output is approximately 3 to 12 kHz corresponding to conductivity of the fluid of 0 to 7 S/m. The SBE 4 has a nominal accuracy of 0.0003 S/m, typical stability of 0.0003 S/m/month, and resolution of 0.00004 S/m at 24 samples per second.

Pre-cruise sensor calibrations were performed at SBE, Inc. The following coefficients were used in SEASOFT:

S/N 1203 (Leg.1: primary), 15 September 2005

g = –4.05182265e+00
h = 4.93483365e–01
i = 9.77451923e–05
j = 2.18599851e–05
CPcor = –9.57e–08 (nominal)
CTcor = 3.25e–06 (nominal)

S/N 2854 (Leg.1: secondary, Leg.2: primary from X14_1 to 351_2, Leg.3: primary),
15 September 2005

g = –1.02631821e+01
h = 1.41526600e+00
i = –9.49444425e–06
j = 5.73270605e–05
CPcor = –9.57e–08 (nominal)
CTcor = 3.25e–06 (nominal)

S/N 3124 (Leg.2: primary from 146_2 to 197_1), 8 November 2005

g = –1.02907974e+01
h = 1.38692851e+00
i = –8.89254353e–05
j = 8.59164344e–05
CPcor = –9.57e–08 (nominal)
CTcor = 3.25e–06 (nominal)

S/N 3036 (Leg.2: secondary from 146_2 to 197_1), 23 September 2005

g = –1.03246469e+01
h = 1.42860596e+00
i = 3.40735271e–04
j = 4.76172694e–05
CPcor = –9.57e–08 (nominal)
CTcor = 3.25e–06 (nominal)

S/N 3116 (Leg.2: secondary from X14_1 to 351_2, Leg.3: secondary), 8 November 2005

g = –1.04289250e+01
h = 1.43335621e+00
i = 4.35984135e–04
j = 3.98255096e–05
CPcor = –9.57e–08 (nominal)
CTcor = 3.25e–06 (nominal)

Conductivity of a fluid in the cell is expressed as:

$$C\ (\mathrm{S/m}) = (g + h \times f^2 + i \times f^3 + j \times f^4) / [10\ (1 + \mathrm{CTcor} \times t + \mathrm{CPcor} \times p)]$$

where f is the instrument frequency (kHz), t is the water temperature (°C) and p is the water pressure (dbar). The value of conductivity at salinity of 35, temperature of 15°C (IPTS-68) and pressure of 0 dbar is 4.2914 S/m.

(4.4) Oxygen (SBE 43)

The SBE 43 oxygen sensor uses a Clark polarographic element to provide in-situ measurements at depths up to 7,000 meters. Calibration stability is improved by an order of magnitude, and pressure hysterisis is largely eliminated in the upper ocean (1,000 m) compared with the previous oxygen sensor (SBE 13). Continuous polarization eliminates wait-time for stabilization after power-up. Signal resolution is increased by on-board temperature compensation. The oxygen sensor is also included in the path of pumped sea water. The oxygen sensor determines dissolved oxygen concentration by counting the number of oxygen molecules per second (flux) that diffuse through a membrane, where the permeability of the membrane to oxygen is a function of temperature and ambient pressure. Computation of dissolved oxygen in engineering units is done in SEASOFT software. The range for dissolved oxygen is 120% of surface saturation in all natural waters, nominal accuracy is 2% of saturation, and typical stability is 2% per 1,000 hours.

Pre-cruise sensor calibrations were performed at SBE, Inc. The following coefficients were used in SEASOFT:

S/N 0391 (Leg.1: primary, Leg.2: primary from 146_2 to WC7), 18 October 2005

Soc = 0.35440

Offset = –0.4919

TCor = 0.0013

PCor = 1.350e–04

S/N 0488 (Leg.1: secondary), 11 October 2005

Soc = 0.58120

Offset = –0.6959

TCor = –0.0004

PCor = 1.350e–04

S/N 0390 (Leg.2: primary from WC8 to 351_2, Leg.3: primary), 18 October 2005

Soc = 0.3877

Offset = –0.5151

TCor = 0.0012

PCor = 1.350e–04

S/N 0394 (Leg.2: secondary from 146_2 to 283_1, Leg.3: secondary), 1 July 2005

Soc = 0.3629

Offset = –0.5220

TCor = 0.0020

PCor = 1.350e–04

S/N 0205 (Leg.2: secondary from 285_1 to 351_2), 10 May 2005

Soc = 0.4131

Offset = –0.4688

TCor = –0.0009

PCor = 1.350e–04

Oxygen (ml/l) is computed as

$$\text{Oxygen (ml/l)} = \{\text{Soc} \times (v + \text{Offset})\} \times \exp(\text{TCor} \times t + \text{PCor} \times p) \times \text{Oxsat}(t, s)$$

$$\text{Oxsat}(t, s) = \exp[A_1 + A_2 \times (100 / t) + A_3 \times \ln(t / 100) + A_4 \times (t / 100)$$
$$+ s \times \{B_1 + B_2 \times (t / 100) + B_3 \times (t / 100) \times (t / 100)\}]$$

$A_1 = -173.4292$

$A_2 = 249.6339$

$A_3 = 143.3483$

$A_4 = -21.8482$

$B_1 = -0.033096$

$B_2 = -0.00170$

where p is pressure in dbar, t is absolute temperature, and s is salinity in psu. Oxsat is oxygen saturation value minus the volume of oxygen gas (STP) absorbed from humidity-saturated air.

Serial number 0488 is used in SBE's research for oxygen sensor membranes. This sensor has a membrane that is thicker than production SBE 43s. This thicker membrane will cause the sensor to respond more slowly than standard SBE 43s but it may be more stable. The field performance of this sensor is examined in the leg.1.

(4.5) Deep Ocean Standards Thermometer

Deep Ocean Standards Thermometer (SBE 35) is an accurate, ocean-range temperature sensor that can be standardized against Triple Point of Water and Gallium Melt Point cells and is also capable of measuring temperature in the ocean to depths of 6,800 m.

Temperature is determined by applying an AC excitation to reference resistances and an ultrastable aged thermistor with a drift rate of less than 0.001 °C/year. Each of the resulting outputs is digitized by a 20-bit A/D converter. The reference resistor is a hermetically sealed, temperature-controlled VISHAY. The switches are mercury wetted reed relays with a stable contact resistance. AC excitation and ratiometric comparison using a common processing channel removes measurement errors due to parasitic thermocouples, offset voltages, leakage currents, and gain errors. Maximum power dissipated in the thermistor is 0.5 μwatts, and contributes less than 200 μK of overheat error.

The SBE 35 communicates via a standard RS-232 interface at 300 baud, 8 bits, no parity. The SBE 35 can be used with the SBE 32 Carousel Water Sampler and SBE 911plus CTD system. The SBE 35 makes a temperature measurement each time a bottle fire confirmation is received, and stores the value in EEPROM. Calibration coefficients stored in EEPROM allow the SBE 35 to transmit data in engineering units. Commands can be sent to SBE 35 to provide status display, data acquisition setup, data retrieval, and diagnostic test by using terminal software.

Following the methodology used for standards-grade platinum resistance thermometers (SPRT), calibration of the SBE 35 is accomplished in two steps. The first step is to characterize and capture the non-linear resistance vs temperature response of the sensor. The SBE 35 calibrations are performed at SBE, Inc., in a low-gradient temperature bath and against ITS-90 certified SPRTs maintained at Sea-Bird's primary temperature metrology laboratory. The second step is frequent certification of the sensor by measurements in thermodynamic fixed-point cells. Triple point of water (TPW) and gallium melt point (GaMP) cells are appropriate for the SBE 35. The SBE 35 resolves temperature in the fixed-point cells to approximately 25 μK. Like SPRTs, the slow time drift of the SBE 35 is adjusted by a slope and offset correction to the basic non-linear calibration equation.

Pre-cruise sensor calibrations were performed at SBE, Inc. The following coefficients were stored in EEPROM:

S/N 0022 (Leg.1 and 2), 12 October 1999 (1st step: linearization)

$a_0 = 4.320725498e{-}3$

$a_1 = -1.189839279e{-}3$

$a_2 = 1.836299593e{-}3$

$a_3 = -1.032916769e{-}5$

$a_4 = 2.225491125e{-}7$

S/N 0045 (Leg.3), 27 October 2002 (1st step: linearization)

$a_0 = 5.84093815e{-}03$

$a_1 = -1.65529280e{-}03$

$a_2 = 2.37944937e{-}04$

$a_3 = -1.32611385e{-}05$

$a_4 = 2.83355203e{-}07$

Linearized temperature (ITS-90) is computed according to

Linearized temperature (ITS-90) =

$$1 / \{a_0 + a_1 \times [\ln(n)] + a_2 \times [\ln^2(n)] + a_3 \times [\ln^3(n)] + a_4 \times [\ln^4(n)]\} - 273.15$$

where n is the instrument output. Then the SBE 35 is certified by measurements in thermodynamic fixed-point cells of the TPW (0.0100°C) and GaMP (29.7646°C). The slow time drift of the SBE 35 is adjusted by periodic recertification corrections.

S/N 0022 (Leg.1 and 2), 30 September 2005 (2nd step: fixed point calibration)

Slope = 1.000036

Offset = 0.000151

S/N 0045 (Leg.3), 3 October 2005 (2nd step: fixed point calibration)

Slope = 1.000013

Offset = –0.001084

Temperature (ITS-90) is calibrated according to

Temperature (ITS-90) = Slope × Linearized temperature + Offset

The SBE 35 has a time constant of 0.5 seconds. The time required per sample = 1.1 × NCYCLES + 2.7 seconds. The 1.1 seconds is total time per an acquisition cycle. NCYCLES is the number of acquisition cycles per sample. The 2.7 seconds is required for converting the measured values to temperature and storing average in EEPROM. Root mean square (rms) temperature noise for a SBE 35 in a Triple Point of Water cell is typically expressed as 82 / NCYCLES$^{1/2}$ in μK. In this cruise NCYCLES was set to 4 and the rms noise is estimated to be 0.04 mK.

When using the SBE 911 system with SBE 35, the deck unit receives incorrect signal from the under water unit for confirmation of firing bottle #16. In order to correct the signal, a module (Yoshi Ver. 1; EMS Co. Ltd., Kobe, Hyogo, Japan) was used between the under water unit and the deck unit.

Time drift of the SBE 35 based on the fixed point calibrations is shown in Figure 3.1.5.

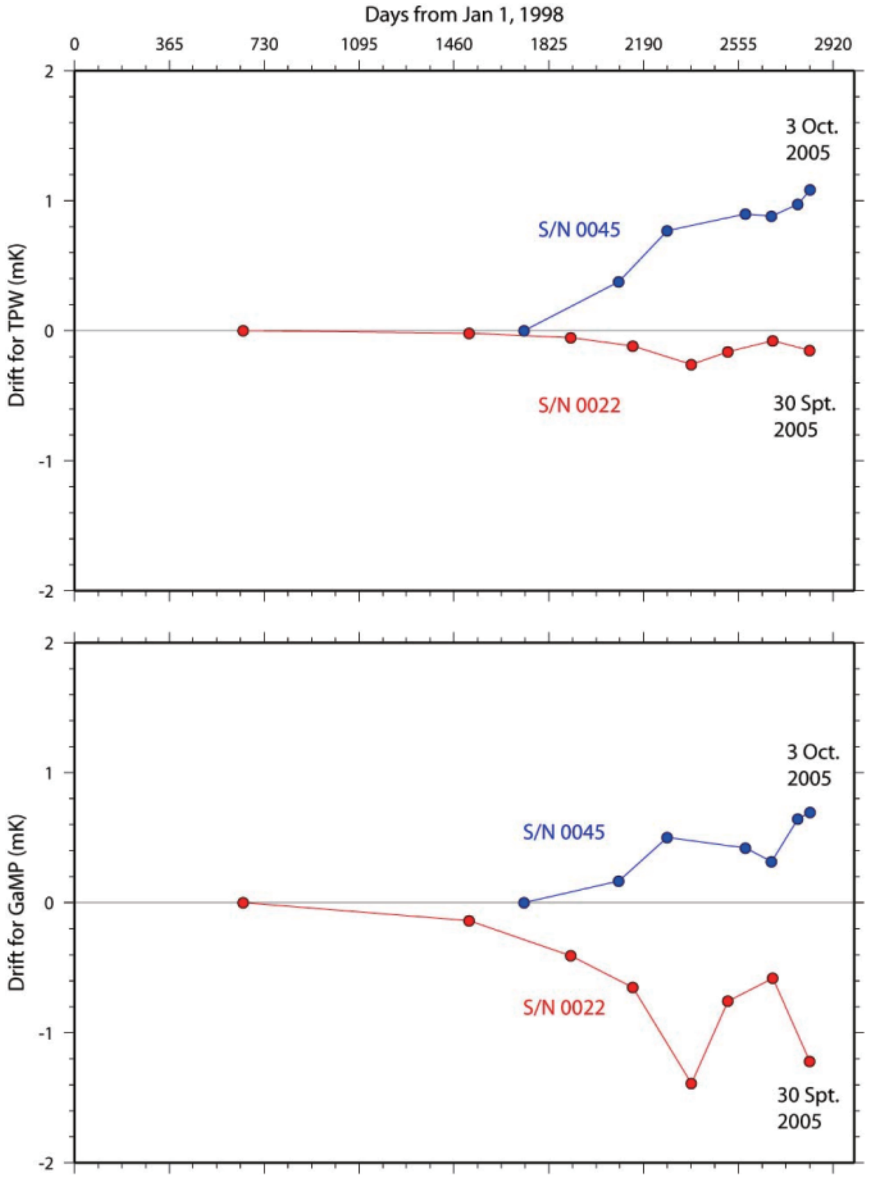


Figure 3.1.5. SBE35 time drift based on laboratory fixed point calibrations (triple point of water, TPW and gallium melt point, GaMP) performed by SBE, Inc.

(4.6) Altimeter

Benthos PSA-916T Sonar Altimeter (Teledyne Benthos, Inc.) determines the distance of the target from the unit by generating a narrow beam acoustic pulse and measuring the travel time for the pulse to bounce back from the target surface. The PSA-916T is the same as the standard PSA-916 Sonar Altimeter except it is housed in a corrosion-resistant titanium pressure case. It is O-ring-sealed and rated for operation in water depths up to 10,000 meters. In this unit, a 250 microseconds pulse at 200 kHz is transmitted 5 times in a second. The PSA-916T uses the nominal speed of sound of 1,500 m/s. Thus the unit itself, neglecting variations in the speed of sound, can be considered accurate to 5% or 0.1 meter, whichever is greater. In the PSA-916T the jitter of the detectors is approximately 5 microseconds or ± 0.4 cm total distance. Since the total travel time is divided by two, the jitter error is ±0.2 cm.

The following scale factors were used in SEASOFT:

S/N 1100, S/N 1157

FSVolt × 300 / FSRange = 15

Offset = 0.0

(4.7) Oxygen Optode

Oxygen Optode 3830 (Aanderaa Instruments AS) is based on the ability of selected substances to act as dynamic fluorescence quenchers. The fluorescent indicator is a special platinum porphyrine complex embedded in a gas permeable foil that is exposed to the surrounding water. A black optical isolation coating protects the complex from sunlight and fluorescent particles in the water. This sensing foil is attached to a sapphire window providing optical access for the measuring system from inside watertight titanium housing. The foil is excited by modulated blue light, and the phase of a returned red light is measured. By linearizing and temperature compensating, with an incorporated temperature sensor, the absolute O_2 concentration can be determined.

In order to use with the SBE 911plus CTD system, an analog adaptor (3966) is connected to the oxygen optode (3830). The analog adaptor is packed into titanium housing made by Alec Electronics Co. Ltd., Kobe, Hyogo, Japan (Figure 3.1.6). The sensor is designed to operate down to 6,000 meters and the titanium housing for the analog adaptor is designed to operate down to 7,000 meters. The range for dissolved oxygen is 120% of surface saturation in all natural waters, nominal accuracy is less than 5% of saturation, and setting time (68%) is shorter than 25 seconds.

The following scale factors were used in SEASOFT:

S/N 612

Phase shift (degrees) = $V_p \times 12 + 10$

Temperature (°C) = $V_t \times 9 - 5$

where V_p and V_t are voltage output (V) of phase shift and temperature, respectively.

Each batch of sensing foils is delivered with calibration data describing the behavior with respect to oxygen concentration and temperature.

Foil batch No. 4104 (S/N 612), 13 November 2004

$C0Coef_0$ = 3.199840e+3

$C0Coef_1$ = –1.119634e+2

$C0Coef_2$ = 2.408296

$C0Coef_3$ = –2.248740e–2

$C1Coef_0$ = –1.744936e+2

$C1Coef_1$ = 5.462500

$C1Coef_2$ = –1.244084e–1

$C1Coef_3$ = 1.239153e–3

$C2Coef_0$ = 3.941711

$C2Coef_1$ = –1.086677e–1

$C2Coef_2$ = 2.719394e–3

$C2Coef_3$ = –2.906343e–5

$C3Coef_0$ = –4.220910e–2

$C3Coef_1$ = 1.018155e–3

$\mathrm{C3Coef}_2 = -2.905609\mathrm{e}{-5}$

$\mathrm{C3Coef}_3 = 3.306610\mathrm{e}{-7}$

$\mathrm{C4Coef}_0 = 1.738870\mathrm{e}{-4}$

$\mathrm{C4Coef}_1 = -3.637668\mathrm{e}{-6}$

$\mathrm{C4Coef}_2 = 1.227403\mathrm{e}{-7}$

$\mathrm{C4Coef}_3 = -1.468399\mathrm{e}{-9}$

Temperature dependent coefficients are calculated as follows.

$$\mathrm{C0Coef} = \mathrm{C0Coef}_0 + \mathrm{C0Coef}_1 \times t + \mathrm{C0Coef}_2 \times t^2 + \mathrm{C0Coef}_3 \times t^3$$

$$\mathrm{C1Coef} = \mathrm{C1Coef}_0 + \mathrm{C1Coef}_1 \times t + \mathrm{C1Coef}_2 \times t^2 + \mathrm{C1Coef}_3 \times t^3$$

$$\mathrm{C2Coef} = \mathrm{C2Coef}_0 + \mathrm{C2Coef}_1 \times t + \mathrm{C2Coef}_2 \times t^2 + \mathrm{C2Coef}_3 \times t^3$$

$$\mathrm{C3Coef} = \mathrm{C3Coef}_0 + \mathrm{C3Coef}_1 \times t + \mathrm{C3Coef}_2 \times t^2 + \mathrm{C3Coef}_3 \times t^3$$

$$\mathrm{C4Coef} = \mathrm{C4Coef}_0 + \mathrm{C4Coef}_1 \times t + \mathrm{C4Coef}_2 \times t^2 + \mathrm{C4Coef}_3 \times t^3$$

where t is temperature (°C). The oxygen concentration can be calculated by use of the following formula.

$$O_2\ (\mu\mathrm{mol/l}) = \mathrm{C0Coef} + \mathrm{C1Coef} \times P + \mathrm{C2Coef} \times P^2 + \mathrm{C3Coef} \times P^3 + \mathrm{C4Coef} \times P^4$$

where P is phase shift (degrees) measured by the Optode. In addition to the above mentioned coefficient, phase measurement is calibrated for individual sensor and foil variations by a two point calibration (one in air saturated water and one in a zero-oxygen solution).

$$P = A + B \times P_b$$

where P is a calibrated phase shift (degrees) and P_b is a raw phase measurement. The coefficients A and B can be calculated by ordinary linear curve fitting and is delivered.

S/N 612, 20 September 2005

$A = -3.00536$

$B = 1.11847$

Outputs from the sensor are the raw phase shift (P_b) and temperature. The raw phase data was calibrated using above coefficients after data acquisition. The oxygen concentration was calculated using temperature data from the first responding CTD temperature sensor instead of temperature data from slow responding optode temperature sensor.

Since the sensing foil is only permeable to gas and not water, the optode can not sense the effect of salt dissolved in the water, hence the optode always measures as if immersed in fresh water. Therefore the oxygen concentration, μmol/l, was multiplied by the following factor.

$$\exp\{S(B_0 + B_1 \times T_S + B_2 \times T_S^{\,2} + B_3 \times T_S^{\,3}) + C_0 \times S^2\}$$

where S is salinity, T_S is scaled temperature ($= \ln\{(298.15 - t)/(273.15 + t)\}$), t is temperature (°C),

$B_0 = -6.24097\mathrm{e}{-3}$

$B_1 = -6.93498\mathrm{e}{-3}$

$B_2 = -6.90358\mathrm{e}{-3}$

$B_3 = -4.29155\mathrm{e}{-3}$

$C_0 = -3.11680\mathrm{e}{-7}$

The response of the sensing foil decreases to some extent with the ambient water pressure. Therefore the oxygen concentration was multiplied by the following factor.

$$(1 + 0.03 \times P_r / 1000)$$

where P_r is pressure in dbar. This factor (0.03) is empirically determined and different from that in the user's manual. (The factor was changed as 0.032 after analyzing the data obtained in this cruise.)

Figure 3.1.6. Oxygen Optode (3830) with analog adaptor (3966). The analog adaptor is packed into titanium housing made by Alec Electronics Co., Ltd.

(5) Data collection and processing

(5.1) Data collection

CTD measurements were made by using a SBE 9plus equipped with two pumped temperature-conductivity (TC) sensors. The TC pairs were monitored to check drift and shifts by examining the differences between the two pairs. A dissolved oxygen sensor was placed between the primary conductivity sensor module and the pump. Auxiliary sensors included Deep Ocean Standards Thermometer, altimeter and oxygen optode. The SBE 9plus was mounted horizontally in a 36-position carousel frame.

CTD system was powered on at least 30 minutes in advance of the data acquisition and was powered off at least two minutes after the operation in order to acquire pressure data on the ship's deck.

The package was lowered into the water from the starboard side and held 10 m beneath the surface for about one minute in order to activate the pump. After the pump was activated, the package was lifted to the surface and lowered at a rate of 1.0 m/s to 200 m (or 300 m when significant wave height is high) then the package was stopped in order to operate the heave compensator of the crane. The package was lowered again at a rate of 1.2 m/s to the bottom. The position of the package relative to the bottom was monitored by the altimeter reading. Also the bottom depth was monitored by the SEABEAM multi-narrow beam sounder on board. For the up cast, the package was lifted at a rate of 1.1 m/s except for bottle firing stops. At each bottle firing stops, the bottle was fired after waiting from the stop for 30 seconds and the package was stayed at least 5 seconds for measurement of the Deep Ocean Standards Thermometer. At 200 m (or 300 m) from the surface, the package was stopped in order to stop the heave compensator of the crane.

Water samples were collected using a 36-bottle SBE 32 Carousel Water Sampler with 12-litre Nisken-X bottles. Before a cast taken water for CFCs, the 36-bottle frame and Niskin-X bottles were wiped with acetone.

The SBE 11plus deck unit received the data signal from the CTD. Digitized data were forwarded to a personal computer running the SEASAVE data acquisition software. Temperature, conductivity, salinity, oxygen and descent rate profiles were displayed in real-time with the package depth and altimeter reading. Differences in temperature, salinity and oxygen between primary and secondary sensor were also displayed in order to monitor the status of the sensors.

Data acquisition software

SEASAVE-Win32, version 5.27b

(5.2) Data collection problems

Leg.1:

At following stations, trigger of the bottle was not released. Therefore the latch assembly was replaced after the cast.

33_1 (#12), 51_1 (#28), 116_1 (#36)

At station 38_1, bottle #19 did not trip correctly. It was found by temperature reading at dissolved oxygen sampling. Therefore the latch assembly was replaced after the cast.

At station 51_1, bottle #26 was not fired by missed operation.

After station 51_1, bottle #15 was changed from S/N X12006 to S/N X12009 due to frequent leak.

At following stations, output from the sensor showed abnormal values.

94_1, secondary sensors, 32-96 dbar (down cast)

114_1, secondary conductivity, 1,192-2,546 dbar (down cast)

118_1, primary conductivity, 1,391-1,438 dbar (down cast)

Leg.2:

At following stations, trigger of the bottle was not released. Therefore the latch assembly was replaced after the cast.

X14_1 (#17), 201_1 (#17), 203_1 (#10), 217_2 (#28), 231_1 (#26), 322_1 (#18), 351_2 (#14)

At following stations, bottle did not trip correctly. It was found by temperature reading at dissolved oxygen sampling. Therefore the latch assembly was replaced after the cast.

WC5_1 (#8), 291_1 (#20), 351_2 (21)

At following stations, bottle did not trip correctly. It was found by sampled water analysis.

185_1 (#17): The latch assembly was replaced after station 195_1.

WC2_1 (#1): The latch assembly was replaced after station WC5_1.

357_1 (#17): The bottle tripped before firing the bottle.

At station 217_2, bottle #36 was not fired by missed operation.

After station 267_1, bottle #23 was changed from S/N X12043 to S/N X12005.

At following stations, output from the sensor showed abnormal values.

146_2, secondary sensors

148_1, secondary sensors

WC7_1, primary sensors

328_1, primary sensors, 0-1,106 dbar (up cast), Jellyfish in primary TC duct

At station 299_1, the deck unit fuzed at 2,790 dbar of up cast. The system was re-started at the depth.

At station 347_1, system error occurred at 2,743-2,744 dbar of up cast by unknown reason.

For primary oxygen sensor S/N 0391, noise became large near surface (0-400 dbar) compared to the data obtained from the same sensor in leg 1. The sensor was bleached after stations 171_1, 209_1 and WC6_1. Noise became large again although it was improved after bleaching.

After station 197_1, the primary conductivity sensor was changed from S/N 3124 to S/N 2854, and the secondary conductivity sensor was also changed from S/N 3036 to S/N 3116, due to large time drift.

After station WC7_1, the primary oxygen sensor was changed from S/N 0391 to S/N 0390 due to shift and noise.

After station 283_1, the secondary oxygen sensor was changed from S/N 0394 to S/N 0205 due to small noise. But the noise was found in the secondary oxygen data after the sensor change as well. So the connecting cable for the secondary oxygen sensor after station 285_1. But the noise was found as well. At station 333_1, the connecting port was changed from AUX3 to AUX2 and the noise disappeared after that.

Leg.3:

At station 380_1, bottle #23 was not trip correctly. It was found by temperature reading at dissolved oxygen sampling. Therefore the latch assembly was replaced after the cast.

(5.3) Data processing

SEASOFT consists of modular menu driven routines for acquisition, display, processing, and archiving of oceanographic data acquired with SBE equipment, and is designed to work with a compatible personal computer. Raw data are acquired from instruments and are stored as unmodified data. The conversion module DATCNV uses instrument configuration and calibration coefficients to create a converted engineering unit data file that is operated on by all SEASOFT post processing modules. Each SEASOFT module that modifies the converted data file adds proper information to the header of the converted file permitting tracking of how the various oceanographic parameters were obtained. The converted data is stored in rows and columns of ASCII numbers. The last data column is a flag field used to mark scans as good or bad.

The following are the SEASOFT data processing module sequence and specifications used in the reduction of CTD data in this cruise.

Data processing software

SEASOFT-Win32, version 5.27b

DATCNV converted the raw data to scan number, pressure, depth, temperatures, conductivities, oxygen voltage, descent rate, altitude, and optode phase shift. DATCNV also extracted bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 4.4 seconds, and the offset was set to 0.0 seconds.

ROSSUM created a summary of the bottle data. The bottle position, date, and time were output as the first two columns. Scan number, pressure, depth, temperatures, conductivities, oxygen voltage, descent rate, altitude and optode phase shift were averaged over 4.4 seconds. And salinity, potential temperature, density (σ_0) and oxygen were computed.

ALIGNCTD converted the time-sequence of conductivity and oxygen sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. For a SBE 9plus CTD with the ducted temperature and conductivity sensors and a 3,000-rpm pump, the typical net advance of the conductivity relative to the temperature is 0.073 seconds. So, the SBE 11plus deck unit was set to advance the primary and the secondary conductivity for 1.73 scans (1.75/24 = 0.073 seconds). Oxygen data are also systematically delayed with respect to depth mainly because of the long time constant of the oxygen sensor and of an additional delay from the transit time of water in the pumped plumbing line. This delay was compensated by 6 seconds advancing oxygen sensor output (oxygen voltage) relative to the temperature. For the serial number 0488 that have thicker membrane than standard SBE 43s, the delay was compensated by 14 seconds. Oxygen optode data are also delayed by relatively slow response time of the sensor. The delay was compensated by 8 seconds advancing optode sensor output (phase shift and optode temperature) relative to the CTD temperature.

WILDEDIT marked extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1,000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1,000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to all variables.

CELLTM used a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

FILTER performed a low pass filter on pressure with a time constant of 0.15 seconds. In order to produce zero phase lag (no time shift) the filter runs forward first then backwards.

SECTION selected a time span of data based on scan number in order to reduce a file size. The minimum number was set to be the start time when the CTD package was beneath the sea-surface after activation of the pump. The maximum number was set to be the end time when the package came up from the surface. Data for estimation of the CTD pressure drift were prepared before SECTION.

LOOPEDIT marked scans where the CTD was moving less than the minimum velocity of 0.0 m/s (traveling backwards due to ship roll).

DERIVE was used to compute oxygen.

BINAVG averaged the data into 1-dbar pressure bins. The center value of the first bin was set equal to the bin size. The bin minimum and maximum values are the center value plus and minus half the bin size. Scans with pressures greater than the minimum and less than or equal to the maximum were averaged. Scans were interpolated so that a data record exist every dbar.

DERIVE was re-used to compute salinity, potential temperature, and density (σ_0).

SPLIT was used to split data into the down cast and the up cast.

For stations from 146_2 to 331_1 in Leg.2, small noise was found in the secondary oxygen data because the sensor connected to the port of AUX3. Therefore the sensor output (voltage) was low-pass filtered with a time constant of 1 second at the same time of the low-pass filtering for the pressure data mentioned above. At following stations, the noise could not be removed completely from down cast profile data.

X14_1: 5,650-5,800 dbar
201_1: 5,600-5,760 dbar
203_1: 5,710-5,850 dbar
205_1: 5,760-5,820 dbar
207_1: 5,660-5,860 dbar
213_1: 5,840-5,880 dbar
215_1: 5,750-5,920 dbar
217_1: 5,730-5,880 dbar

Remaining spikes in salinity or oxygen data were manually eliminated from the raw data or the 1-dbar-averaged data. When number of data in the 1-dbar-pressure bin was less than 10, the data of the bin was not used. The data gap over 1-dbar was linearly interpolated with a quality flag of 6.

For the oxygen optode data, the delay due to the long time constant was compensated by 8 seconds using the software module ALIGNCTD mentioned above. However it was found that the delay was dependent on temperature. So the delay was compensated advancing optode sensor output relative to the CTD temperature as a following function of temperature.

align (sec) = 25 × exp(–0.13 × t) (for $0 \le t \le 16.3$ °C)

align (sec) = 25 (for $t < 0$ °C)

align (sec) = 3 (for $t > 16.3$ °C)

where t is CTD temperature (°C).

(6) Post-cruise calibration

Post-cruise calibration is basically performed for each leg. However the cruise period of Leg.2 is longer than usual (53 days). So the data of Leg.2 is divided into two periods for the post-cruise calibration. In this section the two periods are called as Leg.2a (from station 146_2 to WC10_1) and Leg. 2b (from station 217_2 to 351_2).

(6.1) Pressure

The CTD pressure sensor offset in the period of the cruise is estimated from the pressure readings on the ship deck. For best results the Paroscientific sensor has to be powered for at least 10 minutes before the operation and carefully temperature equilibrated. Therefore CTD system was powered on for 30 minutes in advance of the data acquisition (from 55_1, Leg.1). In order to get the calibration data for the pre- and post-cast pressure sensor drift, the CTD deck pressure is averaged over first and last one minute, respectively. Then the atmospheric pressure deviation from a standard atmospheric pressure (14.7 psi) is subtracted from the CTD deck pressure. The atmospheric pressure was measured at the captain deck (20 m high from the base line) and sub-sampled one-minute interval as a meteorological data. Time series of the CTD deck pressure is shown in from Figure 3.1.7 to Figure 3.1.10.

The CTD pressure sensor offset is estimated from the deck pressure obtained above. Mean of the pre- and the post-casts data over the whole period gave an estimation of the pressure sensor offset from the pre-cruise calibration. Mean residual pressure between the dead-weight piston gauge and the calibrated CTD data at 0 dbar of the pre-cruise calibration is subtracted from the mean deck pressure. Estimated offset of the pressure data is summarized in Table 3.1.1. The post-cruise correction of the pressure data is not deemed necessary for the pressure sensor.

Table 3.1.1. Offset of the pressure data. Mean and standard deviation are calculated from time series of the average of the pre- and the post-cast deck pressures.

Leg	S/N	Mean deck Pressure (dbar)	Standard deviation (dbar)	Residual pressure (dbar)	Estimated offset (dbar)
Leg.1	0677	–0.53	0.03	0.03	–0.56
Leg.2a	0677	–0.54	0.03	0.03	–0.57
Leg.2b	0677	–0.53	0.02	0.03	–0.56
Leg.3	0677	–0.49	0.02	0.03	–0.52

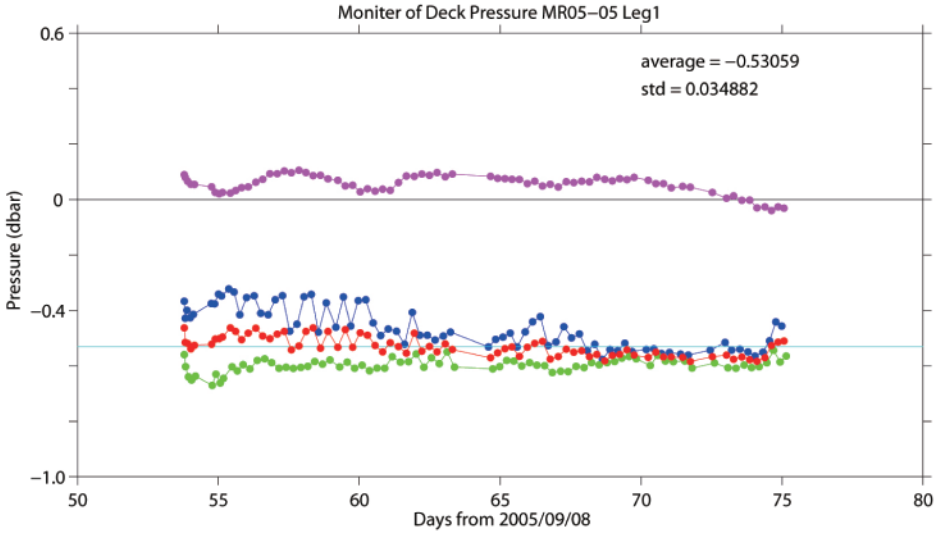


Figure 3.1.7. Time series of the CTD deck pressure for Leg.1. Pink dot indicates atmospheric pressure anomaly. Blue and green dots indicate pre- and post-cast deck pressures, respectively. Red dot indicates an average of the pre- and the post-cast deck pressures.

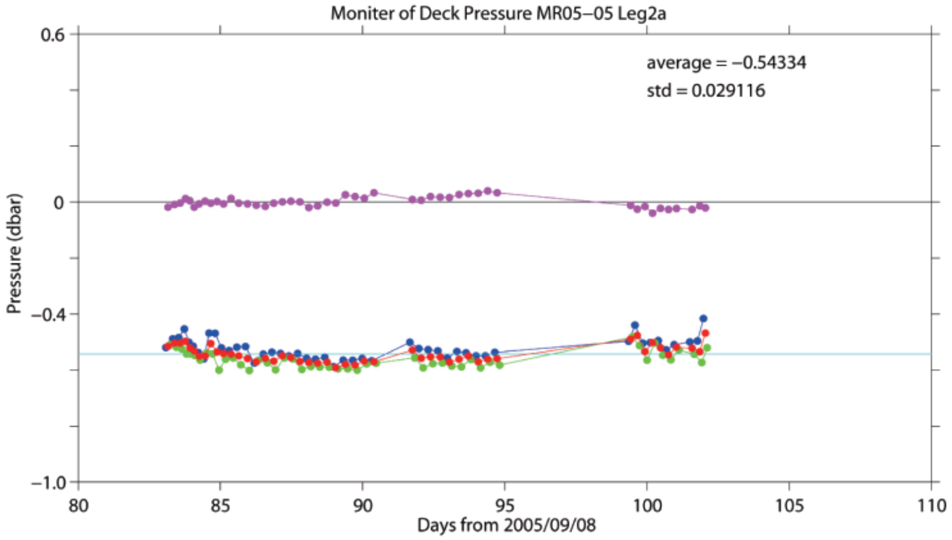


Figure 3.1.8. Same as Figure 3.1.7, but for Leg.2a.

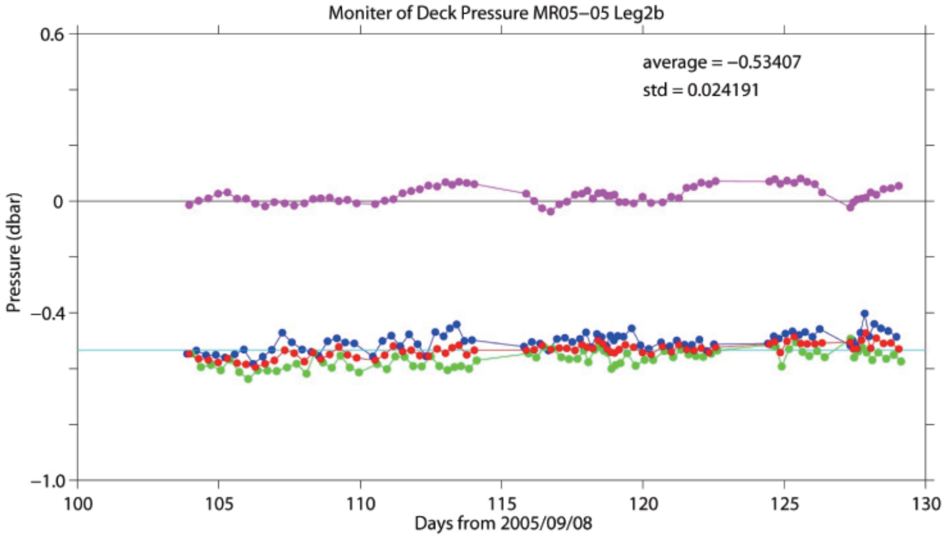


Figure 3.1.9. Same as Figure 3.1.7, but for Leg.2b.

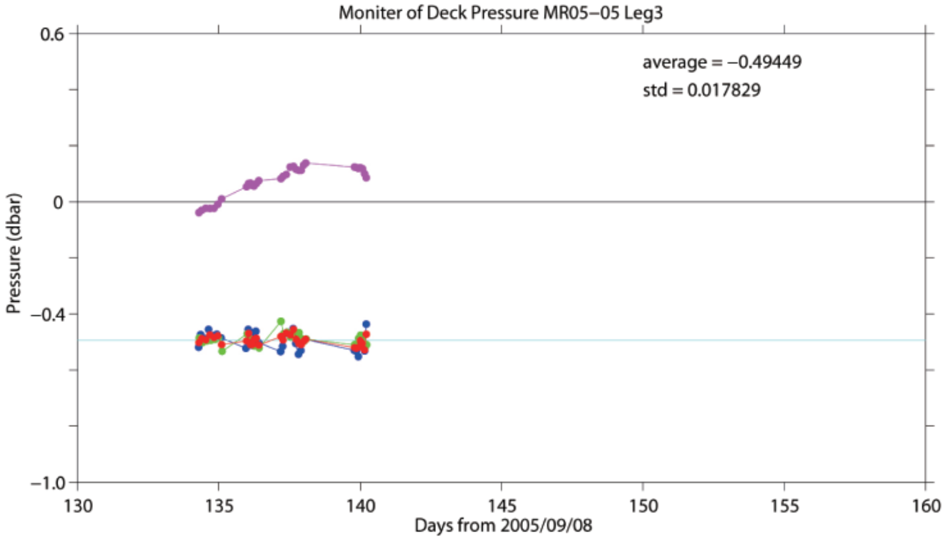


Figure 3.1.10. Same as Figure 3.1.7, but for Leg.3.

(6.2) Temperature

The CTD temperature sensors (SBE 3) were calibrated with the SBE 35 under the assumption that discrepancies between SBE 3 and SBE 35 data were due to pressure sensitivity, the viscous heating effect, and time drift of the SBE 3, according to a method by Uchida et al. (2007).

Post-cruise sensor calibrations for the SBE 35 were performed at SBE, Inc.

S/N 0022, 1 February 2006 (2nd step: fixed point calibration)

Slope = 1.000034

Offset = 0.000038

S/N 0045, 21 February 2006 (2nd step: fixed point calibration)

Slope = 1.000009

Offset = –0.001109

Offset of the SBE 35 (S/N 0022) data from the pre-cruise calibration is estimated to be 0.1 mK for temperature less than 4°C. So the post-cruise correction of the SBE 35 temperature data is not deemed necessary for the SBE 35.

The CTD temperature is calibrated as

Calibrated temperature = $T - (c_0 \times P + c_1 \times t + c_2)$

where T is CTD temperature in °C, P is pressure in dbar, t is time in days from pre-cruise calibration date of CTD temperature and c_0, c_1, and c_2 are calibration coefficients. The best fit sets of coefficients are determined by minimizing the sum of absolute deviation from the SBE 35 data. The MATLAB® function FMINSEARCH is used to determine the sets.

The calibration is performed for the CTD data created by the software module ROSSUM. The deviation of CTD temperature from the SBE 35 temperature at depth shallower than 2,000 dbar is large for determining the coefficients with sufficient accuracy since the vertical temperature gradient is too large in the regions. So the coefficients are determined using the data for the depth deeper than 1,950 dbar. For Leg.3 the calibration coefficients determined for Leg.2b are used for the calibration because the maximum pressure of the CTD casts is shallower than 2,000 dbar in Leg.3.

Finally following temperature data are used for the data set in consideration for the data quality.

Leg.1: secondary (S/N 4216) except for 94_1 and 114_1
primary (S/N 1464) for 94_1 and 114_1
Leg.2: primary (S/N 4216) except for WC7_1 and 328_1
secondary (S/N 1525) for WC7_1 and 328_1
Leg.3: primary (S/N 4216)

The number of data used for the calibration and the mean absolute deviation from the SBE 35 are listed in Table 3.1.2 and the calibration coefficients are listed in Table 3.1.3. The results of the post-cruise calibration for the CTD temperature are summarized in Table 3.1.4 and shown in from Figure 3.1.11 to Figure 3.1.17.

Table 3.1.2. Number of data used for the calibration (pressure ≥ 1,950 dbar) and mean absolute deviation (ADEV) between the CTD temperature and the SBE 35.

Leg	S/N	Number of data	ADEV (mK)	Note
Leg.1	1464	976	0.10	for 94_1, 114_1
	4216	976	0.10	
Leg.2a	4216	672	0.12	
	1525	661	0.10	for WC7_1
Leg.2b	4216	1070	0.14	
	1525	1070	0.11	for 328_1

Table 3.1.3. Calibration coefficients for the CTD temperature sensors.

Leg	S/N	c_0 (°C/dbar)	c_1 (°C/day)	c_2 (°C)
Leg.1	1464	–1.090e–7	1.3833e–5	–0.34e–3
	4216	1.8917e–8	–4.1245e–6	0.55e–3
Leg.2a	4216	–3.9923e–9	–1.1221e–6	0.70e–3
	1525	1.0202e–9	–5.4892e–6	0.84e–3
Leg.2b	4216	–7.2153e–9	1.0834e–5	–0.65e–3
	1525	2.7008e–9	1.8342e–6	–0.07e–3
Leg.3	4216	Same as Leg.2b	Same as Leg.2b	Same as Leg.2b

Table 3.1.4. Difference between the CTD temperature and the SBE 35 after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 1,950 dbar. Number of data used (Num) is also shown.

Leg	S/N	Pressure ≥ 1,950 dbar			Pressure < 1,950 dbar		
		Num	Mean (mK)	Sdev (mK)	Num	Mean (mK)	Sdev (mK)
Leg.1	1464	976	–0.01	0.14	1392	–0.57	4.3
	4216	976	–0.01	0.14	1392	–0.13	4.0
Leg.2a	4216	672	0.02	0.17	888	–0.04	4.6
	1525	661	–0.00	0.17	872	0.16	5.5
Leg.2b	4216	1070	–0.00	0.18	1407	–0.11	4.3
	1525	1070	–0.01	0.15	1421	–0.21	4.4
Leg.3	4216	–	–	–	332	–0.59	5.5

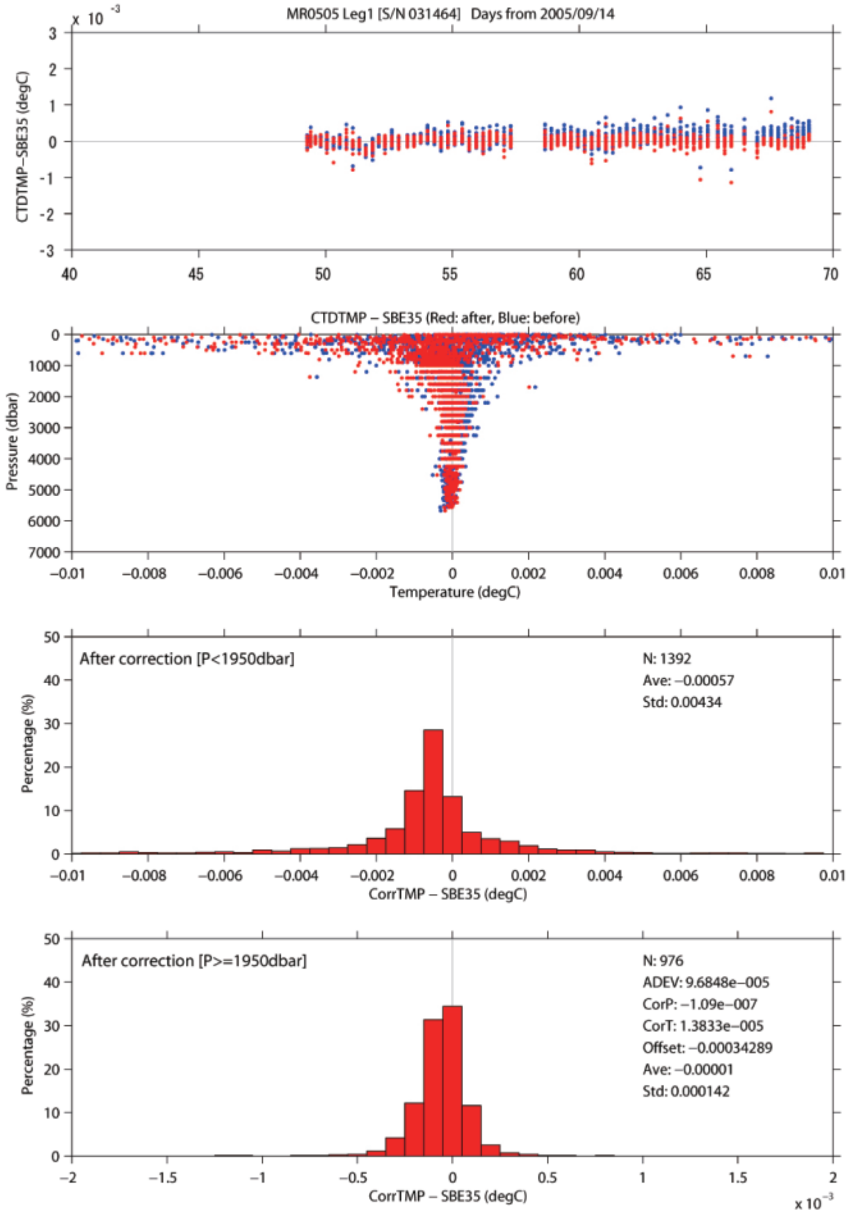


Figure 3.1.11. Difference between the CTD temperature (primary) and the SBE 35 for Leg.1. Blue and red dots indicate before and after the post-cruise calibration using the SBE 35 data, respectively. Top panel shows for P ≥ 1950 dbar. Lower two panels show histogram of the difference after the calibration.

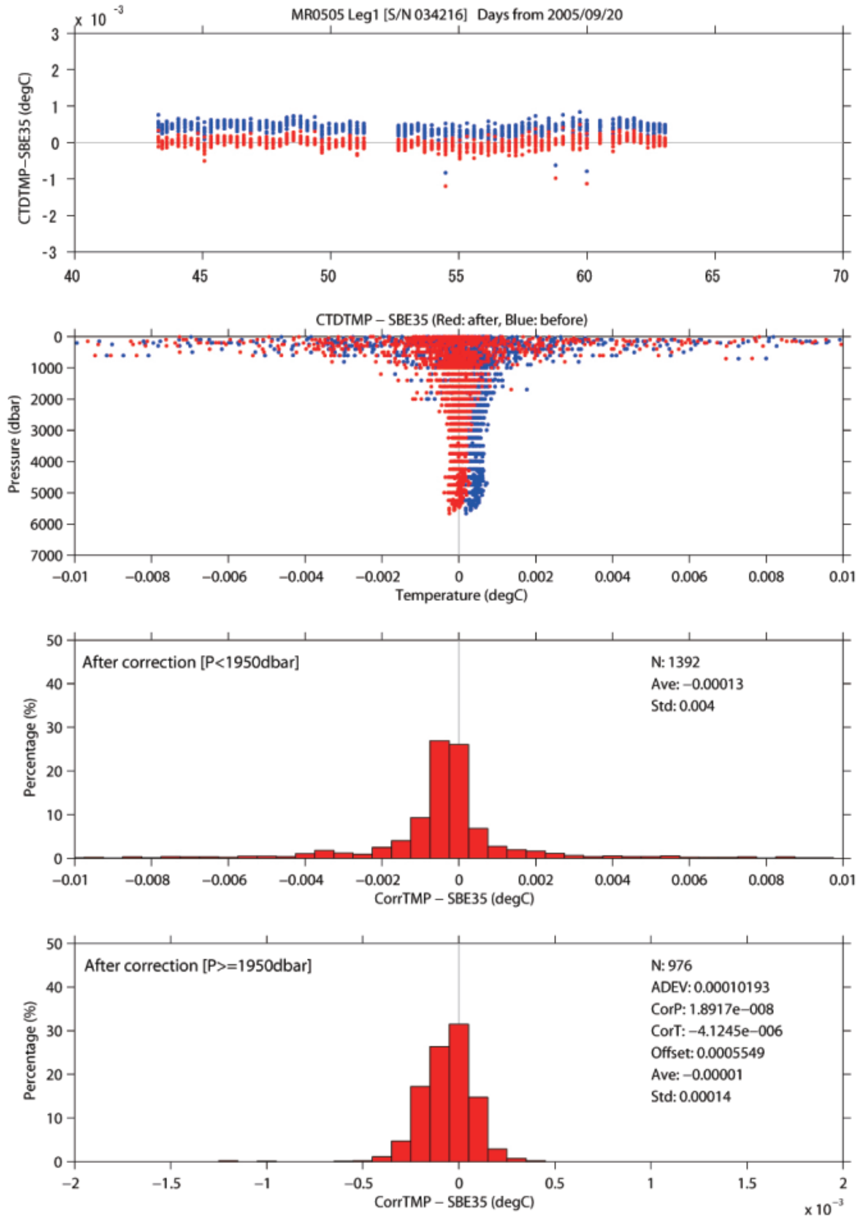


Figure 3.1.12. Same as Figure 3.1.11, but for the secondary CTD temperature for Leg.1.

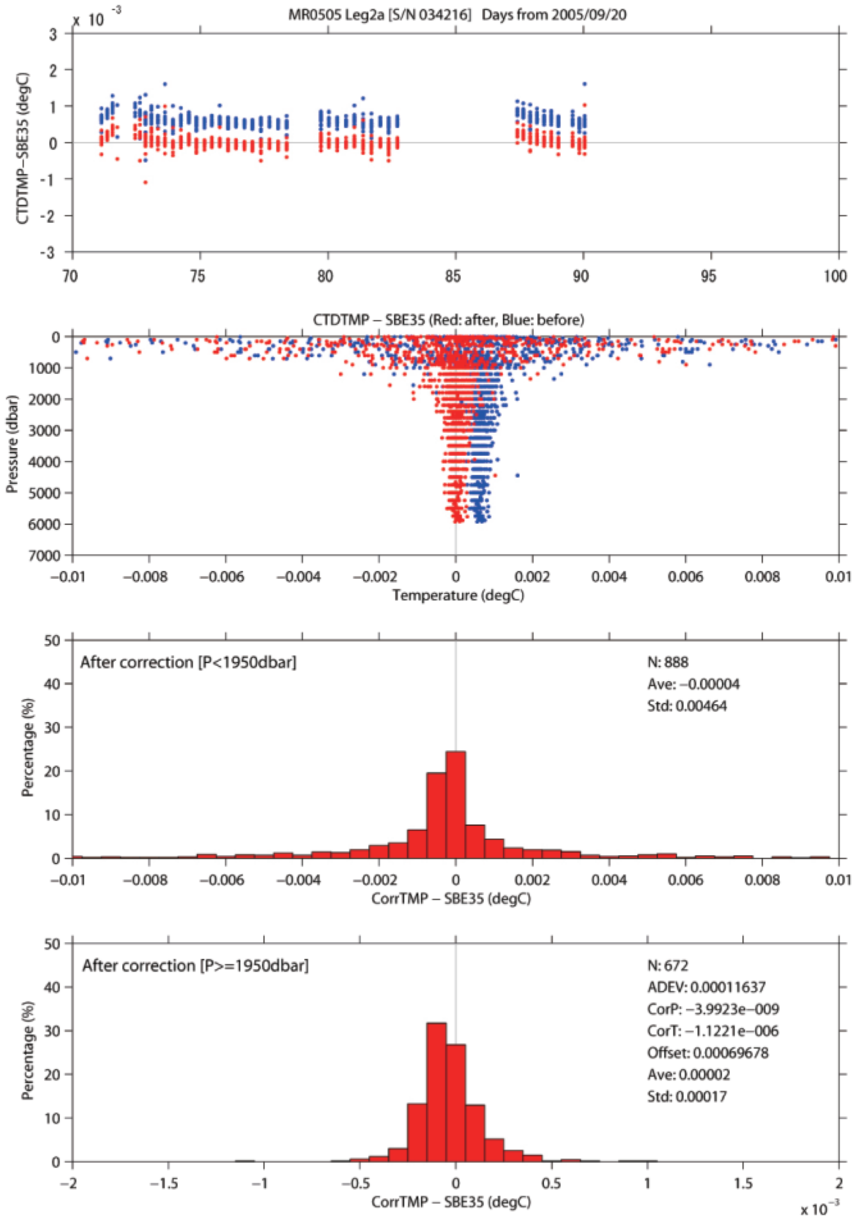


Figure 3.1.13. Same as Figure 3.1.11, but for the primary CTD temperature for Leg.2a.

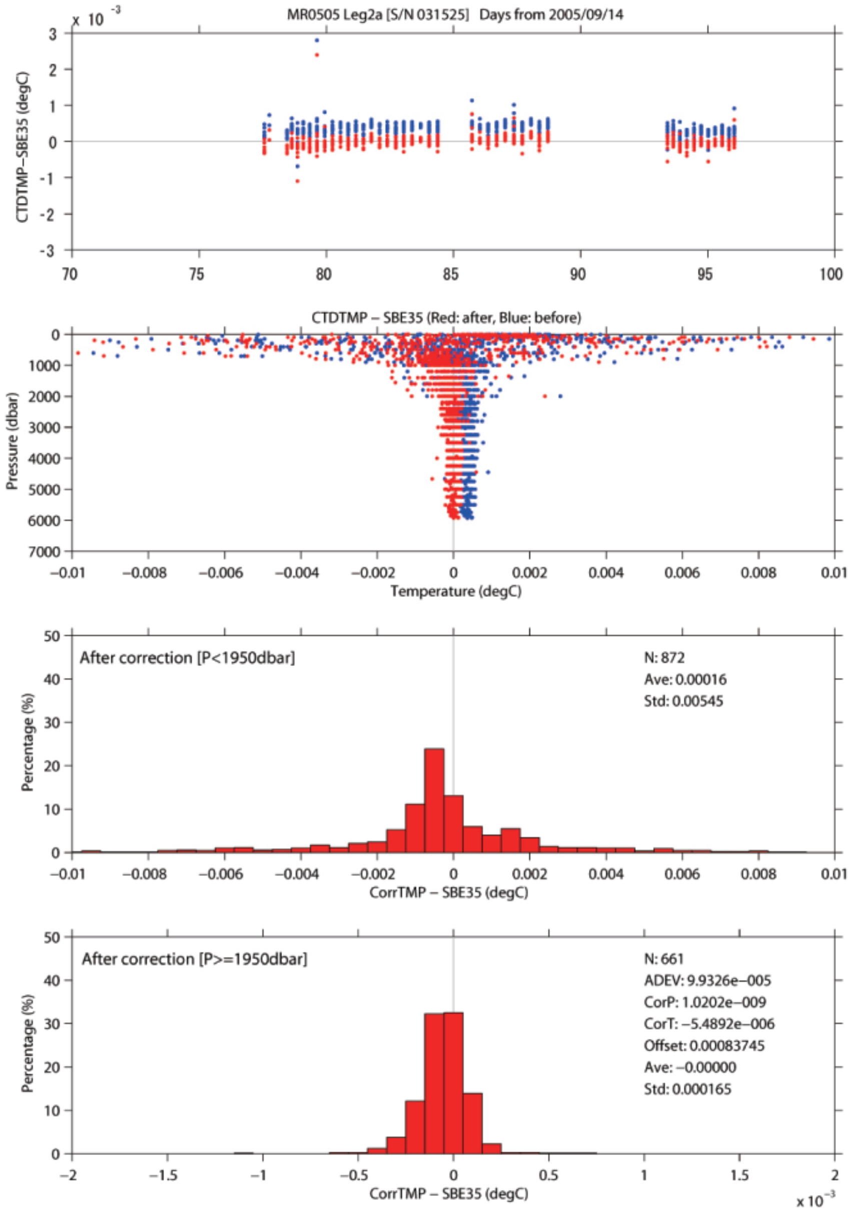


Figure 3.1.14. Same as Figure 3.1.11, but for the secondary CTD temperature for Leg.2a.

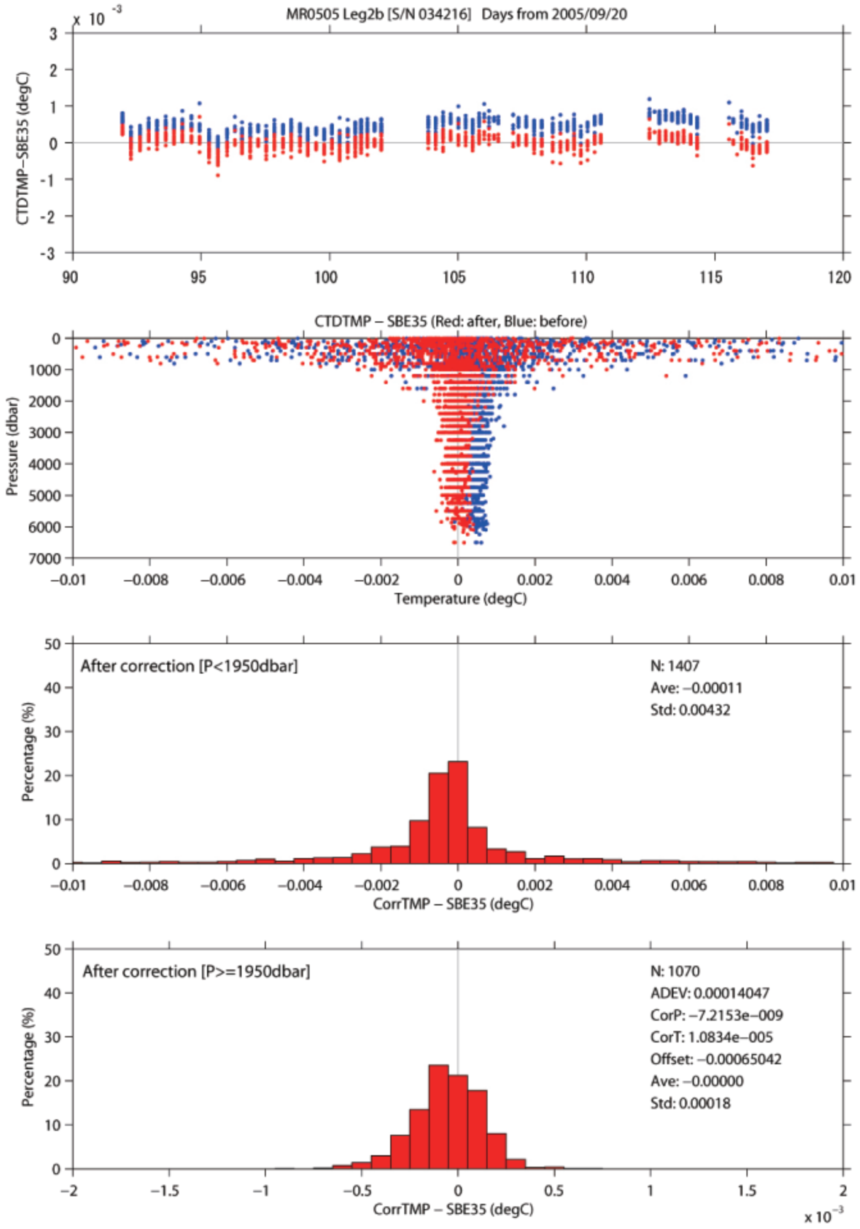


Figure 3.1.15. Same as Figure 3.1.11, but for the primary CTD temperature for Leg.2b.

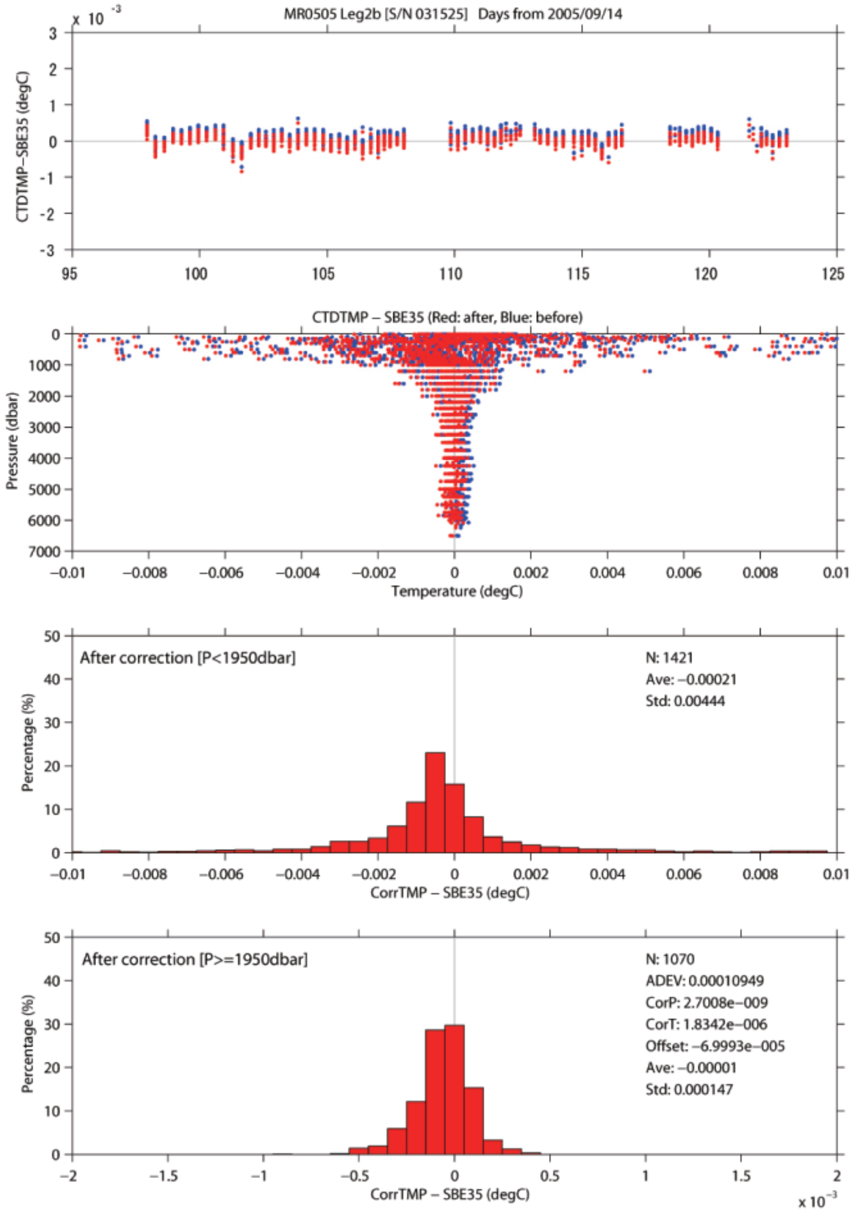


Figure 3.1.16. Same as Figure 3.1.11, but for the secondary CTD temperature for Leg.2b.

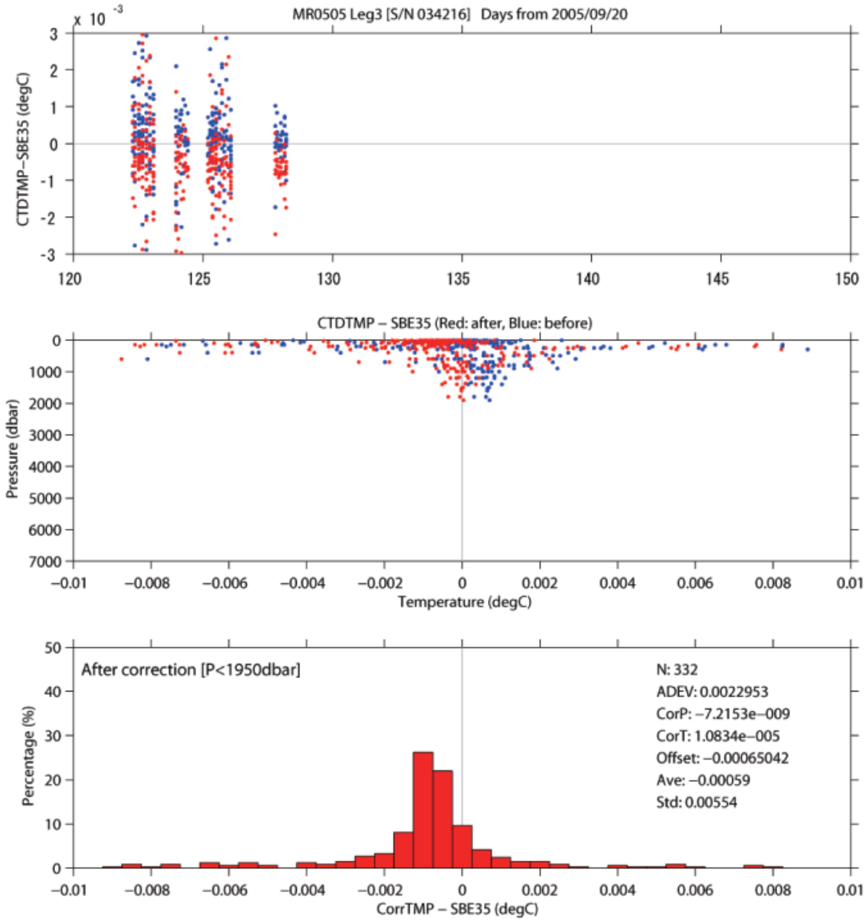


Figure 3.1.17. Same as Figure 3.1.11, but for the primary CTD temperature for Leg.3. Top and bottom panels show for full pressure range.

(6.3) Salinity

The discrepancy between the CTD salinity and the bottle salinity is considered to be a function of conductivity and pressure. The CTD salinity is calibrated as

$$\text{Calibrated salinity} = S - (c_0 \times P + c_1 \times C + c_2 \times C \times P + c_3)$$

where S is CTD salinity, P is pressure in dbar, C is conductivity in S/m and c_0, c_1, c_2 and c_3 are calibration coefficients. The best fit sets of coefficients are determined by minimizing the sum of absolute deviation with a weight from the bottle salinity data. The MATLAB® function FMINSEARCH is used to determine the sets. The weight is given as a function of vertical salinity gradient and pressure as

$$\text{Weight} = \min[4, \exp\{\log(4) \times \text{Gr} / \text{Grad}\}] \times \min[4, \exp\{\log(4) \times \text{P}^2 / \text{PR}^2\}]$$

where Grad is vertical salinity gradient in PSU dbar^{-1}, and P is pressure in dbar. Gr and PR are threshold of the salinity gradient (0.5 mPSU dbar^{-1}) and pressure (1,000 dbar), respectively. When salinity gradient is small (large) and pressure is large (small), the weight is large (small) at maximum (minimum) value of 16 (1). The salinity gradient is calculated using up-cast CTD salinity data. The up-cast CTD salinity data is low-pass filtered with a 3-point (weights are 1/4, 1/2, 1/4) triangle filter before the calculation.

Finally salinity data derived from following conductivity sensor are used for the data set in consideration for the data quality.

Leg.1: secondary (S/N 2854) except for 94_1 and 114_1
primary (S/N 1203) for 94_1 and 114_1
Leg.2: primary (S/N 3124 and S/N 2854) except for WC7_1 and 328_1
secondary (S/N 3116) for WC7_1 and 328_1
Leg.3: primary (S/N 2854)

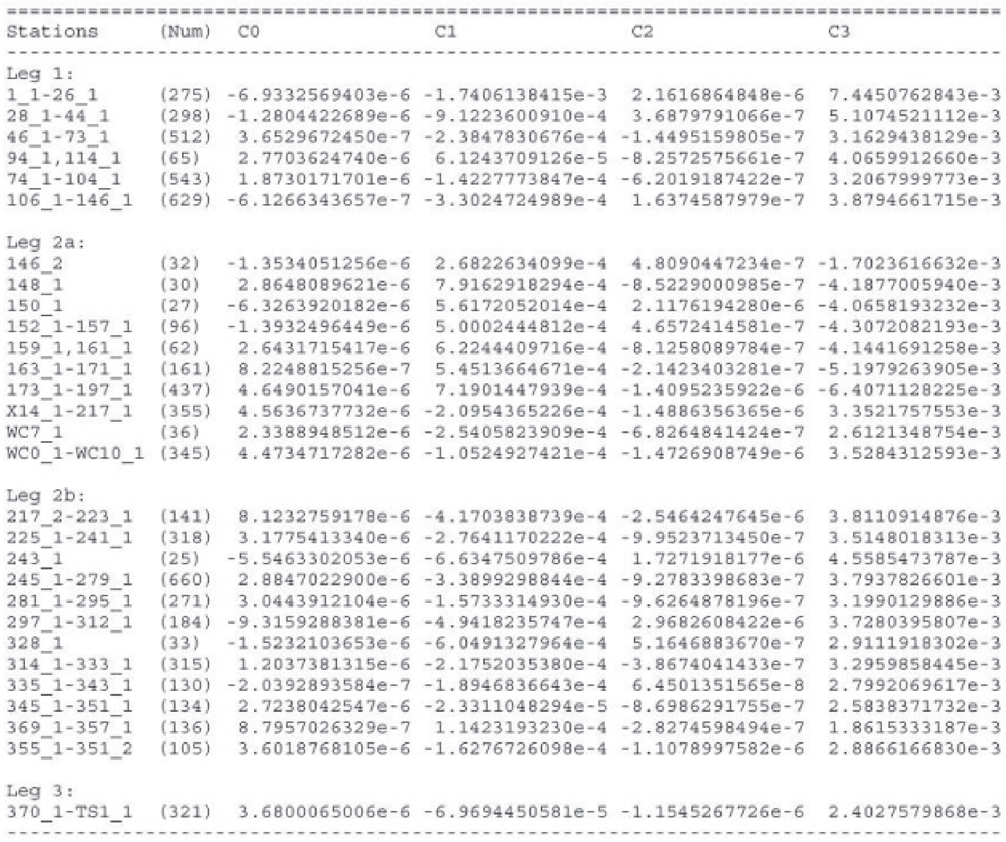
The CTD data created by the software module ROSSUM are used after the post-cruise calibration for the CTD temperature.

The coefficients are determined for some groups of the CTD stations. The results of the post-cruise calibration for the CTD salinity are summarized in Table 3.1.5 and shown in from Figure 3.1.18 to Figure 3.1.21. And the calibration coefficients and the number of the data used for the calibration are listed in Table 3.1.6.

Table 3.1.5. Difference between the CTD salinity and the bottle salinity after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 950 dbar. Number of data used (Num) is also shown.

Leg	Pressure ≥ 950 dbar			Pressure < 950 dbar		
	Num	Mean (mPSU)	Sdev (mPSU)	Num	Mean (mPSU)	Sdev (mPSU)
Leg.1	1320	0.01	0.32	1002	0.06	6.36
Leg.2a	920	–0.02	0.34	656	0.72	5.89
Leg.2b	1422	–0.02	0.36	1025	0.67	3.16
Leg.3	25	–0.04	0.41	296	–0.17	1.86

Table 3.1.6. Calibration coefficients for the CTD salinity. Number of data used (Num) is also shown.



```
===================================================================================
Stations      (Num)  C0                C1                C2                C3
-----------------------------------------------------------------------------------
Leg 1:
1_1-26_1      (275) -6.9332569403e-6 -1.7406138415e-3  2.1616864848e-6  7.4450762843e-3
28_1-44_1     (298) -1.2804422689e-6 -9.1223600910e-4  3.6879791066e-7  5.1074521112e-3
46_1-73_1     (512)  3.6529672450e-7 -2.3847830676e-4 -1.4495159805e-7  3.1629438129e-3
94_1,114_1    (65)   2.7703624740e-6  6.1243709126e-5 -8.2572575661e-7  4.0659912660e-3
74_1-104_1    (543)  1.8730171701e-6 -1.4227773847e-4 -6.2019187422e-7  3.2067999773e-3
106_1-146_1   (629) -6.1266343657e-7 -3.3024724989e-4  1.6374587979e-7  3.8794661715e-3

Leg 2a:
146_2         (32)  -1.3534051256e-6  2.6822634099e-4  4.8090447234e-7 -1.7023616632e-3
148_1         (30)   2.8648089621e-6  7.9162918294e-4 -8.5229000985e-7 -4.1877005940e-3
150_1         (27)  -6.3263920182e-6  5.6172052014e-4  2.1176194280e-6 -4.0658193232e-3
152_1-157_1   (96)  -1.3932496449e-6  5.0002444812e-4  4.6572414581e-7 -4.3072082193e-3
159_1,161_1   (62)   2.6431715417e-6  6.2244409716e-4 -8.1258089784e-7 -4.1441691258e-3
163_1-171_1   (161)  8.2248815256e-7  5.4513664671e-4 -2.1423403281e-7 -5.1979263905e-3
173_1-197_1   (437)  4.6490157041e-6  7.1901447939e-4 -1.4095235922e-6 -6.4071128225e-3
X14_1-217_1   (355)  4.5636737732e-6 -2.0954365226e-4 -1.4886356365e-6  3.3521757553e-3
WC7_1         (36)   2.3388948512e-6 -2.5405823909e-4 -6.8264841424e-7  2.6121348754e-3
WC0_1-WC10_1  (345)  4.4734717282e-6 -1.0524927421e-4 -1.4726908749e-6  3.5284312593e-3

Leg 2b:
217_2-223_1   (141)  8.1232759178e-6 -4.1703838739e-4 -2.5464247645e-6  3.8110914876e-3
225_1-241_1   (318)  3.1775413340e-6 -2.7641170222e-4 -9.9523713450e-7  3.5148018313e-3
243_1         (25)  -5.5463302053e-6 -6.6347509786e-4  1.7271918177e-6  4.5585473787e-3
245_1-279_1   (660)  2.8847022900e-6 -3.3899298844e-4 -9.2783398683e-7  3.7937826601e-3
281_1-295_1   (271)  3.0443912104e-6 -1.5733314930e-4 -9.6264878196e-7  3.1990129886e-3
297_1-312_1   (184) -9.3159288381e-6 -4.9418235747e-4  2.9682608422e-6  3.7280395807e-3
328_1         (33)  -1.5232103653e-6 -6.0491327964e-4  5.1646883670e-7  2.9111918302e-3
314_1-333_1   (315)  1.2037381315e-6 -2.1752035380e-4 -3.8674041433e-7  3.2959858445e-3
335_1-343_1   (130) -2.0392893584e-7 -1.8946836643e-4  6.4501351565e-8  2.7992069617e-3
345_1-351_1   (134)  2.7238042547e-6 -2.3311048294e-5 -8.6986291755e-7  2.5838371732e-3
369_1-357_1   (136)  8.7957026329e-7  1.1423193230e-4 -2.8274598494e-7  1.8615333187e-3
355_1-351_2   (105)  3.6018768105e-6 -1.6276726098e-4 -1.1078997582e-6  2.8866166830e-3

Leg 3:
370_1-TS1_1   (321)  3.6800065006e-6 -6.9694450581e-5 -1.1545267726e-6  2.4027579868e-3
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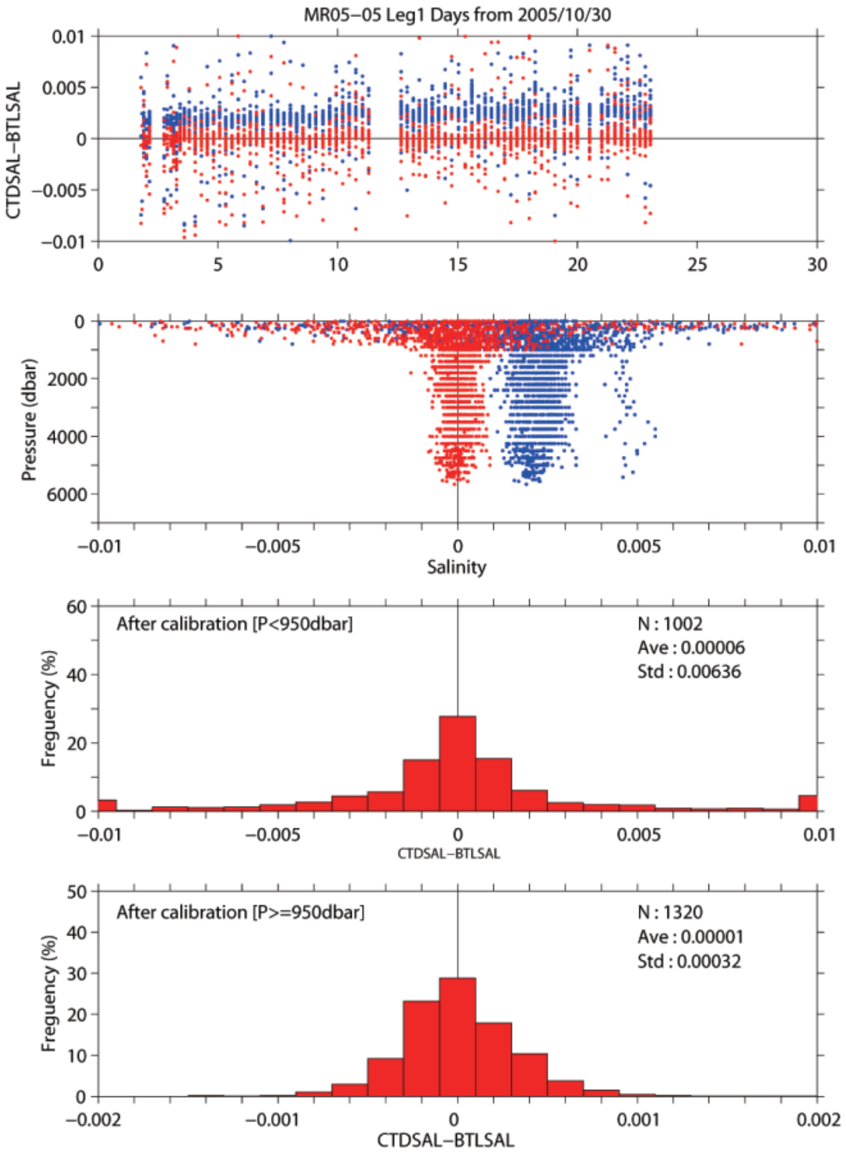

Figure 3.1.18. Difference between the CTD salinity and the bottle salinity for Leg.1. Blue and red dots indicate before and after the post-cruise calibration using the bottle salinity data, respectively. Top panel shows for P ≥ 950 dbar. Lower two panels show histogram of the difference after the calibration.

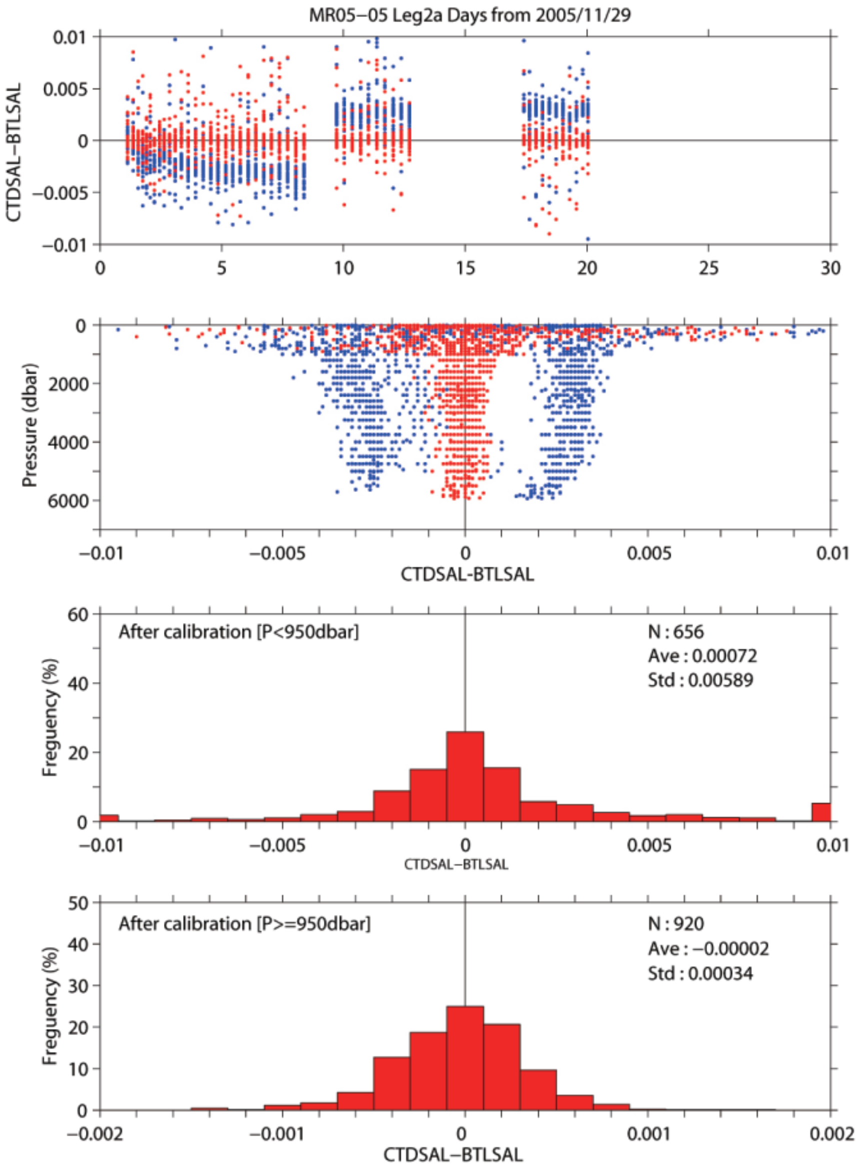

Figure 3.1.19. Same as Figure 3.1.18, but for Leg.2a.

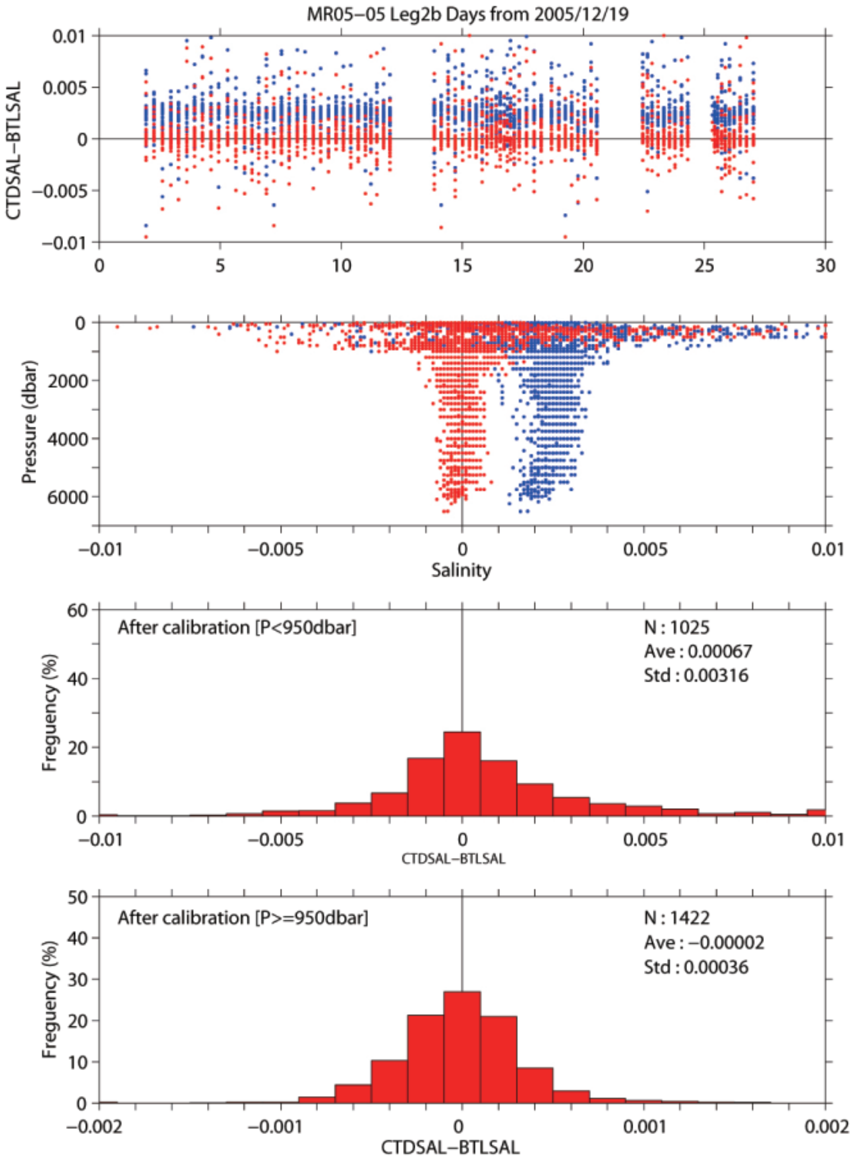

Figure 3.1.20. Same as Figure 3.1.18, but for Leg.2b.

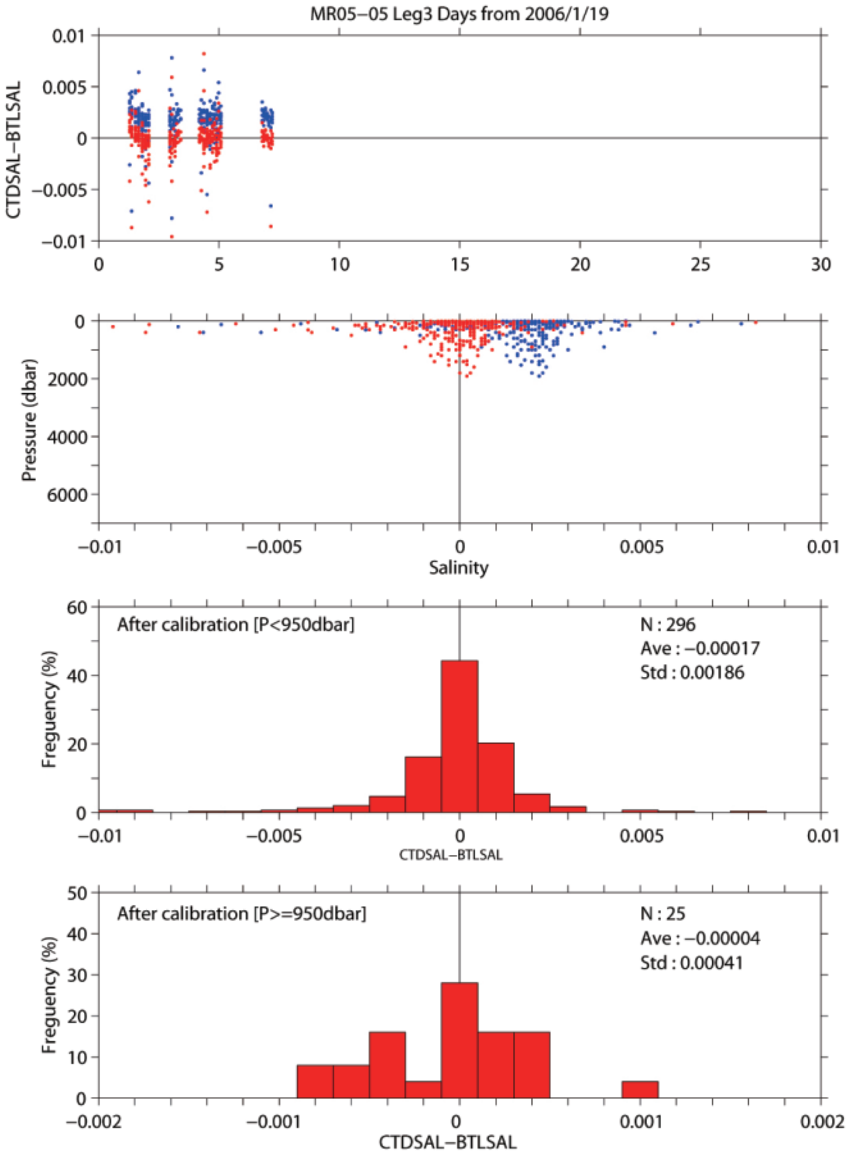

Figure 3.1.21. Same as Figure 3.1.18, but for Leg.3. Top panel shows for full pressure range.

(6.4) Oxygen (SBE 43)

The CTD oxygen is calibrated using the oxygen model as

Calibrated oxygen (ml/l)

$$= \{(Soc+dSoc) \times \{v+offset+doffset\} \times \exp\{(TCor+dTCor) \times t + (PCor+dPCor) \times p\}\}$$

$$\times Oxsat(t, s)$$

where p is pressure in dbar, t is absolute temperature and s is salinity in psu. Oxsat is oxygen saturation value minus the volume of oxygen gas (STP) absorbed from humidity-saturated air. Soc, offset, TCor and PCor are the pre-cruise calibration coefficients and dSoc, doffset, dTCor and dPCor are calibration coefficients. The best fit sets of coefficients are determined by minimizing the sum of absolute deviation with a weight from the bottle oxygen data. The MATLAB® function FMINSEARCH is used to determine the sets. The weight is given as a function of vertical oxygen gradient and pressure as

$$Weight = \min[4, \exp\{\log(4) \times Gr / Grad\}] \times \min[4, \exp\{\log(4) \times P^2 / PR^2\}]$$

where Grad is vertical oxygen gradient in μmol kg^{-1} dbar^{-1}, and P is pressure in dbar. Gr and PR are threshold of the oxygen gradient (0.3 μmol kg^{-1} dbar^{-1}) and pressure (1,000 dbar), respectively. When oxygen gradient is small (large) and pressure is large (small), the weight is large (small) at maximum (minimum) value of 16 (1). The oxygen gradient is calculated using down-cast CTD oxygen data. The down-cast CTD oxygen data is low-pass filtered with a 3-point (weights are 1/4, 1/2, 1/4) triangle filter before the calculation.

Finally oxygen data derived from following oxygen sensor are used for the data set in consideration for the data quality.

Leg.1: primary (S/N 0391)

Leg.2: primary (S/N 0391) for 146_2 and 148_1

secondary (S/N 0394) from 150_1 to WC8_1

primary (S/N 0390) from WC9_1 to 351_2

Leg.3: primary (S/N 0390)

The down-cast CTD data sampled at same density of the up-cast CTD data created by the software module ROSSUM are used after the post-cruise calibration for the CTD temperature and salinity.

The coefficients are basically determined for each station. Some stations, especially for shallow stations, are grouped for determining the calibration coefficients. The results of the post-cruise calibration for the CTD oxygen are summarized in Table 3.1.7 and shown in from Figure 3.1.22 to Figure 3.1.5.19. And the calibration coefficients and number of the data used for the calibration are listed in Table 3.1.8.

Table 3.1.7. Difference between the CTD oxygen and the bottle oxygen after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 950 dbar. Number of data used (Num) is also shown.

Leg	Pressure ≥ 950 dbar			Pressure < 950 dbar		
	Num	Mean (μmol/kg)	Sdev (μmol/kg)	Num	Mean (μmol/kg)	Sdev (μmol/kg)
Leg.1	1325	–0.04	0.65	1006	0.05	3.58
Leg.2a	925	0.04	0.66	643	0.08	2.94
Leg.2b	1419	–0.03	0.91	1012	0.07	2.54
Leg.3	25	–0.10	0.33	295	–0.03	2.23

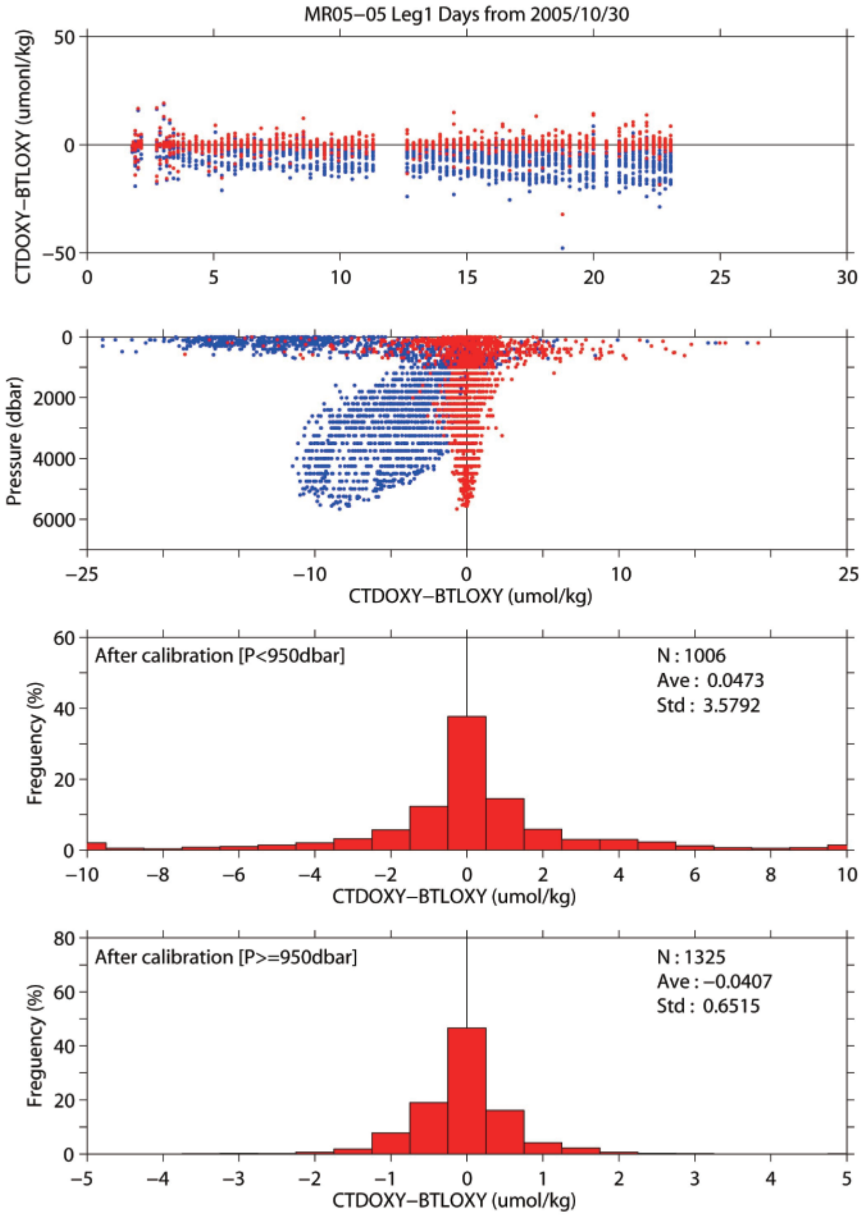

Figure 3.1.22. Difference between the CTD oxygen and the bottle oxygen for Leg.1. Blue and red dots indicate before and after the post-cruise calibration using the bottle oxygen data, respectively. Top panel shows for P ≥ 950 dbar. Lower two panels show histogram of the difference after the calibration.

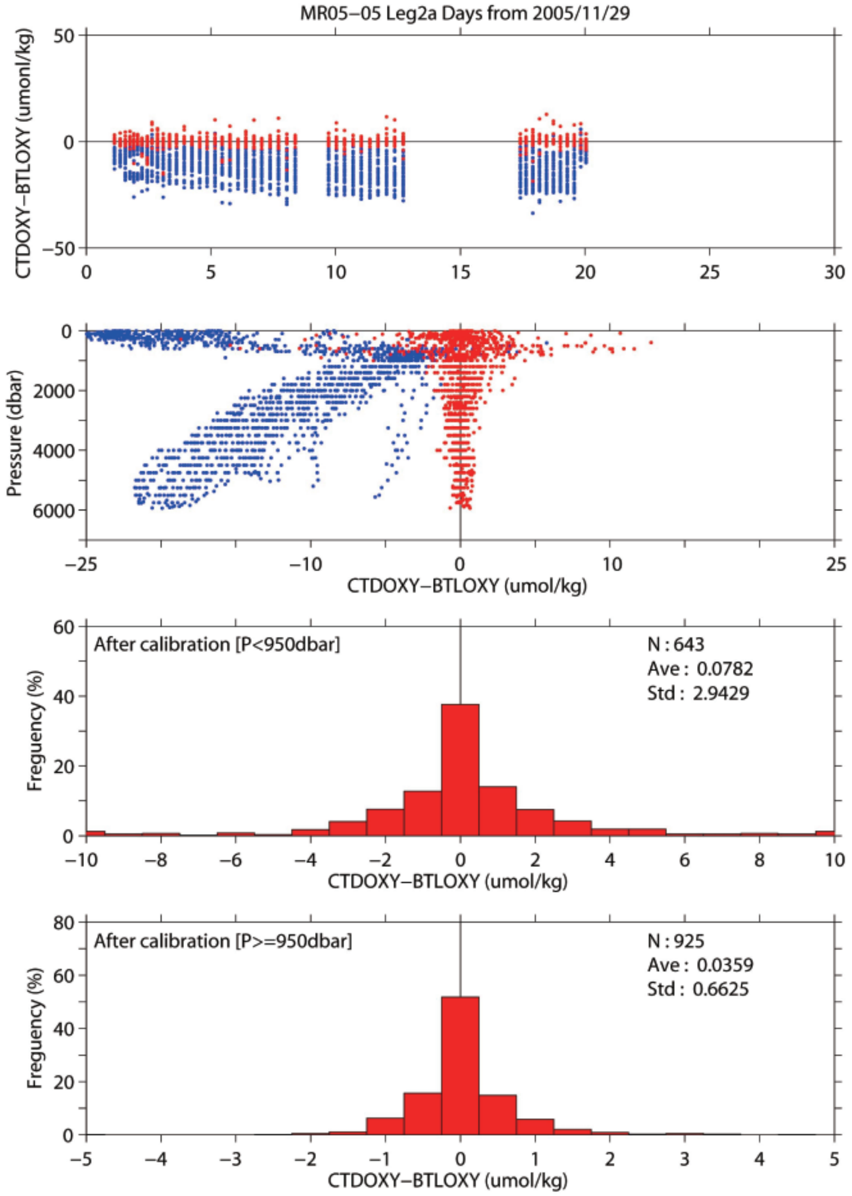

Figure 3.1.23. Same as Figure 3.1.22, but for Leg.2a.

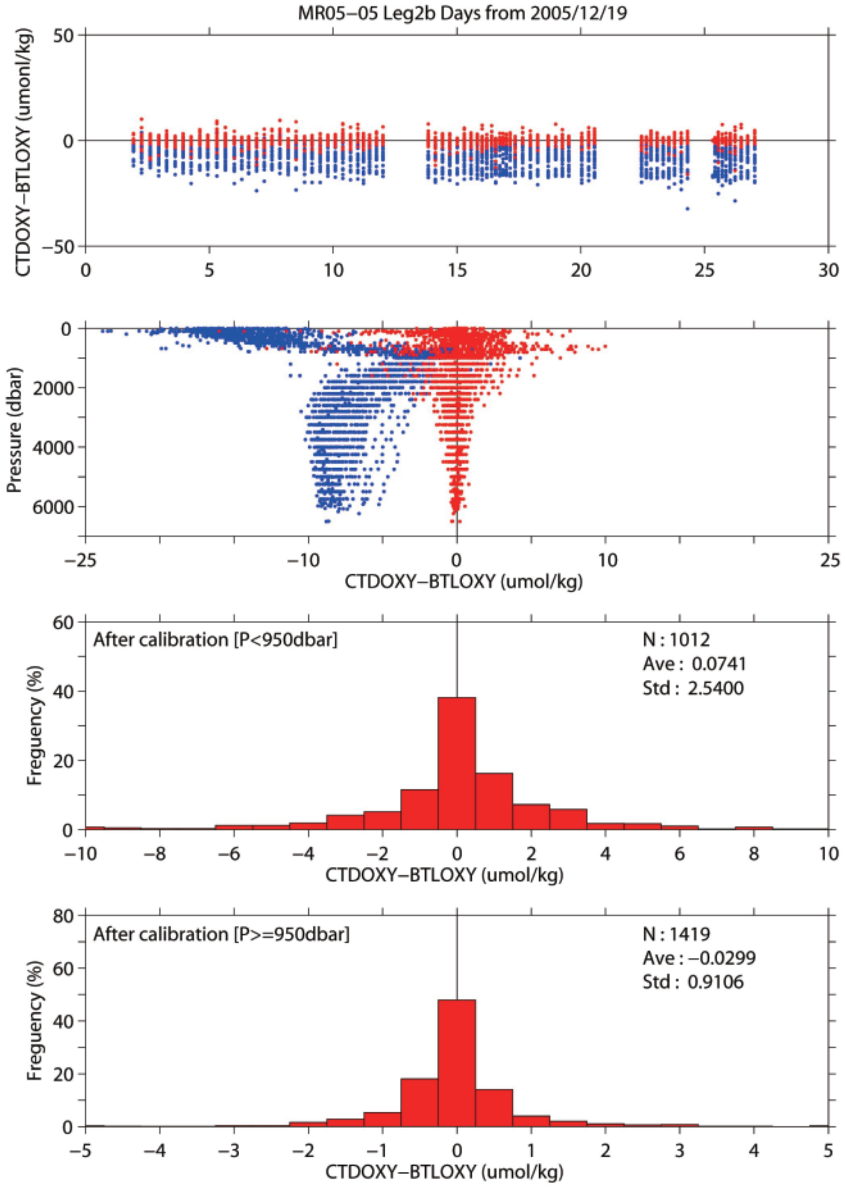

Figure 3.1.24. Same as Figure 3.1.22, but for Leg.2b.

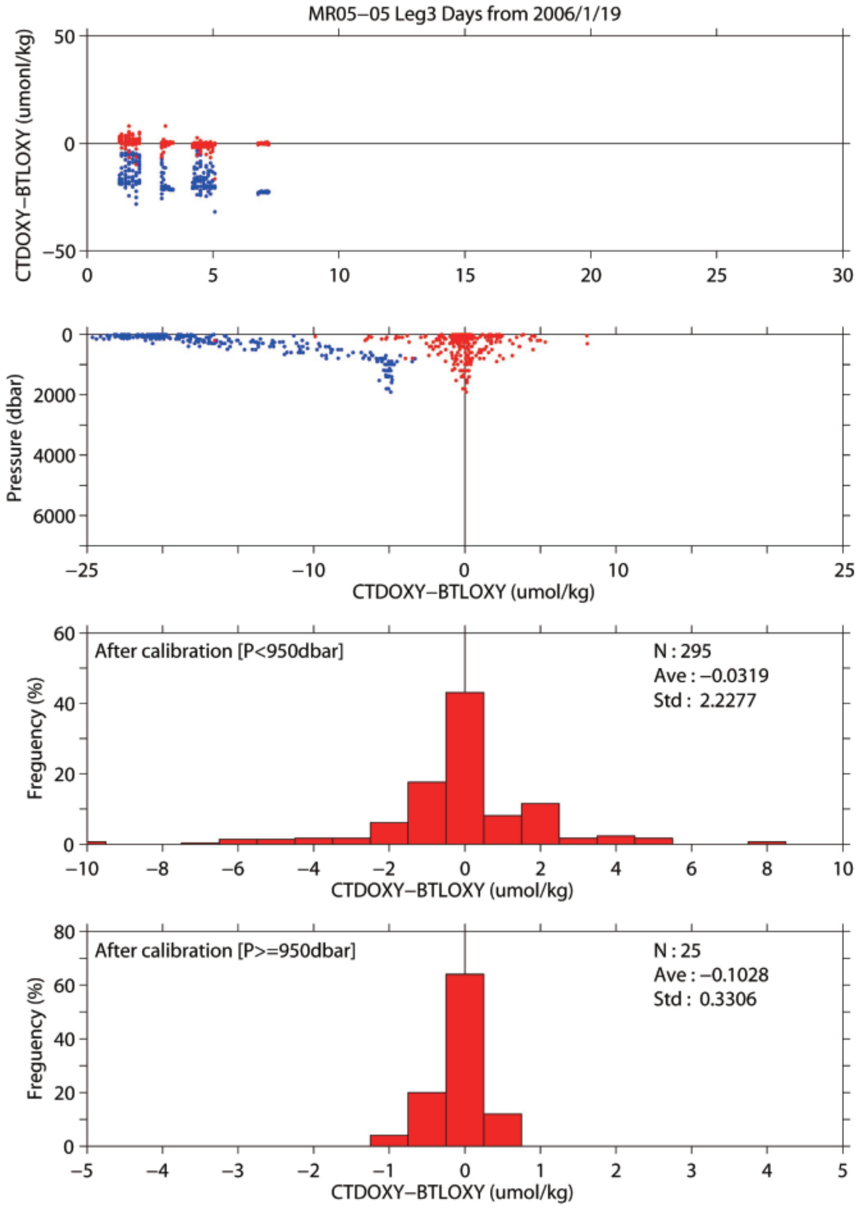

Figure 3.1.25. Same as Figure 3.1.22, but for Leg.3. Top panel shows for full pressure range.

Table 3.1.8. Calibration coefficients for the CTD oxygen. Number of data used (Num) is also shown.

Stations	(Num)	dSoc	dTCor	dPCor	doffset
Leg1:					
1_1-16_1	(136)	2.8411653261e-4	1.1157544479e-3	2.7913096082e-6	-1.2818258956e-3
18_1	(28)	4.2389172171e-3	6.5527402402e-4	-2.9529810502e-6	2.0664010586e-3
20_1	(27)	5.9072097463e-3	5.9612891352e-4	-3.1353113762e-8	-4.4323898789e-3
22_1	(28)	1.4921406865e-2	-6.5325808935e-4	-4.4711358817e-6	-7.6317176255e-3
24_1	(28)	1.9502900984e-2	-1.2552442883e-3	-7.9727251405e-6	-6.3244004082e-3
26_1	(28)	6.6080225258e-3	1.3348273077e-3	2.0108004441e-6	-6.9442801869e-3
28_1	(31)	2.3907902710e-3	1.3980340097e-3	2.0147433243e-6	-9.6097019240e-4
30_1	(30)	3.8642832072e-3	1.1394308990e-3	1.2625937853e-6	4.5201954492e-4
31_1,33_1	(58)	1.6612524428e-2	-2.9661153407e-4	-2.3286171688e-6	-1.1730133444e-2
34_1	(30)	1.1671470168e-2	6.0064381700e-4	-2.9265249203e-6	2.3737334951e-4
36_1	(30)	1.4742805723e-2	3.5139798210e-4	-3.8078312299e-6	-3.4660381192e-3
38_1	(29)	1.7756937413e-2	-2.8662753525e-4	-2.0696816014e-6	-1.0350116601e-2
40_1	(31)	1.3605434044e-2	2.6150325230e-4	-2.2558010990e-6	-2.7140487884e-3
42_1	(32)	1.3966404403e-2	3.5366741890e-4	4.1330466301e-7	-1.1009394537e-2
44_1	(30)	1.3481142712e-2	6.4280517854e-4	1.4713187709e-6	-1.2103442471e-2
46_1	(32)	4.4694794291e-3	1.4883454168e-3	2.3644833952e-6	1.5721113166e-3
48_1	(32)	1.1130737563e-2	4.8450882920e-4	-1.6510862104e-6	1.4630265016e-3
50_1	(31)	8.4763091288e-3	1.0883086434e-3	9.1712758329e-7	-5.5864118041e-4
51_1	(32)	1.4944199059e-2	2.4506097776e-4	-2.8283437473e-6	1.4945106511e-4
53_1	(32)	1.3910303466e-2	3.4172740013e-4	-1.3691189313e-6	-2.1255254705e-3
55_1	(32)	6.8014008640e-3	1.1531861650e-3	-2.0020125795e-6	1.1410714798e-2
56_1	(33)	1.2517626809e-2	8.1108907052e-4	3.7872190066e-7	-4.5176222009e-3
58_1	(33)	1.6319792743e-2	3.8367617062e-4	-9.3400247948e-7	-6.9070472175e-3
X17_1	(33)	1.7087246890e-2	2.5018727097e-4	-7.9854470212e-7	-7.8186395031e-3
62_1	(31)	1.8545518133e-2	8.4758872479e-5	-5.9882240024e-7	-1.0094825871e-2
64_1	(30)	2.1132916026e-2	-8.4524534367e-5	-1.8460928672e-7	-1.2676220107e-2
66_1	(32)	1.1354464188e-2	8.7840649983e-4	-5.3989278862e-8	1.5023212549e-3
67_1	(33)	1.5723980896e-2	5.5818159188e-4	4.8707807680e-7	-7.7589769151e-3
69_1	(34)	1.4101372227e-2	6.0844509702e-4	-1.1537381873e-6	1.0971585001e-3
71_1	(31)	1.7080867016e-2	3.8066764603e-4	-2.7093763518e-6	4.3505332228e-4
73_1	(33)	1.9235850708e-2	1.8928766136e-4	-7.9818206862e-7	-8.6271606204e-3
74_1	(34)	2.4033941887e-2	-5.3761784646e-4	-3.0412762966e-6	-8.5162384097e-3
76_1	(32)	1.9596836070e-2	1.6094611647e-4	-1.2564144578e-6	-6.0789348597e-3
77_1	(33)	2.5097320053e-2	-4.4172670651e-4	-4.2140610212e-6	-7.5211666372e-3
79_1	(31)	1.8944841633e-2	2.2474686044e-4	-9.4559433507e-7	-6.4465271345e-3
81_1	(33)	1.0772193579e-2	1.0211573501e-3	3.5729065791e-6	-6.4587950227e-3
83_1	(34)	9.2558005344e-3	1.3835520827e-3	-5.3320326791e-7	1.2209320453e-2
84_1	(35)	1.3741033402e-2	1.0442928833e-3	9.8949469261e-7	-5.0156732118e-4
86_1	(35)	3.4387864975e-2	-1.1317622023e-3	-4.2790121263e-6	-1.5226899965e-2
88_1	(34)	1.7501150773e-2	9.6128641172e-4	6.1250499331e-7	-5.5100209139e-3
90_1	(35)	2.4016156189e-2	1.1568638088e-4	-1.9997467064e-6	-4.6192746234e-3
92_1	(36)	2.2801594002e-2	1.4456793205e-4	-7.9206640035e-7	-6.7082483172e-3
94_1	(34)	2.1276396902e-2	4.0236259781e-4	1.6423691110e-7	-5.0113968514e-3
96_1	(34)	1.7586577193e-2	9.5413105512e-4	5.3115223152e-7	1.9169914386e-4
98_1	(34)	2.3281206887e-2	3.6280206888e-4	-7.5538796215e-7	-4.6148055082e-3
100_1	(35)	1.9607360482e-2	8.1086209461e-4	1.0114462418e-6	-4.0591264022e-3
X16_1	(34)	2.4020184788e-2	2.4077815879e-4	-1.6624202265e-6	6.1994742333e-4
104_1	(34)	1.9301698049e-2	9.9716273877e-4	1.1292321372e-6	4.4486781074e-4
106_1	(33)	3.7074454439e-2	-7.0415113930e-4	-2.2511412520e-6	-1.7511769248e-2
108_1	(32)	3.1381730648e-2	-2.6022098343e-4	-3.3289196375e-6	-4.4506707340e-3
110_1	(31)	3.8740835013e-2	-6.7171847217e-4	-1.7338020698e-6	-2.0947323198e-2
112_1	(31)	2.9851343344e-2	1.3176980732e-4	2.3429241248e-6	-1.7478888940e-2
114_1	(31)	2.5236481375e-2	4.2515474628e-4	-2.8443737934e-7	-3.3852598730e-3
116_1	(29)	2.8182488833e-2	4.1209091055e-4	-1.1734305445e-6	-6.1207321567e-3
118_1	(29)	3.0966553786e-2	-1.8365152495e-4	-4.6695530525e-6	8.7521737225e-4
120_1	(31)	3.6079776583e-2	-4.4129565615e-4	-1.3587444647e-6	-1.5705749328e-2
122_1	(33)	2.4804654687e-2	5.5864425693e-4	-1.5070773420e-7	-1.8434122298e-3
124_1	(31)	3.0218657690e-2	-6.6105450515e-5	-3.8921825260e-6	1.5124071439e-3
126_1	(33)	1.9627772037e-2	1.0747655389e-3	-1.1455309895e-7	6.8614333372e-3
128_1	(33)	3.1751674249e-2	2.6634525634e-4	1.5207706274e-6	-1.8176807649e-2
130_1,132_1	(59)	2.5135138070e-2	4.6264106890e-4	-1.3233400851e-6	3.2419344331e-4
134_1	(33)	3.6848282221e-2	-6.9629658189e-4	-5.0952357091e-6	-4.3672708315e-3
136_1	(29)	2.0365730703e-2	1.2968294124e-3	1.1796185243e-6	6.2962100557e-3
138_1	(32)	2.5925077770e-2	4.0679558181e-4	-2.2823266346e-6	4.8879748734e-3
140_1	(32)	3.1645148674e-2	1.7573498412e-4	-5.4619663287e-7	-8.6145005433e-3
142_1	(33)	3.8874259815e-2	-5.9068769855e-4	-5.1241960385e-6	-6.1837227227e-3
144_1	(33)	3.6412320564e-2	-3.4000701047e-4	-3.9279452812e-6	-4.9847908143e-3
146_1	(33)	2.2070939078e-2	9.4495827134e-4	-1.4157172415e-6	1.1513223600e-2
Leg 2a:					
146_2	(25)	3.4314628587e-2	-9.3087500529e-4	-5.1774381094e-6	-1.5863348468e-3
148_1	(22)	3.2787911160e-2	-1.8951084925e-3	-3.3737557039e-6	-2.9190789136e-3
150_1-153_1	(64)	2.5939275226e-2	5.8341281881e-4	2.4271007242e-6	4.8524650166e-4
154_1-157_1	(58)	2.8993026397e-2	4.1358222390e-4	4.6262134422e-7	-3.8917174759e-3
159_1	(29)	2.3671436937e-2	6.0668908919e-4	-1.6050283868e-8	7.8797883704e-3
161_1	(33)	1.7959585689e-2	1.4581104937e-3	4.7421483103e-6	3.7108799009e-3
163_1	(32)	3.3039432219e-2	2.7056495638e-4	2.3740557128e-6	-9.3147770455e-3
165_1	(33)	4.2098350448e-2	-5.0218598391e-4	-2.8123331458e-6	-4.8009569225e-3
167_1	(33)	3.7764962871e-2	-6.0439598978e-5	-8.9579324600e-8	-5.3543364649e-3
169_1	(32)	2.3366472536e-2	1.5811519737e-3	3.7498971961e-6	6.9415934824e-3
171_1	(30)	3.2743285288e-2	7.8562913198e-4	2.5525877190e-6	-5.7288474494e-3
173_1	(32)	3.6955509296e-2	1.3047463430e-4	5.4386804400e-7	-4.3942727261e-3
175_1	(33)	4.0412229604e-2	-2.3744782362e-4	-6.7955266657e-7	-5.4708015570e-3
177_1	(32)	4.6038615178e-2	-6.5919437663e-4	-3.6095984231e-6	-4.6795688138e-3
179_1	(32)	4.7738138295e-2	-6.4931578091e-4	-3.4784044639e-6	-6.8768481257e-3
181_1	(33)	3.0680150470e-2	1.0156732020e-3	1.5894924638e-6	6.0376304730e-3
183_1	(33)	3.0927480026e-2	8.7281771302e-4	1.1434245322e-6	5.8615454707e-3
185_1	(33)	3.6961229943e-2	4.7267257934e-4	1.7753732215e-6	-2.0386870435e-3
187_1	(33)	4.4041803780e-2	-3.0653791419e-4	-4.9529632456e-7	-4.8585260781e-3
189_1	(35)	4.1230624896e-2	-2.3475304483e-4	-9.0027846510e-7	5.7346596474e-4
191_1	(35)	4.2873626830e-2	9.7286236144e-5	-8.4617114359e-7	-2.4650686939e-3
193_1	(36)	3.9442648834e-2	3.5370315306e-4	1.3825964189e-7	2.4706505339e-3
195_1	(35)	4.0231962682e-2	4.0194034466e-4	3.0879060666e-8	1.5214770553e-3
197_1	(35)	4.9305465420e-2	-4.1553546611e-4	-1.2071765611e-6	-5.2369019988e-3
X14_1	(35)	4.8649246131e-2	-2.3252731062e-4	1.1713381440e-6	-1.2685843191e-2
201_1	(35)	4.5284704927e-2	-8.2615636615e-5	-6.2012793313e-7	-7.1027511901e-4
203_1	(35)	4.7552939186e-2	-4.8590730975e-5	1.7025056715e-6	-1.0853698496e-2
205_1	(36)	4.3741241447e-2	2.5572741624e-4	-5.4911817903e-7	2.0157911802e-3
207_1	(36)	5.7273010477e-2	-8.4596838497e-4	-2.8849689879e-6	-7.8158037303e-3
209_1	(35)	5.3815950683e-2	-4.7418286785e-4	-5.3271208808e-7	-1.0658556788e-2
211_1	(35)	4.9668992028e-2	-3.3559334921e-4	-2.2789914830e-6	1.6589818767e-3
213_1	(36)	4.4632934294e-2	1.6278162093e-4	4.2187340843e-8	9.6870681172e-4
215_1	(36)	5.5441477813e-2	-5.5603708022e-4	-1.2903845758e-6	-9.1761021056e-3
217_1	(36)	4.4606439334e-2	7.9483025294e-4	2.0501362639e-6	-4.8188980107e-3
WC0_1	(32)	5.5269865276e-2	-4.7098937472e-4	-2.9910876150e-6	-1.5292206654e-3
WC1_1	(35)	7.5738327199e-2	-1.7994997437e-3	-3.0389895056e-6	-3.2843242964e-2
WC2_1	(34)	5.2966630242e-2	-4.1723074942e-4	-3.5368895693e-6	1.9405918433e-3
WC3_1	(36)	7.4004798635e-2	-1.8761873194e-3	-4.1685886695e-6	-2.4790244089e-2
WC4_1	(36)	5.0829528972e-2	-2.6199986394e-4	-1.4437585540e-6	-2.0612940486e-3
WC5_1	(35)	6.0278043794e-2	-8.2511933755e-4	-1.4142267198e-6	-1.4181791492e-2
WC6_1	(36)	6.1475221525e-2	-9.8736797630e-4	-3.5722125874e-6	-8.5024898299e-3
WC7_1	(36)	5.8888850329e-2	-8.1411320495e-4	-2.2600006743e-6	-9.1651772015e-3
WC8_1	(36)	5.2525433623e-2	-3.2445960541e-4	-1.3361085098e-6	-2.3393469061e-3
WC9_1	(36)	4.7383116804e-3	1.1773826217e-3	4.1229638265e-6	-4.5298972869e-3
WC10_1	(32)	1.8037240627e-2	1.1209367205e-4	-1.7493706458e-6	-6.8355346588e-3
Leg 2b:					
217_2	(34)	1.3859683202e-2	8.7865744863e-4	2.1575656745e-6	-1.2261575788e-2
219_1	(36)	1.3074798332e-2	8.0970975722e-4	1.5084212045e-6	-5.4274390121e-3
221_1	(36)	2.3184695947e-2	-5.9719556684e-5	9.6208770650e-8	-1.4418283950e-2
223_1	(36)	2.4106582742e-2	-4.4805055833e-5	-2.2718214043e-6	-5.7829858128e-3
225_1	(36)	2.1266719121e-2	2.7658412180e-4	-2.3675746915e-6	-1.2249768897e-4
227_1	(36)	3.1227181589e-2	-6.0691044587e-4	-2.6756225964e-6	-1.1247862730e-2
229_1-231_1	(70)	2.4632852068e-2	2.0144398223e-4	-2.8192616115e-7	-9.3271646280e-3
233_1	(36)	2.5698457819e-2	4.4026259921e-5	-2.1031541932e-6	-4.2830342568e-3
X13_1	(36)	2.3670576933e-2	3.2769060768e-4	6.9031178357e-7	-1.0698361026e-2
237_1	(36)	1.8880629571e-2	2.3204631835e-4	-3.2461564835e-6	1.1038409710e-2
239_1	(36)	1.8186891316e-2	6.0112097624e-4	-1.4100636286e-6	5.1951553512e-3
241_1	(34)	1.9306988158e-2	7.1495272321e-4	-6.1293787337e-7	2.1737786791e-3
243_1	(25)	2.7452283092e-2	-1.1306367268e-5	-2.0174062086e-6	-7.2829365708e-3
245_1	(33)	2.8607681486e-2	-1.5693228943e-4	-1.6035097568e-6	-9.9751279706e-3
247_1	(35)	2.3406903498e-2	2.2634888584e-4	-1.2428838346e-6	-2.8028712675e-3
249_1	(30)	2.4379344567e-2	1.7624386839e-4	-6.0417727965e-7	-4.7733548727e-3
251_1	(36)	3.5037057890e-2	-4.4864770263e-4	1.0101907361e-6	-2.4883695670e-2
253_1	(36)	2.4737209429e-2	6.5386249491e-5	-3.6891334773e-6	3.8676579842e-3
255_1	(36)	2.5204948867e-2	2.1148221671e-4	-1.6627604637e-6	-2.8852759960e-3
257_1	(35)	2.8147353031e-2	2.4518110139e-4	7.2327710002e-7	-1.4255861726e-2
259_1	(35)	2.5991896341e-2	2.6037276039e-4	-1.0456864393e-6	-5.5426444388e-3
261_1	(32)	2.2628837230e-2	7.5988075820e-4	-4.1655542103e-7	-2.7188889288e-3
263_1	(34)	1.9820650775e-2	5.3416060580e-4	-3.7524950179e-6	1.2251561256e-2
265_1	(35)	2.7649119002e-2	9.6611670814e-5	-3.3745623692e-6	1.8094666686e-4
267_1	(36)	2.5889555278e-2	2.3810926839e-4	-1.4902513772e-6	-3.1345608292e-3
269_1	(35)	2.1537855427e-2	5.7684341816e-4	-5.3150780999e-7	1.2250063549e-3
271_1	(34)	3.4828346976e-2	-5.6474346490e-4	-5.3330785639e-6	-3.1602764225e-3
273_1	(33)	2.6291484155e-2	5.7527391628e-4	8.1295727807e-7	-9.2704985927e-3
X10_1	(36)	3.5553664861e-2	-3.0585410534e-5	-2.8516682561e-7	-1.8883963792e-2
275_1	(36)	2.9512580596e-2	2.7084784103e-4	2.7468918385e-7	-1.3176498089e-2
277_1	(36)	3.2869124611e-2	-1.5631215638e-4	-3.0053837187e-6	-5.8748364848e-3
279_1	(36)	2.8614311784e-2	3.2363073786e-4	-1.2661986058e-6	-6.1863453418e-3
281_1	(36)	2.8390077921e-2	2.0887458832e-4	-3.4246497985e-6	1.0895303144e-4
283_1	(36)	3.3715138680e-2	-2.5486483162e-5	-1.3087010034e-6	-1.1668278730e-2
285_1	(35)	4.4223880210e-2	-9.6428011720e-4	-2.6560586416e-6	-2.1032712908e-2

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287_1        (35)   2.6985592235e-2  3.9370057732e-4 -2.1485456457e-6 -1.2372384187e-4
289_1        (33)   3.1648346109e-2  1.0209081769e-4 -2.9449735995e-6 -5.1844643144e-3
291_1        (32)   2.1071386983e-2  9.6682327066e-4  8.6254878867e-7  4.0345079093e-4
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295_1        (31)   2.1827713280e-2  8.3899007041e-4 -3.9382326997e-6  1.3688594235e-2
297_1-305_1  (105)  2.7773001546e-2  5.3712710561e-4  1.5328461785e-6 -6.4399478014e-3
306_1-312_1  (82)   2.8855216555e-2  4.0256345493e-4 -1.5020063602e-6 -2.9411348970e-3
314_1        (32)   2.8381615612e-2  5.1649089138e-4 -1.0137338402e-6 -4.7646204413e-3
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318_1        (33)   3.2008771738e-2  7.7384707595e-5 -4.6814092805e-6  2.0662254975e-4
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322_1        (28)   3.1994634299e-2  3.4390392314e-4 -4.5403354019e-7 -1.0745791088e-2
324_1        (34)   3.3294243001e-2  4.4030381498e-5 -3.3439134505e-6 -5.4361571929e-3
326_1        (32)   3.5898295823e-2 -1.4000676176e-4 -3.2516563294e-6 -9.0008117504e-3
328_1        (33)   3.5788937582e-2 -2.3402600597e-5 -2.6823510232e-6 -9.3382310020e-3
329_1        (32)   4.2977005787e-2 -7.4179814417e-4 -3.9768295833e-6 -1.6326476855e-2
331_1        (31)   4.6514831613e-2 -1.0118166177e-3 -2.1244413320e-6 -2.4699312293e-2
333_1        (29)   3.1668688954e-2  3.1526164252e-4 -2.1655040828e-6 -5.4802508657e-3
335_1-339_1  (72)   2.8426491060e-2  7.0598619161e-4 -1.0388347171e-8 -3.9515056753e-3
341_1        (31)   2.9990461926e-2  5.1622503234e-4 -7.3588786235e-7 -6.3253881314e-3
343_1        (29)   3.0898134526e-2  4.8361719865e-4 -3.4659105792e-7 -7.8545493062e-3
345_1        (30)   4.0806999958e-2 -5.2565812016e-4 -5.8795417378e-6 -8.8450313289e-3
347_1        (33)   3.6806813506e-2 -4.5030400280e-4 -2.9333374736e-6 -1.0612626829e-2
349_1        (36)   3.2713863609e-2  6.1559624613e-4 -3.2628342407e-6 -3.8115855611e-3
351_1        (36)   4.3360572024e-2 -6.0097470278e-4 -3.6958898061e-6 -1.5120605017e-2
369_1-359_1  (105)  3.0037218808e-2  4.5359665354e-4 -1.2846640466e-6 -4.3799960663e-3
357_1        (32)   3.4594812288e-2 -4.3505352461e-4 -3.3943737245e-6 -5.7232208372e-3
355_1        (36)   3.4943624686e-2  5.0034863107e-5 -1.2519124546e-6 -1.0984065650e-2
353_1,351_2  (69)   3.7404467500e-2  1.0345046957e-5 -1.3470606487e-6 -1.2981773806e-2

Leg 3:
370_1-TS1_1  (320)  3.8115006786e-2  4.4123814357e-4  2.1389358081e-7 -1.1949938654e-2
--------------------------------------------------------------------------------------
```

(6.5) Oxygen optode

The optode oxygen is calibrated by the Stern-Volmer equation, according to a method by Uchida et al. (submitted manuscript):

$$O_2\ (\mu mol/l) = (\tau_0 / \tau - 1) / K_{sv}$$

where τ is decay time, τ_0 is decay time in the absence of oxygen and K_{sv} is Stern-Volmer constant. The τ_0 and the K_{sv} are assumed to be functions of temperature as follows.

$$K_{sv} = C_{11} + C_{12} \times t + C_{13} \times t^2$$

$$\tau_0 = C_{21} + C_{22} \times t$$

$$\tau = C_{31} + C_{32} \times P_b$$

where t is CTD temperature (°C) and P_b is raw phase measurement (deg). The calibration coefficients (C_{11}, C_{12}, C_{13}, C_{21}, C_{22}, C_{31} and C_{32}) are determined for post-cruise calibration. The best fit sets of coefficients are determined by minimizing the sum of absolute deviation from the bottle oxygen data. The FORTRAN subroutine DMINF1 of the Scientific Subroutine Library II (Fujitsu Ltd., Kanagawa, Japan) is used to determine the sets.

For compensation of the pressure response of the sensing foil, the oxygen concentration is multiplied by the following factor $1 + 0.032 \times P_r / 1000$, where P_r is pressure in dbar.

The calibration is performed for the up-cast phase data created by the software module ROSSUM after the post-cruise calibration for the CTD temperature and salinity.

The calibration coefficients are determined for Leg.1 and Leg.2 to 3. The results of the post-cruise calibration for the optode oxygen are summarized in Table 3.1.9 and shown in from Figure 3.1.26 and Figure 3.1.5.21. And the calibration coefficients and number of the data used for the calibration are listed in Table 3.1.10.

Table 3.1.9. Difference between the optode oxygen and the bottle oxygen after the post-cruise calibration. Mean and standard deviation (Sdev) are calculated for the data below and above 950 dbar. Number of data (Num) used is also shown.

Leg	Pressure ≥ 950 dbar			Pressure < 950 dbar		
	Num	Mean (μmol/kg)	Sdev (μmol/kg)	Num	Mean (μmol/kg)	Sdev (μmol/kg)
Leg.1	1319	–0.11	0.38	1013	0.04	0.86
Leg.2/3	2365	–0.01	0.35	2004	–0.01	0.90

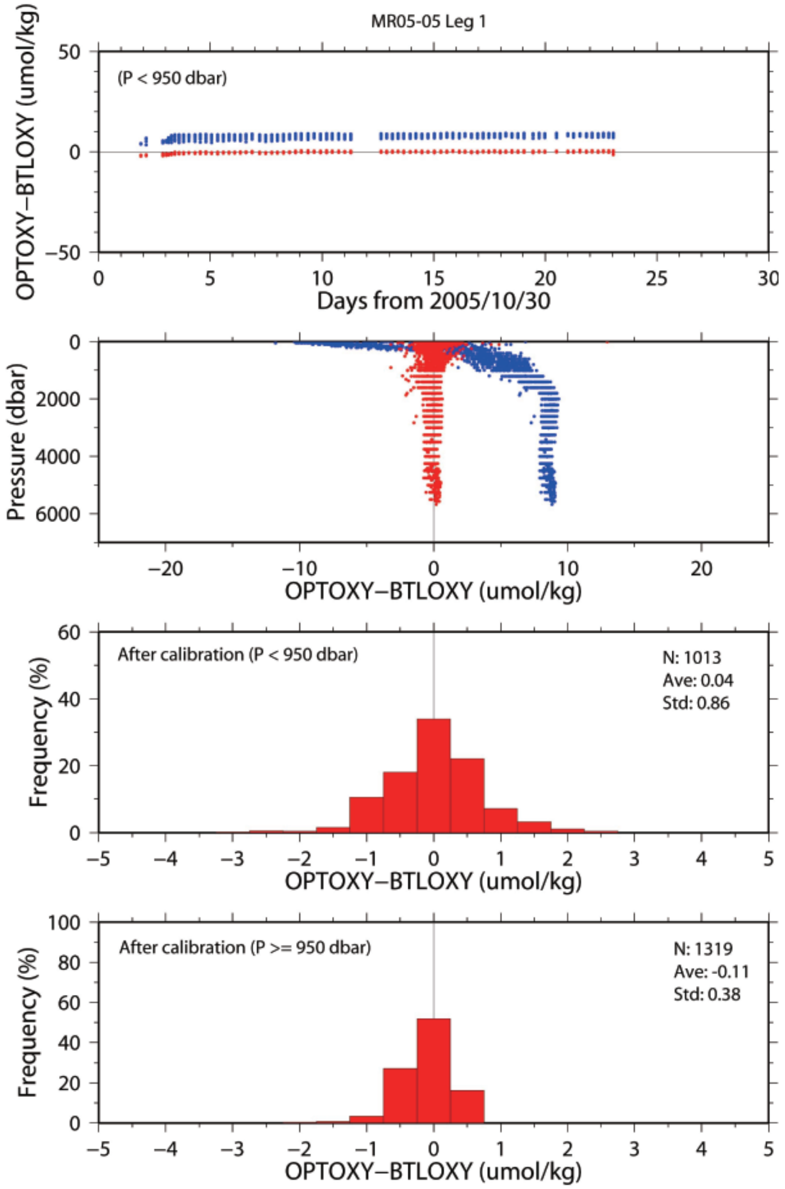

Figure 3.1.26. Difference between the optode oxygen and the bottle oxygen for Leg.1. Blue and red dots indicate before and after the post-cruise calibration using the bottle oxygen data, respectively. Top panel shows for P ≥ 950 dbar. Lower two panels show histogram of the difference after the calibration.

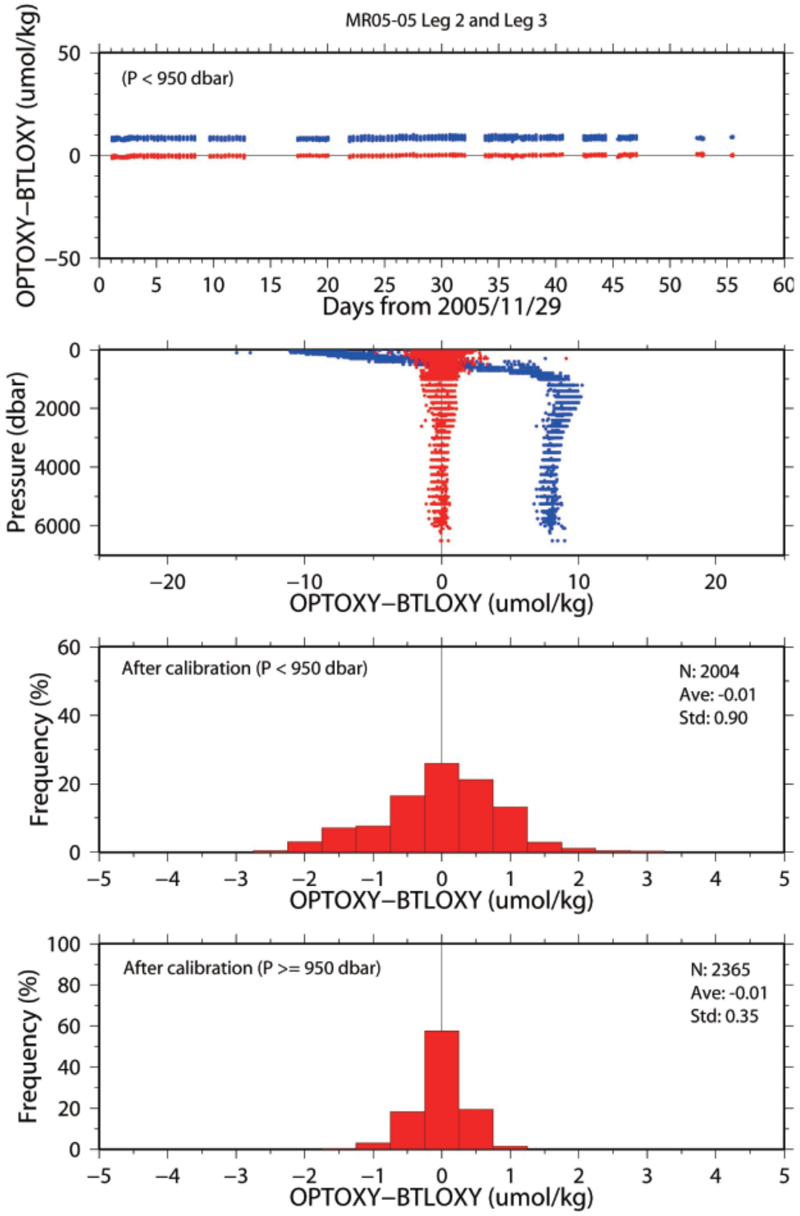

Figure 3.1.27. Same as Figure 3.1.26, but for Leg.2 and Leg.3.

Table 3.1.10. Calibration coefficients for the optode oxygen. Number of data used (Num) for the calibration and mean absolute deviation (ADEV) between the optode oxygen and the bottle oxygen are also shown.

Leg.1	Num	= 2332,	ADEV	= 0.41 μmol/kg
	C_{11}	= 3.05627e–3		
	C_{12}	= 1.40559e–4		
	C_{13}	= 2.14264e–6		
	C_{21}	= 61.1209		
	C_{22}	= 9.86981e–2		
	C_{31}	= –8.48263		
	C_{32}	= 1.10631		
Leg.2/3	Num	= 4369,	ADEV	= 0.45 μmol/kg
	C_{11}	= 2.85451e–3		
	C_{12}	= 1.30281e–4		
	C_{13}	= 2.00579e–6		
	C_{21}	= 61.6282		
	C_{22}	= 0.101157		
	C_{31}	= –7.42425		
	C_{32}	= 1.11110		

References

Uchida, H., K. Ohyama, S. Ozawa, and M. Fukasawa (2007): In-situ calibration of the Sea-Bird 9plus CTD thermometer, *J. Atmos. Oceanic Technol.* (in press)

Uchida, H., T. Kawano, I. Kaneko, and M. Fukasawa: In-situ calibration of optode-based oxygen sensors, submitted to *J. Atmos. Oceanic Technol. (accepted)*

3.2 Bottle Salinity

September 7, 2007

(1) Personnel

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Fujio Kobayashi	***(MWJ)***
Naoko Takahashi	***(MWJ)***
Tatsuya Tanaka	***(MWJ)***

(2) Objectives

Bottle salinities were measured to compare with CTD salinities for identifying leaking bottles and for calibrating CTD salinities.

(3) Instrument and Method

(3.1) Salinity Sample Collection

The bottles in which the salinity samples are collected and stored are 250 ml Phoenix brown glass bottles with screw caps. Each bottle was rinsed three times with sample water and was filled to the shoulder of the bottle. The caps were also thoroughly rinsed. Salinity samples were stored more than 12 hours in the same laboratory as where the salinity measurement was made.

(3.2) Instruments and Method

The salinity analysis was carried out on Guildline Autosal salinometer model 8400B (S/N 62556), which was modified by attaching an Ocean Science International peristaltic-type sample intake pump and two Guildline platinum thermometers model 9450. One thermometer monitored an ambient temperature and the other monitored a bath temperature. The resolution of the thermometers was 0.001 degrees C. The measurement system was almost same as Aoyama et al (2003). The salinometer was operated in an air-conditioned laboratory of the ship at a bath temperature of 24 degrees C.

An ambient temperature varied from approximately 19 degrees C to 24 degrees C, while a bath temperature was very stable and varied within +/- 0.002 degrees C on rare occasion. A measure of a double conductivity ratio of a sample is taken as a median of thirty-one reading. Data collection was started after 5 seconds and it took about 10 seconds to collect 31 readings by a personal computer. Data were sampled for the sixth and seventh filling of the cell for Leg.1 and the eighth and ninth filling for Leg.2 and Leg.3. In the case where the difference between the double conductivity ratio of this two fillings is smaller than 0.00002, the average value of the two double conductivity ratios is used to calculate the bottle salinity with the algorithm for practical salinity scale, 1978 (UNESCO, 1981). If the difference is greater than or equal to 0.00003, we measure another additional filling of the cell. In the case where the double conductivity ratio of the additional filling does not satisfy the criteria above, we measure two other fillings of the cell and the median of the double conductivity ratios of five fillings are used to calculate the bottle salinity.

The measurement was conducted for about 10 to 18 hours per day (typically from 3:00 to 17:00) and the cell was cleaned with ethanol or soap or both after the measurement of the day. We measured more than 8,000 samples in total.

(4) Preliminary Result

(4.1) Stand Seawater

Leg.1

Standardization control was set to 501 and all measurements were done by this setting. STNBY was 5517 ±0001 and ZERO was 0.00001 ±0.00001. We used IAPSO Standard Seawater batch P145 whose conductivity ratio was 0.99981 (double conductivity ratio is 1.99962) as the standard for salinity. We measured 117 bottles of P145 during routine measurement. There were 5 bad bottles which conductivities are extremely high. Data of these 5 bottles are not taken into consideration hereafter.

Figure 3.2.1 shows the history of double conductivity ratio of the Standard Seawater batch P145.

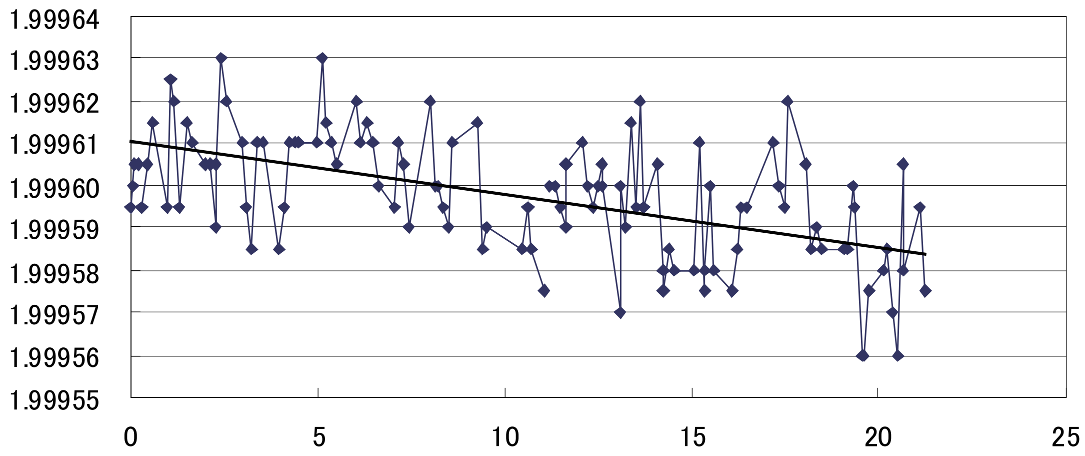

Figure 3.2.1. History of Double conductivity ratio of P145 during Leg.1. X and Y axes represent time (Julian day) and double conductivity ratio, respectively.

Drifts were calculated by fitting data from P145 to the equation obtained by the least square method (solid lines). Correction for the double conductivity ratio of the sample was made to compensate for the drift (Figure 3.2.2). After correction, the average of double conductivity ratio became 1.99961 and the standard deviation was 0.00012, which is equivalent to 0.0002 in salinity. We added 0.00001 to the corrected measured double conductivity ratio.

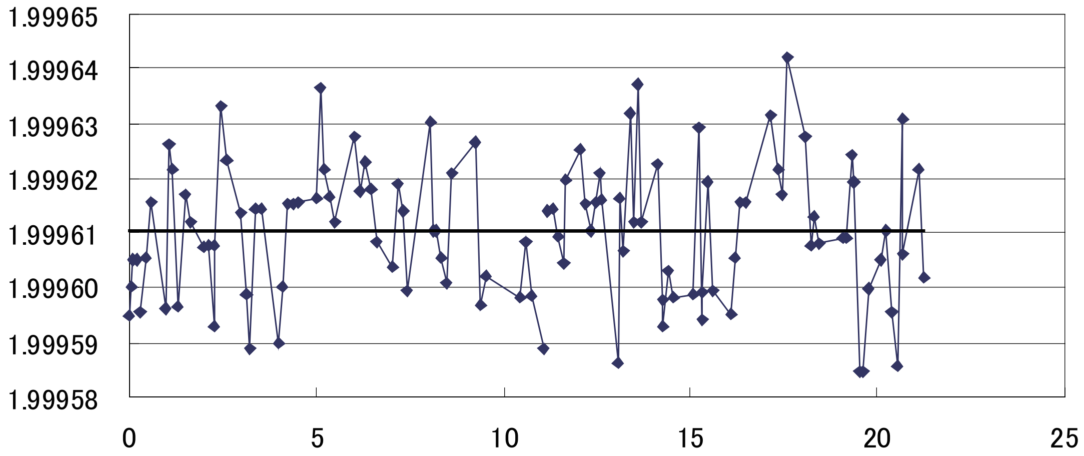

Figure 3.2.2. History of Double conductivity ratio of P145 during Leg.1. X and Y axes represent time (Julian day) and double conductivity ratio, respectively. (after correction)

Leg.2

Standardization control was set to 474 before WIPE (Wake Islands passage Flux Experiment). STNBY was 5498 ±0001 and ZERO was 0.00001 ±0.00001. We removed the conductivity cell and washed it thoroughly with soap. Then, standardization control was changed to 479. STNBY became 5501 ±0001 and ZERO was 0.00001 ±0.00001.

We used IAPSO Standard Seawater batch P145 whose conductivity ratio was 0.99981 (double conductivity ratio is 1.99962) as the standard for salinity. We measured 54 bottles of P145 during routine measurement before WIPE and 109 bottles after WIPE. There were 2 bad bottles whose conductivities were extremely high. Data of these 2 bottles are not taken into consideration hereafter.

Figure 3.2.3 shows the history of double conductivity ratio of the Standard Seawater batch P145. Drifts were calculated by fitting data from P145 to the equation obtained by the least square method (solid lines). Correction for the double conductivity ratio of the sample was made to compensate for the drift (Figure 3.2.4). After correction, the average of double conductivity ratio became 1.99962 and the standard deviation was 0.00012 before WIPE and 0.00011 after WIPE, those are equivalent to 0.0002 in salinity. We added 0.000021 before WIPE and 0.000012 after WIPE to the corrected measured double conductivity ratio.

Leg.3

Standardization control was set to 484 and all the measurements were done by this setting. STNBY was 5505 ±0001 and ZERO was 0.00001 ±0.00001. We used IAPSO Standard Seawater batch P145 whose conductivity ratio was 0.99981 (double conductivity ratio is 1.99962) as the standard for salinity. We measured 25 bottles of P145 during routine measurement.

Figure 3.2.5 shows the history of double conductivity ratio of the Standard Seawater batch P145. Drifts were calculated by fitting data from P145 to the equation obtained by the least square method (solid lines). Correction for the double conductivity ratio of the sample was made to compensate for the drift (Figure 3.2.6). After correction, the average of double conductivity ratio became 1.99962 and the standard deviation was 0.00014, which is equivalent to 0.0003 in salinity. We added 0.000004 to the corrected measured double conductivity ratio.

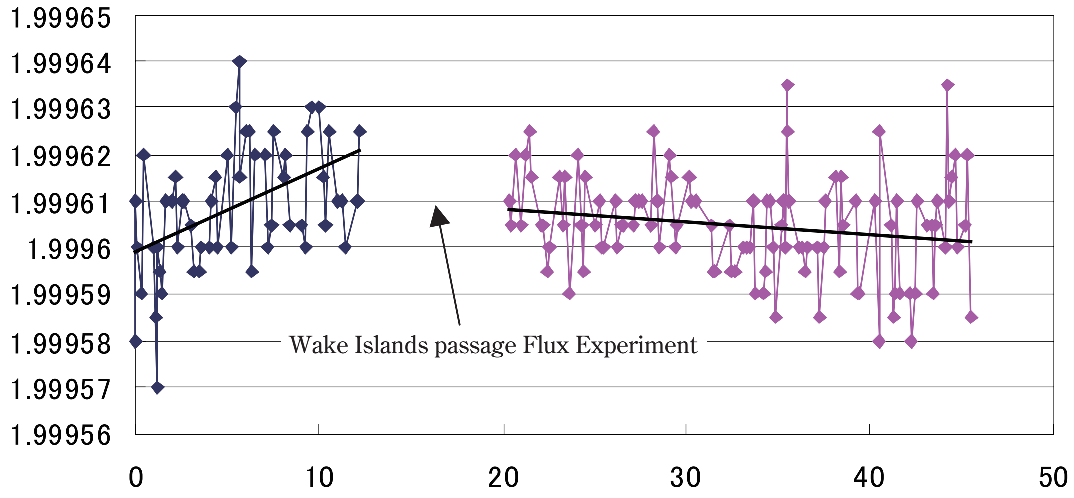

Figure 3.2.3. History of Double conductivity ratio of P145 during Leg.2. X and Y axes represent time (Julian day) and double conductivity ratio, respectively.

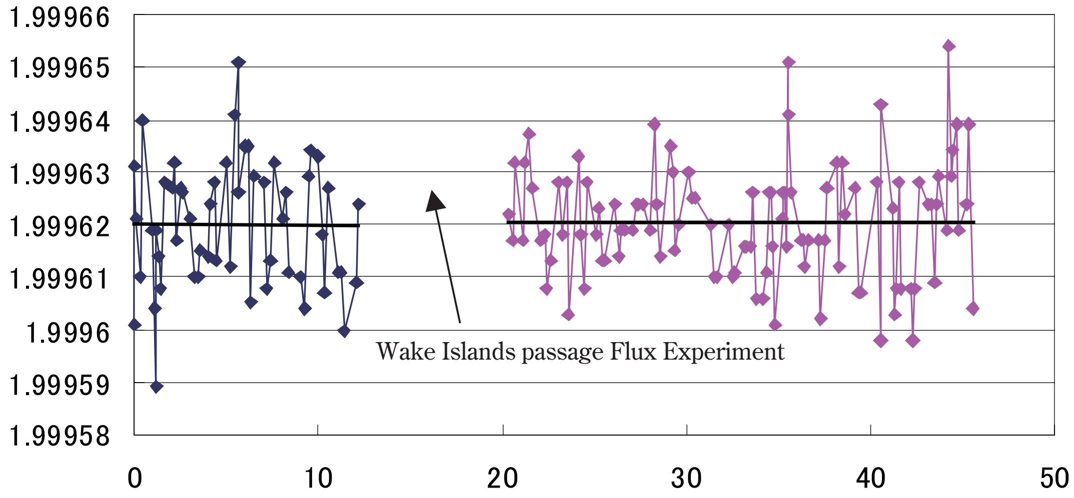

Figure 3.2.4. History of Double conductivity ratio of P145 during Leg.2. X and Y axes represent time (Julian day) and double conductivity ratio, respectively. (after correction)

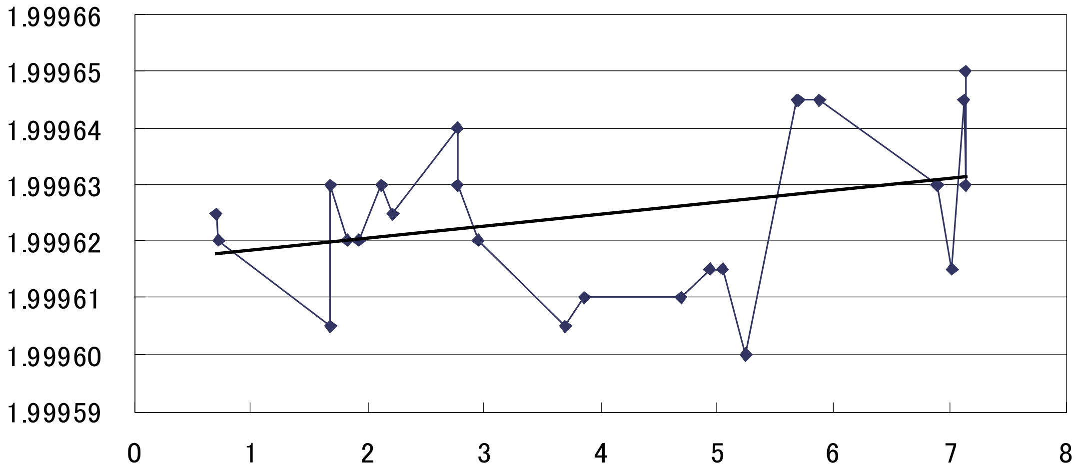

Figure 3.2.5. History of Double conductivity ratio of P145 during Leg.3. X and Y axes represent time (Julian day) and double conductivity ratio, respectively.

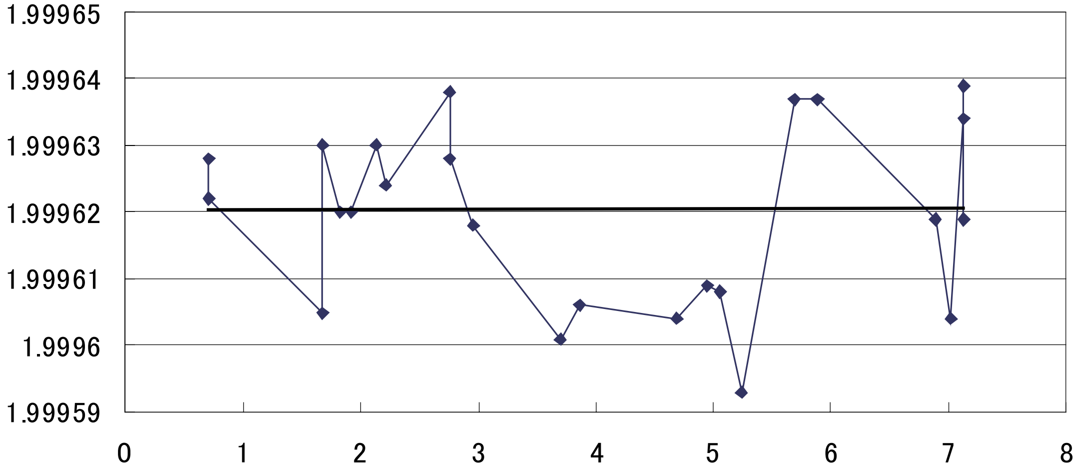

Figure 3.2.6. History of Double conductivity ratio of P145 during Leg.3. X and Y axes represent time (Julian day) and double conductivity ratio, respectively. (after correction)

(4.2) Sub-Standard Seawater

We also used sub-standard seawater which was a deep-sea water filtered by pore size of 0.45 micrometer and was stored in a 20 liter cubitainer made of polyethylene and stirred for at least 24 hours before measuring. It was measured every six samples in order to check possible sudden drift of the salinometer. During the whole measurements, there was no detectable sudden drift of the salinometer.

(4.3) Replicate and Duplicate Samples

Leg.1

We took 435 pairs of replicate and 27 pairs of duplicate samples. Figure 3.2.7 (a) and (b) shows the histogram of the absolute difference between each pair the replicate samples and that of the duplicate samples, respectively. There were 2 bad measurements in the replicate samples. Particularly, one of the pair was extremely high (more than 0.01in salinity). Excluding these bad measurements, the standard deviation of the absolute difference in 433 pairs of the replicate samples was 0.00017 in salinity and that in 27 pairs of the duplicate samples was 0.00032 in salinity.

Leg.2

We took 668 pairs of replicate and 20 pairs of duplicate samples. Figure 3.2.8 (a) and (b) shows the histogram of the absolute difference between each pair of the replicate samples and that of the duplicate samples, respectively. There were 3 questionable measurements in the replicate samples. Excluding these questionable measurements, the standard deviation of the absolute difference in 665 pairs of the replicate samples was 0.00017 in salinity and that in 20 pairs of the duplicate samples was 0.00025 in salinity.

Leg.3

We took 48 pairs of replicate and 3 pairs of duplicate samples. Figure 3.2.9 shows the histogram of the absolute difference between each pair of the replicate samples. There was one bad (miss-trip) sample for duplicates. The standard deviation of the absolute difference of 48 pairs of the replicate samples was 0.00011 in salinity. The absolute differences in salinity between 2 duplicate samples were 0.0002 and 0.0007.

The results of replicate samples were averaged and flagged as 6 in the seafile.

Reference

Aoyama, M., T. Joyce, T. Kawano and Y. Takatsuki : Standard seawater comparison up to P129. *Deep-Sea Research, I*, **Vol. 49**, 1103~1114, 2002

UNESCO : Tenth report of the Joint Panel on Oceanographic Tables and Standards. *UNESCO Tech. Papers in Mar. Sci.*, **36**, 25 pp., 198

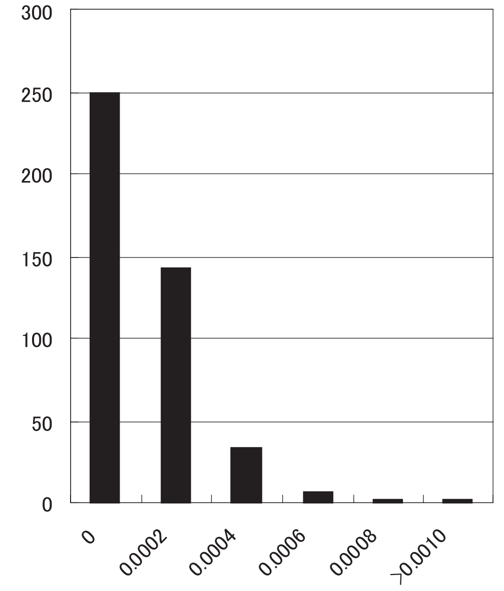

Figure 3.2.7 (a). The histogram of the absolute difference between replicate samples in Leg.1.

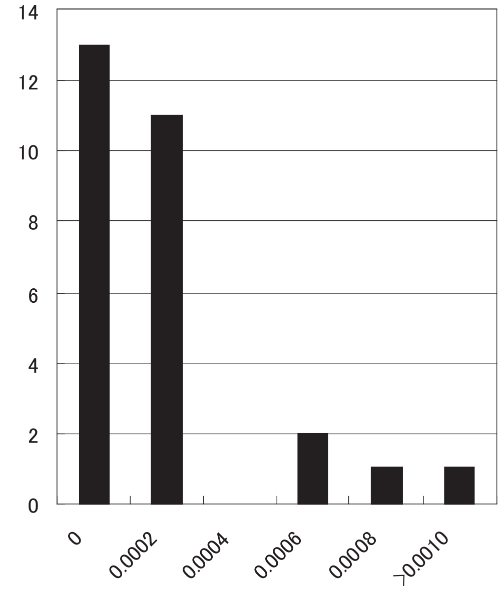

Figure 3.2.7 (b). The histogram of the absolute samples between duplicate samples in Leg.1.

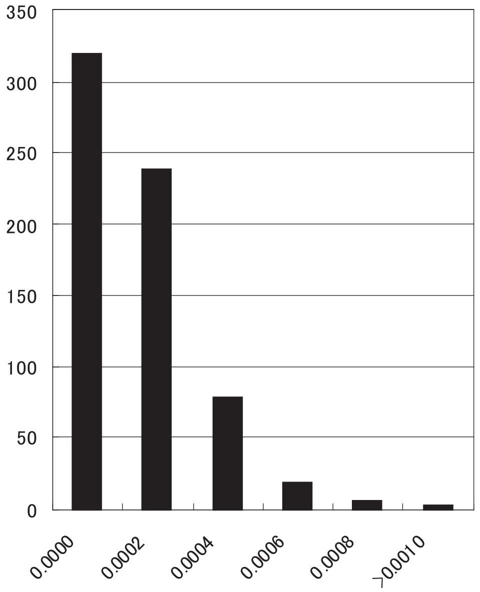

Figure 3.2.8 (a). The histogram of the absolute difference between replicate samples in Leg.2

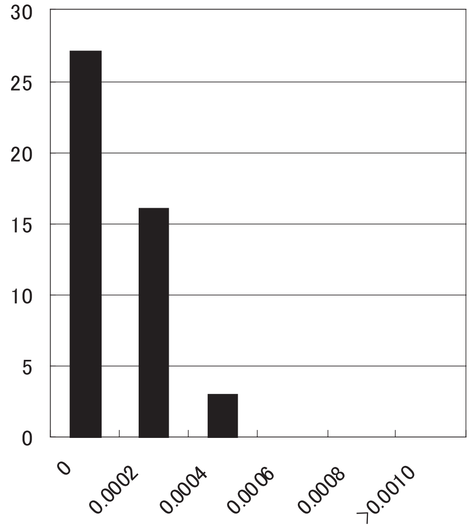

Figure 3.2.9. The histogram of the absolute difference between replicate samples in Leg.3.

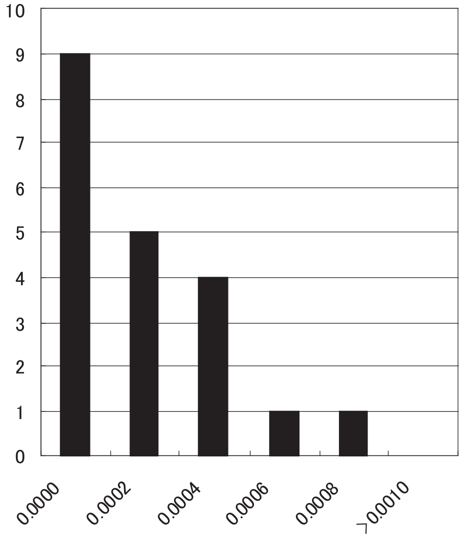

Figure 3.2.8 (b). The histogram of the absolute samples between duplicate samples in Leg.2.

3.3 Bottle Oxygen

May 1, 2007

(1) Personnel

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Takuhei Shiozaki	***(MWJ)***

(2) Objectives

Dissolved oxygen is one of significant tracers for ocean circulation study. Recent studies on the subarctic North Pacific indicated that dissolved oxygen concentration in intermediate layers decreased in basin wide scale during the past decades. The causes of the decrease, however, are still unclear. During MR05-05 Leg.1 (from 31-Oct-05 to 24-Nov-05), Leg.2 (from 27-Nov-05 to 17-Jan-06), and Leg.3 (from 20-Jan-06 to 30-Jan-06), we measured dissolved oxygen concentration from surface to bottom layers at all the hydrocast stations along around 24^{o}N. These stations were the reoccupation of the WHP-P03 stations in 1985. Our purpose is to evaluate change of dissolved oxygen in the subtropical North Pacific between 1985 and 2005/2006.

(3) Reagents

Pickling Reagent I: Manganous chloride solution (3 M)

Pickling Reagent II: Sodium hydroxide (8 M) / sodium iodide solution (4 M)

Sulfuric acid solution (5 M)

Sodium thiosulfate (0.025 M)

Potassium iodate (0.001667 M)

CSK standard of potassium iodate: Lot ASE8281, Wako Pure Chemical Industries Ltd., 0.0100 N

(4) Instruments

Burette for sodium thiosulfate;

APB-510 manufactured by Kyoto Electronic Co. Ltd. / 10 cm^3 of titration vessel

Burette for potassium iodate;

APB-410 manufactured by Kyoto Electronic Co. Ltd. / 20 cm^3 of titration vessel

Detector; Automatic photometric titrator manufactured, Kimoto Electronic Co. Ltd.

(5) Seawater sampling

Following procedure is based on a determination method in the WHP Operations Manual (Dickson, 1996). Seawater samples were collected from Niskin sampler bottles attached to the CTD-system. Seawater for bottle oxygen measurement was transferred from the Niskin sampler bottle to a volume calibrated glass flask (ca. 100 cm^3). Three times volume of the flask of seawater was overflowed. Sample temperature was measured by a thermometer during the overflowing. Then two reagent solutions (Reagent I, II) of 0.5 cm^3 each were added immediately into the sample flask and the stopper was inserted carefully into the flask. The sample flask was then shaken vigorously to mix the contents and to disperse the precipitate finely throughout. After the precipitate has settled at least halfway down the flask, the flask was shaken again vigorously to disperse the precipitate. The sample flasks containing pickled samples were stored in a laboratory until they were titrated.

(6) Sample measurement

At least two hours after the re-shaking, the pickled samples were measured on board. A magnetic stirrer bar and 1 cm^3 sulfuric acid solution were added into the sample flask and stirring began. Samples were titrated by sodium thiosulfate solution whose molarity was determined by potassium iodate solution (section 3.3.7).

Temperature of sodium thiosulfate during titration was recorded by a thermometer. We measured dissolved oxygen concentration using two sets of the titration apparatus, named DOT-1 and DOT-3. Dissolved oxygen concentration (μmol kg^{-1}) was calculated by the sample temperature during the sampling, CTD salinity, flask volume, and titrated volume of the sodium thiosulfate solution.

(7) Standardization

Concentration of sodium thiosulfate titrant (ca. 0.025 M) was determined by potassium iodate solution. Pure potassium iodate was dried in an oven at 130°C. 1.7835 g potassium iodate accurately weighed out was dissolved in deionized water and diluted to final volume of 5 dm^3 in a calibrated volumetric flask (0.001667 M). 10 cm^3 of the standard potassium iodate solution was added to a flask using a volume-calibrated dispenser. Then, 90 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I were added into the flask in order. Amount of titrated volume of sodium thiosulfate (usually 5 times measurements average) gave the molarity of the sodium thiosulfate titrant. Table 3.3.1 shows the result of the standardization during this cruise. Error (C.V.) of the standardization was 0.02±0.01%, c.a. 0.05 μmol kg^{-1}.

(8) Determination of the blank

The oxygen in the pickling reagents I (0.5 cm^3) and II (0.5 cm^3) was assumed to be 3.8 x 10^{-8} mol (Murray *et al.*, 1968). The blank from the presence of redox species apart from oxygen in the reagents (the pickling reagents I, II, and the sulfuric acid solution) was determined as follows. 1 cm^3 and 2 cm^3 of the standard potassium iodate solution were added to two flasks, respectively. Then 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the two flasks in order. The blank was determined by difference between the two times of the first (1 cm^3 of KIO_3) titrated volume of the sodium thiosulfate and the second (2 cm^3 of KIO_3) one. The results of 3 times blank determinations were averaged (Table 3.3.1). The averaged blank of DOT-1 and DOT-3 during the whole legs were -0.009 and -0.005 cm^3, respectively.

Table 3.3.1. Results of the standardization and the blank determinations during MR05-05.

Date (UTC)	KIO_3		DOT-1 (cm^3)			DOT-3 (cm^3)			Samples (Stations)
	#	bottle	$Na_2S_2O_3$	E.P.	blank	$Na_2S_2O_3$	E.P.	blank	
2005/10/30	1	20050829-25	20051028-3	3.960	-0.010	20051028-4	3.961	-0.005	1-16
2005/11/02		20050829-26	20051028-3	3.961	-0.010	20051028-4	3.959	-0.004	18-26
2005/11/03		20050829-27	20051031-1	3.960	-0.011	20051031-2	3.961	-0.005	28-34
2005/11/04		20050829-28	20051031-1	3.960	-0.009	20051031-2	3.959	0.000	36-44
2005/11/06		20050829-29	20051031-3	3.960	-0.011	20051031-4	3.960	-0.008	46-53
2005/11/07		20050829-30	20051031-3	3.958	-0.008	20051031-4	3.958	-0.004	55-58,X17,62
2005/11/09		20050829-31	20051105-1	3.960	-0.012	20051105-2	3.960	-0.006	64-73
2005/11/11	2	20050829-37	20051105-3	3.960	-0.011	20051105-4	3.963	-0.004	74-81
2005/11/12		20050829-38	20051105-3	3.960	-0.010	20051105-4	3.960	-0.008	83-90
2005/11/14		20050829-39	20051112-1	3.962	-0.009	20051112-2	3.964	-0.005	92-100
2005/11/15		20050829-40	20051112-1	3.960	-0.010	20051112-2	3.963	-0.004	X16,104-110
2005/11/17		20050829-41	20051112-3	3.963	-0.010	20051112-4	3.963	-0.006	112-120
2005/11/18		20050829-42	20051112-3	3.963	-0.009	20051112-4	3.964	-0.004	122-130
2005/11/20		20050829-43	20051116-1	3.957	-0.010	20051116-2	3.958	-0.007	132-140
2005/11/21		20050829-44	20051116-1	3.957	-0.009	20051116-2	3.959	-0.005	142-146
2005/11/30	3	20050830-49	20051128-1	3.960	-0.011	20051128-2	3.961	-0.005	146(2)-153
2005/12/01		20050829-50	20051128-1	3.959	-0.010	20051128-2	3.958	-0.005	154-163
2005/12/02		20050829-51	20051128-3	3.961	-0.009	20051128-4	3.961	-0.006	165-173
2005/12/03		20050829-52	20051128-3	3.959	-0.010	20051128-4	3.959	-0.005	175-183
2005/12/05		20050829-53	20051203-1	3.960	-0.010	20051203-2	3.960	-0.008	185-193
2005/12/07		20050829-54	20051203-1	3.960	-0.009	20051203-2	3.960	-0.006	195,197,X14, 201,203
2005/12/09		20050829-55	20051203-3	3.959	-0.010	20051203-4	3.960	-0.005	205-213
2005/12/11		20050829-56	20051203-3	3.961	-0.010	20051203-4	3.960	-0.004	215,217

Batch number of the KIO_3 standard solution.

Table 3.3.1. (continued)

Date (UTC)	KIO_3 #	KIO_3 bottle	DOT-1 (cm^3) $Na_2S_2O_3$	DOT-1 (cm^3) E.P.	DOT-1 (cm^3) blank	DOT-3 (cm^3) $Na_2S_2O_3$	DOT-3 (cm^3) E.P.	DOT-3 (cm^3) blank	Samples (Stations)
2005/12/16	4	20050829-61	20051211-1	3.963	-0.009	20051211-2	3.966	-0.005	WC0-WC4
2005/12/17		20050829-62	20051211-1	3.962	-0.008	20051211-2	3.960	-0.007	WC5-WC10
2005/12/20		20050829-63	20051211-3	3.961	-0.010	20051211-4	3.962	-0.003	217(2)-225
2005/12/22		20050829-64	20051211-3	3.964	-0.010	20051211-4	3.964	-0.006	227-233,X13
2005/12/24		20050829-65	20051223-1	3.964	-0.008	20051223-2	3.963	-0.005	237-245
2005/12/25		20050829-66	20051223-1	3.964	-0.009	20051223-2	3.963	-0.004	247-253
2005/12/27		20050829-67	20051223-3	3.965	-0.011	20051223-4	3.965	-0.005	255-263
2005/12/28		20050829-68	20051223-3	3.963	-0.007	20051223-4	3.964	-0.003	265-273
2005/12/30	5	20050829-73	20051229-1	3.964	-0.010	20051229-2	3.964	-0.006	X10,275-279
2006/01/01		20050829-74	20051229-1	3.964	-0.007	20051229-2	3.965	-0.005	281-289
2006/01/03		20050829-75	20051229-3	3.965	-0.010	20051229-4	3.963	-0.007	291-299
2006/01/04		20050829-76	20051229-3	3.966	-0.010	20051229-4	3.966	-0.006	301-312
2006/01/05		20050829-77	20060105-1	3.961	-0.007	20060105-2	3.961	-0.004	314-318,X09,322
2006/01/07		20050829-78	20060105-1	3.961	-0.009	20060105-2	3.961	-0.002	324-333
2006/01/10		20050829-79	20060105-3	3.959	-0.008	20060105-4	3.960	-0.005	335-343
2006/01/11		20050829-80	20060105-3	3.962	-0.009	20060105-4	3.962	-0.005	345-351
2006/01/12	6	20050829-85	20060112-1	3.965	-0.011	20060112-2	3.966	-0.005	369-355
2006/01/14		20050829-86	20060112-1	3.963	-0.009	20060112-2	3.966	-0.004	353,351(2)
2006/01/20	6	20050829-88	20060112-3	3.968	-0.009	20060112-4	3.970	-0.004	370-389
2006/01/23		20050829-89	20060112-3	3.967	-0.006	20060112-4	3.967	-0.006	390-408
2006/01/25		20050829-90	20060120-1	3.964	-0.008	20060120-2	3.969	-0.001	TS7- TS1

Batch number of the KIO_3 standard solution.

(9) Reagent blank

The blank determined in section 3.3.8, pure water blank ($V_{blk, dw}$) can be represented by equation 1,

$$V_{blk, dw} = V_{blk, ep} + V_{blk, reg} \qquad (1)$$

where

$V_{blk, ep}$ = blank due to differences between the measured end-point and the equivalence point;

$V_{blk, reg}$ = blank due to oxidants or reductants in the reagent.

Here, the reagent blank ($V_{blk, reg}$) was determined by following procedure. 1 cm^3 of the standard potassium iodate solution and 100 cm^3 of deionized water were added to two flasks each. 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the first flask in order. Then, two times volume of the reagents (2 cm^3 of sulfuric acid solution, and 1.0 cm^3 of pickling reagent solution II and I each) was added to the second flask. The reagent blank was determined by difference between the first (2 cm^3 of the total reagent volume added) titrated volume of the sodium thiosulfate and the second (4 cm^3 of the total reagent volume added) one. We also carried out experiments for three and four times volume of the reagents. The results are shown in Figure 3.3.1

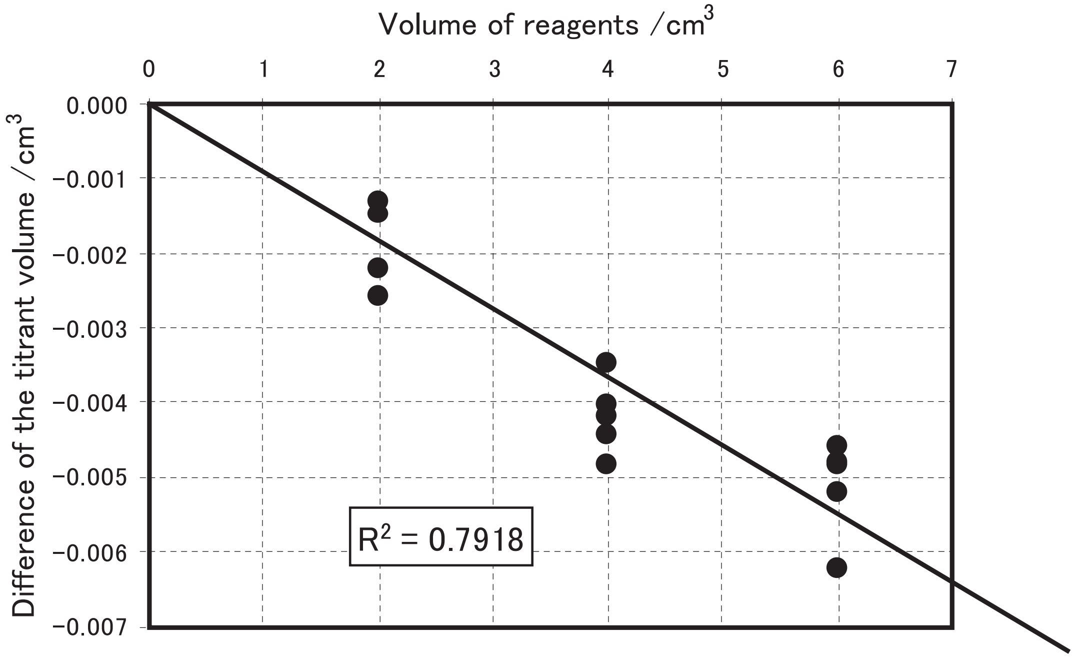

Figure 3.3.1. Blank (cm^3) due to redox species apart from oxygen in the reagents.

The relation between difference of the titrant ($Na_2S_2O_3$) volume and the volume of the reagents added

($V_{reagent}$) is expressed by equation 2,

$$\text{Difference of the titrant volume} = -0.0009\ V_{reagent} \qquad (2)$$

There was no significant difference between the results of DOT-1 and DOT-3. $V_{blk,\ reg}$ was estimated to be about -0.002 cm^3, suggesting that about 0.01 μmol of reductants was contained in every 2 cm^3 of the reagents added. In other words, the difference of the pure water blank ($V_{blk,\ dw}$) between DOT-1 and DOT-3, determined in the section 3.3.8, was due to the difference of the end-point blank ($V_{blk,\ ep}$) between the two titration apparatus (-0.007 and -0.003 cm^3 for DOT-1 and DOT-3, respectively).

(10) Sample blank

Blank due to redox species other than oxygen in the sample ($V_{blk,\ spl}$) can be a potential source of measurement error. The total blank during the seawater measurement, the seawater blank ($V_{blk,\ sw}$) can be represented by equation 3,

$$V_{blk,\ sw} = V_{blk,\ spl} + V_{blk,\ dw} \qquad (3)$$

If the pure water blank ($V_{blk,\ dw}$) that is determined in section 3.3.8 is identical both in pure water and in seawater, the difference between the seawater blank and the pure water one gives the sample blank ($V_{blk,\ spl}$).

Here, $V_{blk,\ spl}$ was determined by following procedure. Seawater sample was collected in the volume calibrated glass flask (ca. 100 cm^3) without the pickling. Then 1 cm^3 of the standard potassium iodate solution, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I each were added into the flask in order. Additionally a flask contained 1 cm^3 of the standard potassium iodate solution, 100 cm^3 of deionized water, 1 cm^3 of sulfuric acid solution, and 0.5 cm^3 of pickling reagent solution II and I was prepared. The difference of the titrant volumes of the seawater flask and the deionized water one gave the sample blank ($V_{blk,\ spl}$).

We measured vertical profiles of the sample blank at four stations (Table 3.3.2) using DOT-1 system. The sample blank ranged from 0.4 to 0.8 μmol kg^{-1} and its vertical and horizontal variations are small. Our results agree to reported values ranged from 0.4 to 0.8 μmol kg^{-1} (Culberson *et al.*, 1991) and our previous results obtained in the western North Pacific, reoccupation of WHP-P10 in 2005. Ignorant of the sample blank will cause systematic errors in the oxygen calculations, but these errors are expected to be the same to all investigators and not to affect the comparison of results from different investigators (Culberson, 1994).

Table 3.3.2. Results of the sample blank determinations during MR05-05.

Station: P03-006 32.5°N / 118.0°W		Station: P03-031 29.1°N / 123.9°W		Station: P03-136 25.5°N / 164.3°W		Station: P03-215 24.2°N / 172.8°E	
CTD Pres. dbar	Sample blank μmol kg^{-1}	CTD Pres. dbar	Sample blank μmol kg^{-1}	CTD Pres. dbar	Sample blank μmol kg^{-1}	CTD Pres. dbar	Sample blank μmol kg^{-1}
9	0.48	10	0.45	9	0.38	10	0.39
149	0.71	51	0.50	48	0.38	50	0.40
249	0.68	101	0.56	100	0.51	100	0.48
400	0.63	152	0.56	150	0.57	150	0.53
600	0.74	501	0.63	200	0.64	200	0.63
800	0.70	1001	0.70	600	0.59	502	0.76
1003	0.76	2003	0.66	1201	0.52	1003	0.66
1403	0.69	3001	0.68	2201	0.60	2000	0.69
1801	0.70	4249	0.73	3251	0.60	3500	0.71
1867	0.78	4459	0.72	3751	0.62	5002	0.72

(11) Replicate sample measurement

Replicate samples were taken from every CTD cast. Total amount of the replicate sample pairs in good measurement (flag=2) was 837. The standard deviation of the replicate measurement was 0.08 μmol kg^{-1} and there was no significant difference between DOT-1 and DOT-3 measurements. The standard deviation was calculated by a procedure (SOP23) in DOE (1994). The difference between the replicate sample pairs did not depend on sampling pressure (Figure 3.3.2) and measurement date (Figure 3.3.3). The standard deviations during

Leg.1, Leg.2, and Leg.3 were 0.083 (n=299) and 0.083 (n=493), and 0.085 μmol kg^{-1} (n=45), respectively. In the hydrographic data sheet, a mean of replicate sample pairs is shown with the flag 2.

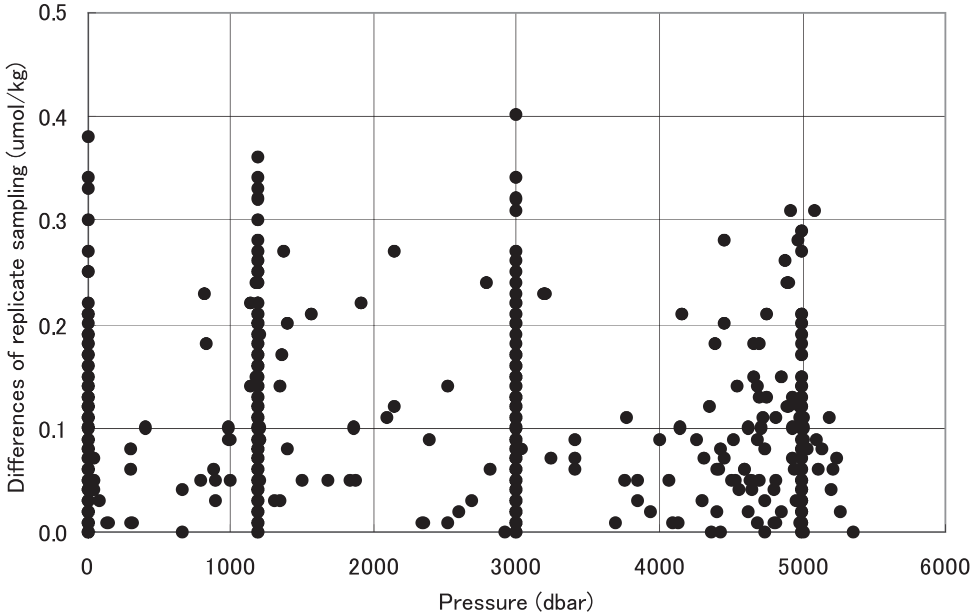

Figure 3.3.2. Differences in the replicate measurements against sampling pressure.

(12) Duplicate sample measurement

We also collected seawater samples from two Niskin samplers that were collected at same depth (duplicate sampling). Total 50 pairs of the duplicate samples were taken in deep layers below 800 dbar during all the legs. The standard deviation of the total duplicate measurement was 0.10 μmol kg^{-1}. We concluded that total measurement error of bottle oxygen was less than 0.10 μmol kg^{-1} during MR05-05 cruise.

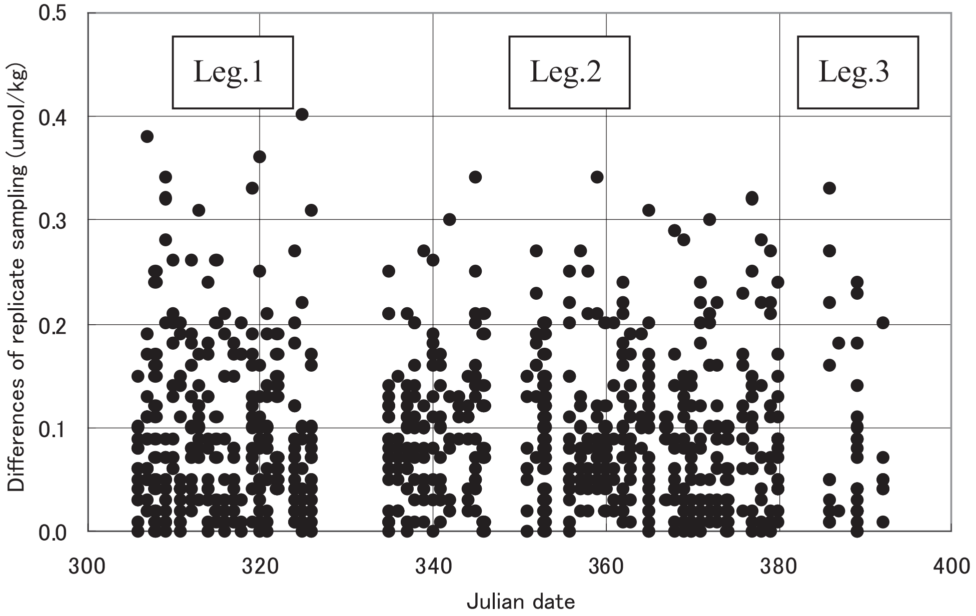

Figure 3.3.3. Differences in the replicate measurements against measurement date (Julian date).

(13) CSK standard measurements

The CSK standard solution is commercial potassium iodate solution (0.0100 N) for analysis of oxygen in seawater. During the cruises, we measured concentration of the CSK standard solution (Lot ASE8281) against our KIO_3 standard in order to confirm the accuracy of our oxygen measurement on board (Table 3.3.3). Error weighted means of DOT-1 and DOT-3 results were 0.009999±0.000005 and 0.010002±0.000006 normal (N) respectively, which indicates that there was no systematic difference between DOT-1 and DOT-3 measurements. The averaged value of the CSK standard solution was so close to the certified value (0.0100 N) that we did not correct sample measurements results using the CSK standard results. Additionally, we also measured the same lot (ASE8281) of the CSK standard solution during our previous cruise in 2005 (MR05-02). Results of the CSK measurements in the both cruises agreed well within the errors (less than 0.1%), suggesting that there was no systematic difference in the oxygen measurements between MR05-02 and MR05-05.

Table 3.3.3. Results of the CSK standard measurements.

Date (UTC)	KIO_3 batch#	DOT-1		DOT-3	
		Conc. (N)	error (N)	Conc. (N)	error (N)
2005/11/07	ASE8281-1	0.010005	0.000005	0.010006	0.000003
2005/11/18	ASE8281-2	0.009998	0.000003	0.009993	0.000017
2005/12/07	ASE8281-3	0.010004	0.000007	0.010001	0.000007
2005/12/25	ASE8281-4	0.010001	0.000004	0.010005	0.000007
2006/01/11	ASE8281-5	0.009997	0.000006	0.009998	0.000011
2006/01/14	ASE8281-6	0.009998	0.000008	0.009997	0.000009
2006/01/26	ASE8281-7	0.009989	0.000006	0.009990	0.000005
Weighted mean		0.009999	0.000005	0.010002	0.000006
Date (UTC)	KIO_3 batch#	DOT-1		DOT-2	
		Conc. (N)	error (N)	Conc. (N)	error (N)
2005/6/21	ASE8281-0	0.010005	0.000010	0.010002	0.000006

(14) Quality control flag assignment

Quality flag values were assigned to oxygen measurements using the code defined in Table 0.2 of WHP Office Report WHPO 91-1 Rev.2 section 4.5.2 (Joyce *et al.*, 1994). Measurement flags of 2 (good), 3 (questionable), 4 (bad), and 5 (missing) have been assigned (Table 3.3.4). The replicate data (section 3.3-11) were averaged and flagged 2 if both of them were flagged 2. If either of them was flagged 3 or 4, a datum with "younger" flag was selected. Thus, we did not use flag of 6 (replicate measurements). For the choice between 2, 3, or 4, we basically followed a flagging procedure as listed below:

a. Bottle oxygen concentration and difference between bottle oxygen and CTD oxygen at the sampling were plotted against CTD pressure. Any points not lying on a generally smooth trend were noted.
b. Dissolved oxygen was then plotted against potential temperature or sigma-theta. If a datum deviated from a group of plots, it was flagged 3.
c. Vertical sections against pressure and potential density were drawn. If a datum was anomalous on the section plots, datum flag was degraded from 2 to 3, or from 3 to 4.
d. If the bottle flag was 4 (did not trip correctly), a datum was flagged 4 (bad). In the case of the bottle flag 3 (leaking) or 5 (unknown problem), a datum was flagged based on steps a, b, and c.

Table 3.3.4. Summary of assigned quality control flags.

Flag	Definition	
2	Good	6,698
3	Questionable	5
4	Bad (Faulty)	10
5	Not reported (missing)	4
	Total	6,717

(15) Results

(15.1) Comparison at cross-stations during MR05-05

At stations of P03-146, 217, and 351, hydrocast sampling for dissolved oxygen was conducted two times at interval of about a week. Dissolved oxygen profiles of the two hydrocasts at the three cross-stations agreed well (Figure 3.3.4). In the layers deeper than 4,000 dbar, difference of dissolved oxygen between the two hydrocasts was calculated to be 0.20 μmol kg^{-1} (standard deviation, n=24).

(15.2) Comparison at cross-stations of MR05-05 and MR05-02

During June of 2006, we also conducted another repeat cruise of WHP-P10, named MR05-02 cruise, along about 149°E in the western North Pacific. At the cross point of MR05-05 and MR05-02, we carried out two cross-stations at 24.5°N/149.4°E (MR05-02_P10-067 and MR05-05_P03-X10) and 24.2°N/149.0°E (MR05-02_P10-X03 and MR05-05_P03-275). Repeat measurements of dissolved oxygen at interval of about six months showed that dissolved oxygen decreased by 20 μmol kg^{-1} in deep layers ranged from about 1,500 to 2,500 dbar (Figure 3.3.5). It should also be noted that oxygen concentration also decreased slightly (about 2 μmol kg^{-1}) in bottom water below 5,000 dbar at the both two cross-stations. As mentioned in section 3.3.15.1, the results at the cross-stations during MR05-05 cruise showed that the repeat measurements of dissolved oxygen in bottom water agreed within 0.2 μmol kg^{-1}. Additionally, using the CSK standard solution we ensured traceability of dissolved oxygen analyses during MR05-02 and MR05-05 cruises within about 0.1% correspondent to about 0.2 μmol kg^{-1} (section 3.3.13). These results indicate that total reproducibility of our oxygen measurement is about 0.2 μmol kg^{-1}, suggesting that observed oxygen decreases of about 2 μmol kg^{-1} in the bottom water at the cross-stations are significant. The variability of oxygen concentration within six months in the deep and bottom waters implies that apparent decadal change of dissolved oxygen derived from repeat hydrography should be discussed carefully.

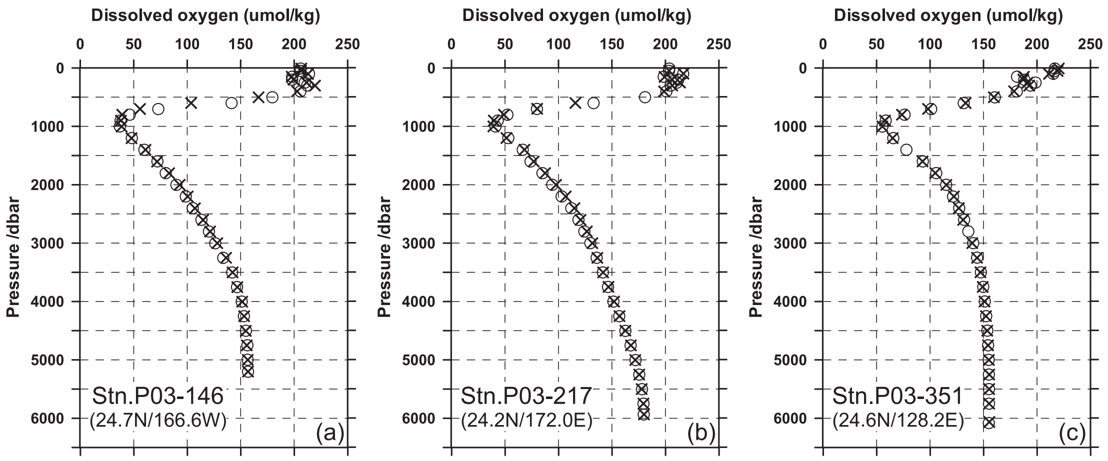

Figure 3.3.4. Comparison of dissolved oxygen profiles between the first hydrocast (circles) and the second one (crosses) at the cross-stations of Stn. P03-146 (a), -217 (b), and -351 (c) during MR05-05 cruise.

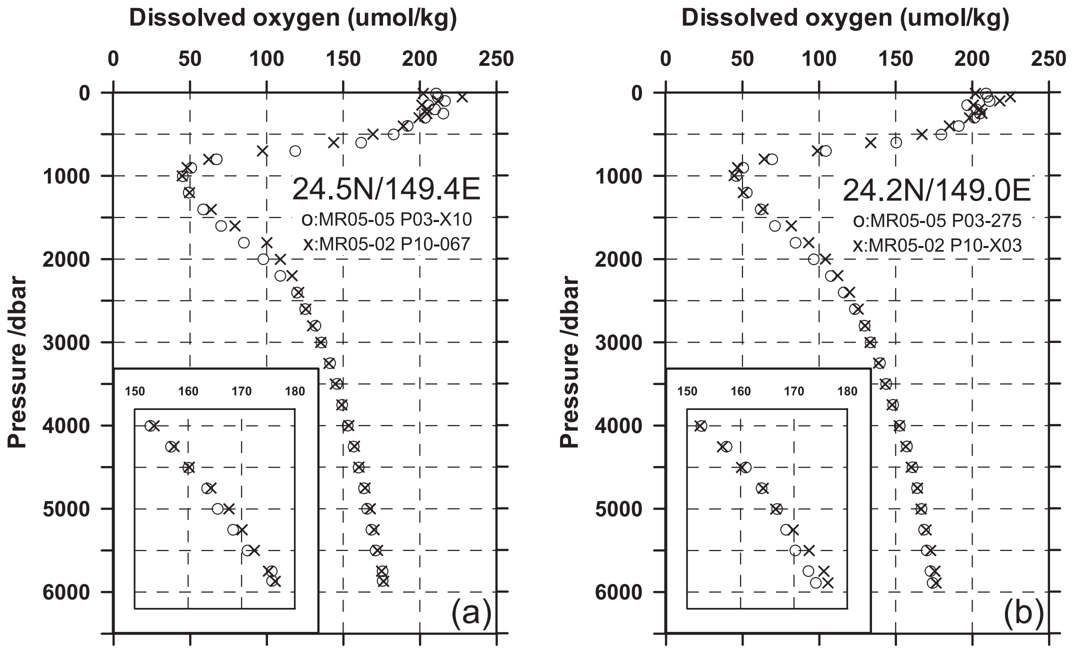

Figure 3.3.5. Comparison of dissolved oxygen profiles during MR05-02 and MR05-05 cruises at the cross-stations located at 24.5°N/149.4°E (a) and 24.2°N/149.0°E (b). Circles show data obtained at Stn. P03-X10 (a) and P03-275 (b) of MR05-05 cruise on December/12/2005. Crosses indicate data obtained at Stn. P10-067 (a) and P10-X03 (b) of MR05-02 cruise on June/10/2005.

(15.3) Comparison with WHP-P03 oxygen data in 1985

We compared our oxygen data and gridded data of WHP-P03 in 1985 and found that our oxygen data were slightly lower than those of WHP-P03. Below 2,000 m depth the difference in average is calculated in –2.2± 1.7 μmol kg^{-1} (Figure 3.3.6). This "offset" value is closed to reported adjustments, about minus 3 μmol kg^{-1} for dissolved oxygen data of WHP-P03 (Johnson *et al*., 2001; Gouretski and Jancke, 2001). We here corrected oxygen data of WHP-P03 by the averaged offset value, 2.2 μmol kg^{-1}.

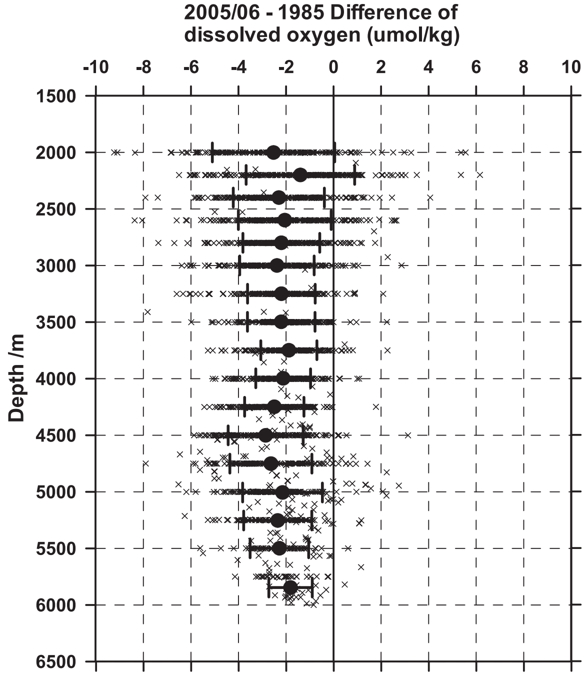

Figure 3.3.6. Oxygen difference (2005/2006 data minus 1985 data, μmol kg^{-1}) against water depth. Closed circles denote mean of the differences with 1 sigma error at sampling layers.

Figure 3.3.7(a) shows distribution of oxygen difference (2005/2006 data minus 1985 data) against water depth. Below 1,000 m depth, there were not differences more than 5 μmol kg^{-1}. The dispersion of the difference in the deep/bottom water (±1.7 μmol kg^{-1} for 1 sigma) was also independent from the sampling depths, suggesting that the dispersion was derived from analytical errors and the data gridding. The dispersion of 2 sigma (±3.4 μmol) and the offset correction of 2.2 μmol kg^{-1} imply that oxygen differences less than 5 μmol kg^{-1} between 1985 and 2005/06 is not significant. In the layers shallower than 1,000 m depth, we found some increases and decreases of dissolved oxygen. In order to focus on the shallow variations, the differences were plotted against water density (sigma theta) from 24.5 to 27.5 (approximately correspondent to layers from 200 to1,200 m depth) in Figure 3.3.7(b).

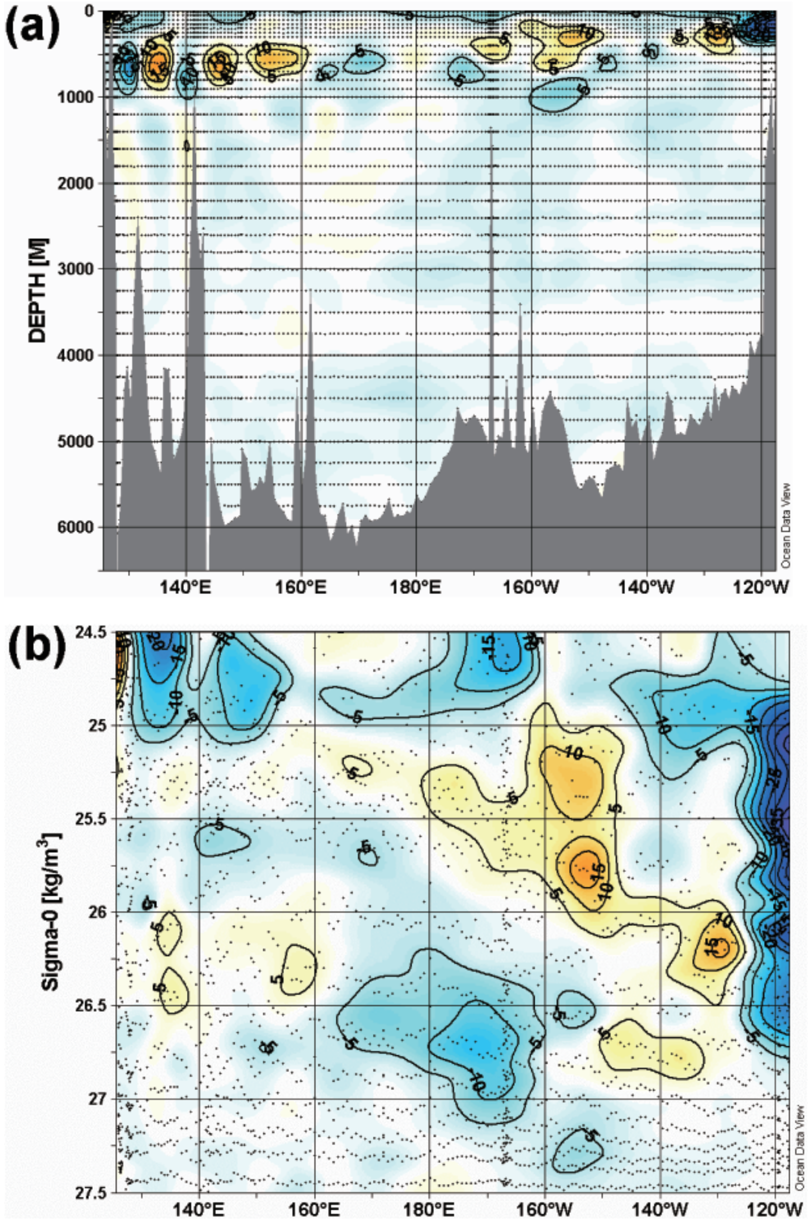

Figure 3.3.7. Differences of dissolved oxygen (μmol kg^{-1}) between 2005/06 and 1985 (2005/2006 data minus 1985 data) against water depth (a) and water density, sigma-theta (b). Data of WHP-P03 in 1985 were corrected by the deep/bottom offset. Contour intervals are 5 μmol kg^{-1}. Small dots indicate sampling layers of dissolved oxygen during MR05-05 in 2005/06.

We found a significant decrease of dissolved oxygen at the eastern end where oxygen concentration was relatively low. This decrease may be due to variability of local upwelling. Oxygen increase around 130°W to the International Date Line ranged from 25.0 to 26.2 sigma theta implies variation of mesoscale eddies. From 160°W to 160°E, around 26.8 sigma theta dissolved oxygen decreased, which is similar to the intermediate oxygen decrease in the subarctic regions in the North Pacific (Emerson *et al*., 2001; Watanabe *et al.*, 2001). The decadal change along around 24°N, however, was smaller than that found in the subarctic North Pacific.

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3.4 Nutrients

July 19, 2007

(1) Personnel

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Ayumi Takeuchi	***(MWJ)***
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Junko Hamanaka	***(MWJ)***
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Leg.3

Junko Hamanaka	***(MWJ)***
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(2) Objectives

The objectives of nutrients analyses during the R/V MIRAI MR0505 cruise along 24N line in the Western North Pacific are as follows;

Describe the present status of nutrients concentration with excellent comparability.

The determinants are nitrate, nitrite, phosphate and silicate (Although silicic acid is correct, we use silicate because a term of silicate is widely used in oceanographic community.)

Study the temporal and spatial variation of nutrients based on the previous high quality experiments data of WOCE, GOESECS, IGY and so on.

Study temporal and spatial variation of nitrate: phosphate ratio, so-called Redfield ratio.

Obtain more accurate estimation of total amount of nitrate, phosphate and silicate in the interested area.

Provide more accurate nutrients data for physical oceanographers to use as tracers for water mass movement.

(3) Equipment and techniques

(3.1) Analytical detail using TRAACS 800 systems (BRAN+LUEBBE)

The phosphate analysis is a modification of the procedure of Murphy and Riley (1962).

Molybdic acid is added to the seawater sample to form phosphomolybdic acid which is in turn reduced to phosphomolybdous acid using L-ascorbic acid as the reductant.

Nitrate + nitrite and nitrite are analyzed by according to the modification method of Grasshoff (1970).

The sample nitrate is reduced to nitrite in a cadmium tube inside of which is coated with metallic copper. The sample stream with its equivalent nitrite is treated with an acidic, sulfanilamide reagent and the nitrite forms nitrous acid which reacts with sulfanilamide to produce a diazonium ion. N1-Naphthylethylene-diamine added to the sample stream then couples with the diazonium ion to produce a red, azo dye. With reduction of the nitrate to nitrite, both nitrate and nitrite react and are measured; without reduction, only nitrite reacts. Thus, for the nitrite analysis, no reduction is performed and the alkaline buffer is not necessary. Nitrate is computed by difference.

The silicate method is analogous to that described for phosphate. The method used is essentially that of Grasshoff et al. (1983), wherein silicomolybdic acid is first formed from the silicic acid in the sample and added molybdic acid; then the silicomolybdic acid is reduced to silicomolybdous acid, or "molybdenum blue," using ascorbic acid as the reductant.

The flow diagrams and regents for each parameter are shown in Figures 3.4.1-3.4.4.

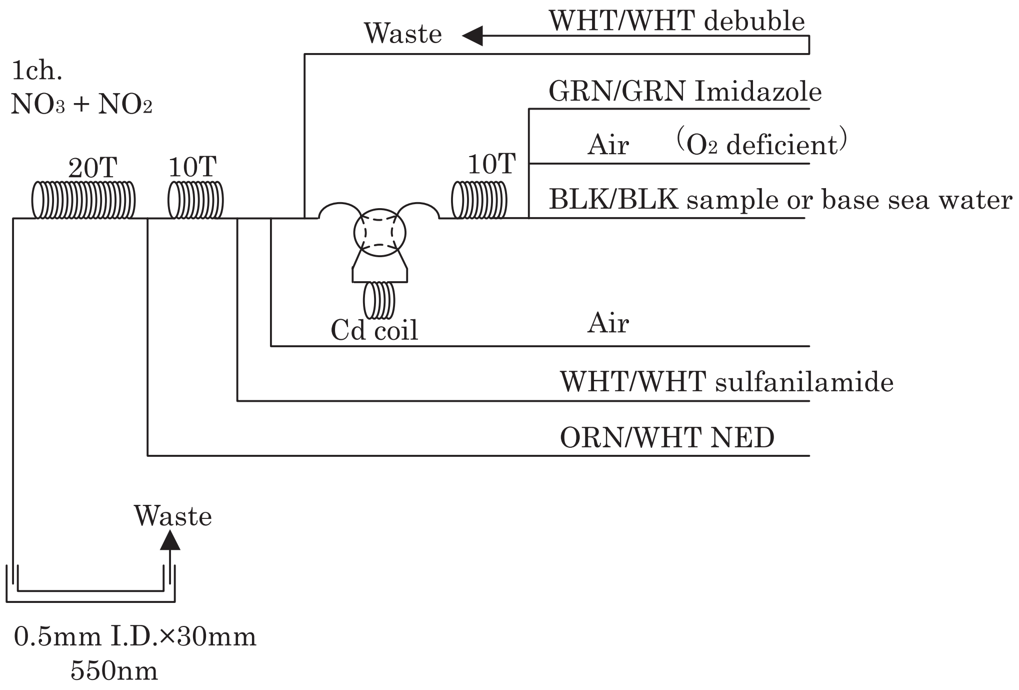

Figure 3.4.1. 1ch. (NO_3+NO_2) Flow diagram.

Nitrate Reagents

Imidazole (buffer), 0.06 M (0.4% w/v)

Dissolve 4 g imidazole, $C_3H_4N_2$, in ca. 900 ml DIW; add 2ml concentrated HCl; make up to 1,000 ml with DIW. After mixing, 1ml Triton(R)X-100 (50% solution in ethanol) is added.

Sulfanilamide, 0.06 M (1% w/v) in 1.2 M HCl

Dissolve 10 g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 1,000 ml of 1.2 M (10%) HCl. After mixing, 1 ml Triton(R)X-100 (50% solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride, 0.004 M (0.1% w/v)

Dissolve 1 g NEDA, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1,000 ml of DIW; containing 10 ml concentrated HCl. Stored in a dark bottle.

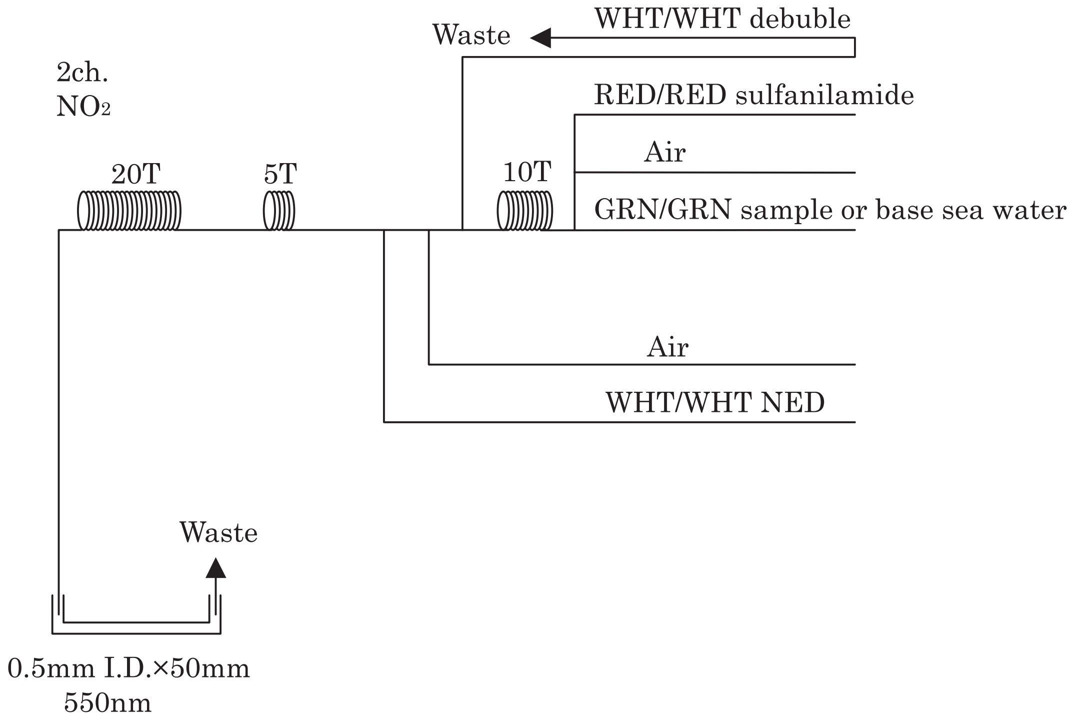

Figure 3.4.2. 2ch. (NO_2) Flow diagram.

Nitrite Reagents

Sulfanilamide, 0.06 M (1% w/v) in 1.2 M HCl

Dissolve 10 g sulfanilamide, 4-$NH_2C_6H_4SO_3H$, in 1,000 ml of 1.2 M (10%) HCl. After mixing, 1ml Triton(R)X-100 (50% solution in ethanol) is added.

N-1-Napthylethylene-diamine dihydrochloride , 0.004 M (0.1% w/v)

Dissolve 1 g NEDA, $C_{10}H_7NHCH_2CH_2NH_2 \cdot 2HCl$, in 1,000 ml of DIW; containing 10 ml concentrated HCl. Stored in a dark bottle.

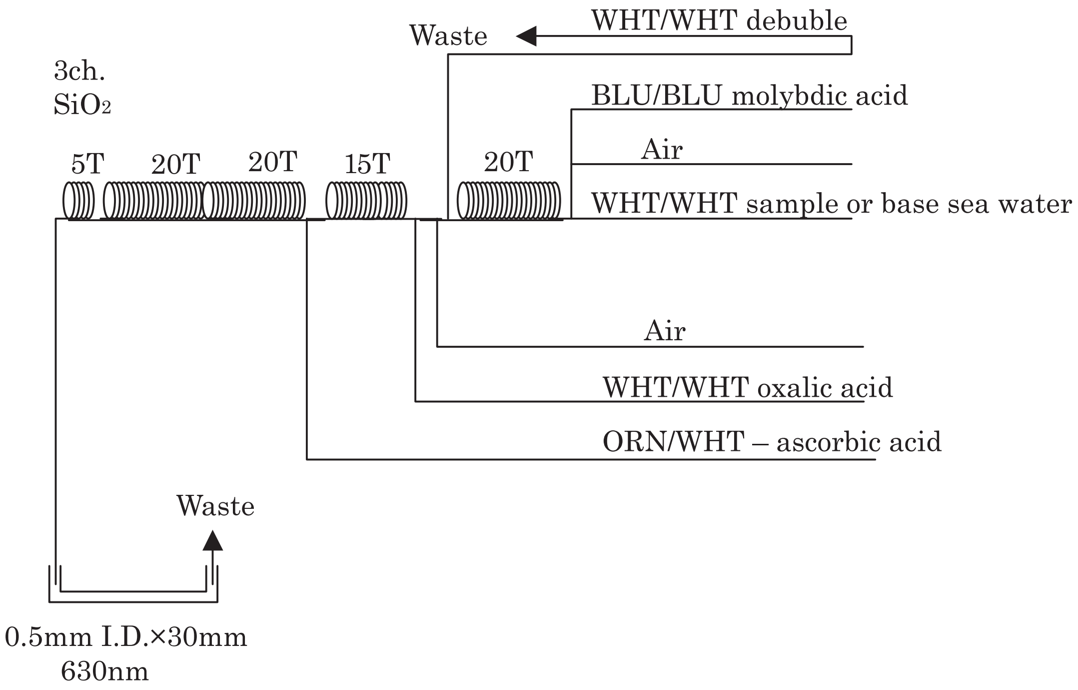

Figure 3.4.3. 3ch. (SiO2) Flow diagram.

Silicic Acid Reagents

Molybdic acid, 0.06 M (2% w/v)

Dissolve 15 g Disodium Molybdate(VI) Dihydrate, $Na_2MoO_4 \cdot 2H_2O$, in 1,000 ml DIW containing 6 ml H_2SO_4. After mixing, 20 ml sodium dodecyl sulphate (15% solution in water) is added.

Oxalic acid, 0.6 M (5% w/v)

Dissolve 50 g Oxalic Acid Anhydrous, HOOC: COOH, in 1,000 ml of DIW.

Ascorbic acid, 0.01 M (3% w/v)

Dissolve 2.5 g L (+)-Ascorbic Acid, $C_6H_8O_6$, in 100 ml of DIW. Stored in a dark bottle and freshly prepared before every measurement.

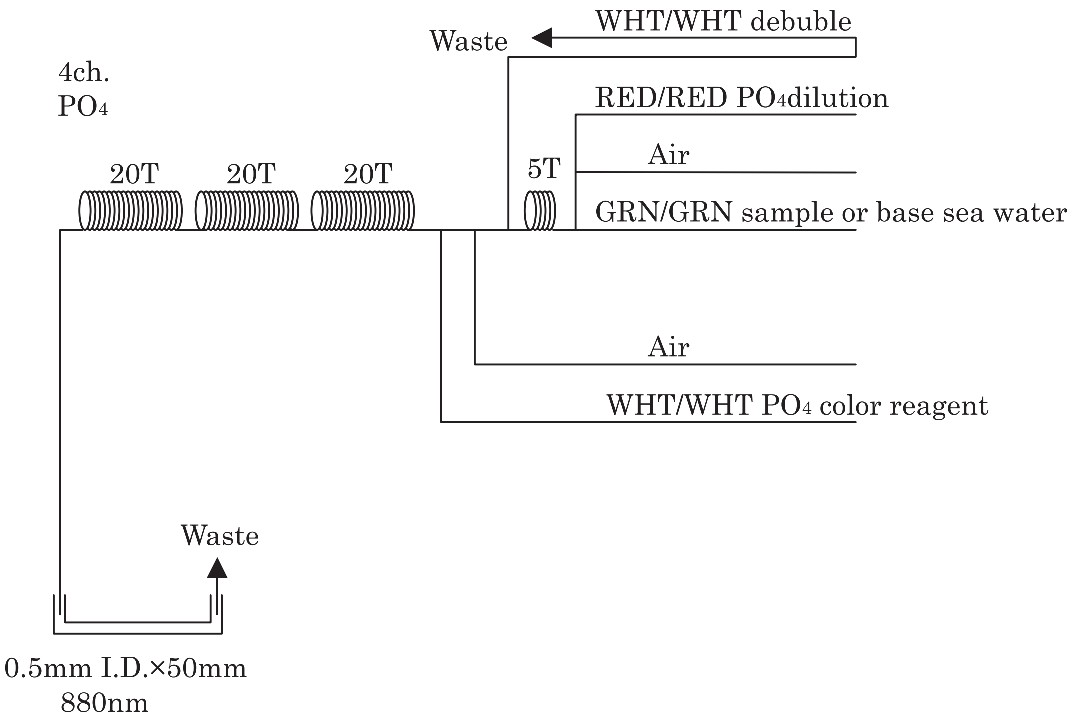

Figure 3.4.4. 4ch. (PO$_4$) Flow diagram.

Phosphate Reagents

Stock molybdate solution, 0.03 M (0.8% w/v)

Dissolve 8 g Disodium Molybdate(VI) Dihydrate, $Na_2MoO_4 \cdot 2H_2O$and 0.17 g Antimony Potas- sium Tartrate, $C_8H_4K_2O_{12}Sb_2 \cdot 3H_2O$ in 1,000 ml of DIW containing 50 ml concentrated H_2SO_4.

Mixed Reagent

Dissolve 0.8 g L (+)-Ascorbic Acid, $C_6H_8O_6$, in 100 ml of stock molybdate solution. After mixing, 2 ml sodium dodecyl sulphate (15% solution in water) is added. Stored in a dark bottle and freshly prepared before every measurement.

PO$_4$ dilution

Dissolve Sodium Hydrate, NaCl, 10 g in ca. 900 ml, add 50 ml Acetone and 4 ml concentrated H_2SO_4, make up to 1,000 ml. After mixing, 5 ml sodium dodecyl sulphate (15% solution in water) is added.

(3.2) Sampling procedures

Sampling of nutrients followed that of oxygen, trace gases and salinity. Samples were drawn into two of virgin 10 ml polyacrylates vials without sample drawing tubes. These were rinsed three times before filling and vials were capped immediately after the drawing. The vials are put into water bath at 25 +-1deg. C for 10 minutes before used to stabilize the temperature of samples.

No transfer was made and the vials were set an auto sampler tray directly. Samples were analyzed after collection, basically within 17 hours.

(3.3) Data processing

Raw data from TRAACS800 were treated as follows:

Check baseline shift.

Check the shape of each peak and the positions of the peak values taken, and then change the positions of the peak values taken if necessary.

Carryover correction and baseline drift correction were applied to peak heights of each sample followed by sensitivity correction.

Baseline correction and sensitivity correction were done basically by using liner regression

Load pressure and salinity from CTD data to calculate density of seawater.

Calibration curves to get nutrients concentration were assumed second order equations.

(4) Nutrients standards

(4.1) In-house standards

(i) Volumetric Laboratory Ware

All volumetric glass- and plastic (PMP)-ware used were gravimetrically calibrated. Plastic volumetric flasks were gravimetrically calibrated at the temperature of use within 2-3 K.

Volumetric flasks

Volumetric flasks of Class quality (Class A) are used because their nominal tolerances are 0.05% or less over the size ranges that are likely to be used in this work. Class A flasks are made of borosilicate glass, and the standard solutions were transferred to plastic bottles as quickly as possible after they were made up to volume and well mixed in order to prevent excessive dissolution of silicic acid from the glass. High quality plastic (polymethylpentene, PMP, or polypropylene) volumetric flasks were gravimetrically calibrated and used only within 3-4 K of the calibration temperature.

The computation of volume contained by glass flasks at various temperatures other than the calibration temperatures were done by using the coefficient of linear expansion of borosilicate crown glass.

Because of their larger temperature coefficients of cubical expansion and lack of tables constructed for these materials, the plastic volumetric flasks were gravimetrically calibrated over the temperature range of intended use and used at the temperature of calibration within 3-4 K. The weights obtained in the calibration weightings were corrected for the density of water and air buoyancy.

Pipettes and pipettors

All pipettes have nominal calibration tolerances of 0.1% or better. These were gravimetrically calibrated in order to verify and improve upon this nominal tolerance.

(ii) Reagents, general considerations

General Specifications

All reagents were of very high purity such as “Analytical Grade,” “Analyzed Reagent Grade” and others. In addition, assay of nitrite was determined according as JISK8019 and assays of nitrite salts were 98.9%. We use that value to adjust the weights taken.

For the silicate standards solution, we use commercial available silicon standard solution for atomic absorption spectrometry of 1,000 mg L^{-1}. Since this solution is alkaline solution of 0.5 M KOH, an aliquot of 40ml solution were diluted to 500 ml as B standard together with an aliquot of 20 ml of 1 M HCl. Then the pH of B standard for silicate prepared to be 6.9.

Ultra pure water

Ultra pure water (MilliQ water) freshly drawn was used for preparation of reagents, higher concentration standards and for measurement of reagent and system blanks.

Low-Nutrient Seawater (LNSW)

Surface water with low nutrient concentration was taken and filtered using 0.45 μm pore size membrane filter. This water is stored in 20 liter cubitainer with paper box. The concentrations of nutrient of this water were measured carefully in March 2005.

(iii) Concentrations of nutrients for A, B and C standards

Concentrations of nutrients for A, B and C standards are set as shown in Table 3.4.1. The C standard is prepared by according as recipes, as shown in Table 3.4.2. All volumetric laboratory tools were calibrated prior to the cruise as stated in chapter (i). Then the actual concentration of nutrients in each fresh standard was calculated based on the ambient, solution temperature and determined factors of volumetric laboratory wares.

Table 3.4.1. Nominal concentrations of nutrients for A, B and C standards.

	A	B	B'	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
NO_3(μM)	45000	900	900	0	BA	AY	AX	AV	BC	55.0	55.0
NO_2(μM)	4000	20	20	0	BA	AY	AX	AV	BC	1.2	1.2
SiO_2(μM)	36000	2880	3240	0	BA	AY	AX	AV	BC	172.8	194.4
PO_4(μM)	3000	60	60	0	BA	AY	AX	AV	BC	3.6	3.6

Table 3.4.2. Working calibration standard recipes.

C-STD	B-1 STD	B-1' STD	B-2 STD
C-7	30 ml	0 ml	30 ml
C-8	0 ml	30 ml	30 ml

B-1 STD: Mixture of nitrate, silicate and phosphate

B-1' STD: Mixture of nitrate, silicate and phosphate

B-2 STD: Nitrite

(iv) Renewal of in-house standard solutions

In-house standard solutions as stated in (iii) were renewed as shown in Table 3.4.3.

(4.2) Reference material of nutrients in seawater

To obtain more accurate and high quality nutrients data to achieve the objectives stated above, huge numbers of the bottles of the reference material of nutrients in seawater (hereafter RMNS) are prepared (Aoyama et al., submitted). In the previous world wide expeditions, such as WOCE cruises, higher reproducibility and precision of nutrients measurements were required (Joyce and Corry, 1994). Since no standards were available for the measurement of nutrients in seawater at that time, the requirements were described in term of reproducibility. The required reproducibility was 1%, 1-2%, 1-3% for nitrate, phosphate and silicate, respectively. Although nutrient data from the WOCE one-time survey was of unprecedented quality and coverage due to much care in sampling and measurements, the differences of nutrients concentration at crossover points are still found among the expeditions (Aoyama and Joyce, 1996, Mordy et al., 2000, Gouretski and Jancke, 2001).

Table 3.4.3. Timing of renewal of in-house standards.

NO_3, NO_2, SiO_2, PO_4	**Renewal**
A-1 Std. (NO_3)	**maximum 1 month**
A-2 Std. (NO_2)	**maximum 1 month**
A-3 Std. (SiO_2)	**commercial prepared solution**
A-4 Std. (PO_4)	**maximum 1 month**
B-1 Std. and B-1' Std.	
(mixture of NO_3, SiO_2, PO_4)	**8 days**
B-2 Std. (NO_2)	**8 days**

C Std	**Renewal**
C-7~C-8 Std (mixture of B1 (B1') and B2 Std.)	**24 hours**

Reduction estimation	**Renewal**
D-1 Std.	**when A-1renewed**
43μM NO_3	**when C-std renewed**
47μM NO_2	**when C-std renewed**

For instance, the mean offset of nitrate concentration at deep waters was 0.5 μmol kg^{-1} for 345 crossovers at the world oceans, though the maximum was 1.7 μmol kg^{-1} (Gouretski and Jancke, 2001). At the 31 crossover points in the Pacific WHP one-time lines, the WOCE standard of reproducibility for nitrate of 1% was fulfilled at about half of the crossover points and the maximum difference was 7% at deeper layers below 1.6 deg. C in potential temperature (Aoyama and Joyce, 1996).

(i) RMNS preparation

RMNS preparation and homogeneity for previous lots

The study on reference material for nutrients in seawater (RMNS) on the seawater base has been carried out to establish traceability on nutrient analyses in seawater since 1994 in Japan. Autoclaving to produce RMNS has been studied (Aminot and Kerouel, 1991, 1995) and autoclaving was used to stabilize the samples for the 5th intercompariosn exercise in 1992/1993 (Aminot and Kirkwood, 1995). Aminot and Kerouel (1995) concluded that nitrate and nitrite were extremely stable throughout their 27 months storage experiment with overall standard deviations lower than 0.3% (range 5-50 μmol l^{-1}) and 0.8% (range 0.5-5 μmol l^{-1}), respectively. For phosphate, slight increase by 0.02-0.07 μmol l^{-1} per year was observed due to the leaching from the container glass. The main source of nutrient variation in seawater is believed to be microorganism activity, hence, production of RMNS depends on biological inactivation of samples. In this point of view, previous study showed that autoclaving to inactivate the biological activity is acceptable for RMNS preparation.

In the R/V MIRAI BEAGLE2003 cruise, which was an around the world cruise along ca. 30 deg. S and conducted in 2003 and 2004, RMNS was analyzed at about 500 stations. The results of BEAGLE2003 cruise will be available soon. (Databook of BEAGLE2003)

The seawater for RMNS production was sampled in the North Pacific Ocean at the depths of the surface where the nutrients are almost depleted and the depths of 1,500-2,000 meters where the nutrients concentrations reach its maximum. The seawater was gravity-filtered through a membrane filter with a pore size of 0.45 μm (Millipore HA). The latest procedure of autoclaving for RMNS preparation is that the seawater in a stainless steel container of 40 liters was autoclaved at 120 deg. C, for 2 hours, 2 times in two days. The filling procedure of autoclaved seawater basically remained the same throughout our study. After cooled at room temperature in two days, polypropylene bottles of 100 ml capacity were filled with the autoclaved seawater of 90 ml through a membrane filter with a pore size of 0.2 μm (Millipore HA) at a clean bench in a clean room. The polypropylene caps were immediately and tightly screwed on and a label containing lot number and serial number of each bottle was attached on all of the bottles. Then the bottles were vacuum-sealed to avid potential contamination from the environment.

RMNSs for this cruise

RMNS lots BC, AV, AX, AY and BA, which covers full range of nutrients concentrations in the western North Pacific were prepared as packages. These packages were renewed daily and analyzed every 2 runs on the same day. 250 bottles of RMNS lot AZ were prepared to use every analysis at every hydrographic station. These RMNS assignment were completely done based on random number. The RMNS bottles were stored at a room, REGENT STORE, where the temperature was maintained around 24-26 deg. C.

Assigned concentration for RMNSs

We assigned nutrients concentrations for RMNS lots BC, AV, AX, AY and BA as shown in Table 3.4.4.

(ii) The homogeneity of RMNSs

The homogeneity of lot BC and analytical precisions are shown in Table 3.4.4. These are for the assessment of the magnitude of homogeneity of the RMNS bottles, which were used during the cruise. As shown in Table 3.4.5, the homogeneity of RMNS lot BC for nitrate and silicate are the same magnitude of analytical precision derived from fresh raw seawater. The homogeneity for phosphate, however, exceeds the analytical precision at some extent.

Table 3.4.4. Assigned concentration of RMNSs

	Nitrate	Phosphate	Silicate
RMNS-BA	0.1 ± 0.0	0.06 ± 0.01	1.6 ± 0.1
RMNS-AY	5.6 ± 0.0	0.52 ± 0.01	30.1 ± 0.1
RMNS-AX	21.4 ± 0.1	1.61 ± 0.01	59.5 ± 0.1
RMNS-AV	33.4 ± 0.1	2.52 ± 0.01	157.9 ± 0.2
RMNS-BC	40.7 ± 0.1	2.78 ± 0.01	160.0 ± 0.2
RMNS-AZ	42.3 ± 0.1	3.02 ± 0.01	137.2 ± 0.2

Table 3.4.5. Homogeneity of lot BC and previous lots derived from simultaneous 30 samples measurements and analytical precision onboard R/V Mirai in May 2005.

	Nitrate	Phosphate	Silicate
	CV%	CV%	CV%
BC	0.22	0.32	0.19
(AH)	(0.39)	(0.83)	(0.13)
(K)	(0.3)	(1.0)	(0.2)
Precision	0.22	0.22	0.12

Note: N=30 x 2

(5) Quality control

(5.1) Precision of nutrients analyses during the cruise

Precision of nutrients analyses during the cruise was evaluated based on the 12 measurements, which are measured every 12 samples, during a run at the concentration evaluated n of C-7. We also the reproducibility based on the replicate analyses of five samples in each run. Summary of the precisions are shown in Table

3.4.6. As shown in Table 3.4.6 and Figures 3.4.5-3.4.7, the precisions for each parameter are generally good considering analytical precisions estimated from the simultaneous analyses of 60 samples in May 2005. The analytical precisions previously evaluated were 0.22% for phosphate, 0.22% for nitrate and 0.12% for silicate, respectively. During this cruise, analytical precisions were 0.08% for phosphate, 0.07% for nitrate and 0.08% for silicate in terms of median of precision, respectively. Therefore we can conclude that the analytical precisions for phosphate, nitrate and silicate throughout this cruise were maintained or better than those compared to the pre-cruise evaluations. The time series of precision are shown in Figures 3.4.5-3.4.7.

Table 3.4.6. Summary of precision based on the replicate analyses of 12 samples in each run through out cruise.

	Nitrate CV%	Phosphate CV%	Silicate CV%
Median	0.070	0.070	0.090
Mean	0.076	0.072	0.087
Maximum	0.170	0.190	0.170
Minimum	0.030	0.030	0.020
N	277	277	277

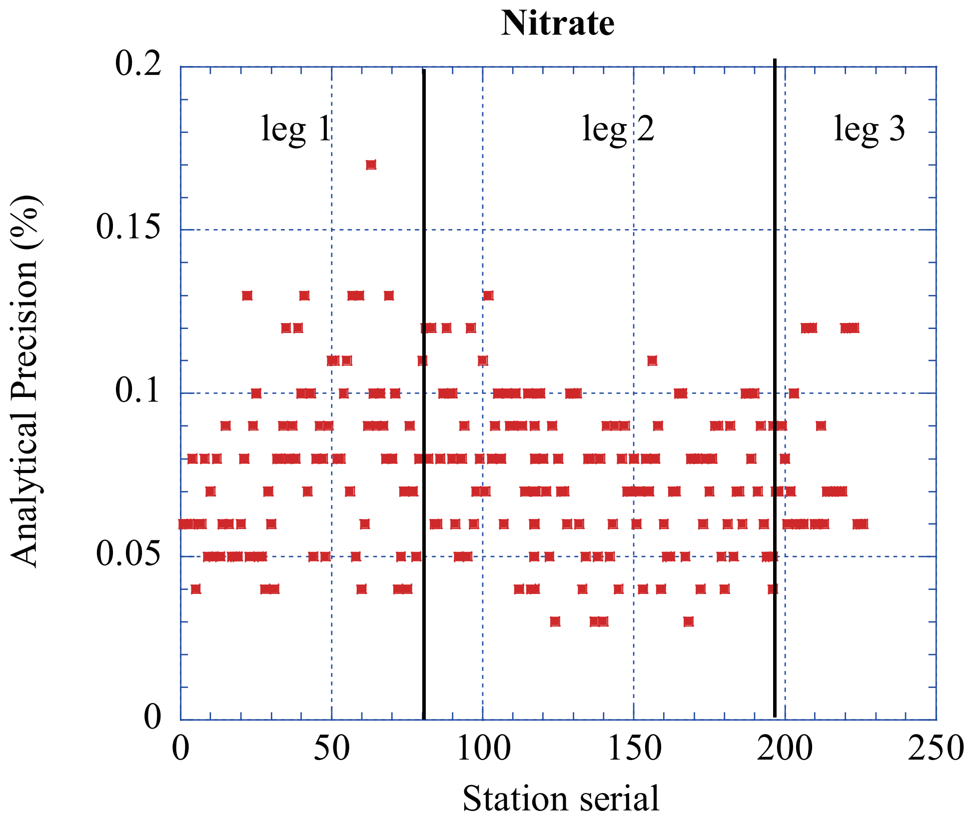

Figure 3.4.5. Time series of precision of nitrate.

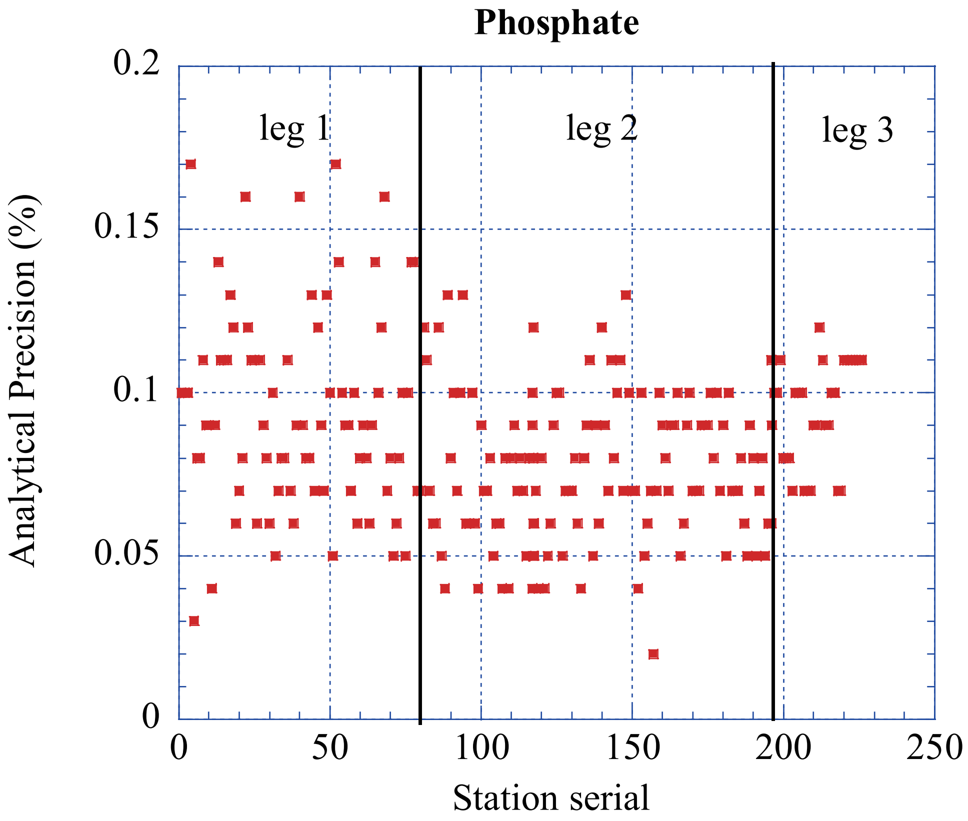

Figure 3.4.6. Time series of precision of phosphate.

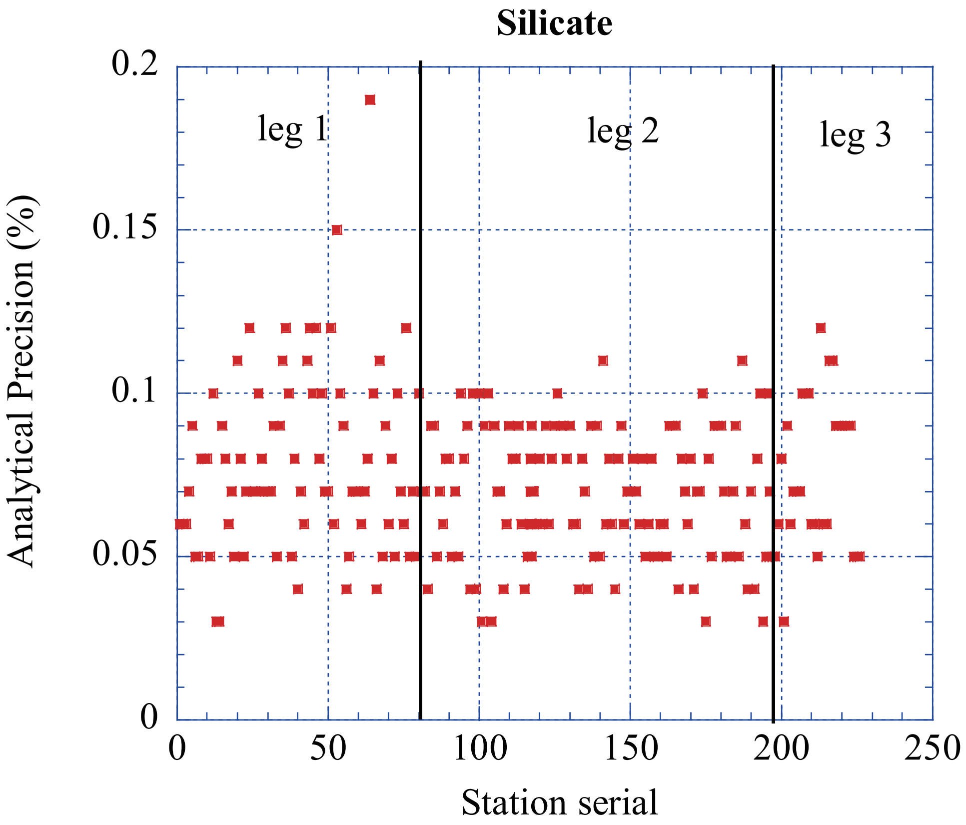

Figure 3.4.7. Time series of precision of silicate.

(5.2) Carry-over

We can also summarize the magnitudes of carry-over throughout the cruise. These are small enough within acceptable levels as shown in Table 3.4.7.

Table 3.4.7. Summary of carry-over through out cruise.

	Nitrate %	Phosphate %	Silicate %
Median	0.21	0.20	0.24
Mean	0.21	0.20	0.23
Maximum	0.40	0.40	0.43
Minimum	0.01	0.00	0.05
N	277	277	277

(6) Evaluation of Z-scores of RMNSs

Since we used RMNSs throughout the cruise, we can evaluate the trueness of our analysis in terms of Z-score of RMNSs.

Z-score for each analysis of RMNS is defined as follows:

$$\mathrm{Zpar} = \mathrm{ABS}((\mathrm{Cpar} - \mathrm{Cnominal})/\mathrm{Ppar}) \qquad (1)$$

Where

Zpar is Z-score for an analysis

Cpar is obtained concentration of a RMNS for interested parameter, nitrate, phosphate or silicate.

Cnominal is assigned concentration of RMNS for interested parameter, nitrate, phosphate or silicate.

Ppar is analytical precision at the concentration of RMNS for interested parameter, nitrate, phosphate or silicate.

Averages of these Z-scores were obtained for three parameters, nitrate, phosphate and silicate based on Z-scores for 7 RMNSs used at each run and shown in Figure 3.4.8. Means of Z-score based on the Z-score of three parameters were also obtained and shown in Figure 3.4.9.

These Z-scores were less than 0.5 in general and indicating that our analyses were in excellent tracerbility throughout the cruise.

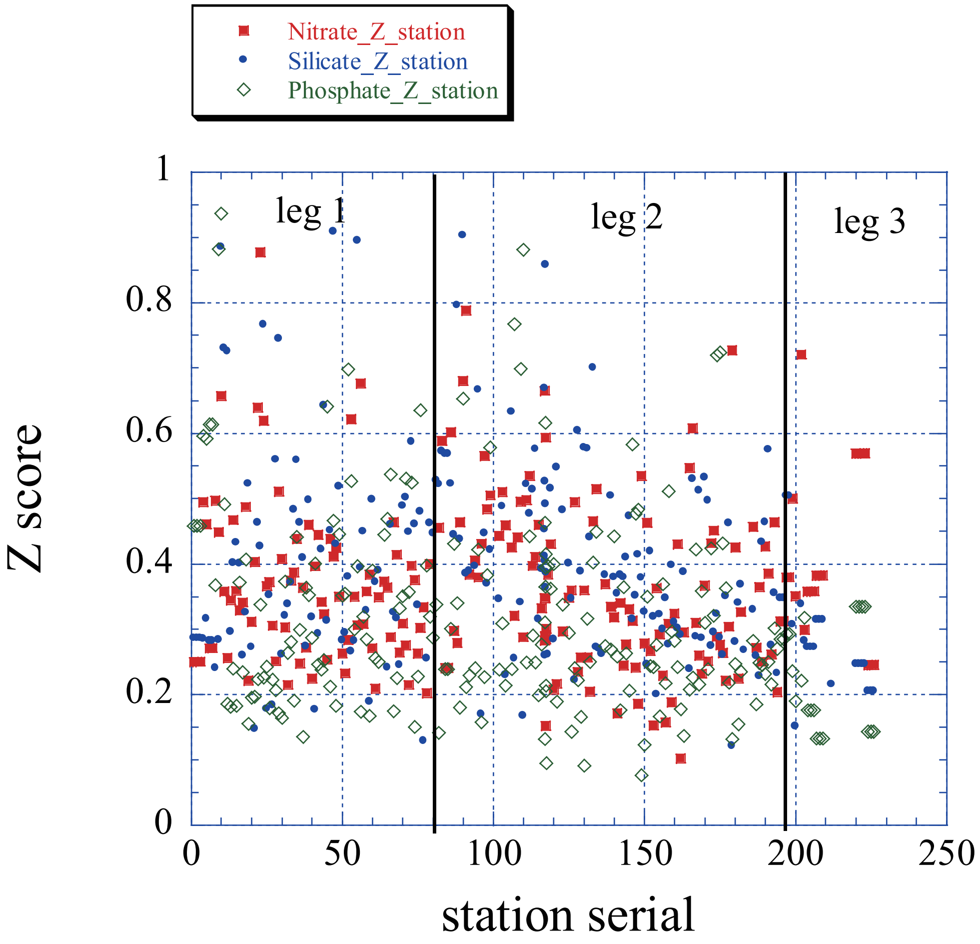

Figure 3.4.8. Z-score of nitrate, silicate and phosphate.

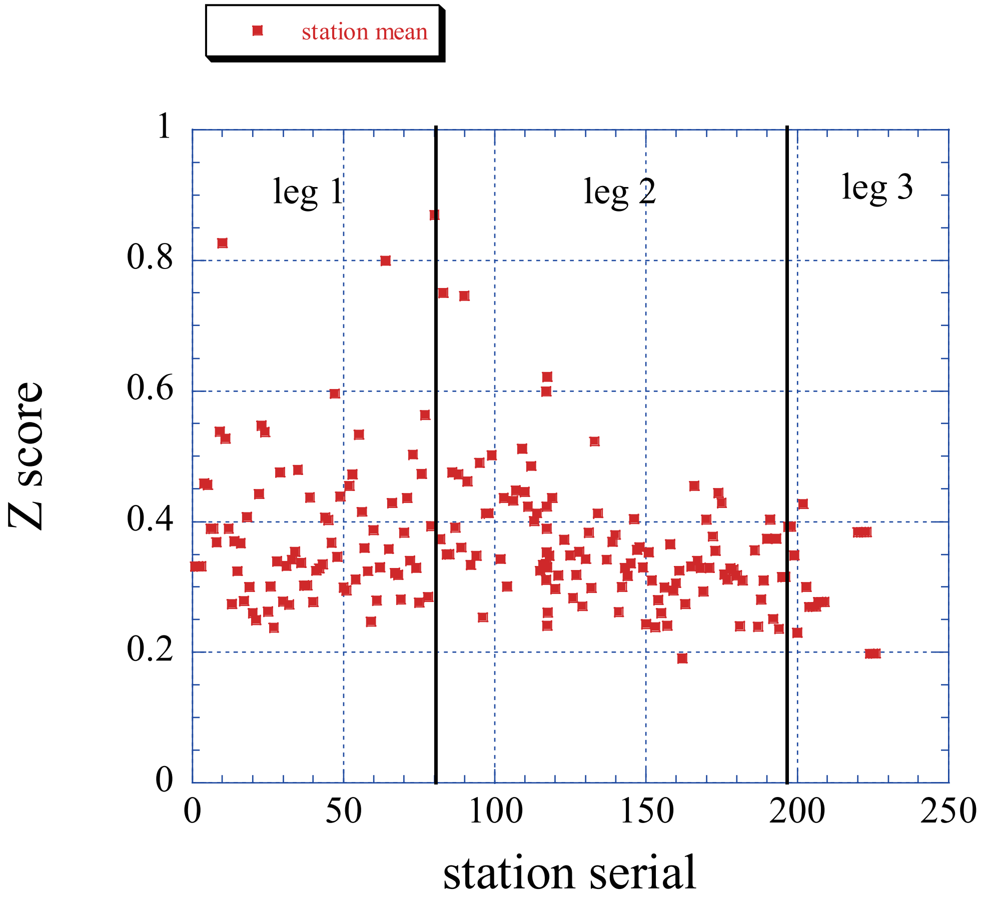

Figure 3.4.9. Means of Z-score at the stations.

(7) Problems/improvements occurred and solutions

Nothing occurred during the cruise.

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3.5 Dissolved inorganic carbon (C_T)

July 18, 2007

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(2) Introduction

Concentrations of CO_2 in the atmosphere are currently increasing at a rate of 1.5 ppmv y^{-1}, due to human activities such as burning of fossil fuels, deforestation, cement production, and so on. It is an urgent task to estimate as accurately as possible the absorption capacity of the ocean against the increasing atmospheric CO_2, as well as to clarify the mechanism of the CO_2 absorption, because the magnitude of the predicted global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise (MR05-05, revisit of WOCE P3 line) using the R/V MIRAI, we aimed to quantify how much anthropogenic CO_2 is absorbed in North Pacific Intermediate Water, which is one of the characteristic waters in the North Pacific. For the purpose, we measured CO_2-system properties such as dissolved inorganic carbon (C_T), total alkalinity (A_T), pH and underway pCO_2.

In this section, we describe data on C_T obtained in the cruise in detail.

(3) Apparatus

Measurements of C_T were made with two total CO_2 measuring systems (systems-A and -B; Nippon ANS, Inc.), which are slightly different from each other. The systems comprise of a seawater dispensing system, a CO_2 extraction system and a coulometer (Model 5012, UIC Inc.).

The seawater dispensing system has an auto-sampler (6 ports), which takes seawater from a 300 ml borosilicate glass bottle and dispenses the seawater to a pipette of nominal 20 or 26 ml volume by a PC control. The pipette is kept at 20°C by a water jacket, where water from a water bath set at 20°C is circulated.

CO_2 dissolved in a seawater sample is extracted in a stripping chamber of a CO_2 extraction system by adding phosphoric acid (10% v/v). The stripping chamber is approximately 25 cm in length and has a fine frit at the bottom. In order to degas CO_2 as quickly as possible, a heating wire kept at 40°C is rolled from the bottom to a 1/3 height of the stripping chamber. Acid is added to the stripping chamber from the bottom of the chamber by pressurizing an acid bottle for a given time to push out a an exact amount of acid. The pressurizing is made with nitrogen gas (99.9999%). After the acid is transferred to the stripping chamber, a seawater sample kept in a pipette is introduced to the stripping chamber by the same method as in adding acid. The seawater reacted with phosphoric acid is stripped of CO_2 by bubbling the nitrogen gas through a fine frit at the bottom of the stripping chamber. The CO_2 stripped in the stripping chamber is carried by the nitrogen gas (140 ml min^{-1} for the systems-A and -B) to the coulometer through a dehydrating module. For the system-A, the module consists of two electric dehumidifiers (kept at 1 - 2°C) and a chemical desiccant ($Mg(ClO_4)_2$). For the system-B, it consists of three electric dehumidifiers with a chemical desiccant.

(4) Shipboard measurement

Sampling

All seawater samples were collected from depths with 12 liter Niskin bottles basically at every other station. The seawater samples for C_T were taken with a plastic drawing tube (PFA tubing connected to silicone rubber tubing) into a 300 ml borosilicate glass bottle. The glass bottle was filled with seawater smoothly from the bottom following a rinse with a seawater of 2 full bottle volumes. The glass bottle was closed by a stopper, which was fitted to the bottle mouth gravimetrically without additional force.

At a chemical laboratory on the ship, a headspace of approximately 1% of the bottle volume was made by removing seawater with a plastic pipette. A saturated mercuric chloride of 100 μl was added to poison seawater samples. The glass bottles were sealed with a greased (Apiezon M, M&I Materials Ltd) ground glass stopper and the clips were secured. The seawater samples were kept at 4°C in a refrigerator until analysis. A few hours just before analysis, the seawater samples were kept at 20°C in a water bath.

Analysis

There were 3 legs in the P3 revisit cruise. At the start of each leg, we calibrated the measuring systems by blank and 5 kinds of Na_2CO_3 solutions (nominally 500, 1,000 1,500, 2,000, 2,500 μmol/L). As it was empirically known that coulometers do not show a stable signal (low repeatability) with fresh (low absorption of carbon) coulometer solutions. Therefore we repeatedly measured 2% CO_2 gas until the measurements became stable. Then we started the calibration.

The measurement sequence such as system blank (phosphoric acid blank), 2% CO_2 gas in a nitrogen base, seawater samples (6) was programmed to repeat. The measurement of 2% CO_2 gas was made to monitor response of coulometer solutions (from UIC, Inc.). For every renewal of coulometer solutions, certified reference materials (CRMs, batch 72 and a small number of batch 69) provided by Prof. A. G. Dickson of Scripps Institution of Oceanography were analyzed. In addition, reference materials (RM) provided by JAMSTEC (2 kinds) and KANSO were measured at the initial, intermediate and end times of a coulometer solution's lifetime.

The preliminary values were reported in a data sheet on the ship. Repeatability and vertical profiles of C_T based on raw data for each station helped us check performances of the measuring systems.

In the cruise, we finished all the analyses for C_T on board the ship. As we used two systems, we did not encountered such a situation as that we had to abandon the measurement due to time limitation. During Leg.2, we replaced the pipette of a volume of 26 ml for the system-B to that of 22 ml after Stn. 251. Furthermore, a ramp of light source of the coulometer for the system-B was replaced. During Leg.3, only the system-A was used.

(5) Quality control

We conducted quality control of the data after returning to a laboratory on land. With calibration factors, which had been determined on board based on blank and 5 kinds of Na_2CO_3 solutions (see *analysis*), we calculated C_T of CRM (batches 69 and 72), and plotted the values as a function of sequential day, separating legs and the systems used. There were no statistically-significant trends of CRM measurements, except for the measurements with the system-A during Leg.3. As shown in Table 3.5.1, averages of C_T of CRM shows a variation, probably implying instability of a coulometer.

Based on the averages of C_T of CRM, we re-calculated the calibration factors so that measurements of seawater samples could become comparable to the certified value of batches 72 or 69.

Temporal variations of RM measurements for one coulomer solution are shown in Figure 3.5.1. This figure clearly shows that RM measurements had a linear trend of ~3 to ~6 μmol kg^{-1} day^{-1} , implying that measurements of seawater samples also have the trend. The trend was also found in temporal changes of 2% CO_2 gas measurements. The trend seems to be due to "cell age" change (Johnson *et al.*, 1998) of a coulometer solution.

Considering these trends, we adjusted measurements of seawater samples to be comparable to the certified value of batches 72 or 69.

Finally, we surveyed vertical profiles of C_T. In particular, we examined whether systematic differences between measurements of the systems-A and -B existed or not. Then taking other information of analyses into account, we determined a flag of each value of C_T.

The average and standard deviation of absolute values of differences of C_T analyzed consecutively were 1.2 and 1.1 μmol kg^{-1} (n=129), 1.0 and 0.7 μmol kg^{-1} (n=197), and 0.5 and 0.5 μmol kg^{-1} (n=21), for Leg.1, 2 and 3, respectively.

To evaluate accuracy of measured C_T, we compared vertical profiles of C_T measured in MR05-05, C_T calculated from A_T and pH measured in MR05-05, and C_T measured at a station of other WOCE lines crossing the P3 line. Results for cross station with WOCE P17 line along 135°W are shown in Figure 3.5.2. From this figure, it is found that C_T measured in this cruise were sufficiently accurate. Together with other comprisons, we estimated the accuracy to be ~ ± 2.0 μmol kg^{-1}.

Reference

Johnson, K. M., A. G. Dickson, G. Eischeid, C. Goyet, P. Guenther, R. M. Key, F. J. Millero, D. Purkerson, C. L. Sabine, R. G. Schottle, D. W. R. Wallace, R. J. Wilke and C. D. Winn (1998), Coulometric total carbon dioxide analysis for marine studies: assessment of the quality of total inorganic carbon measurements made during the US Indian Ocean CO_2 survey 1994-1996, Mar. Chem., 63, 21-37.

Table 3.5.1. Measurements of C_T of CRM (batch 72 or 69) during the MR05-05 (WOCE P3 revisit) cruise.

Leg	System	Num	Ave (μmol kg^{-1})	Std (μmol kg^{-1})	Batch number
1	A	8	1906.2	0.7	69
	A	72	2091.7	1.3	72
	B	24	2088.6	1.5	72
2	A	40	2093.9	1.9	72
	B	9	2095.2	1.0	72
	B	18	2093.4	1.8	72
3	A	2	2090.9		72
	A	2	2088.8		72
	A	2	2088.8		72

The certified values of C_T for batches 69 and 72 are 1907.63 and 2091.61 μmol kg^{-1}, respecticely. During the Leg. 2, the pipette of system-B was replaced.

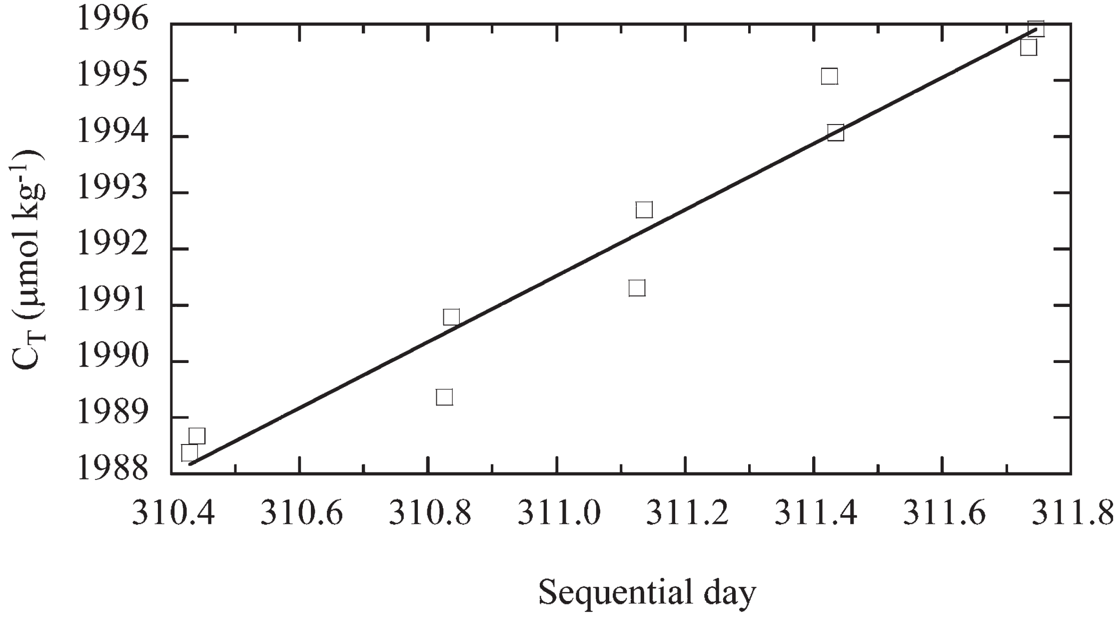

Figure 3.5.1. An example of RM measurements at Stns. 051 and 056, whch show an increasing trend (5.9 μmol kg^{-1} day^{-1}).

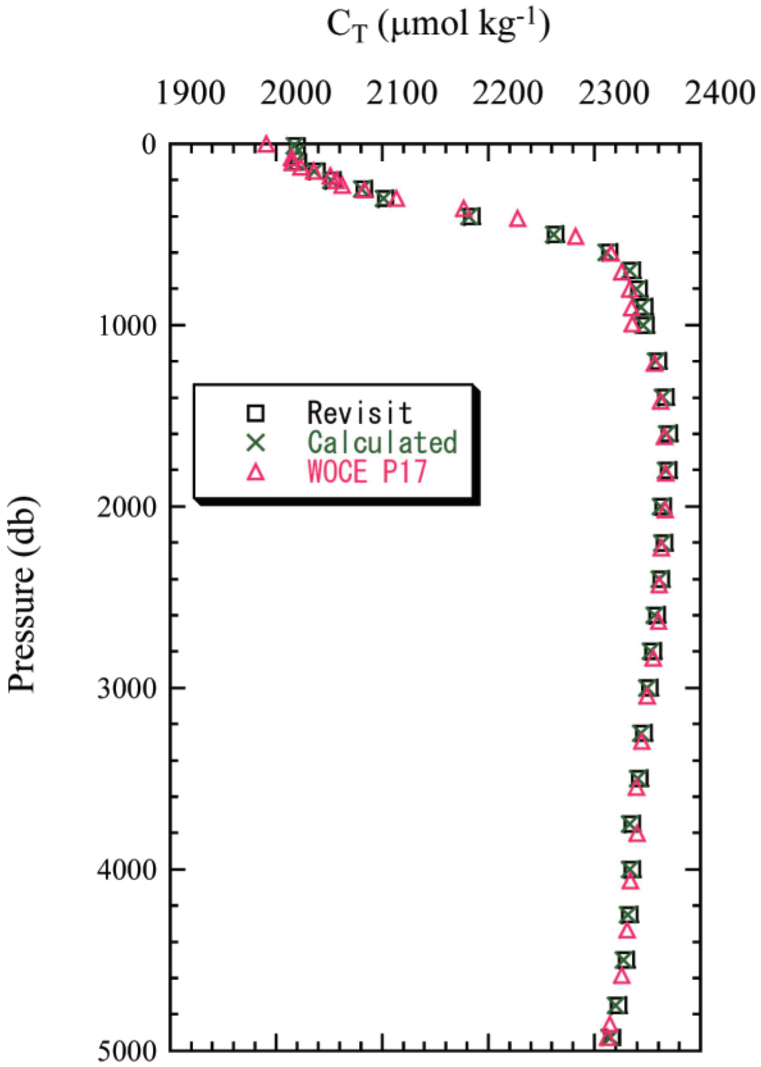

Figure 3.5.2. Comparison of vertical profiles of C_T measured in MR05-05 with C_T calculated from A_T and pH measured also in MR05-05 and C_T measured in WOCE P17C cruise conducted in 1997.

3.6 Total alkalinity (A_T)

July 18, 2007

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Mikio Kitada	***(MWJ)***
Minoru Kamata	***(MWJ)***
Taeko Ohama	***(MWJ)***

(2) Introduction

Concentrations of CO_2 in the atmosphere are currently increasing at a rate of 1.5 ppmv y^{-1} due to human activities such as burning of fossil fuels, deforestation, cement production, and so on. It is an urgent task to estimate as accurately as possible the absorption capacity of the ocean against the increasing atmospheric CO_2, as well as to clarify the mechanism of the CO_2 absorption, because the magnitude of the predicted global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise (MR05-05, revisit of WOCE P3 line), we aimed to quantify how much anthropogenic CO_2 is absorbed in North Pacific Intermediate Water, which is one of the characteristic waters in the North Pacific. For the purpose, we measured CO_2-system properties such as dissolved inorganic carbon (C_T), total alkalinity (A_T), pH and underway pCO_2.

In this section, we describe data on A_T obtained in the cruise in detail.

(3) Apparatus

The measuring system for A_T (customized by Nippon ANS, Inc.) comprises of a water dispensing unit, an auto-burette (Metrohm), a pH meter (Thermo Orion) and an auto-sampler (6 ports). They are automatically controlled by a PC. Separate electrodes (Reference electrode: REF201, (Radiometer), Glass pH electrode: pHG201-7 (Radiometer)), or combined electrodes (ROSS 8102BN, Thermo Orion) were used.

Seawater of approximately 40 ml is transferred from a sample bottle (borosilicate glass bottle; 130 ml) into a water-jacketed (25°C) pressurized by N_2 gas and is introduced into a water-jacketed (25°C) titration cell. Next, a given volume of the titrant is injected into the titration cell. By this, pH of a seawater sample becomes 4.5 – 4.0. The seawater sample mixed with the titrant is stirred for three minutes with a stirring chip. Then a small volume of titrant (~0.1 ml) is injected until pH or e.m.f. reaches a given value. The concentration of the acid titrant is nominally 0.05 M HCl in 0.65 M NaCl.

Calculation of A_T is based on a modified Gran approach.

(4) Shipboard measurement

Sampling

All seawater samples were collected from depths using 12-liter Niskin bottles basically at every other stations. The seawater samples for A_T were taken with a plastic drawing tube (PFA tubing connected to silicone rubber tubing) into borosilicate glass bottles of 130 ml. The glass bottle was filled with seawater smoothly from the bottom, after rinsed with seawater of a half or a full bottle volume. A few hours before analysis, the seawater samples were kept at 25°C in a water bath.

Analysis

For A_T measurement, we selected electrodes, which showed signals close to theoretical Nernstian behavior.

At the start of each leg, we conducted calibration of the acid titrant, which was prepared on land. The calibration was made by measuring A_T of 5 solutions of Na_2CO_3 in 0.7 M NaCl solutions. The computed A_Ts were approximately 0, 100, 1,000, 2,000 and 2,500 μmol kg^{-1}. The measured values of A_T (calculated by assuming 0.05 M acid titrant) should be a linear function of the A_T contributed by the Na_2CO_3. The linear function was fitted by the method of least squares. Theoretically, the slope of the linear function should be unity. If the measured slope is not equal to unity, the acid normality should be adjusted by dividing initial normality by the slope, and the whole set of calculations is repeated until the slope = 1.

Before starting analyses of seawater samples, we measured A_T of dummy seawater samples to confirm a condition of the measuring system. If repeat measurements of A_T were constant within ~3 μmol kg^{-1}, we started measurement of seawater samples. We analyzed reference materials (RM), which were produced for C_T measurement by JAMSTEC and were also efficient for monitoring A_T measurement. In addition, certified reference materials (CRM, batches 69 and 72, certified value = 2114.42 and 2312.79 μmol kg^{-1}, respectively) were analyzed periodically to monitor systematic differences of measured A_T. The reported values of A_T were set to be traceable to the certified value.

The preliminary values were reported in a data sheet on the ship. Repeatability calculated from replicate samples and vertical profiles of A_T based on raw data for each station helped us check the performance of the measuring system.

We finished all A_T analyses on board the ship. Although we did not encounter such a serious problem that we had to give up the analyses, we experienced some malfunctions of the system during the cruise, which are summarized as follows:

After analyses of a large number of samples, a drift of an electrode often occurred, appearing as differences of pH or e.m.f. against a constant volume of the titrant injected into a seawater sample. In this case, we changed pH or e.m.f. ranges for the subsequent A_T calculation.

(5) Quality control

Temporal changes of A_T, which originate from analytical problems (drifts and sudden changes of responces of electrodes used, etc), were monitored by measuring A_T of CRM. For example, discontinuous changes of A_T are illustrated in Figure. 3.6.1. Based on averaged and certified values of A_T of CRM, we re-calculated normality of HCl. Using the re-calibrated normality, we re-calculated A_T of seawater samples. By this procedure, we could obtain A_T values, which are comparable to CRM.

After making the measured values of A_T comparable to CRM, we examined vertical profiles of A_T. Then, taking other information of analyses into account, we determined a flag of each A_T value.

The average and standard deviation of absolute values of differences in A_T analyzed consecutively were 2.1 and 1.9 μmol kg^{-1} (n = 123), 1.9 and 1.5 μmol kg^{-1} (n = 203) and 2.2 and 1.9 μmol kg^{-1} (n = 20) for Leg.1, 2 and 3, respectively.

To evaluate the accuracy of measured A_T, we compared vertical profiles of A_T measured in MR05-05 with A_T calculated from C_T and pH measured in MR05-05, and with A_T measured at a station of other WOCE lines crossing the P3 line. Results for cross station with the WOCE P16 line along 153^{o}W are shown in Figure. 3.6.2. From this figure, it is found that A_T measured in this cruise were sufficiently accurate. Together with other comparisons, we estimated the accuracy to be 3 – 2 μmol kg^{-1}.

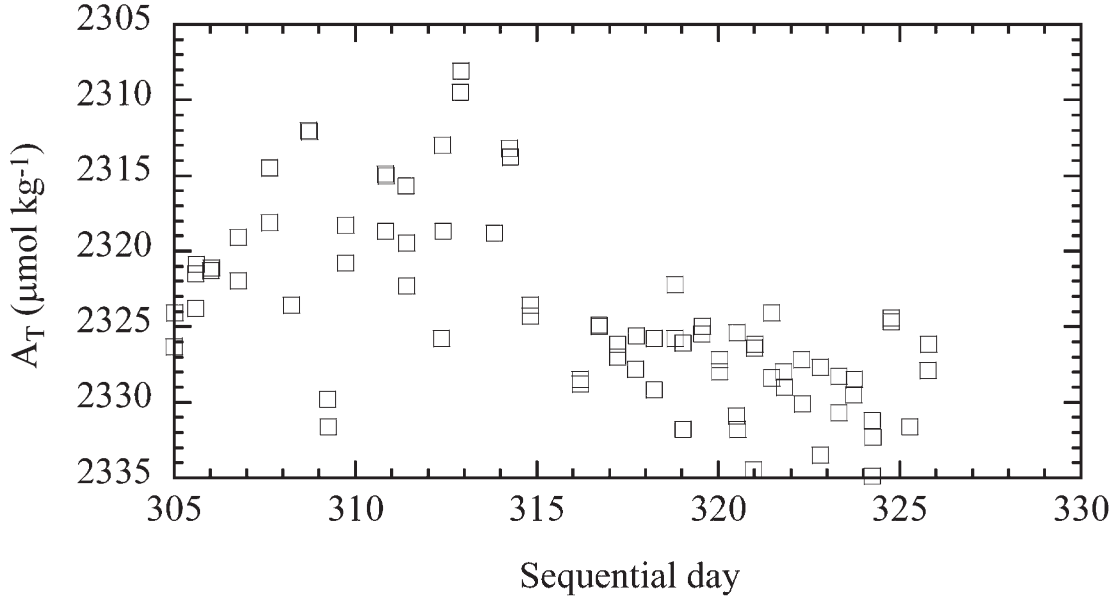

Figure 3.6.1. RM measurements during Leg.1, which illustrate discontinuous changes at about 315 sequential day.

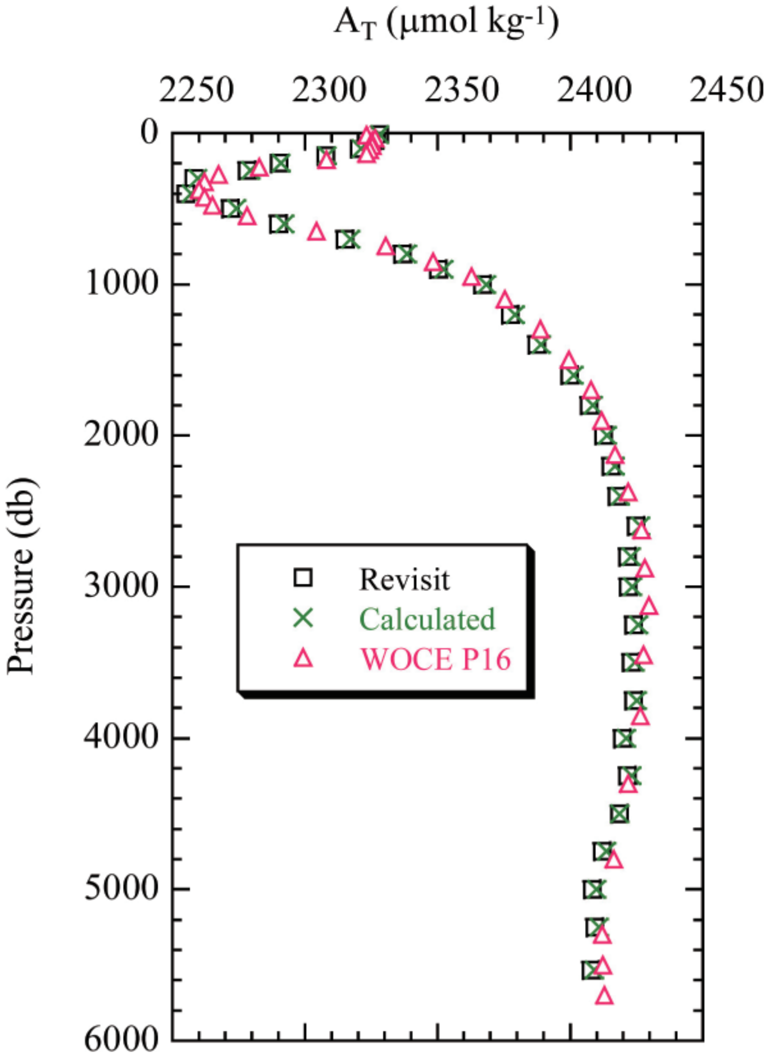

Figure 3.6.2. Comparison of vertical profiles of A_T measured in MR05-05 with A_T calculated from C_T and pH measured also in MR05-05 and with A_T measured in WOCE P16 revisit cruise conducted in 2006.

3.7 pH

July 19, 2007

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(2) Introduction

Concentrations of CO_2 in the atmosphere are currently increasing at a rate of 1.5 ppmv y^{-1} due to human activities such as burning of fossil fuels, deforestation, cement production, and so on. It is an urgent task to estimate as accurately as possible the absorption capacity of the ocean against the increasing atmospheric CO_2, as well as to clarify the mechanism of the CO_2 absorption, because the magnitude of the anticipated global warming depends on the levels of CO_2 in the atmosphere, and because the ocean currently absorbs 1/3 of the 6 Gt of carbon emitted into the atmosphere each year by human activities.

In this cruise (MR05-05, revisit of WOCE P3 line), we aimed to quantify how much anthropogenic CO_2 absorbed in North Pacific Intermediate Water, which is one of the characteristic waters in the North Pacific. For the purpose, we measured CO_2-system properties such as dissolved inorganic carbon (C_T), total alkalinity (A_T), pH and underway pCO_2.

In this section, we describe data on pH obtained in the cruise in detail.

(3) Apparatus

Measurement of pH was made by a pH measuring system (Nippon ANS, Inc.), which adopts spectrophotometry. The system comprises of a water dispensing unit and a spectrophotometer (Carry 50 Scan, Varian).

Seawater is transferred from borosilicate glass bottle (300 ml) to a sample cell in the spectrophotometer. The length and volume of the cell are 8 cm and 13 ml, respectively, and the sample cell was kept at 25.00 ± 0.05°C in a thermostated compartment. First, absorbance of seawater only is measured at three wavelengths (730, 578 and 434 nm). Then an indicator is injected and circulated for about 4 minutes to mix with seawater sufficiently. After the pump is stopped, the absorbance of seawater + indicator is measured at the same wavelengths.

The pH is calculated based on the following equation (Clayton and Byrne, 1993):

$$pH = pK_2 + \log\left(\frac{A_1 / A_2 - 0.00691}{2.2220 - 0.1331(A_1 / A_2)}\right) \qquad (1)$$

where A_1 and A_2 indicate the absorbance at 578 and 434 nm, respectively, and pK_2 is calculated as a function of water temperature and salinity.

(4) Shipboard measurement

Sampling

All seawater samples were collected from depth with 12-liter Niskin bottles basically at every other stations. The seawater samples for pH were taken with a plastic drawing tube (PFA tubing connected to silicone rubber tubing) into a 300 ml borosilicate glass bottle, which was the same as used for C_T sampling. The glass bottle was smoothly filled from its bottom with seawater after rinsed with an amount of seawater equal to the volume of two full bottles. The glass bottle was closed by a stopper, which was fitted to the bottle mouth gravimetrically without additional force.

A few hours just before analysis, the seawater samples were kept at 25°C in a water bath.

Analysis

For indicator solution, *m*-cresol purple (2 mM) was used. The indicator solution was produced on board the ship, and retained in a 1,000 ml DURAN® laboratory bottle. We renewed indicator solution 3 times when the headspace of the bottle became large, and monitored pH or absorbance ratio of the indicator solution by another spectrophotometer (Carry 50 Scan, Varian) using a cell with a short path length of 0.5 mm. In most indicator solutions, the absorbance ratios of the indicator solution were initially in the range 1.4 – 1.6, and decreased to 1.1.

It is difficult to mix seawater with indicator solution sufficiently under no headspace condition. However, by circulating the mixed solution with a peristaltic pump, a well-mixed condition came to be obtained rather shortly, leading to a rapid stabilization of absorbance. We renewed a TYGON® tube of a peristaltic pump periodically, when a tube deteriorated.

Absorbance of seawater only and that of seawater + indicator solutions were measured 15 times for each, and the averages computed from the last five values of the absorbance were used for pH calculation (Eq. 1).

The preliminary values of pH were reported in a data sheet on the ship. Repeatability calculated from replicate samples and vertical profiles of pH based on raw data for each station helped us check performance of the measuring system.

We finished all the analyses for pH on board the ship. We did not encounter such a serious problem that we had to give up the analyses. However, we sometimes experienced malfunctions of the system during the cruise:

Differences between absorbance of seawater only and that of seawater + indicator solution were infrequently greater than ± 0.001. This implies dirt of the cell. In this case, we cleaned or replaced the cell.

(5) Quality control

Correction for pH change resulting from addition of indicator solutions is recommended (DOE, 1994). To check the perturbation of pH due to the addition, we measured absorbance ratios by doubling the volume of indicator solutions added to a same seawater sample. We corrected absorbance ratios based on an empirical method (DOE, 1994). Figure 3.7.1 illustrates an example of perturbation of absorbance ratios by adding indicator solutions.

We surveyed vertical profiles of pH. In particular, we examined whether systematic differences between before and after the renewal of indicator solutions existed or not. Then taking other information of analyses into account, we determined a flag of each pH value.

The average and standard deviation of absolute values of differences of pH analyzed consecutively were 0.0007 and 0.0012 pH unit (n = 163), 0.0007 and 0.0006 pH unit (n = 255), and 0.0009 and 0.0009 (n = 36) for Leg.1, 2 and 3, respectively.

All values are reported in total pH scale.

References

Clayton T.D. & R.H. Byrne (1993) Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results. *Deep-Sea Research* **40**, 2115-2129.

DOE (1994) Handbook of methods for the analysis of the various parameters of the carbon dioxide system in sea water, version 2, A. G. Dickson & C. Goyet, eds. (unpublished manuscript).

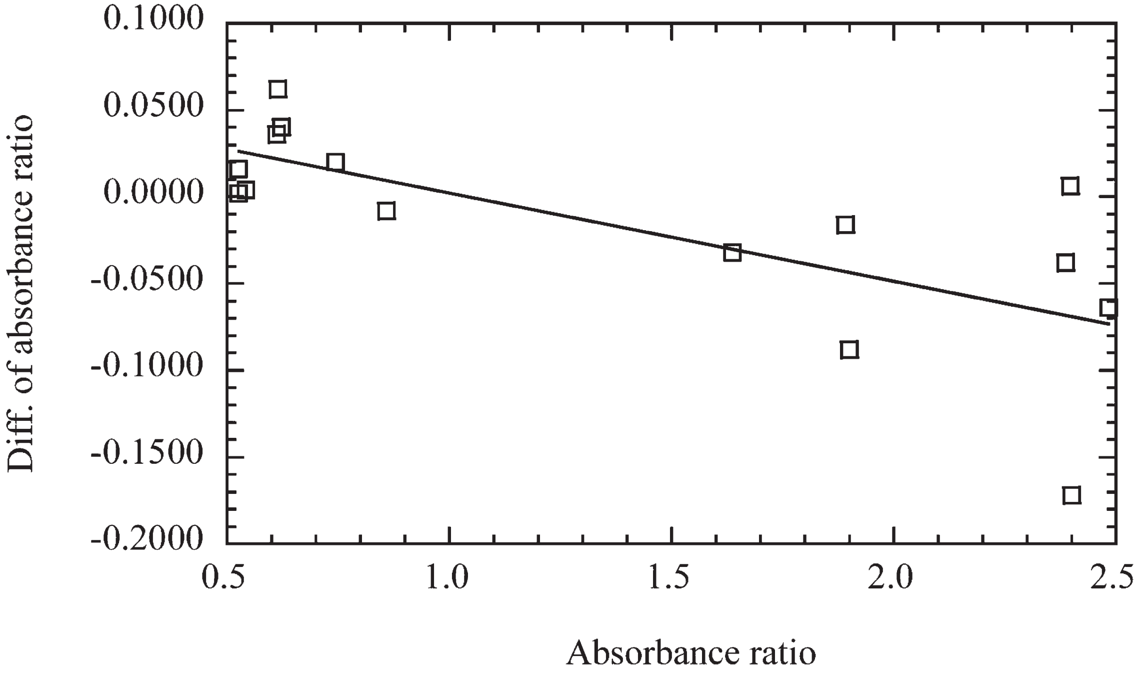

Figure 3.7.1. Perturbation of absorbance ratios by adding indicator solutions. The line ($y = -0.0509x + 0.0529$, $R^2 = 0.510$) was determined by the method of least squares.

3.8 Chloroflurocarbons (CFCs)

October 3, 2007

(1) Personnel

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Masanori Enoki	***(MWJ)***

(2) Introduction

Chlorofluorocarbons (CFCs) are completely man-made compounds that are chemically and biologically stable gasses in the environment. The CFCs have been accumulated in the atmosphere since 1930's (Walker et al., 2000). The atmospheric CFCs can slightly dissolve in sea surface water and then penetrated into the ocean interior by water circulation. The dissolved CFC concentrations in sea water have been used as transient tracers for the ocean circulation with times scale on the order of decades.

In this cruise, we determined the concentrations of three CFC species, CFC-11 (CCl_3F), CFC-12 (CCl_2F_2) and CFC-113 ($C_2Cl_3F_3$).

(3) Apparatus

Dissolved CFCs were measured by a method modified from the original design of Bullister and Weiss (1988). Two analytical systems were used in this cruise. A custom made purging and trapping system was attached to gas chromatograph (GC-14B: Shimadzu Ltd). Stainless steel packed column ("1/8 OD tubing, 100-120 mesh Porapak T® packed 5cm) was used as a cold trap. Silica Plot capillary column [i.d.: 0.53 mm, length: 4 m, tick: 0.25 μm] and a tandem capillary column (Pola Bond-Q [i.d.: 0.53 mm, length: 7 m, tick: 6.0 μm] followed by Silica Plot [i.d.: 0.53 mm, length: 22 m, tick: 0.25 μm]) was used as a pre-column and main column, respectively. Each CFC was detected by an electron capture detector (ECD-14: Shimadzu Ltd).

(4) Shipboard measurement

Sampling

Seawater sub-samples for CFC measurements were collected from 12 liter Niskin bottles to 300 ml sub-sampling glass bottles which were developed for CFC analyses in JAMSTEC. The sub-sampling bottles have stainless steel union altered from original design of Swagelok® on the end of the bottle. A 6 mm OD glass tube goes through the union into the bottle interior and reaches to near the bottom of bottle. A small plastic stop valve was on the upper end of glass tube. The bottles were filled by nitrogen gas before sampling. The stop valve was connected to Niskin bottle. The sub-sample was introduced from the bottom. Two times of the bottle volumes of seawater sample were overflowed from vent valve put on side of the union and then the all valves closed from downstream. The bottles filled by seawater sample were kept in water bathes roughly controlled on sample temperature. The CFC concentrations were determined as soon as possible after sampling. These procedures were needed in order to minimize contamination from atmospheric CFCs.

Analysis

The CFCs analytical system is modified from the original design of Bullister and Weiss (1988). Analytical conditions are listed in Table 3.8.1. Constant volume of sample water (50 ml) is taken into the purging & trapping system. Dissolved CFCs are de-gassed by N_2 gas purge and concentrated in a cold trap column. The CFCs are desorbed by electrically heating the trap column, and lead into the pre-column. CFCs and other compounds are roughly separated in the pre-column. The pre-column is switched to cleaning line and flushed buck by counter flow of pure nitrogen gas when CFCs completely go through pre-column. The back flush system is prevent to enter any compounds that have higher retention time than CFC-113 into main analytical column and permits short time analysis. CFCs which are sent into main column are separated further and detected by an electron capture detector (ECD).

Gas loops that the volumes were around 1, 3 and 10 ml were used for introducing standard gases into the analytical system. The standard gasses had been made by Japan Fine Products co. ltd. Cylinder numbers of CPB28620, CPB30532 and CPB30528 for working gases and CPB30524 for reference gas were used for calibration. Mixing ratios of the standard gasses were calculated by gravimetric data (Table 3.8.2). The standard gases used in this cruise have not been calibrated to SIO scale standard gases yet because SIO scale standard gasses is hard to obtain due to legal difficulties for CFCs import into Japan. The data will be corrected as soon as possible after calibrations of the standard gasses.

Table 3.8.1. Analytical conditions of dissolved CFCs in seawater.

Temperature	
Column oven:	95 °C (Constant)
Detector (ECD):	240 °C
Trap column:	-45 °C (at adsorbing) & 140 °C (at desorbing)
Mass flow rate of nitrogen gas	
Carrier gas:	15 ml/min
Detector make-up gas:	22 ml/min
Back flush gas:	>15 ml/min
Sample purge gas:	150 ml/min

Table 3.8.2. CFC mixing ratios of standard gasses.

Cylinder	CFC-11	CFC-12	CFC-113	Application
		pptv		
CPB28620	301	169	50.3	Working gas for Leg.2 & 3
CPB30524	300	159	30.2	Reference gas for all Legs
CPB30528	300	158	29.9	Working gas for Leg.2
CPB30532	300	158	29.9	Working gas for Leg.1 & 2

(5) Quality control

Blank

Some blank water samples which were made by nitrogen purge of seawater in CFCs sample bottle were analyzed and any CFCs were not detected. Significant increase in CFCs concentration during keeping sampling bottle in a water bath was not found for around one week. CFC concentrations in deep water which was one of oldest water masses of the ocean were low but not zero for CFC-11 and -12. Average concentrations of CFC-11, 12 in denser water than 27.6 sigma-0 were 0.022 ± 0.008 (n = 1430), 0.009 ± 0.004 (n = 1379). These values were assumed as sampling blanks which was contaminations from Niskin bottle and/or during sub-sampling and were subtracted from all data.

Concentration of CFC-113 in deep water mass is less than detection limit at about half of stations but significant blank had been found in other stations(0.006 ± 0.003 pmol kg^{-1} in average (n = 773)). Cause of the blank was unknown. In this case, mean value in deep water samples at each station was considered to be blank for analysis at the station and was subtracted from measurements.

Interfering compound for CFC-113 analysis

A large and broad peak was interfered determining CFC-113 peak area for samples collected from surface layer. Retention time of the interfering peak was around 3% shorter than that of CFC-113. The peak of a compound interfering CFC-113 determination could not be completely separated from the peak of CFC-113 by our analytical condition. We tried to split these peaks on chromatogram analysis and give flag “4”. In the case of the interfering peak completely covering the CFC-113 peak, we could not determine CFC-113 peak area and give flag “5”.

Precisions

The analytical precisions were estimated from replicate sample analyses. The replicate samples were basically collected from two sampling depths which is around 250 m and 800 m depth. The precisions were estimated by two methods. One (A) is estimated by following equation, $s= (S\ (DC^2)\ /(2n-1))^{0.5}$, where DC is difference between replicate analyses. Another (B) is average difference of replicate analyses (with standard deviation, SD). Precisions estimated from former equation were 0.006 (n = 377), 0.004 (n = 376) and 0.004 (n = 298) pmol kg^{-1} for CFC-11, -12 and -113 determinations. These from latter were 0.006 (SD=0.007), 0.004 (0.004) and 0.004 (0.005) pmol kg^{-1} for CFC-11, -12 and -113 determinations.

References

Walker, S.J., Weiss, R.F. and Salameh, P.K., Reconstructed histories of the annual mean atmospheric mole fractions for the halocarbons CFC-11, CFC-12, CFC-113 and Carbon Tetrachloride, *Journal of Geophysical Research*, **105**, 14,285-14,296, (2000).

Bullister, J.L and Weiss, R.F. Determination of CCl_3F and CCl_2F_2 in seawater and air. *Deep Sea Research*, **35**, 839-853 (1988).

3.9 LADCP(Lowered Acoustic Doppler Current Profiler)

September 3, 2007

(1) Personnel

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Shuichi Watanabe	***(JAMSTEC)***
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Takayoshi Seike	***(MWJ)***

(2) Instrument and method

Direct flow measurement from sea surface to sea bottom was carried out using a lowered acoustic Doppler current profiler (LADCP). The instrument was the RDI Workhorse Monitor 307.2 kHz unit (RD Instruments, USA). The instrument was attached downward on the CTD/RMS frame. The CPU firmware version was 16.27.

One ping raw data were recorded. From Sta. 1 to St. 48, a bin length was set to 16 m. The bin length of 8m was used from Sta. 50. A total of 79, 126 and 31 operations were made with CTD observations in Leg.1 from San Diego to Honolulu, in Leg.2 from Honolulu to Nakagusuku, and in Leg.3 from Nakagusuku to Sekinehama, respectively. Since the pressure resistance of the instrument is 6,500 dbar, the instrument was detached on the CTD/RMS frame at Stas. 223, 293, 353 and 357 where the depth was deeper than about 6,000 dbar. The performance of the LADCP instrument was not good from Sta. 1 to Sta. 110 in Leg.1. The data near the bottom were often missed. We replaced the Serial Number (SN) 2553 of the instruments with the SN 1512 of it from Sta. 112. The performance was improved. Profiles of the area over 100 m distance from LADCP in shallow depths and of the area to almost 60 m in deeper depths were obtained. Echo intensity was weak between stations 351 and 367. Backscatters might be especially too few in this section.

(3) Data process and result

Vertical profiles of velocity are obtained by the inversion method (Visbeck, 2002). Since the first bin from LADCP is influenced by turbulence generated by CTD frame, the weight for the inversion is set to small value of 0.1. GPS navigation data are used in the calculation of reference velocities and the bottom-track data are used for correcting the reference velocities. Shipboard ADCP (SADCP) data averaged for 3 minutes are also included in the calculation. The CTD data are used for sound speed and depth calculation. IGRF (International Geomagnetic Reference Field) 10th generation data are used for calculating magnetic deviation to correct the direction of velocity. In the process, we use Matlab routines provided from M. Visbeck and G. Krahmann (http://ladcp.ldeo.columbia.edu/ladcp).

Error velocities estimated by the inversion are small values of 0.05 – 0.2 m/s, but the typical value of the surface currents is about 0.2 m/s in this section. It may be difficult to describe the detailed structure of currents by using these values. In Leg.3 (Okinawa trough, Tokara strait, and Tsushima strait cross sections), small error velocities (less than 10 cm/s) were estimated.

Velocities using bottom tracks were 5 – 10 cm/s. The large bottom flow of about 15 cm/s was observed near the shore of the United States. The errors of 0.5 - 2 cm/s were quite small. It is sufficient to detect the bottom current. The velocities near the bottom are not shown in Leg.3, since the depths were shallow and the inversion errors were sufficient small all through the water columns.

Reference

Visbeck, M. (2002): Deep velocity profiling using Lowered Acoustic Doppler Current Profilers: Bottom track and inverse solutions. *J. Atmos. Oceanic Technol.*, **19**, 794-807.

49MR0505_1.sum file

```
P03 REV R/V MIRAI CRUISE MR0505 LEG 1
SHIP/CRS    WOCE                CAST         UTC EVENT          POSITION             UNC    COR HT ABOVE   WIRE    MAX  NO. OF
EXPOCODE    SECT  STNNBR CASTNO TYPE DATE   TIME  CODE LATITUDE   LONGITUDE   NAV  DEPTH  DEPTH   BOTTOM    OUT  PRESS BOTTLES PARAMETERS                                    COMMENTS
49MR0505_1   P03       1      1  ROS 103105 1856    BE 32 39.14 N 117 19.93 W GPS    110    110
49MR0505_1   P03       1      1  BUC 103105 1859    UN 32 39.11 N 117 19.88 W GPS    108    108                                1,33                                          16.1C
49MR0505_1   P03       1      1  UNK 103105 1859    UN 32 39.11 N 117 19.88 W GPS    108    108                                                                              AIR N2O SMPL
49MR0505_1   P03       1      1  ROS 103105 1902    BO 32 39.08 N 117 19.85 W GPS    107    108        9     92     95       3 1-8,27
49MR0505_1   P03       1      1  ROS 103105 1909    EN 32 39.02 N 117 19.84 W GPS    108    108
49MR0505_1   P03       2      1  ROS 103105 1947    BE 32 38.38 N 117 25.88 W GPS    150    151
49MR0505_1   P03       2      1  BUC 103105 1948    UN 32 38.38 N 117 25.89 W GPS    150    151                                1                                             17.5C
49MR0505_1   P03       2      1  ROS 103105 1954    BO 32 38.32 N 117 25.95 W GPS    150    151        7    138    140       4 1-8,27
49MR0505_1   P03       2      1  ROS 103105 2006    EN 32 38.19 N 117 25.97 W GPS    151    151
49MR0505_1   P03       3      1  ROS 103105 2114    BE 32 37.02 N 117 30.16 W GPS   1192   1191
49MR0505_1   P03       3      1  BUC 103105 2121    UN 32 36.94 N 117 30.19 W GPS   1192   1191                                1,31,33                                       18.2C
49MR0505_1   P03       3      1  UNK 103105 2121    UN 32 36.94 N 117 30.19 W GPS   1192   1191                                                                              AIR N2O SMPL
49MR0505_1   P03       3      1  ROS 103105 2139    BO 32 36.80 N 117 30.27 W GPS   1193   1192       10   1189   1189      22 1-8,23,24,26,27,31,33,64,81                   #2 AT OXYCLINE
49MR0505_1   P03       3      1  ROS 103105 2235    EN 32 36.31 N 117 30.55 W GPS   1206   1204
49MR0505_1           501      1  UNK 103105 2255    UN 32 36.41 N 117 32.06 W GPS   1203   1204                                                                              AEROSOL SMPL
49MR0505_1   P03       4      1  ROS 110105 0002    BE 32 38.39 N 117 40.54 W GPS   1048   1047
49MR0505_1   P03       4      1  BUC 110105 0010    UN 32 38.31 N 117 40.60 W GPS   1023   1031                                1                                             18.4C
49MR0505_1   P03       4      1  ROS 110105 0027    BO 32 38.25 N 117 40.76 W GPS    973    971        8    984    994      14 1-8,27
49MR0505_1   P03       4      1  ROS 110105 0116    EN 32 37.86 N 117 41.01 W GPS    968    970
49MR0505_1   P03       6      1  ROS 110105 0246    BE 32 31.70 N 118  1.83 W GPS   1895   1888
49MR0505_1   P03       6      1  BUC 110105 0254    UN 32 31.61 N 118  1.75 W GPS   1909   1906                                1,33                                          17.9C
49MR0505_1   P03       6      1  UNK 110105 0254    UN 32 31.61 N 118  1.75 W GPS   1909   1906                                                                              AIR N2O SMPL
49MR0505_1   P03       6      1  ROS 110105 0322    BO 32 31.33 N 118  1.61 W GPS   1877   1883        9   1883   1866      19 1-8,23,24,26,27                               
49MR0505_1   P03       6      1  ROS 110105 0436    EN 32 30.58 N 118  1.66 W GPS   1880   1877
49MR0505_1   P03       8      1  ROS 110105 1758    BE 32 21.83 N 118 20.31 W GPS    637    639
49MR0505_1   P03       8      1  BUC 110105 1800    UN 32 21.85 N 118 20.30 W GPS    638    638                                1,33                                          17.9C
49MR0505_1   P03       8      1  UNK 110105 1800    UN 32 21.85 N 118 20.30 W GPS    638    638                                                                              AIR N2O SMPL
49MR0505_1   P03       8      1  ROS 110105 1814    BO 32 21.94 N 118 20.17 W GPS    677    677       12    664    669      11 1-8,23,24,26,27
49MR0505_1   P03       8      1  ROS 110105 1847    EN 32 22.08 N 118 19.87 W GPS    718    715
49MR0505_1   P03      10      1  ROS 110105 2044    BE 32  9.19 N 118 45.83 W GPS   1314   1314
49MR0505_1   P03      10      1  BUC 110105 2053    UN 32  9.14 N 118 45.71 W GPS   1304   1303                                1,33                                          18.4C
49MR0505_1   P03      10      1  UNK 110105 2053    UN 32  9.14 N 118 45.71 W GPS   1304   1303                                                                              AIR N2O SMPL
49MR0505_1   P03      10      1  ROS 110105 2110    BO 32  8.97 N 118 45.65 W GPS   1288   1300       10   1314   1303      16 1-8,27
49MR0505_1   P03      10      1  ROS 110105 2203    EN 32  8.39 N 118 45.48 W GPS   1276   1270
49MR0505_1           502      1  UNK 110105 2217    UN 32  7.50 N 118 47.20 W GPS   1251   1269                                                                              AEROSOL SMPL
49MR0505_1   P03      12      1  ROS 110205 0011    BE 31 54.62 N 119 15.44 W GPS   1460   1459
49MR0505_1   P03      12      1  BUC 110205 0018    UN 31 54.55 N 119 15.48 W GPS   1414   1413                                1,33                                          18.4C
49MR0505_1   P03      12      1  UNK 110205 0018    UN 31 54.55 N 119 15.48 W GPS   1414   1413                                                                              AIR N2O SMPL
49MR0505_1   P03      12      1  ROS 110205 0041    BO 31 54.34 N 119 15.49 W GPS   1293   1287       11   1364   1365      16 1-8,23,24,26,27
49MR0505_1   P03      12      1  ROS 110205 0132    EN 31 53.92 N 119 15.53 W GPS   1108   1106
49MR0505_1   P03      14      1  ROS 110205 0250    BE 31 51.16 N 119 21.53 W GPS   1575   1580
49MR0505_1   P03      14      1  BUC 110205 0258    UN 31 51.09 N 119 21.56 W GPS   1639   1633                                1                                             17.9C
49MR0505_1   P03      14      1  ROS 110205 0323    BO 31 50.89 N 119 21.60 W GPS   1736   1741       14   1691   1694      18 1-8,23,24,26,27                               #5-6 FILTRATED SEAWATER SAMPLE
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49MR0505_1   P03       14       1 ROS 110205 0421    EN 31 50.50 N 119 21.64 W GPS   1763   1762
49MR0505_1   P03       16       1 ROS 110205 0542    BE 31 46.14 N 119 31.85 W GPS   2754   2751
49MR0505_1   P03       16       1 BUC 110205 0549    UN 31 46.10 N 119 31.86 W GPS   2776   2772                                  1                                               18.0C
49MR0505_1   P03       16       1 ROS 110205 0628    BO 31 45.87 N 119 31.96 W GPS   2882   2885        11   2813   2822       23 1-8,27
49MR0505_1   P03       16       1 ROS 110205 0753    EN 31 45.29 N 119 32.02 W GPS   3322   3316
49MR0505_1   P03       18       1 ROS 110205 0857    BE 31 40.42 N 119 43.02 W GPS   3750   3739
49MR0505_1   P03       18       1 BUC 110205 0904    UN 31 40.37 N 119 43.00 W GPS   3745   3736                                  1                                               17.8C
49MR0505_1   P03       18       1 ROS 110205 0957    BO 31 40.25 N 119 43.16 W GPS   3756   3745        13   3736   3777       28 1-8,23,24,26,27
49MR0505_1   P03       18       1 ROS 110205 1140    EN 31 40.06 N 119 43.43 W GPS   3751   3742
49MR0505_1   P03       20       1 ROS 110205 1323    BE 31 30.46 N 120  2.52 W GPS   3735   3725
49MR0505_1   P03       20       1 BUC 110205 1331    UN 31 30.39 N 120  2.55 W GPS   3735   3725                                  1,33                                            16.8C
49MR0505_1   P03       20       1 UNK 110205 1340    UN 31 30.30 N 120  2.54 W GPS   3729   3727                                                                                  AIR N2O SMPL
49MR0505_1   P03       20       1 ROS 110205 1423    BO 31 29.92 N 120  2.73 W GPS   3737   3729        10   3774   3764       27 1-8,27
49MR0505_1   P03       20       1 ROS 110205 1614    EN 31 29.01 N 120  3.66 W GPS   3760   3746
49MR0505_1   P03       22       1 ROS 110205 1820    BE 31 14.04 N 120 33.13 W GPS   3815   3813
49MR0505_1   P03       22       1 BUC 110205 1827    UN 31 14.00 N 120 33.09 W GPS   3812   3812                                  1,33                                            17.7C
49MR0505_1   P03       22       1 UNK 110205 1833    UN 31 13.96 N 120 33.08 W GPS   3814   3813                                                                                  AIR N2O SMPL
49MR0505_1   P03       22       1 ROS 110205 1919    BO 31 13.67 N 120 33.16 W GPS   3811   3810         9   3834   3855       36 1-8,22,27
49MR0505_1   P03       22       1 UNK 110205 1929    BE 31 13.67 N 120 33.16 W GPS   3811   3811                                                                                  80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03       22       1 UNK 110205 1947    EN 31 13.67 N 120 33.16 W GPS   3811   3813
49MR0505_1   P03       22       1 ROS 110205 2110    EN 31 13.14 N 120 33.06 W GPS   3815   3814
49MR0505_1            503       1 UNK 110205 2212    UN 31  6.00 N 120 47.30 W GPS   3927   3929                                                                                  AEROSOL SMPL
49MR0505_1   P03       24       1 ROS 110305 0001    BE 30 53.18 N 121 14.21 W GPS   3955   3954
49MR0505_1   P03       24       1 BUC 110305 0009    UN 30 53.11 N 121 14.15 W GPS   3953   3951                                  1,33                                            18.1C
49MR0505_1   P03       24       1 UNK 110305 0015    UN 30 53.06 N 121 14.08 W GPS   3960   3958                                                                                  AIR N2O SMPL
49MR0505_1   P03       24       1 ROS 110305 0105    BO 30 52.71 N 121 14.08 W GPS   3960   3960        10   3974   4007       28 1-8,12,13,23,24,26,27
49MR0505_1   P03       24       1 ROS 110305 0257    EN 30 52.25 N 121 13.86 W GPS   3989   3989
49MR0505_1   P03       26       1 ROS 110305 0627    BE 30 29.02 N 122  1.72 W GPS   3794   3795
49MR0505_1   P03       26       1 BUC 110305 0634    UN 30 28.95 N 122  1.72 W GPS   3794   3794                                  1                                               18.2C
49MR0505_1   P03       26       1 ROS 110305 0727    BO 30 28.69 N 122  1.98 W GPS   3854   3854        11   3825   3848       28 1-8,27
49MR0505_1   P03       26       1 ROS 110305 0911    EN 30 28.09 N 122  2.26 W GPS   3954   3942
49MR0505_1   P03       28       1 ROS 110305 1212    BE 30  1.33 N 122 35.09 W GPS   4324   4327
49MR0505_1   P03       28       1 BUC 110305 1219    UN 30  1.27 N 122 35.10 W GPS   4318   4319                                  1,31,33,82                                      19.0C
49MR0505_1   P03       28       1 UNK 110305 1300    UN 30  0.96 N 122 35.23 W GPS   4301   4324                                                                                  AIR N2O SMPL
49MR0505_1   P03       28       1 ROS 110305 1319    BO 30  0.88 N 122 35.33 W GPS   4317   4319        10   4324   4357       35 1-8,23,24,26,27,31,33,64,82                     #2 AT OXYCLINE
49MR0505_1   P03       28       1 ROS 110305 1524    EN 30  0.01 N 122 36.40 W GPS   4312   4313
49MR0505_1   P03       28       2 UNK 110305 1524    UN 30  0.01 N 122 36.40 W GPS   4312   4313                                                                                  AIR CH4 SMPL
49MR0505_1   P03       30       1 ROS 110305 1826    BE 29 32.59 N 123 14.25 W GPS   4248   4252
49MR0505_1   P03       30       1 BUC 110305 1833    UN 29 32.51 N 123 14.31 W GPS   4251   4255                                  1,33                                            18.9C
49MR0505_1   P03       30       1 UNK 110305 1834    UN 29 32.50 N 123 14.32 W GPS   4265   4257                                                                                  AIR N2O SMPL
49MR0505_1   P03       30       1 ROS 110305 1933    BO 29 32.25 N 123 14.81 W GPS   4257   4260         9   4303   4324       30 1-8,27
49MR0505_1   P03       30       1 ROS 110305 2129    EN 29 31.95 N 123 15.65 W GPS   4218   4203
49MR0505_1            504       1 UNK 110305 2150    UN 29 30.04 N 123 18.33 W GPS   4244   4264                                                                                  AEROSOL SMPL
49MR0505_1   P03       31       1 ROS 110405 0031    BE 29  3.05 N 123 52.38 W GPS   4468   4442
49MR0505_1   P03       31       1 BUC 110405 0038    UN 29  3.04 N 123 52.48 W GPS   4416   4412                                  1,33                                            19.3C
49MR0505_1   P03       31       1 UNK 110405 0043    UN 29  3.05 N 123 52.55 W GPS   4418   4419                                                                                  AIR N2O SMPL
49MR0505_1   P03       31       1 ROS 110405 0143    BO 29  2.97 N 123 53.35 W GPS   4395   4392        11   4510   4459       30 1-8,23,24,26,27
49MR0505_1   P03       31       1 ROS 110405 0343    EN 29  2.98 N 123 54.93 W GPS   4418   4423
49MR0505_1   P03       33       1 ROS 110405 0643    BE 28 35.19 N 124 30.59 W GPS   4358   4359
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49MR0505_1   P03       33      1  BUC 110405 0649    UN 28 35.15 N 124 30.68 W GPS   4351   4354                                  1                                               19.8C
49MR0505_1   P03       33      1  ROS 110405 0751    BO 28 35.07 N 124 31.33 W GPS   4334   4333         9   4403   4413       29 1-8,27                                           #12 MISS FIRE
49MR0505_1   P03       33      1  ROS 110405 0941    EN 28 35.28 N 124 32.35 W GPS   4318   4321
49MR0505_1   P03       34      1  ROS 110405 1246    BE 28  6.15 N 125  7.49 W GPS   4318   4319
49MR0505_1   P03       34      1  BUC 110405 1254    UN 28  6.14 N 125  7.58 W GPS   4310   4316                                  1,33                                            20.7C
49MR0505_1   P03       34      1  UNK 110405 1300    UN 28  6.15 N 125  7.65 W GPS   4300   4303                                                                                  AIR N2O SMPL
49MR0505_1   P03       34      1  ROS 110405 1356    BO 28  6.13 N 125  8.28 W GPS   4289   4295         9   4359   4363       30 1-8,23,24,26,27
49MR0505_1   P03       34      1  ROS 110405 1555    EN 28  6.25 N 125  9.20 W GPS   4154   4154
49MR0505_1   P03       36      1  ROS 110405 1904    BE 27 35.94 N 125 45.65 W GPS   4409   4414
49MR0505_1   P03       36      1  BUC 110405 1911    UN 27 35.95 N 125 45.70 W GPS   4418   4423                                  1,33                                            20.1C
49MR0505_1   P03       36      1  UNK 110405 1919    UN 27 35.95 N 125 45.75 W GPS   4418   4437                                                                                  AIR N2O SMPL
49MR0505_1   P03       36      1  UNK 110405 2011    BE 27 35.88 N 125 46.16 W GPS   4493   4489                                                                                  80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03       36      1  ROS 110405 2016    BO 27 35.88 N 125 46.16 W GPS   4493   4494         9   4481   4521       33 1-8,22,27
49MR0505_1   P03       36      1  UNK 110405 2022    EN 27 35.87 N 125 46.20 W GPS   4493   4494
49MR0505_1   P03       36      1  ROS 110405 2211    EN 27 35.59 N 125 46.95 W GPS   4488   4484
49MR0505_1            505      1  UNK 110405 2229    UN 27 34.09 N 125 49.21 W GPS   4511   4521                                                                                  AEROSOL SMPL
49MR0505_1   P03       38      1  ROS 110505 0106    BE 27  9.13 N 126 22.65 W GPS   4353   4356
49MR0505_1   P03       38      1  BUC 110505 0114    UN 27  9.07 N 126 22.68 W GPS   4346   4348                                  1,33                                            20.9C
49MR0505_1   P03       38      1  UNK 110505 0121    UN 27  9.05 N 126 22.71 W GPS   4348   4348                                                                                  AIR N2O SMPL
49MR0505_1   P03       38      1  ROS 110505 0215    BO 27  8.88 N 126 22.93 W GPS   4383   4385        11   4355   4402       30 1-8,12,13,23,24,26,27                            #19 MISS TRIP
49MR0505_1   P03       38      1  ROS 110505 0411    EN 27  8.60 N 126 23.90 W GPS   4437   4432
49MR0505_1   P03       40      1  ROS 110505 0709    BE 26 39.58 N 126 57.24 W GPS   4317   4324
49MR0505_1   P03       40      1  BUC 110505 0715    UN 26 39.61 N 126 57.35 W GPS   4322   4329                                  1                                               20.6C
49MR0505_1   P03       40      1  ROS 110505 0819    BO 26 40.00 N 126 58.08 W GPS   4524   4522         9   4504   4459       31 1-8,27                                           #1=#2 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       40      1  ROS 110505 1012    EN 26 40.65 N 126 58.68 W GPS   4684   4684
49MR0505_1   P03       42      1  ROS 110505 1322    BE 26 10.69 N 127 34.52 W GPS   4629   4628
49MR0505_1   P03       42      1  BUC 110505 1331    UN 26 10.72 N 127 34.67 W GPS   4628   4627                                  1,31,33                                         20.4C
49MR0505_1   P03       42      1  UNK 110505 1351    UN 26 10.78 N 127 34.97 W GPS   4611   4597                                                                                  AIR N2O SMPL
49MR0505_1   P03       42      1  ROS 110505 1438    BO 26 10.97 N 127 35.56 W GPS   4545   4554         8   4721   4668       36 1-8,23,24,26,27,31,33,64,81                      #2 AT OXYCLINE
49MR0505_1   P03       42      1  ROS 110505 1646    EN 26 11.01 N 127 37.21 W GPS   4555   4549
49MR0505_1   P03       42      2  UNK 110505 1646    UN 26 11.01 N 127 37.21 W GPS   4555   4549                                                                                  AIR CH4 SMPL
49MR0505_1   P03       44      1  ROS 110505 1955    BE 25 40.98 N 128 11.85 W GPS   4280   4276
49MR0505_1   P03       44      1  BUC 110505 2002    UN 25 41.01 N 128 11.90 W GPS   4292   4278                                  1,33                                            21.0C
49MR0505_1   P03       44      1  UNK 110505 2008    UN 25 41.06 N 128 11.94 W GPS   4267   4266                                                                                  AIR N2O SMPL
49MR0505_1   P03       44      1  ROS 110505 2106    BO 25 41.23 N 128 12.48 W GPS   4208   4206         9   4264   4277       30 1-8,27                                           #1=#3 (B-10) DUPLICATE SMPLS
49MR0505_1            506      1  UNK 110505 2156    UN 25 41.36 N 128 12.75 W GPS   4347   4335                                                                                  AEROSOL SMPL
49MR0505_1   P03       44      1  ROS 110505 2301    EN 25 41.56 N 128 13.38 W GPS   4466   4464
49MR0505_1   P03       46      1  ROS 110605 0400    BE 25 12.87 N 128 48.79 W GPS   4744   4743
49MR0505_1   P03       46      1  BUC 110605 0407    UN 25 12.86 N 128 48.88 W GPS   4741   4704                                  1,33                                            21.0C
49MR0505_1   P03       46      1  UNK 110605 0420    UN 25 12.82 N 128 49.02 W GPS   4741   4743                                                                                  AIR N2O SMPL
49MR0505_1   P03       46      1  ROS 110605 0515    BO 25 12.86 N 128 49.47 W GPS   4669   4675         8   4775   4804       32 1-8,23,24,26,27
49MR0505_1   P03       46      1  ROS 110605 0720    EN 25 13.49 N 128 50.32 W GPS   4547   4546
49MR0505_1   P03       48      1  ROS 110605 1032    BE 24 42.70 N 129 24.94 W GPS   4500   4500
49MR0505_1   P03       48      1  BUC 110605 1040    UN 24 42.75 N 129 25.00 W GPS   4501   4500                                  1                                               21.4C
49MR0505_1   P03       48      1  ROS 110605 1143    BO 24 43.05 N 129 25.41 W GPS   4478   4484         9   4523   4556       32 1-8,27                                           #1=#4 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       48      1  ROS 110605 1347    EN 24 43.01 N 129 26.16 W GPS   4491   4486
49MR0505_1   P03       50      1  ROS 110605 1648    BE 24 15.44 N 130  1.79 W GPS   4613   4614
49MR0505_1   P03       50      1  BUC 110605 1656    UN 24 15.47 N 130  1.85 W GPS   4616   4619                                  1,33                                            21.1C
49MR0505_1   P03       50      1  UNK 110605 1659    UN 24 15.47 N 130  1.88 W GPS   4626   4626                                                                                  AIR N2O SMPL
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49MR0505_1   P03       50      1  ROS 110605 1800    BO 24 15.51 N 130  2.31 W GPS   4614   4614       9   4635   4684      35 1-8,22,27                                       #1=#5 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       50      1  UNK 110605 1806    BE 24 15.51 N 130  2.31 W GPS   4614   4624                                                                               80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03       50      1  UNK 110605 1824    EN 24 15.51 N 130  2.31 W GPS   4614   4611
49MR0505_1   P03       50      1  ROS 110605 2008    EN 24 15.58 N 130  3.17 W GPS   4644   4640
49MR0505_1            507      1  UNK 110605 2212    UN 24 15.32 N 130 35.75 W GPS   4872   4873                                                                               AEROSOL SMPL
49MR0505_1   P03       51      1  ROS 110605 2310    BE 24 15.62 N 130 49.99 W GPS   4725   4726
49MR0505_1   P03       51      1  BUC 110605 2317    UN 24 15.59 N 130 50.06 W GPS   4742   4742                                1,33                                            21.9C
49MR0505_1   P03       51      1  UNK 110605 2322    UN 24 15.59 N 130 50.11 W GPS   4754   4744                                                                               AIR N2O SMPL
49MR0505_1   P03       51      1  ROS 110705 0024    BO 24 15.55 N 130 50.83 W GPS   4747   4758      10   4826   4821      32 1-8,12,13,23,24,26,27                           #1=#6 (B-10) DUPLICATE SMPLS, #28 MISS FIRE
49MR0505_1   P03       51      1  ROS 110705 0228    EN 24 15.71 N 130 51.90 W GPS   4758   4756
49MR0505_1   P03       53      1  ROS 110705 0532    BE 24 16.29 N 131 39.16 W GPS   4692   4694
49MR0505_1   P03       53      1  BUC 110705 0539    UN 24 16.31 N 131 39.17 W GPS   4696   4694                                1,33                                            21.6C
49MR0505_1   P03       53      1  UNK 110705 0547    UN 24 16.30 N 131 39.20 W GPS   4696   4693                                                                               AIR N2O SMPL
49MR0505_1   P03       53      1  ROS 110705 0643    BO 24 16.31 N 131 39.38 W GPS   4695   4694       9   4693   4761      32 1-8,27                                          #1=#7 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       53      1  ROS 110705 0845    EN 24 16.14 N 131 39.95 W GPS   4681   4677
49MR0505_1   P03       55      1  ROS 110705 1149    BE 24 14.79 N 132 25.84 W GPS   4625   4625
49MR0505_1   P03       55      1  BUC 110705 1157    UN 24 14.81 N 132 25.86 W GPS   4642   4626                                1                                               21.5C
49MR0505_1   P03       55      1  ROS 110705 1304    BO 24 14.71 N 132 26.11 W GPS   4626   4625      10   4646   4701      32 1-8,27                                          #1=#8 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       55      1  ROS 110705 1515    EN 24 14.46 N 132 26.73 W GPS   4642   4670
49MR0505_1   P03       56      1  ROS 110705 1820    BE 24 15.42 N 133 14.25 W GPS   4874   4866
49MR0505_1   P03       56      1  BUC 110705 1827    UN 24 15.37 N 133 14.28 W GPS   4863   4865                                1,31,33,82                                      21.4C
49MR0505_1   P03       56      1  UNK 110705 1832    UN 24 15.36 N 133 14.31 W GPS   4873   4864                                                                               AIR N2O SMPL
49MR0505_1   P03       56      1  ROS 110705 1935    BO 24 15.22 N 133 14.66 W GPS   4860   4857       9   4881   4938      33 1-8,23,24,26,27,31,33,82                        #1=#9 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       56      1  ROS 110705 2139    EN 24 14.91 N 133 15.38 W GPS   4841   4840
49MR0505_1            508      1  UNK 110705 2225    UN 24 14.75 N 133 25.90 W GPS   4882   4872                                                                               AEROSOL SMPL
49MR0505_1   P03       58      1  ROS 110805 0045    BE 24 15.06 N 134  2.78 W GPS   4796   4804
49MR0505_1   P03       58      1  BUC 110805 0052    UN 24 15.00 N 134  2.80 W GPS   4808   4798                                1,33                                            21.8C
49MR0505_1   P03       58      1  UNK 110805 0058    UN 24 14.95 N 134  2.83 W GPS   4815   4809                                                                               AIR N2O SMPL
49MR0505_1   P03       58      1  ROS 110805 0159    BO 24 14.60 N 134  3.16 W GPS   4842   4831      10   4866   4907      33 1-8,27                                          #1=#10 (B-10) DUPLICATE SMPLS
49MR0505_1            509      1  UNK 110805 0300    UN 24 14.18 N 134  3.43 W GPS   4842   4845                                                                               RAIN SMPL (0.3MM/HR)
49MR0505_1   P03       58      1  ROS 110805 0407    EN 24 13.60 N 134  4.21 W GPS   4843   4843
49MR0505_1   P03      X17      1  ROS 110805 0748    BE 23 59.89 N 135  0.10 W GPS   4858   4867
49MR0505_1   P03      X17      1  BUC 110805 0756    UN 23 59.80 N 135  0.20 W GPS   4875   4868                                1                                               22.0C
49MR0505_1   P03      X17      1  ROS 110805 0904    BO 23 59.80 N 135  0.63 W GPS   4841   4842       9   4865   4926      33 1-8,12,13,23,24,26,27                           #1=#11 (B-10) DUPLICATE SMPLS
49MR0505_1   P03      X17      1  ROS 110805 1107    EN 23 59.85 N 135  1.68 W GPS   4824   4824
49MR0505_1   P03       62      1  ROS 110805 1433    BE 24 15.15 N 135 37.46 W GPS   4491   4500
49MR0505_1   P03       62      1  BUC 110805 1444    UN 24 15.24 N 135 37.57 W GPS   4497   4492                                1,33                                            21.7C
49MR0505_1   P03       62      1  UNK 110805 1449    UN 24 15.26 N 135 37.64 W GPS   4478   4474                                                                               AIR N2O SMPL
49MR0505_1   P03       62      1  ROS 110805 1550    BO 24 15.47 N 135 37.98 W GPS   4462   4472      10   4487   4537      31 1-8,27                                          #1=#12 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       62      1  ROS 110805 1758    EN 24 15.96 N 135 39.74 W GPS   4442   4438
49MR0505_1   P03       64      1  ROS 110805 2110    BE 24 14.13 N 136 26.57 W GPS   4450   4461
49MR0505_1   P03       64      1  BUC 110805 2120    UN 24 14.25 N 136 26.64 W GPS   4459   4462                                1,33                                            22.1C
49MR0505_1   P03       64      1  UNK 110805 2133    UN 24 14.38 N 136 26.74 W GPS   4417   4425                                                                               AIR N2O SMPL
49MR0505_1   P03       64      1  ROS 110805 2229    BO 24 14.74 N 136 27.37 W GPS   4272   4293      10   4492   4459      31 1-8,23,24,26,27                                 #1=#13 (B-10) DUPLICATE SMPLS
49MR0505_1            510      1  UNK 110805 2237    UN 24 14.81 N 136 27.46 W GPS   4287   4287                                                                               AEROSOL SMPL
49MR0505_1   P03       64      1  ROS 110905 0037    EN 24 15.28 N 136 28.65 W GPS   4593   4589
49MR0505_1   P03       66      1  ROS 110905 0336    BE 24 14.14 N 137 13.14 W GPS   4841   4840
49MR0505_1   P03       66      1  BUC 110905 0346    UN 24 14.10 N 137 13.19 W GPS   4840   4835                                1,33                                            22.0C
49MR0505_1   P03       66      1  UNK 110905 0353    UN 24 14.07 N 137 13.22 W GPS   4840   4830                                                                               AIR N2O SMPL
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49MR0505_1   P03       66      1  ROS 110905 0454    BO 24 14.08 N 137 13.84 W GPS    4838   4828         9   4909   4900       33 1-8,27                                         #1=#14 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       66      1  ROS 110905 0702    EN 24 14.44 N 137 15.01 W GPS    4827   4832
49MR0505_1   P03       67      1  ROS 110905 0958    BE 24 13.86 N 137 59.86 W GPS    4894   4894
49MR0505_1   P03       67      1  BUC 110905 1006    UN 24 13.86 N 137 59.97 W GPS    4914   4904                                 1                                              22.5C
49MR0505_1   P03       67      1  ROS 110905 1117    BO 24 14.17 N 138  0.53 W GPS    4942   4944        10   4990   5012       33 1-8,27                                         #1=#15 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       67      1  ROS 110905 1333    EN 24 14.68 N 138  1.32 W GPS    4958   4957
49MR0505_1   P03       69      1  ROS 110905 1634    BE 24 14.60 N 138 47.98 W GPS    5169   5171
49MR0505_1   P03       69      1  BUC 110905 1644    UN 24 14.66 N 138 48.13 W GPS    5172   5173                                 1,31,33                                        22.4C
49MR0505_1   P03       69      1  UNK 110905 1650    UN 24 14.71 N 138 48.19 W GPS    5168   5174                                                                                AIR N2O SMPL
49MR0505_1   P03       69      1  ROS 110905 1756    BO 24 14.94 N 138 48.19 W GPS    5174   5180        10   5178   5255       34 1-8,23,24,26,27,31,33                          #1=#16 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       69      1  ROS 110905 2014    EN 24 15.49 N 138 48.77 W GPS    5187   5190
49MR0505_1   P03       69      2  UNK 110905 2014    UN 24 15.49 N 138 48.77 W GPS    5187   5190                                                                                AIR CH4 SMPL
49MR0505_1   P03       71      1  ROS 110905 2332    BE 24 14.67 N 139 37.38 W GPS    4691   4696
49MR0505_1            511      1  UNK 110905 2338    UN 24 14.72 N 139 37.41 W GPS    4687   4687                                                                                AEROSOL SMPL
49MR0505_1   P03       71      1  BUC 110905 2340    UN 24 14.73 N 139 37.42 W GPS    4706   4701                                 1,33                                           22.6C
49MR0505_1   P03       71      1  UNK 110905 2344    UN 24 14.77 N 139 37.45 W GPS    4678   4709                                                                                AIR N2O SMPL
49MR0505_1   P03       71      1  ROS 111005 0045    BO 24 15.37 N 139 37.70 W GPS    4719   4723        10   4718   4719       35 1-8,27,64,81
49MR0505_1   P03       71      1  ROS 111005 0253    EN 24 15.99 N 139 38.91 W GPS    4817   4821
49MR0505_1   P03       73      1  ROS 111005 0542    BE 24 14.16 N 140 21.37 W GPS    4810   4807
49MR0505_1   P03       73      1  BUC 111005 0551    UN 24 14.15 N 140 21.53 W GPS    4816   4813                                 1                                              22.5C
49MR0505_1   P03       73      1  ROS 111005 0657    BO 24 14.58 N 140 21.99 W GPS    4809   4812        10   4887   4882       36 1-8,22,27                                      #1=#17 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       73      1  UNK 111005 0700    BE 24 14.62 N 140 22.01 W GPS    4810   4811                                                                                80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03       73      1  UNK 111005 0713    EN 24 14.70 N 140 22.06 W GPS    4810   4811
49MR0505_1   P03       73      1  ROS 111005 0902    EN 24 15.34 N 140 22.70 W GPS    4810   4810
49MR0505_1            512      1  UNK 111005 2306    UN 24 12.88 N 140 44.16 W GPS    4777   4775                                                                                AEROSOL SMPL
49MR0505_1            513      1  UNK 111105 0000    BE 24 13.58 N 140 45.13 W GPS    4439   4446                                                                                FIGURE-OF-EIGHT SAILING FOR MAGNETOMETER
49MR0505_1            513      1  UNK 111105 0023    EN 24 13.91 N 140 45.26 W GPS    4418   4453
49MR0505_1   P03       74      1  ROS 111105 1403    BE 24 16.37 N 141  8.47 W GPS    4989   4990
49MR0505_1   P03       74      1  BUC 111105 1410    UN 24 16.41 N 141  8.51 W GPS    4990   4990                                 1,33                                           22.2C
49MR0505_1   P03       74      1  UNK 111105 1420    UN 24 16.46 N 141  8.59 W GPS    4989   4992                                                                                AIR N2O SMPL
49MR0505_1   P03       74      1  ROS 111105 1523    BO 24 16.94 N 141  8.96 W GPS    4992   4991         9   5043   5066       34 1-8,12,13,23,24,26,27                          #1=#18 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       74      1  ROS 111105 1735    EN 24 18.01 N 141  9.59 W GPS    5014   5015
49MR0505_1   P03       76      1  ROS 111105 2016    BE 24 15.06 N 141 50.83 W GPS    4645   4642
49MR0505_1   P03       76      1  BUC 111105 2024    UN 24 15.13 N 141 50.89 W GPS    4629   4632                                 1,33                                           22.5C
49MR0505_1   P03       76      1  UNK 111105 2030    UN 24 15.17 N 141 50.95 W GPS    4632   4629                                                                                AIR N2O SMPL
49MR0505_1            514      1  UNK 111105 2106    UN 24 15.50 N 141 51.17 W GPS    4594   4600                                                                                RAIN SMPL (0.6MM/HR)
49MR0505_1   P03       76      1  ROS 111105 2133    BO 24 15.64 N 141 51.34 W GPS    4612   4613         9   4697   4698       32 1-8,27                                         #1=#19 (B-10) DUPLICATE SMPLS
49MR0505_1            515      1  UNK 111105 2309    UN 24 16.41 N 141 52.04 W GPS    4628   4619                                                                                AEROSOL SMPL
49MR0505_1   P03       76      1  ROS 111105 2337    EN 24 16.67 N 141 52.41 W GPS    4600   4600
49MR0505_1   P03       77      1  ROS 111205 0222    BE 24 14.70 N 142 34.96 W GPS    4800   4798
49MR0505_1   P03       77      1  BUC 111205 0228    UN 24 14.77 N 142 35.01 W GPS    4801   4800                                 1,31,33,82                                     23.1C
49MR0505_1   P03       77      1  UNK 111205 0240    UN 24 14.90 N 142 35.12 W GPS    4796   4784                                                                                AIR N2O SMPL
49MR0505_1   P03       77      1  ROS 111205 0335    BO 24 15.46 N 142 35.32 W GPS    4794   4794         9   4861   4854       33 1-8,23,24,26,27,31,33,82                       #1=#20 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       77      1  ROS 111205 0538    EN 24 16.60 N 142 35.93 W GPS    4762   4762
49MR0505_1   P03       77      2  UNK 111205 0540    UN 24 16.61 N 142 35.97 W GPS    4744   4744                                                                                AIR N2O SMPL
49MR0505_1   P03       79      1  ROS 111205 0831    BE 24 15.43 N 143 19.04 W GPS    4464   4458
49MR0505_1   P03       79      1  BUC 111205 0840    UN 24 15.55 N 143 19.02 W GPS    4452   4452                                 1                                              23.2C
49MR0505_1   P03       79      1  ROS 111205 0942    BO 24 15.92 N 143 18.92 W GPS    4417   4418         9   4468   4506       31 1-8,27                                         #1=#21 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       79      1  ROS 111205 1137    EN 24 16.29 N 143 18.75 W GPS    4460   4463
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49MR0505_1   P03       81      1  ROS 111205 1430    BE 24 14.23 N 144  2.15 W GPS   5197   5207
49MR0505_1   P03       81      1  BUC 111205 1438    UN 24 14.36 N 144  2.20 W GPS   5269   5272                                 1,33                                           22.5C
49MR0505_1   P03       81      1  UNK 111205 1443    UN 24 14.44 N 144  2.22 W GPS   5270   5272                                                                                AIR N2O SMPL
49MR0505_1   P03       81      1  ROS 111205 1556    BO 24 15.27 N 144  2.42 W GPS   5293   5292        10  5376   5362       35 1-8,23,24,26,27                                #1=#22 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       81      1  ROS 111205 1824    EN 24 17.16 N 144  3.11 W GPS   5253   5255
49MR0505_1   P03       83      1  ROS 111205 2119    BE 24 13.87 N 144 47.82 W GPS   5210   5204
49MR0505_1   P03       83      1  BUC 111205 2126    UN 24 13.93 N 144 47.90 W GPS   5205   5202                                 1,33                                           23.7C
49MR0505_1   P03       83      1  UNK 111205 2135    UN 24 14.01 N 144 47.97 W GPS   5206   5204                                                                                AIR N2O SMPL
49MR0505_1            516      1  UNK 111205 2235    UN 24 14.63 N 144 48.25 W GPS   5209   5205                                                                                AEROSOL SMPL
49MR0505_1   P03       83      1  ROS 111205 2244    BO 24 14.71 N 144 48.31 W GPS   5205   5203        10  5335   5282       34 1-8,27                                         #1=#23 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       83      1  ROS 111305 0105    EN 24 16.14 N 144 49.34 W GPS   5221   5220
49MR0505_1   P03       84      1  ROS 111305 0337    BE 24 17.26 N 145 28.07 W GPS   5181   5190
49MR0505_1   P03       84      1  BUC 111305 0343    UN 24 17.33 N 145 28.10 W GPS   5189   5188                                 1,33                                           23.1C
49MR0505_1   P03       84      1  UNK 111305 0350    UN 24 17.40 N 145 28.14 W GPS   5205   5218                                                                                AIR N2O SMPL
49MR0505_1   P03       84      1  ROS 111305 0458    BO 24 18.15 N 145 28.53 W GPS   5162   5172        10  5306   5277       35 1-8,23,24,26,27                                #1=#24 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       84      1  ROS 111305 0714    EN 24 19.54 N 145 28.88 W GPS   5172   5186
49MR0505_1   P03       86      1  ROS 111305 1015    BE 24 13.71 N 146 13.70 W GPS   5270   5243
49MR0505_1   P03       86      1  BUC 111305 1022    UN 24 13.79 N 146 13.69 W GPS   5250   5240                                 1                                              23.8C
49MR0505_1   P03       86      1  ROS 111305 1135    BO 24 14.38 N 146 13.56 W GPS   5258   5259         9  5285   5316       35 1-8,27                                         #1=#25 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       86      1  ROS 111305 1353    EN 24 15.74 N 146 13.60 W GPS   5308   5308
49MR0505_1   P03       88      1  ROS 111305 1645    BE 24 13.76 N 146 55.99 W GPS   5221   5228
49MR0505_1   P03       88      1  BUC 111305 1653    UN 24 13.88 N 146 56.01 W GPS   5222   5219                                 1,33                                           23.8C
49MR0505_1   P03       88      1  UNK 111305 1657    UN 24 13.90 N 146 56.00 W GPS   5225   5226                                                                                AIR N2O SMPL
49MR0505_1   P03       88      1  ROS 111305 1808    BO 24 14.44 N 146 56.11 W GPS   5257   5263        10  5282   5342       36 1-8,22,27
49MR0505_1   P03       88      1  UNK 111305 1815    BE 24 14.48 N 146 56.10 W GPS   5268   5260                                                                                80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03       88      1  UNK 111305 1828    EN 24 14.54 N 146 56.06 W GPS   5240   5257
49MR0505_1   P03       88      1  ROS 111305 2028    EN 24 15.27 N 146 55.98 W GPS   5291   5284
49MR0505_1   P03       90      1  ROS 111305 2331    BE 24 15.40 N 147 41.79 W GPS   5566   5555
49MR0505_1   P03       90      1  BUC 111305 2338    UN 24 15.49 N 147 41.78 W GPS   5569   5567                                 1,33                                           24.1C
49MR0505_1            517      1  UNK 111305 2338    UN 24 15.49 N 147 41.79 W GPS   5534   5567                                                                                AEROSOL SMPL
49MR0505_1   P03       90      1  UNK 111305 2344    UN 24 15.58 N 147 41.78 W GPS   5542   5557                                                                                AIR N2O SMPL
49MR0505_1   P03       90      1  ROS 111405 0102    BO 24 16.58 N 147 41.88 W GPS   5526   5530        10  5748   5666       35 1-8,12,13,23,24,26,27
49MR0505_1   P03       90      1  ROS 111405 0326    EN 24 17.94 N 147 42.14 W GPS   5519   5504
49MR0505_1   P03       92      1  ROS 111405 0619    BE 24 14.97 N 148 26.07 W GPS   5487   5472
49MR0505_1   P03       92      1  BUC 111405 0626    UN 24 15.02 N 148 26.09 W GPS   5481   5483                                 1,33                                           23.7C
49MR0505_1   P03       92      1  UNK 111405 0632    UN 24 15.05 N 148 26.13 W GPS   5483   5482                                                                                AIR N2O SMPL
49MR0505_1   P03       92      1  ROS 111405 0742    BO 24 15.35 N 148 26.27 W GPS   5472   5474         9  5480   5566       36 1-8,27                                         #1=#26 (B-10) DUPLICATE SMPLS
49MR0505_1   P03       92      1  ROS 111405 1002    EN 24 15.78 N 148 26.50 W GPS   5442   5472
49MR0505_1   P03       94      1  ROS 111405 1250    BE 24 14.39 N 149  9.11 W GPS   5407   5411
49MR0505_1   P03       94      1  BUC 111405 1257    UN 24 14.44 N 149  9.17 W GPS   5417   5413                                 1,31,33                                        23.7C
49MR0505_1   P03       94      1  ROS 111405 1414    BO 24 15.09 N 149  9.50 W GPS   5340   5337        13  5399   5417       34 1-8,23,24,26,27,31,33
49MR0505_1   P03       94      1  ROS 111405 1636    EN 24 16.65 N 149  9.74 W GPS   5396   5387
49MR0505_1   P03       94      1  UNK 111405 1636    UN 24 16.65 N 149  9.74 W GPS   5396   5387                                                                                AIR CH4 SMPL
49MR0505_1   P03       96      1  ROS 111405 1930    BE 24 14.63 N 149 53.26 W GPS   5331   5330
49MR0505_1   P03       96      1  BUC 111405 1936    UN 24 14.65 N 149 53.31 W GPS   5342   5340                                 1,33                                           24.0C
49MR0505_1   P03       96      1  UNK 111405 1945    UN 24 14.70 N 149 53.37 W GPS   5356   5340                                                                                AIR N2O SMPL
49MR0505_1   P03       96      1  ROS 111405 2053    BO 24 15.18 N 149 53.63 W GPS   5340   5346        10  5369   5422       35 1-8,27,64,81                                   #3=150 AT OXYCLINE SMPL, #26 NOT FIRE
49MR0505_1            518      1  UNK 111405 2248    UN 24 15.95 N 149 54.20 W GPS   5335   5322                                                                                AEROSOL SMPL
49MR0505_1   P03       96      1  ROS 111405 2321    EN 24 16.24 N 149 54.39 W GPS   5327   5324
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49MR0505_1	P03	98	1	ROS	111505	0211	BE	24 14.42 N	150 38.05 W	GPS	5382	5384						
49MR0505_1	P03	98	1	BUC	111505	0218	UN	24 14.52 N	150 38.14 W	GPS	5382	5377					1,33	24.1C
49MR0505_1	P03	98	1	UNK	111505	0224	UN	24 14.59 N	150 38.16 W	GPS	5368	5375						AIR N2O SMPL
49MR0505_1	P03	98	1	ROS	111505	0333	BO	24 15.15 N	150 38.37 W	GPS	5374	5374	9	5424	5464	34	1-8,23,24,26,27	#23 NUTRIENT DAMMY SMPL
49MR0505_1	P03	98	1	ROS	111505	0549	EN	24 16.03 N	150 38.89 W	GPS	5422	5422						
49MR0505_1	P03	100	1	ROS	111505	0829	BE	24 15.51 N	151 18.89 W	GPS	5473	5470						
49MR0505_1	P03	100	1	BUC	111505	0836	UN	24 15.58 N	151 18.93 W	GPS	5481	5474					1	24.2C
49MR0505_1	P03	100	1	ROS	111505	0953	BO	24 16.08 N	151 19.18 W	GPS	5463	5458	9	5518	5564	35	1-8,27	
49MR0505_1	P03	100	1	ROS	111505	1218	EN	24 16.91 N	151 19.68 W	GPS	5472	5473						
49MR0505_1	P03	X16	1	ROS	111505	1506	BE	23 59.69 N	151 58.67 W	GPS	5461	5462						
49MR0505_1	P03	X16	1	BUC	111505	1512	UN	23 59.71 N	151 58.73 W	GPS	5452	5454					1,33	24.0C
49MR0505_1	P03	X16	1	UNK	111505	1518	UN	23 59.76 N	151 58.77 W	GPS	5442	5445						AIR N2O SMPL
49MR0505_1	P03	X16	1	ROS	111505	1632	BO	24 0.42 N	151 59.12 W	GPS	5466	5468	10	5495	5531	34	1-8,12,13,23,24,26,27	
49MR0505_1	P03	X16	1	ROS	111505	1856	EN	24 1.64 N	151 59.54 W	GPS	5514	5515						
49MR0505_1	P03	104	1	ROS	111505	2140	BE	24 15.35 N	152 37.96 W	GPS	5333	5327						
49MR0505_1	P03	104	1	BUC	111505	2146	UN	24 15.41 N	152 38.02 W	GPS	5335	5337					1,33	24.7C
49MR0505_1	P03	104	1	UNK	111505	2152	UN	24 15.46 N	152 38.06 W	GPS	5366	5371						AIR N2O SMPL
49MR0505_1	P03	104	1	ROS	111505	2307	BO	24 16.18 N	152 38.31 W	GPS	5255	5260	10	5419	5408	34	1-8,27	
49MR0505_1		519	1	UNK	111505	2322	UN	24 16.31 N	152 38.34 W	GPS	5267	5267						AEROSOL SMPL
49MR0505_1	P03	104	1	ROS	111605	0126	EN	24 17.36 N	152 39.06 W	GPS	5249	5249						
49MR0505_1	P03	106	1	ROS	111605	0401	BE	24 15.40 N	153 18.16 W	GPS	5142	5143						
49MR0505_1	P03	106	1	BUC	111605	0408	UN	24 15.48 N	153 18.21 W	GPS	5142	5144					1,31,33,82	24.6C
49MR0505_1	P03	106	1	UNK	111605	0420	UN	24 15.64 N	153 18.32 W	GPS	5140	5139						AIR N2O SMPL
49MR0505_1	P03	106	1	ROS	111605	0521	BO	24 16.34 N	153 18.49 W	GPS	5154	5146	10	5267	5213	33	1-8,23,24,26,27,31,33,82	
49MR0505_1	P03	106	1	ROS	111605	0741	EN	24 17.49 N	153 18.68 W	GPS	5124	5124						
49MR0505_1	P03	108	1	ROS	111605	1016	BE	24 15.39 N	153 57.28 W	GPS	4861	4851						
49MR0505_1	P03	108	1	BUC	111605	1023	UN	24 15.49 N	153 57.28 W	GPS	4863	4863					1	24.4C
49MR0505_1	P03	108	1	ROS	111605	1133	BO	24 16.14 N	153 57.22 W	GPS	4877	4877	9	4943	4932	32	1-8,27	
49MR0505_1	P03	108	1	ROS	111605	1345	EN	24 17.25 N	153 57.24 W	GPS	4913	4913						
49MR0505_1		520	1	UNK	111605	1620	UN	24 14.17 N	154 37.59 W	GPS	4665	4664						RAIN SMPL (1.6MM/HR)
49MR0505_1	P03	110	1	ROS	111605	1624	BE	24 14.14 N	154 37.59 W	GPS	4663	4664						
49MR0505_1	P03	110	1	BUC	111605	1631	UN	24 14.22 N	154 37.65 W	GPS	4662	4666					1,33	24.3C
49MR0505_1	P03	110	1	UNK	111605	1636	UN	24 14.28 N	154 37.67 W	GPS	4666	4666						AIR N2O SMPL
49MR0505_1	P03	110	1	ROS	111605	1740	BO	24 15.01 N	154 37.95 W	GPS	4681	4681	10	4755	4743	31	1-8,23,24,26,27	
49MR0505_1	P03	110	1	ROS	111605	1955	EN	24 16.53 N	154 38.27 W	GPS	4697	4689						
49MR0505_1	P03	112	1	ROS	111605	2227	BE	24 17.12 N	155 16.62 W	GPS	4578	4583						
49MR0505_1	P03	112	1	BUC	111605	2234	UN	24 17.23 N	155 16.67 W	GPS	4581	4582					1,33	25.1C
49MR0505_1		521	1	UNK	111605	2234	UN	24 17.23 N	155 16.67 W	GPS	4582	4582						AEROSOL SMPL
49MR0505_1	P03	112	1	UNK	111605	2239	UN	24 17.30 N	155 16.70 W	GPS	4581	4581						AIR N2O SMPL
49MR0505_1	P03	112	1	UNK	111605	2342	BE	24 18.08 N	155 17.09 W	GPS	4582	4583						80L THROUGH HULL PUMP FOR R.N.
49MR0505_1	P03	112	1	ROS	111605	2344	BO	24 18.10 N	155 17.10 W	GPS	4585	4583	10	4715	4645	34	1-8,22,27	
49MR0505_1	P03	112	1	UNK	111605	2354	EN	24 18.21 N	155 17.13 W	GPS	4582	4582						
49MR0505_1	P03	112	1	ROS	111705	0144	EN	24 19.75 N	155 17.69 W	GPS	4581	4583						
49MR0505_1	P03	114	1	ROS	111705	0427	BE	24 15.97 N	155 57.39 W	GPS	4547	4525						
49MR0505_1	P03	114	1	BUC	111705	0433	UN	24 16.07 N	155 57.39 W	GPS	4534	4532					1,33	25.0C
49MR0505_1	P03	114	1	UNK	111705	0440	UN	24 16.16 N	155 57.39 W	GPS	4541	4533						AIR N2O SMPL
49MR0505_1	P03	114	1	ROS	111705	0539	BO	24 16.93 N	155 57.46 W	GPS	4515	4515	9	4643	4600	31	1-8,12,13,23,24,26,27	JERRY FISH AT TC DUCT
49MR0505_1	P03	114	1	ROS	111705	0745	EN	24 18.38 N	155 57.11 W	GPS	4520	4525						
49MR0505_1	P03	116	1	ROS	111705	1056	BE	24 14.96 N	156 43.73 W	GPS	4309	4331						

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49MR0505_1   P03     116       1  BUC 111705 1103    UN 24 15.07 N 156 43.68 W GPS   4354   4350                              1                                       24.9C
49MR0505_1   P03     116       1  ROS 111705 1205    BO 24 15.64 N 156 43.54 W GPS   4409   4405     10   4414   4421      29 1-8,27                                  #36 MISS FIRE
49MR0505_1   P03     116       1  ROS 111705 1407    EN 24 16.60 N 156 43.27 W GPS   4453   4453
49MR0505_1   P03     118       1  ROS 111705 1719    BE 24 15.81 N 157 29.66 W GPS   4423   4466
49MR0505_1   P03     118       1  BUC 111705 1726    UN 24 15.89 N 157 29.65 W GPS   4459   4471                              1,31,33                                 24.8C
49MR0505_1   P03     118       1  UNK 111705 1740    UN 24 16.08 N 157 29.62 W GPS   4510   4482                                                                      AIR N2O SMPL
49MR0505_1   P03     118       1  ROS 111705 1832    BO 24 16.60 N 157 29.53 W GPS   4488   4484     10   4543   4539      30 1-8,23,24,26,27,31,33
49MR0505_1   P03     118       1  ROS 111705 2036    EN 24 17.60 N 157 28.95 W GPS   4511   4489
49MR0505_1   P03     118       2  UNK 111705 2036    UN 24 17.60 N 157 28.95 W GPS   4511   4489                                                                      AIR CH4 SMPL
49MR0505_1           522       1  UNK 111705 2216    UN 24 36.40 N 157 43.41 W GPS   4633   4635                                                                      AEROSOL SMPL
49MR0505_1   P03     120       1  ROS 111805 0013    BE 25  0.05 N 157 59.97 W GPS   4597   4599                                                                      STATION POSITION WAS SHIFTED NORTH
49MR0505_1   P03     120       1  BUC 111805 0020    UN 25  0.11 N 158  0.01 W GPS   4582   4589                              1,33                                    25.2C
49MR0505_1   P03     120       1  UNK 111805 0032    UN 25  0.18 N 158  0.12 W GPS   4607   4604                                                                      AIR N2O SMPL
49MR0505_1   P03     120       1  ROS 111805 0124    BO 25  0.32 N 158  0.15 W GPS   4648   4630     10   4596   4653      35 1-8,27,64,81
49MR0505_1   P03     120       1  ROS 111805 0325    EN 25  0.84 N 158  0.40 W GPS   4731   4743
49MR0505_1   P03     122       1  ROS 111805 0940    BE 25 49.98 N 159  0.45 W GPS   5054   5060                                                                      STATION POSITION WAS SHIFTED NORTH
49MR0505_1   P03     122       1  BUC 111805 0947    UN 25 49.96 N 159  0.47 W GPS   5058   5060                              1                                       25.1C
49MR0505_1   P03     122       1  ROS 111805 1100    BO 25 50.19 N 159  0.84 W GPS   5058   5061     10   5095   5137      33 1-8,23,24,26,27
49MR0505_1   P03     122       1  ROS 111805 1312    EN 25 50.86 N 159  1.82 W GPS   5057   5062
49MR0505_1   P03     124       1  ROS 111805 1612    BE 25 50.14 N 159 46.69 W GPS   4563   4564                                                                      STATION POSITION WAS SHIFTED NORTH
49MR0505_1   P03     124       1  BUC 111805 1619    UN 25 50.20 N 159 46.72 W GPS   4556   4558                              1,33                                    25.2C
49MR0505_1   P03     124       1  UNK 111805 1624    UN 25 50.21 N 159 46.76 W GPS   4549   4554                                                                      AIR N2O SMPL
49MR0505_1   P03     124       1  ROS 111805 1724    BO 25 50.38 N 159 47.24 W GPS   4534   4535      8   4582   4620      34 1-8,22,27
49MR0505_1   P03     124       1  UNK 111805 1724    BE 25 50.39 N 159 47.27 W GPS   4535   4535                                                                      80L THROUGH HULL PUMP FOR R.N.
49MR0505_1   P03     124       1  UNK 111805 1724    EN 25 50.51 N 159 47.41 W GPS   4507   4535
49MR0505_1   P03     124       1  ROS 111805 1933    EN 25 50.96 N 159 48.30 W GPS   4376   4376
49MR0505_1           523       1  UNK 111805 2152    UN 25 50.11 N 160 25.67 W GPS   5076   5073                                                                      AEROSOL SMPL
49MR0505_1   P03     126       1  ROS 111805 2221    BE 25 50.12 N 160 31.78 W GPS   5089   5083
49MR0505_1   P03     126       1  BUC 111805 2228    UN 25 50.17 N 160 31.85 W GPS   5077   5080                              1,33                                    25.5C
49MR0505_1   P03     126       1  UNK 111805 2233    UN 25 50.22 N 160 31.90 W GPS   5078   5088                                                                      AIR N2O SMPL
49MR0505_1   P03     126       1  ROS 111805 2345    BO 25 50.73 N 160 32.69 W GPS   5079   5077     10   5213   5160      33 1-8,12,13,23,24,26,27
49MR0505_1   P03     126       1  ROS 111905 0157    EN 25 51.24 N 160 34.32 W GPS   5074   5075
49MR0505_1   P03     128       1  ROS 111905 1057    BE 25 50.13 N 161 15.26 W GPS   4994   4992
49MR0505_1   P03     128       1  BUC 111905 1104    UN 25 50.18 N 161 15.31 W GPS   4992   4991                              1                                       25.2C
49MR0505_1   P03     128       1  ROS 111905 1215    BO 25 50.71 N 161 15.36 W GPS   4994   4996     10   5021   5068      33 1-8,23,24,26,27
49MR0505_1   P03     128       1  ROS 111905 1428    EN 25 51.70 N 161 15.40 W GPS   4997   5002
49MR0505_1           524       1  UNK 111905 2232    UN 25  9.84 N 161 58.56 W GPS   3029   3016                                                                      RAIN SMPL (1.5MM/HR)
49MR0505_1           525       1  UNK 111905 2246    UN 25  8.57 N 161 59.78 W GPS   2227   2227                                                                      AEROSOL SMPL
49MR0505_1   P03     130       1  ROS 111905 2328    BE 25  5.70 N 162  1.94 W GPS   3314   3309
49MR0505_1   P03     130       1  BUC 111905 2335    UN 25  5.68 N 162  1.82 W GPS   3348   3356                              1,33                                    25.7C
49MR0505_1   P03     130       1  UNK 111905 2335    UN 25  5.68 N 162  1.82 W GPS   3350   3356                                                                      AIR N2O SMPL
49MR0505_1   P03     130       1  ROS 112005 0023    BO 25  5.78 N 162  1.66 W GPS   3350   3335     10   3377   3410      26 1-8,23,24,26,27
49MR0505_1           526       1  UNK 112005 0110    UN 25  6.06 N 162  1.74 W GPS   3145   3138                                                                      RAIN SMPL (1.3MM/HR)
49MR0505_1   P03     130       1  ROS 112005 0202    EN 25  6.21 N 162  1.67 W GPS   3010   3012
49MR0505_1   P03     132       1  ROS 112005 0508    BE 25 16.72 N 162 44.30 W GPS   5006   5006
49MR0505_1   P03     132       1  BUC 112005 0515    UN 25 16.72 N 162 44.20 W GPS   5005   5006                              1,33                                    25.5C
49MR0505_1   P03     132       1  UNK 112005 0518    UN 25 16.71 N 162 44.18 W GPS   5007   5006                                                                      AIR N2O SMPL
49MR0505_1   P03     132       1  ROS 112005 0626    BO 25 16.43 N 162 43.44 W GPS   5005   5006     10   5104   5078      33 1-8,27
49MR0505_1   P03     132       1  ROS 112005 0845    EN 25 16.17 N 162 42.32 W GPS   5008   5006
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49MR0505_1	P03	134	1	ROS	112005	1208	BE	25 30.64 N	163 29.56 W	GPS	5006	5005					
49MR0505_1	P03	134	1	BUC	112005	1215	UN	25 30.66 N	163 29.51 W	GPS	5000	5001				1,31,33,82	24.8C
49MR0505_1	P03	134	1	ROS	112005	1327	BO	25 30.92 N	163 28.72 W	GPS	5005	4999	10	5077	5070	36 1-8,23,24,26,27,31,33,64,82	
49MR0505_1	P03	134	1	ROS	112005	1539	EN	25 31.31 N	163 27.62 W	GPS	4994	5000					
49MR0505_1	P03	136	1	ROS	112005	1859	BE	25 30.47 N	164 18.36 W	GPS	4347	4344					
49MR0505_1	P03	136	1	BUC	112005	1905	UN	25 30.52 N	164 18.26 W	GPS	4332	4331				1,33	24.9C
49MR0505_1	P03	136	1	UNK	112005	1910	UN	25 30.51 N	164 18.20 W	GPS	4330	4321					AIR N2O SMPL
49MR0505_1	P03	136	1	ROS	112005	2005	BO	25 30.35 N	164 17.48 W	GPS	4225	4225	10	4334	4295	32 1-8,22,27	
49MR0505_1	P03	136	1	UNK	112005	2013	BE	25 30.31 N	164 17.42 W	GPS	4238	4223					80L THROUGH HULL PUMP FOR R.N.
49MR0505_1	P03	136	1	UNK	112005	2027	EN	25 30.24 N	164 17.29 W	GPS	4202	4194					
49MR0505_1		527	1	UNK	112005	2146	UN	25 29.94 N	164 16.34 W	GPS	4022	4022					AEROSOL SMPL
49MR0505_1	P03	136	1	ROS	112005	2204	EN	25 29.93 N	164 16.06 W	GPS	3957	3933					
49MR0505_1	P03	138	1	ROS	112105	0107	BE	25 30.08 N	165 0.33 W	GPS	4892	4887					
49MR0505_1	P03	138	1	BUC	112105	0114	UN	25 30.07 N	165 0.25 W	GPS	4885	4892				1,33	25.3C
49MR0505_1	P03	138	1	UNK	112105	0119	UN	25 30.08 N	165 0.19 W	GPS	4885	4889					AIR N2O SMPL
49MR0505_1	P03	138	1	ROS	112105	0222	BO	25 29.98 N	164 59.62 W	GPS	4887	4883	10	4917	4954	32 1-8,12,13,23,24,26,27	
49MR0505_1	P03	138	1	ROS	112105	0429	EN	25 29.82 N	164 58.71 W	GPS	4876	4876					
49MR0505_1	P03	140	1	ROS	112105	0743	BE	25 28.95 N	165 43.64 W	GPS	4869	4871					
49MR0505_1	P03	140	1	BUC	112105	0751	UN	25 28.86 N	165 43.45 W	GPS	4870	4872				1,33	25.7C
49MR0505_1	P03	140	1	UNK	112105	0757	UN	25 28.80 N	165 43.39 W	GPS	4870	4871					AIR N2O SMPL
49MR0505_1	P03	140	1	ROS	112105	0900	BO	25 28.23 N	165 42.82 W	GPS	4870	4870	8	4970	4938	32 1-8,27	
49MR0505_1	P03	140	1	ROS	112105	1109	EN	25 27.12 N	165 41.74 W	GPS	4886	4882					
49MR0505_1	P03	142	1	ROS	112105	1318	BE	25 10.37 N	166 4.12 W	GPS	5015	5018					
49MR0505_1	P03	142	1	BUC	112105	1325	UN	25 10.30 N	166 4.00 W	GPS	5008	5015				1	25.7C
49MR0505_1	P03	142	1	ROS	112105	1435	BO	25 9.85 N	166 3.35 W	GPS	5014	5019	8	5079	5088	33 1-8,23,24,26,27	
49MR0505_1	P03	142	1	ROS	112105	1649	EN	25 8.91 N	166 2.24 W	GPS	5013	5016					
49MR0505_1	P03	144	1	ROS	112105	1843	BE	24 53.73 N	166 21.19 W	GPS	5076	5082					
49MR0505_1	P03	144	1	BUC	112105	1850	UN	24 53.64 N	166 21.06 W	GPS	5086	5090				1,33	25.6C
49MR0505_1	P03	144	1	UNK	112105	1857	UN	24 53.60 N	166 21.01 W	GPS	5076	5083					AIR N2O SMPL
49MR0505_1	P03	144	1	ROS	112105	2003	BO	24 53.20 N	166 20.61 W	GPS	5079	5086	10	5130	5160	33 1-8,27	
49MR0505_1	P03	144	1	ROS	112105	2225	EN	24 52.28 N	166 19.98 W	GPS	5082	5090					
49MR0505_1	P03	146	1	ROS	112105	2348	BE	24 40.67 N	166 33.59 W	GPS	5129	5127					
49MR0505_1		528	1	UNK	112105	2349	UN	24 40.68 N	166 33.60 W	GPS	5128	5128					AEROSOL SMPL
49MR0505_1	P03	146	1	BUC	112105	2354	UN	24 40.64 N	166 33.58 W	GPS	5143	5128				1,33	25.5C
49MR0505_1	P03	146	1	UNK	112105	2359	UN	24 40.61 N	166 33.58 W	GPS	5126	5127					AIR N2O SMPL
49MR0505_1	P03	146	1	ROS	112205	0107	BO	24 40.03 N	166 33.44 W	GPS	5124	5127	10	5169	5202	33 1-8,23,24,26,27	
49MR0505_1	P03	146	1	ROS	112205	0329	EN	24 39.16 N	166 33.38 W	GPS	5116	5114					
49MR0505_1		529	1	UNK	112205	0551	UN	24 28.74 N	166 52.84 W	GPS	1579	1581					RAIN SMPL (1.4MM/HR)
49MR0505_1		530	1	UNK	112205	1632	UN	22 47.77 N	166 29.47 W	GPS	4667	4667					RAIN SMPL (1.2MM/HR)
49MR0505_1		531	1	UNK	112205	2313	UN	22 18.45 N	165 17.57 W	GPS	4653	4653					AEROSOL SMPL
49MR0505_1		532	1	UNK	112205	2326	UN	22 17.33 N	165 14.83 W	GPS	4659	4656					RAIN SMPL (1.2MM/HR)
49MR0505_1		533	1	UNK	112305	0235	UN	22 2.35 N	164 36.79 W	GPS	4586	4586					RAIN SMPL (0.3MM/HR)
49MR0505_1		534	1	UNK	112305	1615	UN	21 0.80 N	162 7.74 W	GPS	4601	4605					RAIN SMPL (3.8MM/HR)
49MR0505_1		535	1	UNK	112305	2136	UN	20 37.13 N	161 10.42 W	GPS	4736	4736					AEROSOL SMPL

Parameter

1=Salinity, 2=Oxygen, 3=Silicate, 4=Nitrate, 5=Nitrite, 6=PHOSPHATE, 7=CFC-11, 8=CFC-12, 12=Δ^{14}C, 13=δ^{13}C, 22=^{137}CS, 23= Total carbon, 24=Alkalinity, 26=PH, 27=CFC-113, 31= CH_4, 33=N_2O, 42= Abundance of bacteria, 64= Incubation, 81= Particulate organic matter, 82=$^{15}NO_3$

49MR0505_2.sum file

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P03 REV R/V MIRAI CRUISE MR0505 LEG 2
SHIP/CRS    WOCE                CAST          UTC EVENT          POSITION            UNC    COR HT ABOVE   WIRE   MAX   NO. OF
EXPOCODE    SECT  STNNBR CASTNO TYPE DATE   TIME  CODE LATITUDE    LONGITUDE  NAV  DEPTH  DEPTH   BOTTOM    OUT  PRESS BOTTLES PARAMETERS                                    COMMENTS
49MR0505_2           536      1  UNK 113005 0019    UN 24 39.48 N 166 19.81 W GPS   4927   4925                                                                              AEROSOL SMPL
49MR0505_2   P03     146      2  ROS 113005 0154    BE 24 40.60 N 166 33.54 W GPS   5125   5125
49MR0505_2   P03     146      2  BUC 113005 0203    UN 24 40.50 N 166 33.50 W GPS   5125   5125                                1,33                                          25.2C
49MR0505_2   P03     146      2  UNK 113005 0217    UN 24 40.40 N 166 33.41 W GPS   5126   5127                                                                              AIR N2O SMPL
49MR0505_2   P03     146      2  ROS 113005 0318    BO 24 39.98 N 166 33.05 W GPS   5110   5110        9   5143   5198      33 1-8,23,24,26,27                               #4 FOR CHLORA FILTERATION (3000DB)
49MR0505_2   P03     146      2  ROS 113005 0540    EN 24 39.40 N 166 32.35 W GPS   5109   5109
49MR0505_2   P03     148      1  ROS 113005 0741    BE 24 36.02 N 166 39.77 W GPS   4176   4177
49MR0505_2   P03     148      1  BUC 113005 0749    UN 24 36.03 N 166 39.78 W GPS   4177   4180                                1,33                                          25.1C
49MR0505_2   P03     148      1  UNK 113005 0801    UN 24 36.05 N 166 39.74 W GPS   4194   4195                                                                              AIR N2O SMPL
49MR0505_2   P03     148      1  ROS 113005 0848    BO 24 36.03 N 166 39.64 W GPS   4209   4213        9   4202   4260      30 1-8,27                                       #2=#1 DUPL SMPLS (B-10DB)
49MR0505_2   P03     148      1  ROS 113005 1044    EN 24 36.23 N 166 39.28 W GPS   4414   4416
49MR0505_2   P03     150      1  ROS 113005 1241    BE 24 30.29 N 166 43.81 W GPS   3368   3377
49MR0505_2   P03     150      1  BUC 113005 1249    UN 24 30.29 N 166 43.81 W GPS   3395   3394                                1                                             25.2C
49MR0505_2   P03     150      1  ROS 113005 1339    BO 24 30.31 N 166 43.89 W GPS   3371   3370        5   3369   3409      27 1-8,23,24,26,27                               #3=#13 DUPL SMPLS (3000DB)
49MR0505_2   P03     150      1  ROS 113005 1518    EN 24 30.11 N 166 44.19 W GPS   3189   3187
49MR0505_2   P03     152      1  ROS 113005 1729    BE 24 26.25 N 166 48.75 W GPS   2036   2037
49MR0505_2   P03     152      1  BUC 113005 1736    UN 24 26.35 N 166 48.76 W GPS   2055   2054                                1                                             25.1C
49MR0505_2   P03     152      1  ROS 113005 1807    BO 24 26.42 N 166 48.74 W GPS   2079   2076       11   2073   2091      20 1-8,23,24,26,27
49MR0505_2   P03     152      1  ROS 113005 1921    EN 24 26.67 N 166 48.64 W GPS   2174   2174
49MR0505_2   P03     153      1  ROS 113005 2123    BE 24 25.27 N 166 49.20 W GPS   1549   1550
49MR0505_2   P03     153      1  BUC 113005 2132    UN 24 25.26 N 166 49.16 W GPS   1545   1549                                1,33                                          25.4C
49MR0505_2   P03     153      1  UNK 113005 2142    UN 24 25.23 N 166 49.18 W GPS   1532   1532                                                                              AIR N2O SMPL
49MR0505_2   P03     153      1  ROS 113005 2153    BO 24 25.20 N 166 49.20 W GPS   1492   1491        5   1551   1560      17 1-8,23,24,26,27
49MR0505_2   P03     153      1  ROS 113005 2255    EN 24 24.98 N 166 49.31 W GPS   1513   1499
49MR0505_2           537      1  UNK 120105 0012    UN 24 16.06 N 167  1.80 W GPS    228    228                                                                              AEROSOL SMPL
49MR0505_2   P03     154      1  ROS 120105 0101    BE 24  8.71 N 167  5.70 W GPS   1221   1222
49MR0505_2   P03     154      1  BUC 120105 0110    UN 24  8.64 N 167  5.79 W GPS   1309   1308                                1                                             25.5C
49MR0505_2   P03     154      1  ROS 120105 0131    BO 24  8.62 N 167  5.94 W GPS   1416   1417       26   1351   1352      16 1-8,23,24,26,27
49MR0505_2   P03     154      1  ROS 120105 0228    EN 24  8.63 N 167  6.42 W GPS   1658   1659
49MR0505_2   P03     155      1  ROS 120105 0514    BE 24  8.82 N 167  7.96 W GPS   2006   1993                                                                              CHANGE LOCATION
49MR0505_2   P03     155      1  BUC 120105 0521    UN 24  8.94 N 167  7.93 W GPS   1946   1946                                1,33                                          25.2C
49MR0505_2   P03     155      1  UNK 120105 0531    UN 24  9.00 N 167  7.80 W GPS   1914   1913                                                                              AIR N2O SMPL
49MR0505_2   P03     155      1  ROS 120105 0548    BO 24  9.00 N 167  7.62 W GPS   1882   1870       20   1889   1885      19 1-8,27
49MR0505_2   P03     155      1  ROS 120105 0658    EN 24  9.18 N 167  6.73 W GPS   1495   1493
49MR0505_2   P03     157      1  ROS 120105 0958    BE 24  6.08 N 167 10.06 W GPS   2856   2856
49MR0505_2   P03     157      1  BUC 120105 1005    UN 24  6.00 N 167  9.96 W GPS   2895   2896                                1,33                                          25.2C
49MR0505_2   P03     157      1  UNK 120105 1016    UN 24  5.90 N 167  9.92 W GPS   2970   2970                                                                              AIR N2O SMPL
49MR0505_2   P03     157      1  ROS 120105 1050    BO 24  5.59 N 167  9.92 W GPS   3011   3039       12   3033   3036      24 1-8,23,24,26,27
49MR0505_2   P03     157      1  ROS 120105 1220    EN 24  4.58 N 167 10.22 W GPS   3082   3094
49MR0505_2   P03     159      1  ROS 120105 1426    BE 24  1.44 N 167 14.27 W GPS   3914   3907
49MR0505_2   P03     159      1  BUC 120105 1434    UN 24  1.37 N 167 14.30 W GPS   3904   3904                                1                                             25.2C
49MR0505_2           538      1  UNK 120105 1510    UN 24  1.27 N 167 14.52 W GPS   3923   3921                                                                              RAIN SMPL (0.9MM/HR)
49MR0505_2   P03     159      1  ROS 120105 1530    BO 24  1.25 N 167 14.62 W GPS   3922   3925       11   3912   3941      29 1-8,27                                       #4=#10 DUPL SMPLS (3750DB)
49MR0505_2   P03     159      1  ROS 120105 1720    EN 24  1.28 N 167 15.44 W GPS   4190   4191
49MR0505_2   P03     161      1  ROS 120105 1925    BE 23 51.03 N 167 22.55 W GPS   4926   4926
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49MR0505_2   P03     161       1 BUC 120105 1932    UN 23 51.02 N 167 22.61 W GPS   4925   4925                                 1,33                                           25.3C
49MR0505_2   P03     161       1 UNK 120105 1945    UN 23 50.99 N 167 22.70 W GPS   4922   4922                                                                                AIR N2O SMPL
49MR0505_2   P03     161       1 ROS 120105 2040    BO 23 50.84 N 167 22.79 W GPS   4927   4927         9   4924   4997      33 1-8,27                                         #5=#6 DUPL SMPLS (4750DB)
49MR0505_2   P03     161       1 ROS 120105 2247    EN 23 50.33 N 167 22.72 W GPS   4930   4930
49MR0505_2           539       1 UNK 120205 0019    UN 23 39.50 N 167 34.58 W GPS   4963   4963                                                                                AEROSOL SMPL
49MR0505_2   P03     163       1 ROS 120205 0049    BE 23 37.42 N 167 37.27 W GPS   4964   4964
49MR0505_2   P03     163       1 BUC 120205 0056    UN 23 37.38 N 167 37.33 W GPS   4962   4962                                 1,31,33                                        25.3C
49MR0505_2   P03     163       1 UNK 120205 0116    UN 23 37.20 N 167 37.36 W GPS   4959   4959                                                                                AIR CH4 & N2O SMPL
49MR0505_2   P03     163       1 ROS 120205 0207    BO 23 36.80 N 167 37.58 W GPS   4961   4960         9   4993   5033      36 1-8,23,24,26,27,31,33,81                       #2,3,4,5 FOR POM
49MR0505_2   P03     163       1 ROS 120205 0419    EN 23 35.84 N 167 38.03 W GPS   4962   4963
49MR0505_2   P03     165       1 ROS 120205 0710    BE 23 14.42 N 168  0.22 W GPS   4875   4877
49MR0505_2   P03     165       1 BUC 120205 0717    UN 23 14.34 N 168  0.23 W GPS   4874   4877                                 1,33                                           25.3C
49MR0505_2   P03     165       1 UNK 120205 0726    UN 23 14.27 N 168  0.27 W GPS   4880   4880                                                                                AIR N2O SMPL
49MR0505_2   P03     165       1 ROS 120205 0825    BO 23 13.96 N 168  0.43 W GPS   4880   4882         9   4909   4944      33 1-8,27                                         #6=#5 DUPL SMPLS (4750DB)
49MR0505_2   P03     165       1 ROS 120205 1033    EN 23 13.21 N 168  0.70 W GPS   4867   4867
49MR0505_2   P03     167       1 ROS 120205 1349    BE 23  0.76 N 168 39.24 W GPS   4774   4774
49MR0505_2   P03     167       1 BUC 120205 1357    UN 23  0.74 N 168 39.25 W GPS   4775   4775                                 1,33                                           25.2C
49MR0505_2   P03     167       1 UNK 120205 1409    UN 23  0.74 N 168 39.25 W GPS   4774   4774                                                                                AIR N2O SMPL
49MR0505_2   P03     167       1 ROS 120205 1503    BO 23  0.67 N 168 39.29 W GPS   4763   4761         9   4756   4827      33 1-8,27                                         #7=#5 DUPL SMPLS (4500DB)
49MR0505_2   P03     167       1 ROS 120205 1712    EN 23  0.61 N 168 39.78 W GPS   4768   4777
49MR0505_2   P03     169       1 ROS 120205 2110    BE 22 44.80 N 169 20.29 W GPS   4691   4693
49MR0505_2   P03     169       1 BUC 120205 2119    UN 22 44.84 N 169 20.27 W GPS   4683   4689                                 1,33                                           25.8C
49MR0505_2   P03     169       1 UNK 120205 2127    UN 22 44.90 N 169 20.26 W GPS   4698   4687                                                                                AIR N2O SMPL
49MR0505_2   P03     169       1 ROS 120205 2221    BO 22 45.13 N 169 19.96 W GPS   4691   4691         8   4702   4754      32 1-8,23,24,26,27                                #8=#7 DUPL SMPLS (4500DB)
49MR0505_2           540       1 UNK 120205 2331    UN 22 45.40 N 169 19.39 W GPS   4683   4684                                                                                AEROSOL SMPL
49MR0505_2   P03     169       1 ROS 120305 0019    EN 22 45.74 N 169 18.93 W GPS   4687   4688
49MR0505_2   P03     171       1 ROS 120305 0432    BE 23  4.44 N 170  1.69 W GPS   4646   4645
49MR0505_2   P03     171       1 BUC 120305 0439    UN 23  4.50 N 170  1.59 W GPS   4645   4645                                 1,33                                           25.8C
49MR0505_2   P03     171       1 UNK 120305 0449    UN 23  4.47 N 170  1.52 W GPS   4650   4652                                                                                AIR N2O SMPL
49MR0505_2   P03     171       1 ROS 120305 0545    BO 23  4.06 N 170  1.20 W GPS   4658   4656         9   4686   4705      34 1-8,22,27                                      #2,3,4 FOR R.N.
49MR0505_2   P03     171       2 UNK 120305 0558    BE 23  4.00 N 170  1.17 W GPS   4639   4640                                                                                80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     171       2 UNK 120305 0617    EN 23  3.87 N 170  1.16 W GPS   4645   4644
49MR0505_2   P03     171       1 ROS 120305 0751    EN 23  3.34 N 170  0.72 W GPS   4644   4644
49MR0505_2   P03     173       1 ROS 120305 1210    BE 23 23.87 N 170 44.55 W GPS   4686   4685
49MR0505_2   P03     173       1 BUC 120305 1217    UN 23 23.81 N 170 44.52 W GPS   4684   4684                                 1                                              26.1C
49MR0505_2   P03     173       1 ROS 120305 1324    BO 23 23.32 N 170 44.48 W GPS   4685   4684        10   4704   4740      32 1-8,12,13,23,24,26,27                          #9=#7 DUPL SMPLS (4500DB)
49MR0505_2   P03     173       1 ROS 120305 1525    EN 23 23.10 N 170 44.03 W GPS   4681   4681
49MR0505_2   P03     175       1 ROS 120305 1920    BE 23 42.86 N 171 22.79 W GPS   4753   4753
49MR0505_2   P03     175       1 BUC 120305 1927    UN 23 42.87 N 171 22.78 W GPS   4751   4751                                 1,33                                           26.1C
49MR0505_2   P03     175       1 UNK 120305 1936    UN 23 42.88 N 171 22.77 W GPS   4750   4750                                                                                AIR N2O SMPL
49MR0505_2   P03     175       1 ROS 120305 2032    BO 23 42.69 N 171 22.91 W GPS   4756   4755         8   4759   4815      33 1-8,27                                         #10=#7 DUPL SMPLS (4500DB)
49MR0505_2           541       1 UNK 120305 2225    UN 23 41.85 N 171 23.87 W GPS   4750   4750                                                                                RAIN SMPL (1.5MM/HR)
49MR0505_2   P03     175       1 ROS 120305 2236    EN 23 41.73 N 171 24.04 W GPS   4750   4749
49MR0505_2           542       1 UNK 120405 0018    UN 23 50.28 N 171 41.88 W GPS   4736   4736                                                                                AEROSOL SMPL
49MR0505_2   P03     177       1 ROS 120405 0240    BE 24  3.97 N 172  5.89 W GPS   4683   4683
49MR0505_2   P03     177       1 BUC 120405 0247    UN 24  3.92 N 172  6.01 W GPS   4682   4682                                 1,33                                           25.4C
49MR0505_2   P03     177       1 UNK 120405 0258    UN 24  3.96 N 172  6.07 W GPS   4686   4684                                                                                AIR N2O SMPL
49MR0505_2   P03     177       1 ROS 120405 0355    BO 24  4.17 N 172  6.24 W GPS   4681   4681        10   4704   4745      32 1-8,23,24,26,27                                #11=#7 DUPL SMPLS (4500DB)
49MR0505_2   P03     177       1 ROS 120405 0559    EN 24  4.23 N 172  7.16 W GPS   4682   4682
49MR0505_2   P03     179       1 ROS 120405 0947    BE 24 14.48 N 172 49.31 W GPS   4576   4575
49MR0505_2   P03     179       1 BUC 120405 0954    UN 24 14.47 N 172 49.35 W GPS   4554   4554                                 1,33                                           25.6C
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49MR0505_2   P03     179      1  UNK 120405 1004    UN 24 14.51 N 172 49.37 W GPS   4568   4564                                                                                AIR N2O SMPL
49MR0505_2   P03     179      1  ROS 120405 1059    BO 24 14.77 N 172 49.73 W GPS   4555   4556       10   4602   4618      32 1-8,27                                          #12=#8 DUPL SMPLS (4250DB)
49MR0505_2   P03     179      1  ROS 120405 1258    EN 24 15.89 N 172 50.02 W GPS   4586   4584
49MR0505_2   P03     181      1  ROS 120405 1711    BE 24 14.27 N 173 37.93 W GPS   4946   4946
49MR0505_2   P03     181      1  BUC 120405 1720    UN 24 14.31 N 173 38.00 W GPS   4946   4946                                1,33                                            25.4C
49MR0505_2   P03     181      1  UNK 120405 1730    UN 24 14.37 N 173 38.03 W GPS   4944   4944                                                                                AIR N2O SMPL
49MR0505_2   P03     181      1  ROS 120405 1829    BO 24 14.80 N 173 38.03 W GPS   4947   4948       10   4977   5019      33 1-8,27                                          #13=#6 DUPL SMPLS (4750DB)
49MR0505_2   P03     181      1  ROS 120405 2039    EN 24 15.71 N 173 37.97 W GPS   4941   4942
49MR0505_2           543      1  UNK 120505 0016    UN 24 14.49 N 174 20.96 W GPS   5065   5064                                                                                AEROSOL SMPL
49MR0505_2   P03     183      1  ROS 120505 0047    BE 24 14.65 N 174 25.92 W GPS   5069   5070
49MR0505_2   P03     183      1  BUC 120505 0055    UN 24 14.69 N 174 25.99 W GPS   5067   5069                                1,31,33,82                                      25.5C
49MR0505_2   P03     183      1  UNK 120505 0107    UN 24 14.67 N 174 26.12 W GPS   5070   5071                                                                                AIR CH4 & N2O SMPL
49MR0505_2   P03     183      1  ROS 120505 0206    BO 24 14.63 N 174 26.60 W GPS   5068   5068       10   5091   5139      36 1-8,23,24,26,27,31,33,64,82                     #2,3,4 FOR INCUBATION
49MR0505_2   P03     183      1  ROS 120505 0419    EN 24 14.28 N 174 27.49 W GPS   5063   5065
49MR0505_2           544      1  UNK 120505 0613    UN 24 14.64 N 174 49.05 W GPS   5077   5079                                                                                RAIN SMPL (1.4MM/HR)
49MR0505_2   P03     185      1  ROS 120505 0814    BE 24 14.02 N 175 12.20 W GPS   5121   5120
49MR0505_2   P03     185      1  BUC 120505 0821    UN 24 13.98 N 175 12.15 W GPS   5124   5124                                1,33                                            25.8C
49MR0505_2   P03     185      1  UNK 120505 0830    UN 24 13.91 N 175 12.10 W GPS   5123   5125                                                                                AIR N2O SMPL
49MR0505_2   P03     185      1  ROS 120505 0932    BO 24 13.48 N 175 11.87 W GPS   5110   5111        8   5166   5194      34 1-8,27                                          #14=#6 DUPL SMPLS (4750DB), #17 MISS TRIP
49MR0505_2   P03     185      1  ROS 120505 1145    EN 24 12.28 N 175 11.09 W GPS   5111   5110
49MR0505_2   P03     187      1  ROS 120505 1610    BE 24 14.11 N 176  1.50 W GPS   5280   5280
49MR0505_2   P03     187      1  BUC 120505 1618    UN 24 14.12 N 176  1.48 W GPS   5286   5287                                1,33                                            26.0C
49MR0505_2   P03     187      1  UNK 120505 1629    UN 24 14.14 N 176  1.47 W GPS   5278   5277                                                                                AIR N2O SMPL
49MR0505_2   P03     187      1  ROS 120505 1731    BO 24 14.09 N 176  1.29 W GPS   5283   5282       10   5283   5366      36 1-8,22,27                                       #2,3,4 FOR R.N.
49MR0505_2   P03     187      2  UNK 120505 1742    BE 24 14.10 N 176  1.25 W GPS   5286   5285                                                                                80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     187      2  UNK 120505 1806    EN 24 14.08 N 176  1.20 W GPS   5301   5294
49MR0505_2   P03     187      1  ROS 120505 1949    EN 24 13.99 N 176  0.77 W GPS   5298   5297
49MR0505_2   P03     189      1  ROS 120505 2337    BE 24 14.44 N 176 45.63 W GPS   5342   5342
49MR0505_2   P03     189      1  BUC 120505 2344    UN 24 14.47 N 176 45.68 W GPS   5345   5345                                1,33                                            26.1C
49MR0505_2   P03     189      1  UNK 120505 2353    UN 24 14.45 N 176 45.63 W GPS   5345   5344                                                                                AIR N2O SMPL
49MR0505_2           545      1  UNK 120605 0032    UN 24 14.38 N 176 45.57 W GPS   5348   5347                                                                                AEROSOL SMPL
49MR0505_2   P03     189      1  ROS 120605 0059    BO 24 14.25 N 176 45.61 W GPS   5353   5348       10   5355   5430      35 1-8,12,13,23,24,26,27                           #15=#5 DUPL SMPLS (5000DB)
49MR0505_2   P03     189      1  ROS 120605 0315    EN 24 14.21 N 176 45.61 W GPS   5349   5350
49MR0505_2   P03     191      1  ROS 120605 0737    BE 24 13.34 N 177 35.25 W GPS   5413   5413
49MR0505_2   P03     191      1  BUC 120605 0744    UN 24 13.33 N 177 35.15 W GPS   5413   5415                                1,33                                            25.4C
49MR0505_2   P03     191      1  UNK 120605 0754    UN 24 13.32 N 177 35.04 W GPS   5423   5420                                                                                AIR N2O SMPL
49MR0505_2   P03     191      1  ROS 120605 0859    BO 24 13.07 N 177 34.55 W GPS   5416   5414        8   5464   5502      35 1-8,27                                          #16=#5 DUPL SMPLS (5000DB)
49MR0505_2   P03     191      1  ROS 120605 1119    EN 24 12.83 N 177 33.52 W GPS   5406   5406
49MR0505_2   P03     193      1  ROS 120605 1534    BE 24 15.19 N 178 22.14 W GPS   5553   5552
49MR0505_2   P03     193      1  BUC 120605 1541    UN 24 15.20 N 178 22.02 W GPS   5541   5541                                1,33                                            25.1C
49MR0505_2   P03     193      1  UNK 120605 1555    UN 24 15.15 N 178 21.83 W GPS   5541   5543                                                                                AIR N2O SMPL
49MR0505_2   P03     193      1  ROS 120605 1659    BO 24 14.78 N 178 21.70 W GPS   5538   5540        9   5570   5635      36 1-8,27                                          #17=#4 DUPL SMPLS (5250DB)
49MR0505_2   P03     193      1  ROS 120605 1924    EN 24 14.34 N 178 21.23 W GPS   5547   5546
49MR0505_2   P03     195      1  ROS 120605 2338    BE 24 14.39 N 179  9.68 W GPS   5609   5611
49MR0505_2   P03     195      1  BUC 120605 2345    UN 24 14.38 N 179  9.67 W GPS   5619   5619                                1,31,33                                         25.4C
49MR0505_2   P03     195      1  UNK 120705 0000    UN 24 14.33 N 179  9.60 W GPS   5620   5620                                                                                AIR CH4 & N2O SMPL
49MR0505_2           546      1  UNK 120705 0024    UN 24 14.38 N 179  9.53 W GPS   5620   5620                                                                                AEROSOL SMPL
49MR0505_2   P03     195      1  ROS 120705 0103    BO 24 14.51 N 179  9.36 W GPS   5615   5614       10   5620   5707      36 1-8,23,24,26,27,31,33,81                        #2 FOR POM
49MR0505_2   P03     195      1  ROS 120705 0323    EN 24 14.53 N 179  8.29 W GPS   5612   5611
49MR0505_2   P03     197      1  ROS 120705 0745    BE 24 14.12 N 179 59.32 W GPS   5536   5538
49MR0505_2   P03     197      1  BUC 120705 0752    UN 24 14.04 N 179 59.33 W GPS   5540   5543                                1,33                                            25.8C
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49MR0505_2	P03	197	1	UNK	120705	0801	UN	24 13.95 N	179 59.39 W	GPS	5533	5535						AIR N2O SMPL
49MR0505_2	P03	197	1	ROS	120705	0908	BO	24 13.63 N	179 59.28 W	GPS	5538	5540	10	5545	5629	36	1-8,22,27	#2 FOR R.N.
49MR0505_2	P03	197	2	UNK	120705	0917	BE	24 13.58 N	179 59.29 W	GPS	5539	5541						80L THROUGH HULL PUMP FOR R.N.
49MR0505_2	P03	197	2	UNK	120705	1005	EN	24 13.34 N	179 59.12 W	GPS	5537	5541						
49MR0505_2	P03	197	1	ROS	120705	1127	EN	24 12.77 N	179 58.88 W	GPS	5546	5546						
49MR0505_2		547	1	UNK	120805	0019	UN	24 7.77 N	179 27.00 E	GPS	5711	5712						AEROSOL SMPL
49MR0505_2		548	1	UNK	120805	0558	BE	24 10.90 N	179 10.50 E	GPS	5737	5736						MAGNETOMETER CALIBRATION
49MR0505_2		548	1	UNK	120805	0623	EN	24 10.63 N	179 9.52 E	GPS	5738	5740						
49MR0505_2	P03	X14	1	ROS	120805	1600	BE	23 59.90 N	178 59.87 E	GPS	5739	5740						PRI AND SEC CND SENSORS REPLACED
49MR0505_2	P03	X14	1	BUC	120805	1609	UN	23 59.90 N	178 59.86 E	GPS	5743	5744					1,33	25.6C
49MR0505_2	P03	X14	1	UNK	120805	1620	UN	23 59.87 N	178 59.82 E	GPS	5741	5740						AIR N2O SMPL
49MR0505_2	P03	X14	1	ROS	120805	1729	BO	23 59.67 N	178 59.77 E	GPS	5748	5748	10	5739	5835	35	1-8,12,13,23,24,26,27	#17 MISS FIRE
49MR0505_2	P03	X14	1	ROS	120805	1957	EN	23 59.23 N	178 59.85 E	GPS	5742	5743						
49MR0505_2		549	1	UNK	120805	2250	UN	24 13.63 N	178 27.18 E	GPS	5733	5725						RAIN SMPL (0.7MM/HR)
49MR0505_2	P03	201	1	ROS	120805	2324	BE	24 15.23 N	178 23.31 E	GPS	5723	5723						
49MR0505_2	P03	201	1	BUC	120805	2332	UN	24 15.18 N	178 23.33 E	GPS	5726	5727					1,33	26.1C
49MR0505_2	P03	201	1	UNK	120805	2340	UN	24 15.14 N	178 23.30 E	GPS	5724	5724						AIR N2O SMPL
49MR0505_2	P03	201	1	ROS	120905	0050	BO	24 14.73 N	178 23.24 E	GPS	5725	5724	10	5744	5819	35	1-8,27	#17 MISS FIRE
49MR0505_2		550	1	UNK	120905	0057	UN	24 14.71 N	178 23.22 E	GPS	5727	5725						AEROSOL SMPL
49MR0505_2	P03	201	1	ROS	120905	0312	EN	24 13.81 N	178 22.93 E	GPS	5731	5730						
49MR0505_2	P03	203	1	ROS	120905	0717	BE	24 13.65 N	177 36.26 E	GPS	5781	5780						
49MR0505_2	P03	203	1	BUC	120905	0724	UN	24 13.58 N	177 36.24 E	GPS	5776	5775					1,33	25.8C
49MR0505_2	P03	203	1	UNK	120905	0732	UN	24 13.51 N	177 36.26 E	GPS	5774	5773						AIR N2O SMPL
49MR0505_2	P03	203	1	ROS	120905	0845	BO	24 12.89 N	177 36.15 E	GPS	5772	5772	8	5812	5872	35	1-8,27	#10 MISS FIRE
49MR0505_2	P03	203	1	ROS	120905	1111	EN	24 11.81 N	177 36.08 E	GPS	5787	5762						
49MR0505_2	P03	205	1	ROS	120905	1524	BE	24 14.94 N	176 47.27 E	GPS	5762	5762						
49MR0505_2	P03	205	1	BUC	120905	1530	UN	24 14.91 N	176 47.23 E	GPS	5755	5756					1,31,33,82	26.1C
49MR0505_2	P03	205	1	UNK	120905	1542	UN	24 14.84 N	176 47.19 E	GPS	5760	5760						AIR CH4 & N2O SMPL
49MR0505_2	P03	205	1	ROS	120905	1651	BO	24 14.42 N	176 46.83 E	GPS	5756	5756	9	5825	5857	36	1-8,23,24,26,27,31,33,64,82	
49MR0505_2	P03	205	1	ROS	120905	1924	EN	24 13.65 N	176 45.93 E	GPS	5761	5760						
49MR0505_2	P03	207	1	ROS	120905	2323	BE	24 14.76 N	175 59.57 E	GPS	5798	5800						
49MR0505_2	P03	207	1	BUC	120905	2331	UN	24 14.80 N	175 59.53 E	GPS	5792	5792					1,33	26.2C
49MR0505_2	P03	207	1	UNK	120905	2341	UN	24 14.85 N	175 59.53 E	GPS	5795	5796						AIR N2O SMPL
49MR0505_2	P03	207	1	ROS	121005	0051	BO	24 15.22 N	175 59.61 E	GPS	5792	5790	9	5808	5889	36	1-8,27	
49MR0505_2		551	1	UNK	121005	0102	UN	24 15.28 N	175 59.64 E	GPS	5801	5802						AEROSOL SMPL
49MR0505_2	P03	207	1	ROS	121005	0312	EN	24 16.28 N	175 59.98 E	GPS	5821	5796						
49MR0505_2	P03	209	1	ROS	121005	0736	BE	24 15.09 N	175 9.99 E	GPS	5557	5551						
49MR0505_2	P03	209	1	BUC	121005	0743	UN	24 15.12 N	175 10.00 E	GPS	5571	5580					1,33	26.4C
49MR0505_2		552	1	UNK	121005	0751	UN	24 15.17 N	175 10.05 E	GPS	5584	5581						RAIN SMPL (1.8MM/HR)
49MR0505_2	P03	209	1	UNK	121005	0753	UN	24 15.17 N	175 10.04 E	GPS	5587	5588						AIR N2O SMPL
49MR0505_2	P03	209	1	ROS	121005	0901	BO	24 15.44 N	175 10.16 E	GPS	5589	5588	10	5587	5676	36	1-8,22,27	#2 FOR R.N.
49MR0505_2	P03	209	2	UNK	121005	0923	BE	24 15.44 N	175 10.22 E	GPS	5605	5604						80L THROUGH HULL PUMP FOR R.N.
49MR0505_2	P03	209	2	UNK	121005	0934	EN	24 15.47 N	175 10.24 E	GPS	5593	5593						
49MR0505_2	P03	209	1	ROS	121005	1120	EN	24 15.79 N	175 10.43 E	GPS	5603	5603						
49MR0505_2	P03	211	1	ROS	121005	1525	BE	24 15.05 N	174 23.04 E	GPS	5728	5728						
49MR0505_2	P03	211	1	BUC	121005	1535	UN	24 15.00 N	174 23.05 E	GPS	5735	5735					1,33	26.2C
49MR0505_2	P03	211	1	UNK	121005	1543	UN	24 14.96 N	174 23.07 E	GPS	5728	5729						AIR N2O SMPL
49MR0505_2	P03	211	1	ROS	121005	1652	BO	24 14.60 N	174 23.09 E	GPS	5727	5728	10	5747	5828	36	1-8,12,13,23,24,26,27	
49MR0505_2	P03	211	1	ROS	121005	1922	EN	24 14.06 N	174 23.16 E	GPS	5728	5729						
49MR0505_2	P03	213	1	ROS	121005	2339	BE	24 15.28 N	173 34.11 E	GPS	5820	5819						
49MR0505_2	P03	213	1	BUC	121005	2346	UN	24 15.22 N	173 34.09 E	GPS	5829	5818					1,33	26.2C

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49MR0505_2   P03     213      1  UNK 121005 2355    UN 24 15.15 N 173 34.05 E GPS   5825   5820                                                                                AIR N2O SMPL
49MR0505_2   P03     213      1  ROS 121105 0107    BO 24 14.89 N 173 33.74 E GPS   5821   5823         9   5828   5915        36 1-8,27                                         
49MR0505_2           553      1  UNK 121105 0117    UN 24 14.89 N 173 33.70 E GPS   5819   5819                                                                                AEROSOL SMPL
49MR0505_2   P03     213      1  ROS 121105 0329    EN 24 14.43 N 173 32.76 E GPS   5819   5821
49MR0505_2   P03     215      1  ROS 121105 0731    BE 24 14.57 N 172 45.99 E GPS   5868   5869
49MR0505_2   P03     215      1  BUC 121105 0738    UN 24 14.51 N 172 46.02 E GPS   5859   5859                                 1,33                                           26.4C
49MR0505_2   P03     215      1  UNK 121105 0747    UN 24 14.41 N 172 46.05 E GPS   5868   5866                                                                                AIR N2O SMPL
49MR0505_2   P03     215      1  ROS 121105 0900    BO 24 13.74 N 172 45.97 E GPS   5835   5835        44   5878   5923        36 1-8,27                                         LADCP SOUNDING
49MR0505_2   P03     215      1  ROS 121105 1126    EN 24 12.53 N 172 45.49 E GPS   5834   5832
49MR0505_2   P03     217      1  ROS 121105 1534    BE 24 14.87 N 171 56.99 E GPS   5834   5835
49MR0505_2   P03     217      1  BUC 121105 1542    UN 24 14.86 N 171 56.99 E GPS   5835   5834                                 1,31,33                                        26.2C
49MR0505_2   P03     217      1  UNK 121105 1559    UN 24 14.91 N 171 56.95 E GPS   5832   5835                                                                                AIR CH4 & N2O SMPL
49MR0505_2   P03     217      1  ROS 121105 1705    BO 24 15.43 N 171 57.00 E GPS   5835   5836         9   5900   5933        36 1-8,23,24,26,27,31,33,81
49MR0505_2   P03     217      1  ROS 121105 1932    EN 24 16.38 N 171 57.59 E GPS   5835   5836
49MR0505_2           554      1  UNK 121305 0039    UN 18 46.87 N 172 42.04 E GPS   2038   2025                                                                                AEROSOL SMPL
49MR0505_2  WIFE     WM5      1  MOR 121305 2042    BE 16 26.41 N 171 32.88 E GPS   5476   5475                                                                                2 RCM11, 1 RCM8, 7 SBE37, 1 OPTODE
49MR0505_2  WIFE     WM5      1  MOR 121305 2200    RE 16 26.78 N 171 31.04 E GPS   5469   5471                                                                                6 GRASS BUOY BROKEN, 1 SBE37 BROKEN
49MR0505_2           555      1  UNK 121405 0108    UN 16 11.08 N 171 59.10 E GPS   5308   5324                                                                                AEROSOL SMPL
49MR0505_2  WIFE     WM4      1  MOR 121405 1943    BE 15 31.28 N 171 14.50 E GPS   5614   5611                                                                                2 RCM11, 1 RCM8, 8 SBE37, 1 OPTODE
49MR0505_2  WIFE     WM4      1  MOR 121405 2103    RE 15 31.75 N 171 14.60 E GPS   5606   5606                                                                                1 SBE37 BROKEN
49MR0505_2           556      1  UNK 121505 0037    UN 14 43.91 N 170 58.72 E GPS   5664   5662                                                                                AEROSOL SMPL
49MR0505_2  WIFE     WM3      1  MOR 121505 0258    BE 14 34.04 N 170 55.08 E GPS   5673   5672                                                                                2 RCM11, 1 RCM8, 8 SBE37, 1 OPTODE
49MR0505_2  WIFE     WM3      1  MOR 121505 0409    RE 14 34.00 N 170 55.02 E GPS   5678   5673                                                                                2 SBE37 BROKEN
49MR0505_2  WIFE     WM2      1  MOR 121505 2133    BE 13 38.40 N 170 34.19 E GPS     -9   5525                                                                                2 RCM11, 1 RCM8, 8 SBE37, 1 OPTODE
49MR0505_2  WIFE     WM2      1  MOR 121505 2259    RE 13 38.28 N 170 33.84 E GPS   5516   5519                                                                                TRANSPONDER BROKEN, 1 SBE37 BROKEN
49MR0505_2           557      1  UNK 121605 0103    UN 13 10.24 N 170 23.96 E GPS   5410   5393                                                                                AEROSOL SMPL
49MR0505_2  WIFE     WM1      1  MOR 121605 0503    BE 12 45.89 N 170 14.60 E GPS   5362   5364                                                                                2 RCM11, 1 RCM8, 7 SBE37, 1 OPTODE
49MR0505_2  WIFE     WM1      1  MOR 121605 0603    RE 12 45.64 N 170 13.58 E GPS   5348   5352                                                                                TRANSPONDER BROKEN, ROTOR OF RCM8 LOST
49MR0505_2  WIFE     WC0      1  ROS 121605 0833    BE 12 43.32 N 170 13.59 E GPS   4560   4563
49MR0505_2  WIFE     WC0      1  BUC 121605 0841    UN 12 43.37 N 170 13.51 E GPS   4545   4556                                 1,33                                           27.8C
49MR0505_2  WIFE     WC0      1  UNK 121605 0850    UN 12 43.43 N 170 13.45 E GPS   4577   4576                                                                                AIR N2O SMPL
49MR0505_2  WIFE     WC0      1  ROS 121605 0947    BO 12 43.80 N 170 13.34 E GPS   4658   4667         9   4625   4669        32 1-8,27
49MR0505_2  WIFE     WC0      1  ROS 121605 1145    EN 12 44.73 N 170 12.96 E GPS   5267   5267
49MR0505_2  WIFE     WC1      1  ROS 121605 1359    BE 12 45.89 N 170 14.88 E GPS   5369   5369                                                                                WITH 7 SBE37 (WM1)
49MR0505_2  WIFE     WC1      1  BUC 121605 1406    UN 12 45.98 N 170 14.85 E GPS   5356   5365                                 1                                              27.8C
49MR0505_2  WIFE     WC1      1  ROS 121605 1524    BO 12 46.60 N 170 14.58 E GPS   5369   5373         7   5426   5450        35 1-8,27
49MR0505_2  WIFE     WC1      1  ROS 121605 1745    EN 12 47.35 N 170 14.24 E GPS   5347   5351
49MR0505_2  WIFE     WC2      1  ROS 121605 2032    BE 13 12.56 N 170 24.85 E GPS   5406   5408
49MR0505_2  WIFE     WC2      1  BUC 121605 2039    UN 13 12.63 N 170 24.72 E GPS   5402   5402                                  1,33                                          27.8C
49MR0505_2  WIFE     WC2      1  UNK 121605 2048    UN 13 12.71 N 170 24.64 E GPS   5406   5403                                                                                AIR N2O SMPL
49MR0505_2  WIFE     WC2      1  ROS 121605 2152    BO 13 13.10 N 170 24.54 E GPS   5401   5403         9   5412   5483        35 1-8,27                                         #1 MISS TRIP
49MR0505_2  WIFE     WC2      1  ROS 121705 0007    EN 13 13.80 N 170 23.85 E GPS   5406   5405
49MR0505_2  WIFE     WC3      1  ROS 121705 0249    BE 13 38.37 N 170 34.54 E GPS   5518   5516                                                                                WITH 6 SBE37 (WM5)
49MR0505_2  WIFE     WC3      1  BUC 121705 0256    UN 13 38.44 N 170 34.40 E GPS   5525   5522                                  1,33                                          27.8C
49MR0505_2  WIFE     WC3      1  UNK 121705 0305    UN 13 38.55 N 170 34.31 E GPS   5520   5519                                                                                AIR N2O SMPL
49MR0505_2  WIFE     WC3      1  ROS 121705 0415    BO 13 39.01 N 170 34.23 E GPS   5518   5519         9   5540   5602        36 1-6
49MR0505_2  WIFE     WC3      1  ROS 121705 0639    EN 13 39.95 N 170 33.68 E GPS   5510   5510
49MR0505_2  WIFE     WC4      1  ROS 121705 0934    BE 14  7.46 N 170 45.04 E GPS   5627   5628                                                                                WITH 7 SBE37 (WM4)
49MR0505_2  WIFE     WC4      1  BUC 121705 0941    UN 14  7.53 N 170 44.98 E GPS   5624   5625                                 1,33                                           27.7C
49MR0505_2  WIFE     WC4      1  UNK 121705 0950    UN 14  7.63 N 170 44.92 E GPS   5627   5625                                                                                AIR N2O SMPL
49MR0505_2  WIFE     WC4      1  ROS 121705 1103    BO 14  8.19 N 170 44.86 E GPS   5627   5629         9   5664   5721        36 1-6
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49MR0505_2  WIFE       WC4     1  ROS 121705 1326    EN 14  9.37 N 170 44.83 E GPS   5658   5651
49MR0505_2  WIFE       WC5     1  ROS 121705 1612    BE 14 34.23 N 170 55.24 E GPS   5672   5673                                                        WITH 6 SBE37 (WM3)
49MR0505_2  WIFE       WC5     1  BUC 121705 1619    UN 14 34.31 N 170 55.18 E GPS   5674   5674                               1,33                     27.7C
49MR0505_2  WIFE       WC5     1  UNK 121705 1628    UN 14 34.38 N 170 55.14 E GPS   5672   5674                                                        AIR N2O SMPL
49MR0505_2  WIFE       WC5     1  ROS 121705 1739    BO 14 34.87 N 170 55.04 E GPS   5674   5674      10   5716   5769      36 1-6                      #8 MISS TRIP
49MR0505_2  WIFE       WC5     1  ROS 121705 2003    EN 14 35.77 N 170 54.57 E GPS   5681   5683
49MR0505_2  WIFE       WC6     1  ROS 121705 2258    BE 15  2.38 N 171  4.81 E GPS   5673   5672
49MR0505_2  WIFE       WC6     1  BUC 121705 2307    UN 15  2.45 N 171  4.72 E GPS   5672   5672                               1,33                     27.9C
49MR0505_2  WIFE       WC6     1  UNK 121705 2316    UN 15  2.52 N 171  4.65 E GPS   5702   5690                                                        AIR N2O SMPL
49MR0505_2  WIFE       WC6     1  ROS 121805 0025    BO 15  3.13 N 171  4.30 E GPS   5663   5670       8   5767   5768      36 1-6
49MR0505_2  WIFE       WC6     1  ROS 121805 0246    EN 15  4.47 N 171  3.60 E GPS   5383   5385
49MR0505_2  WIFE       WC7     1  ROS 121805 0530    BE 15 31.30 N 171 14.83 E GPS   5618   5618                                                        WITH 7 SBE37 (WM2)
49MR0505_2  WIFE       WC7     1  BUC 121805 0537    UN 15 31.37 N 171 14.82 E GPS   5606   5607                                1,33                    27.8C
49MR0505_2  WIFE       WC7     1  UNK 121805 0547    UN 15 31.43 N 171 14.74 E GPS   5619   5618                                                        AIR N2O SMPL
49MR0505_2  WIFE       WC7     1  ROS 121805 0656    BO 15 31.74 N 171 14.64 E GPS   5608   5607      11   5623   5701      36 1-6                      PRI SENSORS SHIFTED
49MR0505_2  WIFE       WC7     1  ROS 121805 0918    EN 15 32.73 N 171 14.42 E GPS   5610   5609                                                        1 SBE37 BROKEN
49MR0505_2  WIFE       WC8     1  ROS 121805 1215    BE 15 57.46 N 171 25.04 E GPS   5538   5537                                                        PRI OXYGEN SENSOR REPLACED, WITH 5 COMPACT-
                                                                                                                                                        OPTODE
49MR0505_2  WIFE       WC8     1  BUC 121805 1222    UN 15 57.50 N 171 25.00 E GPS   5539   5539                               1,33                     27.8C
49MR0505_2  WIFE       WC8     1  UNK 121805 1230    UN 15 57.56 N 171 24.93 E GPS   5538   5538                                                        AIR N2O SMPL
49MR0505_2  WIFE       WC8     1  ROS 121805 1340    BO 15 58.06 N 171 24.76 E GPS   5537   5537       9   5578   5623      36 1-6
49MR0505_2  WIFE       WC8     1  ROS 121805 1557    EN 15 59.32 N 171 24.25 E GPS   5574   5574
49MR0505_2  WIFE       WC9     1  ROS 121805 1839    BE 16 26.28 N 171 33.22 E GPS   5473   5474
49MR0505_2  WIFE       WC9     1  BUC 121805 1847    UN 16 26.34 N 171 33.19 E GPS   5471   5472                               1,33                     27.7C
49MR0505_2  WIFE       WC9     1  UNK 121805 1856    UN 16 26.42 N 171 33.15 E GPS   5472   5474                                                        AIR N2O SMPL
49MR0505_2  WIFE       WC9     1  ROS 121805 2003    BO 16 26.90 N 171 32.95 E GPS   5471   5471       8   5510   5561      36 1-6
49MR0505_2  WIFE       WC9     1  ROS 121805 2218    EN 16 27.96 N 171 32.64 E GPS   5327   5340
49MR0505_2  WIFE      WC10     1  ROS 121805 2346    BE 16 32.92 N 171 32.30 E GPS   4341   4351
49MR0505_2  WIFE      WC10     1  BUC 121805 2353    UN 16 32.98 N 171 32.28 E GPS   4296   4296                               1,33                     27.9C
49MR0505_2  WIFE      WC10     1  UNK 121905 0001    UN 16 33.04 N 171 32.24 E GPS   4288   4287                                                        AIR N2O SMPL
49MR0505_2  WIFE      WC10     1  ROS 121905 0055    BO 16 33.46 N 171 32.15 E GPS   4528   4528      14   4434   4456      32 1-6                      #8=#23 DUPL SMPLS (4000DB)
49MR0505_2  WIFE      WC10     1  ROS 121905 0246    EN 16 33.96 N 171 31.98 E GPS   4468   4468
49MR0505_2             558     1  UNK 122005 0301    BE 21  6.55 N 171 37.43 E GPS   5570   5571                                                        SURFACE WATER SMPL FOR NUTRIENTS (2000L)
49MR0505_2             559     1  UNK 122005 0325    BE 21  6.59 N 171 37.54 E GPS   5574   5573                                                        CWS TEST AT 100M
49MR0505_2             558     1  UNK 122005 0345    EN 21  6.55 N 171 37.64 E GPS   5573   5571
49MR0505_2             559     1  UNK 122005 0416    EN 21  6.57 N 171 37.84 E GPS   5570   5567
49MR0505_2   P03       217     2  ROS 122005 2057    BE 24 14.81 N 171 56.81 E GPS   5842   5842
49MR0505_2   P03       217     2  BUC 122005 2104    UN 24 14.75 N 171 56.83 E GPS   5834   5834                               1,33                     26.3C
49MR0505_2   P03       217     2  UNK 122005 2113    UN 24 14.65 N 171 56.86 E GPS   5835   5834                                                        AIR N2O SMPL
49MR0505_2   P03       217     2  ROS 122005 2223    BO 24 14.34 N 171 56.73 E GPS   5833   5834       8   5836   5933      34 1-8,23,24,26,27,81       #28,#36 MISS FIRE
49MR0505_2   P03       217     2  ROS 122105 0047    EN 24 13.98 N 171 56.72 E GPS   5819   5821
49MR0505_2   P03       219     1  ROS 122105 0451    BE 24 15.89 N 171 10.48 E GPS   5812   5810
49MR0505_2   P03       219     1  BUC 122105 0459    UN 24 15.86 N 171 10.52 E GPS   5786   5788                               1,33                     26.2C
49MR0505_2   P03       219     1  UNK 122105 0509    UN 24 15.84 N 171 10.53 E GPS   5787   5794                                                        AIR N2O SMPL
49MR0505_2   P03       219     1  ROS 122105 0619    BO 24 15.55 N 171 10.58 E GPS   5775   5775       9   5777   5870      36 1-8,27
49MR0505_2   P03       219     1  ROS 122105 0844    EN 24 14.64 N 171 10.43 E GPS   5858   5857
49MR0505_2   P03       221     1  ROS 122105 1311    BE 24 15.20 N 170 21.19 E GPS   5834   5833
49MR0505_2   P03       221     1  BUC 122105 1320    UN 24 15.18 N 170 21.21 E GPS   5830   5817                               1,33                     25.9C
49MR0505_2   P03       221     1  UNK 122105 1329    UN 24 15.16 N 170 21.22 E GPS   5839   5832                                                        AIR N2O SMPL
49MR0505_2   P03       221     1  ROS 122105 1443    BO 24 14.72 N 170 21.24 E GPS   5873   5873      10   5856   5933      36 1-8,22,27
49MR0505_2   P03       221     2  UNK 122105 1502    BE 24 14.57 N 170 21.19 E GPS   5875   5880                                                        80L THROUGH HULL PUMP FOR R.N.
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49MR0505_2   P03     221      2  UNK 122105 1514    EN 24 14.45 N 170 21.18 E GPS   5886   5879
49MR0505_2   P03     221      1  ROS 122105 1708    EN 24 13.49 N 170 20.99 E GPS   5944   5943
49MR0505_2   P03     223      1  ROS 122105 2122    BE 24 16.29 N 169 31.62 E GPS   6136   6135                                                                           WITHOUT LADCP
49MR0505_2   P03     223      1  BUC 122105 2131    UN 24 16.19 N 169 31.56 E GPS   6141   6136                             1,33                                          25.8C
49MR0505_2   P03     223      1  UNK 122105 2140    UN 24 16.12 N 169 31.48 E GPS   6140   6138                                                                           AIR N2O SMPL
49MR0505_2   P03     223      1  ROS 122105 2255    BO 24 15.98 N 169 30.83 E GPS   6136   6138        9   6190   6241      36 1-8,12,13,23,24,26,27
49MR0505_2   P03     223      1  ROS 122205 0130    EN 24 15.57 N 169 29.88 E GPS   6148   6151
49MR0505_2   P03     225      1  ROS 122205 0516    BE 24 16.36 N 168 46.11 E GPS   5887   5888
49MR0505_2   P03     225      1  BUC 122205 0525    UN 24 16.38 N 168 46.20 E GPS   5886   5886                             1,33                                          25.2C
49MR0505_2   P03     225      1  UNK 122205 0534    UN 24 16.39 N 168 46.26 E GPS   5886   5886                                                                           AIR N2O SMPL
49MR0505_2   P03     225      1  ROS 122205 0647    BO 24 16.32 N 168 46.41 E GPS   5889   5888        8   5883   5986      36 1-8,27
49MR0505_2   P03     225      1  ROS 122205 0914    EN 24 15.99 N 168 46.57 E GPS   5887   5886
49MR0505_2   P03     227      1  ROS 122205 1319    BE 24 16.49 N 167 58.15 E GPS   5998   5999
49MR0505_2   P03     227      1  BUC 122205 1327    UN 24 16.48 N 167 58.20 E GPS   5986   5986                             1,31,33,82                                    25.0C
49MR0505_2   P03     227      1  UNK 122205 1339    UN 24 16.51 N 167 58.26 E GPS   5983   5983                                                                           AIR CH4 & N2O SMPL
49MR0505_2   P03     227      1  ROS 122205 1452    BO 24 16.58 N 167 58.68 E GPS   5984   5984        8   6014   6096      36 1-8,23,24,26,27,31,33,64,82
49MR0505_2   P03     227      1  ROS 122205 1720    EN 24 16.92 N 167 59.46 E GPS   5986   5986
49MR0505_2   P03     229      1  ROS 122205 2111    BE 24 14.91 N 167 15.00 E GPS   5626   5622
49MR0505_2   P03     229      1  BUC 122205 2120    UN 24 14.88 N 167 15.02 E GPS   5634   5632                             1,33                                          25.8C
49MR0505_2   P03     229      1  UNK 122205 2130    UN 24 14.87 N 167 15.03 E GPS   5637   5638                                                                           AIR N2O SMPL
49MR0505_2   P03     229      1  ROS 122205 2236    BO 24 14.84 N 167 15.52 E GPS   5675   5675        9   5670   5732      36 1-8,23,24,26,27                               #18=#6 DUPL SMPLS (4750DB)
49MR0505_2   P03     229      1  ROS 122305 0058    EN 24 14.69 N 167 16.50 E GPS   5703   5703
49MR0505_2   P03     231      1  ROS 122305 0504    BE 24 14.89 N 166 28.65 E GPS   5750   5751
49MR0505_2   P03     231      1  BUC 122305 0511    UN 24 14.91 N 166 28.68 E GPS   5747   5751                             1,33                                          26.0C
49MR0505_2   P03     231      1  UNK 122305 0520    UN 24 14.89 N 166 28.68 E GPS   5760   5757                                                                           AIR N2O SMPL
49MR0505_2   P03     231      1  ROS 122305 0630    BO 24 14.82 N 166 28.99 E GPS   5800   5801       10   5771   5858      35 1-8,22,27                                     #2 FOR R.N., #26 MISS FIRE
49MR0505_2   P03     231      2  UNK 122305 0654    BE 24 14.77 N 166 29.12 E GPS   5823   5825                                                                           80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     231      2  UNK 122305 0704    EN 24 14.74 N 166 29.16 E GPS   5843   5841
49MR0505_2   P03     231      1  ROS 122305 0853    EN 24 14.52 N 166 29.75 E GPS   5965   5964
49MR0505_2   P03     233      1  ROS 122305 1314    BE 24 15.56 N 165 39.78 E GPS   5970   5977
49MR0505_2   P03     233      1  BUC 122305 1320    UN 24 15.63 N 165 39.86 E GPS   5970   5970                             1,33                                          25.9C
49MR0505_2   P03     233      1  UNK 122305 1329    UN 24 15.64 N 165 39.95 E GPS   5969   5969                                                                           AIR N2O SMPL
49MR0505_2   P03     233      1  ROS 122305 1445    BO 24 15.51 N 165 40.24 E GPS   5970   5971        9   5992   6067      36 1-8,12,13,23,24,26,27
49MR0505_2   P03     233      1  ROS 122305 1711    EN 24 15.55 N 165 41.04 E GPS   5935   5935
49MR0505_2   P03     X13      1  ROS 122305 2059    BE 24  2.65 N 164 59.09 E GPS   6077   6072                                                                           HEAVY RAIN WHEN BEGINNING THE CAST
49MR0505_2           560      1  UNK 122305 2100    UN 24  2.70 N 164 59.09 E GPS   6069   6064                                                                           RAIN SMPL (38.0MM/HR)
49MR0505_2   P03     X13      1  BUC 122305 2106    UN 24  2.71 N 164 59.08 E GPS   6079   6078                             1,33                                          25.9C
49MR0505_2   P03     X13      1  UNK 122305 2115    UN 24  2.73 N 164 59.09 E GPS   6062   6061                                                                           AIR N2O SMPL
49MR0505_2   P03     X13      1  ROS 122305 2229    BO 24  2.77 N 164 59.25 E GPS   6062   6060        7   6077   6170      36 1-8,23,24,26,27
49MR0505_2   P03     X13      1  ROS 122405 0102    EN 24  3.28 N 164 59.26 E GPS   6054   6055
49MR0505_2           561      1  UNK 122405 0507    UN 24 12.65 N 164 10.92 E GPS   4340   4340                                                                           RAIN SMPL (2.4MM/HR)
49MR0505_2   P03     237      1  ROS 122405 0554    BE 24 14.25 N 164  2.81 E GPS   5786   5786
49MR0505_2   P03     237      1  BUC 122405 0602    UN 24 14.19 N 164  2.83 E GPS   5778   5780                             1,33                                          26.4C
49MR0505_2   P03     237      1  UNK 122405 0611    UN 24 14.16 N 164  2.79 E GPS   5773   5775                                                                           AIR N2O SMPL
49MR0505_2   P03     237      1  ROS 122405 0724    BO 24 13.64 N 164  2.84 E GPS   5739   5734       11   5798   5864      36 1-8,27
49MR0505_2   P03     237      1  ROS 122405 0950    EN 24 12.67 N 164  2.72 E GPS   5556   5571
49MR0505_2   P03     239      1  ROS 122405 1353    BE 24 16.41 N 163 16.09 E GPS   5749   5746
49MR0505_2   P03     239      1  BUC 122405 1404    UN 24 16.44 N 163 16.15 E GPS   5751   5752                             1,31,33                                       26.4C
49MR0505_2   P03     239      1  UNK 122405 1420    UN 24 16.45 N 163 16.29 E GPS   5756   5753                                                                           AIR CH4 & N2O SMPL
49MR0505_2   P03     239      1  ROS 122405 1531    BO 24 16.47 N 163 17.31 E GPS   5757   5755       10   5941   5850      36 1-8,23,24,26,27,31,33,81
49MR0505_2   P03     239      1  ROS 122405 1800    EN 24 16.45 N 163 19.50 E GPS   5726   5726
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49MR0505_2	P03	241	1	ROS	122405	2244	BE	24 14.89 N	162 26.81 E	GPS	5456	5457					
49MR0505_2	P03	241	1	BUC	122405	2253	UN	24 14.77 N	162 26.79 E	GPS	5462	5458				1,33	25.7C
49MR0505_2	P03	241	1	UNK	122405	2302	UN	24 14.69 N	162 26.78 E	GPS	5454	5455					AIR N2O SMPL
49MR0505_2	P03	241	1	ROS	122505	0007	BO	24 14.24 N	162 26.45 E	GPS	5440	5441	10	5517	5542	35 1-8,27,81	#2 LEAKING
49MR0505_2	P03	241	1	ROS	122505	0223	EN	24 13.26 N	162 25.79 E	GPS	5424	5423					
49MR0505_2	P03	243	1	ROS	122505	0638	BE	24 15.11 N	161 35.90 E	GPS	2949	2943					
49MR0505_2	P03	243	1	BUC	122505	0643	UN	24 15.04 N	161 35.84 E	GPS	3032	3031				1,33	25.2C
49MR0505_2	P03	243	1	UNK	122505	0652	UN	24 14.99 N	161 35.73 E	GPS	3157	3158					AIR N2O SMPL
49MR0505_2	P03	243	1	ROS	122505	0730	BO	24 14.90 N	161 35.52 E	GPS	3328	3328	10	3215	3240	25 1-8,23,24,26,27	
49MR0505_2	P03	243	1	ROS	122505	0902	EN	24 14.44 N	161 34.91 E	GPS	3676	3677					
49MR0505_2	P03	245	1	ROS	122505	1247	BE	24 16.00 N	160 50.39 E	GPS	5079	5079					
49MR0505_2	P03	245	1	BUC	122505	1255	UN	24 15.92 N	160 50.38 E	GPS	5086	5087				1	26.3C
49MR0505_2	P03	245	1	ROS	122505	1409	BO	24 15.49 N	160 49.98 E	GPS	5007	5008	9	5076	5120	36 1-8,22,27	#2-4 FOR R.N.
49MR0505_2	P03	245	1	UNK	122505	1528	BE	24 15.09 N	160 49.57 E	GPS	4973	4977					80L THROUGH HULL PUMP FOR R.N.
49MR0505_2	P03	245	1	UNK	122505	1538	EN	24 15.06 N	160 49.48 E	GPS	4966	4963					
49MR0505_2	P03	245	1	ROS	122505	1615	EN	24 14.87 N	160 49.23 E	GPS	4903	4904					
49MR0505_2	P03	247	1	ROS	122505	2015	BE	24 16.20 N	160 3.40 E	GPS	5510	5511					
49MR0505_2	P03	247	1	BUC	122505	2024	UN	24 16.23 N	160 3.40 E	GPS	5508	5515				1,33	26.6C
49MR0505_2	P03	247	1	UNK	122505	2033	UN	24 16.25 N	160 3.45 E	GPS	5509	5509					AIR N2O SMPL
49MR0505_2	P03	247	1	ROS	122505	2139	BO	24 16.20 N	160 3.85 E	GPS	5522	5522	11	5535	5603	35 1-8,12,13,23,24,26,27	
49MR0505_2		562	1	UNK	122505	2250	UN	24 16.28 N	160 4.35 E	GPS	5508	5508					RAIN SMPL (0.5MM/HR)
49MR0505_2	P03	247	1	ROS	122505	2354	EN	24 16.28 N	160 4.77 E	GPS	5533	5520					
49MR0505_2	P03	249	1	ROS	122605	0411	BE	24 14.13 N	159 15.33 E	GPS	4267	4257					
49MR0505_2	P03	249	1	BUC	122605	0419	UN	24 14.16 N	159 15.28 E	GPS	4194	4200				1,33	26.6C
49MR0505_2	P03	249	1	UNK	122605	0427	UN	24 14.16 N	159 15.26 E	GPS	4194	4193					AIR N2O SMPL
49MR0505_2		563	1	UNK	122605	0444	UN	24 14.16 N	159 15.22 E	GPS	4164	4155					RAIN SMPL (0.2MM/HR)
49MR0505_2	P03	249	1	ROS	122605	0521	BO	24 14.19 N	159 15.05 E	GPS	4222	4221	11	4243	4293	30 1-8,23,24,26,27	#19=#11 DUPL SMPLS (3500DB)
49MR0505_2	P03	249	1	ROS	122605	0713	EN	24 13.94 N	159 14.85 E	GPS	4185	4183					
49MR0505_2	P03	251	1	ROS	122605	1117	BE	24 16.72 N	158 26.93 E	GPS	5833	5836					
49MR0505_2	P03	251	1	BUC	122605	1124	UN	24 16.74 N	158 26.90 E	GPS	5840	5840				1,31,33,82	26.4C
49MR0505_2	P03	251	1	UNK	122605	1136	UN	24 16.79 N	158 26.91 E	GPS	5836	5837					AIR CH4 & N2O SMPL
49MR0505_2	P03	251	1	ROS	122605	1245	BO	24 16.75 N	158 26.91 E	GPS	5842	5845	9	5833	5933	36 1-8,23,24,26,27,31,33,64,82	
49MR0505_2	P03	251	1	ROS	122605	1508	EN	24 17.03 N	158 27.25 E	GPS	5834	5838					
49MR0505_2	P03	253	1	ROS	122605	1901	BE	24 14.79 N	157 40.11 E	GPS	5835	5835					
49MR0505_2	P03	253	1	BUC	122605	1908	UN	24 14.78 N	157 40.09 E	GPS	5825	5828				1,33	25.7C
49MR0505_2	P03	253	1	UNK	122605	1917	UN	24 14.76 N	157 40.05 E	GPS	5828	5825					AIR N2O SMPL
49MR0505_2	P03	253	1	ROS	122605	2030	BO	24 14.57 N	157 40.08 E	GPS	5822	5822	9	5821	5921	36 1-8,27	
49MR0505_2	P03	253	1	ROS	122605	2254	EN	24 14.25 N	157 40.59 E	GPS	5834	5830					
49MR0505_2	P03	255	1	ROS	122705	0255	BE	24 13.82 N	156 50.57 E	GPS	5718	5718					
49MR0505_2	P03	255	1	BUC	122705	0302	UN	24 13.70 N	156 50.57 E	GPS	5731	5731				1,33	25.4C
49MR0505_2	P03	255	1	UNK	122705	0311	UN	24 13.64 N	156 50.56 E	GPS	5722	5722					AIR N2O SMPL
49MR0505_2		564	1	UNK	122705	0340	UN	24 13.36 N	156 50.47 E	GPS	5726	5727					RAIN SMPL (0.6MM/HR)
49MR0505_2	P03	255	1	ROS	122705	0424	BO	24 13.03 N	156 50.31 E	GPS	5724	5723	9	5797	5819	36 1-8,23,24,26,27	
49MR0505_2	P03	255	1	ROS	122705	0647	EN	24 11.88 N	156 49.56 E	GPS	5718	5719					
49MR0505_2	P03	257	1	ROS	122705	1040	BE	24 14.29 N	156 4.23 E	GPS	5655	5655					
49MR0505_2	P03	257	1	BUC	122705	1047	UN	24 14.27 N	156 4.25 E	GPS	5657	5657				1,33	25.6C
49MR0505_2	P03	257	1	UNK	122705	1057	UN	24 14.18 N	156 4.27 E	GPS	5655	5657					AIR N2O SMPL
49MR0505_2	P03	257	1	ROS	122705	1206	BO	24 13.59 N	156 4.18 E	GPS	5669	5669	10	5727	5757	36 1-8,22,27	#2 FOR R.N.
49MR0505_2	P03	257	2	UNK	122705	1213	BE	24 13.56 N	156 4.16 E	GPS	5671	5670					80L THROUGH HULL PUMP FOR R.N.
49MR0505_2	P03	257	2	UNK	122705	1232	EN	24 13.37 N	156 4.14 E	GPS	5664	5662					
49MR0505_2	P03	257	1	ROS	122705	1427	EN	24 12.43 N	156 3.72 E	GPS	5655	5656					

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49MR0505_2   P03     259      1  ROS 122705 1852    BE 24 18.41 N 155 13.57 E GPS   5586   5586
49MR0505_2   P03     259      1  BUC 122705 1859    UN 24 18.28 N 155 13.52 E GPS   5578   5585                                 1,33                                           25.1C
49MR0505_2   P03     259      1  UNK 122705 1909    UN 24 18.20 N 155 13.42 E GPS   5586   5587                                                                                AIR N2O SMPL
49MR0505_2   P03     259      1  ROS 122705 2018    BO 24 17.79 N 155 12.79 E GPS   5584   5582       11    5640   5675      35 1-8,12,13,23,24,26,27
49MR0505_2   P03     259      1  ROS 122705 2237    EN 24 16.85 N 155 11.72 E GPS   5583   5582
49MR0505_2   P03     261      1  ROS 122805 0223    BE 24 11.66 N 154 27.02 E GPS   4910   4899
49MR0505_2   P03     261      1  BUC 122805 0232    UN 24 11.52 N 154 26.94 E GPS   4892   4893                                 1,33                                           24.5C
49MR0505_2   P03     261      1  UNK 122805 0242    UN 24 11.46 N 154 26.81 E GPS   4922   4923                                                                                AIR N2O SMPL
49MR0505_2   P03     261      1  ROS 122805 0341    BO 24 11.07 N 154 26.35 E GPS   4985   4987        8    4988   5014      33 1-8,27                                         #20=#7 DUPL SMPLS (4500DB)
49MR0505_2   P03     261      1  ROS 122805 0545    EN 24 10.37 N 154 25.21 E GPS   5043   5043
49MR0505_2   P03     263      1  ROS 122805 1004    BE 24 12.81 N 153 34.06 E GPS   5410   5421
49MR0505_2   P03     263      1  BUC 122805 1013    UN 24 12.78 N 153 34.02 E GPS   5425   5424                                 1,31,33                                        24.4C
49MR0505_2   P03     263      1  UNK 122805 1027    UN 24 12.73 N 153 33.94 E GPS   5418   5419                                                                                AIR CH4 & N2O SMPL
49MR0505_2   P03     263      1  ROS 122805 1127    BO 24 12.34 N 153 33.49 E GPS   5412   5413        8    5481   5507      36 1-8,23,24,26,27,31,33,81                       #2,#3 FOR POM
49MR0505_2   P03     263      1  ROS 122805 1344    EN 24 11.83 N 153 32.39 E GPS   5399   5400
49MR0505_2   P03     265      1  ROS 122805 1728    BE 24 16.19 N 152 49.55 E GPS   5343   5345
49MR0505_2   P03     265      1  BUC 122805 1737    UN 24 16.13 N 152 49.48 E GPS   5342   5342                                 1,33                                           24.5C
49MR0505_2   P03     265      1  UNK 122805 1746    UN 24 16.07 N 152 49.44 E GPS   5342   5343                                                                                AIR N2O SMPL
49MR0505_2   P03     265      1  ROS 122805 1851    BO 24 15.79 N 152 48.89 E GPS   5343   5343        9    5381   5429      35 1-8,27                                         #21=#5 DUPL SMPLS (5000DB)
49MR0505_2   P03     265      1  ROS 122805 2104    EN 24 15.03 N 152 47.86 E GPS   5358   5359
49MR0505_2   P03     267      1  ROS 122905 0043    BE 24 14.45 N 152  3.88 E GPS   5488   5489
49MR0505_2   P03     267      1  BUC 122905 0052    UN 24 14.40 N 152  3.75 E GPS   5482   5485                                 1,33                                           24.8C
49MR0505_2   P03     267      1  UNK 122905 0102    UN 24 14.37 N 152  3.67 E GPS   5489   5488                                                                                AIR N2O SMPL
49MR0505_2   P03     267      1  ROS 122905 0208    BO 24 14.08 N 152  2.71 E GPS   5470   5473        9    5604   5563      36 1-8,23,24,26,27                                #23=#5 DUPL SMPLS (5000DB)
49MR0505_2   P03     267      1  ROS 122905 0422    EN 24 13.97 N 152  1.39 E GPS   5476   5476
49MR0505_2   P03     269      1  ROS 122905 0803    BE 24 14.80 N 151 15.26 E GPS   5493   5490
49MR0505_2   P03     269      1  BUC 122905 0811    UN 24 14.78 N 151 15.22 E GPS   5479   5478                                 1,33                                           25.2C
49MR0505_2   P03     269      1  UNK 122905 0821    UN 24 14.76 N 151 15.14 E GPS   5479   5479                                                                                AIR N2O SMPL
49MR0505_2   P03     269      1  ROS 122905 0928    BO 24 14.73 N 151 14.75 E GPS   5496   5488        9    5489   5573      35 1-8,27                                         #22=#5 DUPL SMPLS (5000DB)
49MR0505_2   P03     269      1  ROS 122905 1142    EN 24 14.46 N 151 13.93 E GPS   5461   5460
49MR0505_2   P03     271      1  ROS 122905 1537    BE 24 17.19 N 150 28.23 E GPS   5125   5116
49MR0505_2   P03     271      1  BUC 122905 1547    UN 24 17.20 N 150 28.18 E GPS   5132   5137                                 1,33                                           24.2C
49MR0505_2   P03     271      1  UNK 122905 1557    UN 24 17.25 N 150 28.10 E GPS   5150   5126                                                                                AIR N2O SMPL
49MR0505_2   P03     271      1  ROS 122905 1658    BO 24 17.41 N 150 27.79 E GPS   5140   5138        9    5139   5208      34 1-8,23,24,26,27                                #23=#7 DUPL SMPLS (4500DB)
49MR0505_2   P03     271      1  ROS 122905 1902    EN 24 17.42 N 150 26.82 E GPS   5106   5106
49MR0505_2   P03     273      1  ROS 122905 2246    BE 24 15.91 N 149 39.83 E GPS   5012   5012
49MR0505_2   P03     273      1  BUC 122905 2255    UN 24 15.86 N 149 39.72 E GPS   5023   5022                                 1,33                                           24.0C
49MR0505_2   P03     273      1  UNK 122905 2307    UN 24 15.82 N 149 39.59 E GPS   5017   5022                                                                                AIR N2O SMPL
49MR0505_2   P03     273      1  ROS 123005 0002    BO 24 15.72 N 149 39.29 E GPS   5036   5035       10    5047   5093      36 1-8,22,27                                      #2-4 FOR R.N.
49MR0505_2   P03     273      2  UNK 123005 0016    BE 24 15.79 N 149 39.19 E GPS   5040   5043                                                                                80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     273      2  UNK 123005 0038    EN 24 15.74 N 149 39.01 E GPS   5044   5044
49MR0505_2   P03     273      1  ROS 123005 0203    EN 24 15.55 N 149 37.90 E GPS   5063   5062
49MR0505_2   P03     X10      1  ROS 123005 0406    BE 24 30.29 N 149 19.94 E GPS   5763   5768
49MR0505_2   P03     X10      1  BUC 123005 0414    UN 24 30.26 N 149 19.83 E GPS   5766   5767                                 1,33                                           24.1C
49MR0505_2   P03     X10      1  UNK 123005 0422    UN 24 30.23 N 149 19.71 E GPS   5768   5768                                                                                AIR N2O SMPL
49MR0505_2   P03     X10      1  ROS 123005 0537    BO 24 30.20 N 149 18.79 E GPS   5770   5770        9    5889   5867      36 1-8,12,13,23,24,26,27
49MR0505_2   P03     X10      1  ROS 123005 0800    EN 24 30.08 N 149 17.71 E GPS   5767   5767
49MR0505_2   P03     275      1  ROS 123005 0954    BE 24 14.57 N 149  1.60 E GPS   5789   5789
49MR0505_2   P03     275      1  BUC 123005 1001    UN 24 14.51 N 149  1.45 E GPS   5790   5787                                 1                                              24.0C
49MR0505_2   P03     275      1  ROS 123005 1120    BO 24 14.49 N 149  0.96 E GPS   5791   5790        9    5839   5888      36 1-8,27
49MR0505_2   P03     275      1  ROS 123005 1342    EN 24 14.54 N 149  0.24 E GPS   5797   5798
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49MR0505_2   P03      277      1  ROS 123005 1628    BE 24 14.77 N 148 26.85 E GPS   5789   5787
49MR0505_2   P03      277      1  BUC 123005 1635    UN 24 14.75 N 148 26.73 E GPS   5787   5788                             1,33                                         23.9C
49MR0505_2   P03      277      1  UNK 123005 1644    UN 24 14.75 N 148 26.61 E GPS   5784   5786                                                                          AIR N2O SMPL
49MR0505_2   P03      277      1  ROS 123005 1758    BO 24 14.73 N 148 26.02 E GPS   5788   5789    11   5852   5891      36 1-8,27
49MR0505_2   P03      277      1  ROS 123005 2014    EN 24 14.44 N 148 24.70 E GPS   5790   5791
49MR0505_2   P03      279      1  ROS 123005 2255    BE 24 15.61 N 147 50.97 E GPS   5841   5843
49MR0505_2   P03      279      1  BUC 123005 2302    UN 24 15.51 N 147 50.90 E GPS   5842   5841                             1,31,33,82                                   25.1C
49MR0505_2   P03      279      1  UNK 123005 2313    UN 24 15.47 N 147 50.80 E GPS   5845   5839                                                                          AIR CH4 & N2O SMPL
49MR0505_2   P03      279      1  ROS 123105 0023    BO 24 15.54 N 147 50.25 E GPS   5838   5841     9   5924   5939      36 1-8,23,24,26,27,31,33,64,82
49MR0505_2   P03      279      1  ROS 123105 0241    EN 24 15.23 N 147 49.00 E GPS   5820   5818
49MR0505_2            565      1  UNK 010106 0355    BE 24 17.29 N 147 28.08 E GPS   5835   5835                                                                          MAGNETOMETER CALIBRATION
49MR0505_2            565      1  UNK 010106 0420    EN 24 17.68 N 147 28.09 E GPS   5834   5834
49MR0505_2   P03      281      1  ROS 010106 1855    BE 24 15.71 N 147 15.39 E GPS   5855   5855
49MR0505_2   P03      281      1  BUC 010106 1901    UN 24 15.67 N 147 15.34 E GPS   5858   5858                             1,33                                         25.0C
49MR0505_2   P03      281      1  UNK 010106 1910    UN 24 15.68 N 147 15.28 E GPS   5856   5858                                                                          AIR N2O SMPL
49MR0505_2   P03      281      1  ROS 010106 2023    BO 24 15.66 N 147 14.76 E GPS   5871   5871     9   5923   5966      36 1-8,27
49MR0505_2   P03      281      1  ROS 010106 2249    EN 24 15.63 N 147 13.23 E GPS   5890   5890
49MR0505_2   P03      283      1  ROS 010206 0133    BE 24 16.08 N 146 39.73 E GPS   5873   5873
49MR0505_2   P03      283      1  BUC 010206 0141    UN 24 16.16 N 146 39.73 E GPS   5875   5875                             1,33                                         25.1C
49MR0505_2   P03      283      1  UNK 010206 0150    UN 24 16.27 N 146 39.75 E GPS   5876   5876                                                                          AIR N2O SMPL
49MR0505_2   P03      283      1  ROS 010206 0305    BO 24 16.82 N 146 39.61 E GPS   5875   5875    10   5995   5979      36 1-8,23,24,26,27
49MR0505_2   P03      283      1  ROS 010206 0529    EN 24 18.35 N 146 39.74 E GPS   5875   5875
49MR0505_2   P03      285      1  ROS 010206 0833    BE 24 16.75 N 146  2.92 E GPS   5732   5730                                                                          SEC OXYGEN SENSOR REPLACED
49MR0505_2   P03      285      1  BUC 010206 0839    UN 24 16.83 N 146  2.86 E GPS   5724   5725                             1,33                                         25.0C
49MR0505_2   P03      285      1  UNK 010206 0848    UN 24 16.90 N 146  2.83 E GPS   5726   5726                                                                          AIR N2O SMPL
49MR0505_2   P03      285      1  ROS 010206 1000    BO 24 17.28 N 146  3.09 E GPS   5726   5725     9   5734   5826      35 1-8,27
49MR0505_2   P03      285      1  ROS 010206 1225    EN 24 18.53 N 146  4.18 E GPS   5724   5724
49MR0505_2   P03      287      1  ROS 010206 1543    BE 24 14.03 N 145 27.19 E GPS   5559   5558
49MR0505_2   P03      287      1  BUC 010206 1551    UN 24 14.13 N 145 27.27 E GPS   5557   5557                             1                                            25.0C
49MR0505_2   P03      287      1  ROS 010206 1710    BO 24 13.90 N 145 27.76 E GPS   5561   5561    10   5571   5645      35 1-8,23,24,26,27
49MR0505_2   P03      287      1  ROS 010206 1927    EN 24 13.57 N 145 29.09 E GPS   5556   5556
49MR0505_2   P03      289      1  ROS 010206 2303    BE 24 13.65 N 144 50.02 E GPS   5348   5349
49MR0505_2   P03      289      1  BUC 010206 2310    UN 24 13.55 N 144 50.18 E GPS   5353   5347                             1,33                                         23.9C
49MR0505_2   P03      289      1  UNK 010206 2320    UN 24 13.52 N 144 50.21 E GPS   5348   5347                                                                          AIR N2O SMPL
49MR0505_2   P03      289      1  ROS 010306 0023    BO 24 13.20 N 144 50.05 E GPS   5359   5359    10   5391   5434      34 1-8,27                                       #20 MISS TRIP
49MR0505_2   P03      289      1  ROS 010306 0237    EN 24 12.52 N 144 49.95 E GPS   5362   5362
49MR0505_2   P03      291      1  ROS 010306 0546    BE 24 15.56 N 144 14.81 E GPS   4898   4898
49MR0505_2   P03      291      1  BUC 010306 0555    UN 24 15.45 N 144 14.77 E GPS   4895   4896                             1,31,33                                      23.3C
49MR0505_2   P03      291      1  UNK 010306 0611    UN 24 15.29 N 144 14.57 E GPS   4896   4896                                                                          AIR CH4 & N2O SMPL
49MR0505_2   P03      291      1  ROS 010306 0706    BO 24 14.84 N 144 14.03 E GPS   4911   4911     9   5022   4969      36 1-8,23,24,26,27,31,33,81                     #2-5 FOR POM
49MR0505_2   P03      291      1  ROS 010306 0915    EN 24 14.29 N 144 12.79 E GPS   4967   4967
49MR0505_2   P03      291      1  FLT 010306 0921    DE 24 14.24 N 144 12.64 E GPS   4981   4982                                                                          ARGO SN2296 (ARGOS_ID 60094)
49MR0505_2   P03      293      1  ROS 010306 1205    BE 24 16.43 N 143 38.26 E GPS   8758   8759                                                                          WITHOUT LADCP
49MR0505_2   P03      293      1  BUC 010306 1213    UN 24 16.34 N 143 38.04 E GPS   8790   8792                             1,33                                         24.2C
49MR0505_2   P03      293      1  UNK 010306 1223    UN 24 16.21 N 143 37.96 E GPS   8795   8793                                                                          AIR N2O SMPL
49MR0505_2   P03      293      1  ROS 010306 1342    BO 24 15.48 N 143 37.68 E GPS   8740   8740    -9   6482   6502      36 1-8,12,13,23,24,26,27
49MR0505_2   P03      293      1  ROS 010306 1627    EN 24 14.33 N 143 37.81 E GPS   8291   8292
49MR0505_2   P03      295      1  ROS 010306 1832    BE 24 15.04 N 143 13.67 E GPS   4674   4674
49MR0505_2   P03      295      1  BUC 010306 1839    UN 24 15.09 N 143 13.66 E GPS   4645   4646                             1,33                                         23.1C
49MR0505_2   P03      295      1  UNK 010306 1849    UN 24 15.10 N 143 13.66 E GPS   4648   4648                                                                          AIR N2O SMPL
49MR0505_2   P03      295      1  ROS 010306 1945    BO 24 15.22 N 143 13.51 E GPS   4624   4625     5   4634   4689      34 1-8,22,27                                    #2-4 FOR R.N.
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49MR0505_2   P03     295       2  UNK 010306 1953    BE 24 15.25 N 143 13.55 E GPS   4619   4618                                                                                 80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     295       2  UNK 010306 2007    EN 24 15.28 N 143 13.62 E GPS   4629   4624
49MR0505_2   P03     295       1  ROS 010306 2147    EN 24 15.63 N 143 13.39 E GPS   4648   4648
49MR0505_2   P03     297       1  ROS 010306 2345    BE 24 14.88 N 142 56.72 E GPS   2472   2480
49MR0505_2   P03     297       1  BUC 010306 2352    UN 24 14.83 N 142 56.66 E GPS   2476   2477                                 1                                               23.4C
49MR0505_2   P03     297       1  ROS 010406 0026    BO 24 14.71 N 142 56.46 E GPS   2583   2591        19   2514   2526      22 1-8,27
49MR0505_2   P03     297       1  ROS 010406 0138    EN 24 14.57 N 142 56.16 E GPS   2675   2693
49MR0505_2   P03     299       1  ROS 010406 0411    BE 24 14.19 N 142 27.31 E GPS   2914   2913
49MR0505_2   P03     299       1  BUC 010406 0419    UN 24 14.14 N 142 27.22 E GPS   2915   2914                                 1,33                                            24.8C
49MR0505_2   P03     299       1  UNK 010406 0428    UN 24 14.12 N 142 27.10 E GPS   2905   2902                                                                                 AIR N2O SMPL
49MR0505_2   P03     299       1  ROS 010406 0500    BO 24 14.02 N 142 26.73 E GPS   2888   2885        10   2970   2926      24 1-8,23,24,26,27                                 DECK UNIT FUZED (AT 2800DB, UPCAST)
49MR0505_2   P03     299       1  ROS 010406 0635    EN 24 13.69 N 142 25.66 E GPS   2854   2851
49MR0505_2   P03     301       1  ROS 010406 0900    BE 24 14.10 N 142  6.68 E GPS   2580   2579
49MR0505_2   P03     301       1  BUC 010406 0907    UN 24 14.04 N 142  6.60 E GPS   2580   2578                                 1                                               24.5C
49MR0505_2   P03     301       1  ROS 010406 0943    BO 24 13.98 N 142  6.11 E GPS   2579   2579         8   2610   2593      22 1-8,27
49MR0505_2   P03     301       1  ROS 010406 1103    EN 24 13.77 N 142  4.94 E GPS   2578   2578
49MR0505_2   P03     303       1  ROS 010406 1256    BE 24 14.35 N 141 45.54 E GPS   2520   2518
49MR0505_2   P03     303       1  BUC 010406 1304    UN 24 14.29 N 141 45.43 E GPS   2513   2516                                 1,33                                            24.9C
49MR0505_2   P03     303       1  UNK 010406 1313    UN 24 14.33 N 141 45.34 E GPS   2517   2515                                                                                 AIR N2O SMPL
49MR0505_2   P03     303       1  ROS 010406 1339    BO 24 14.40 N 141 45.20 E GPS   2507   2509         9   2525   2529      22 1-8,23,24,26,27
49MR0505_2   P03     303       1  ROS 010406 1458    EN 24 14.31 N 141 44.70 E GPS   2501   2501
49MR0505_2   P03     305       1  ROS 010406 1659    BE 24 14.72 N 141 33.59 E GPS   1320   1321                                                                                 NEAR ACTIVE SUBMARINE VOLCANO
49MR0505_2   P03     305       1  BUC 010406 1707    UN 24 14.70 N 141 33.57 E GPS   1322   1322                                 1                                               24.3C
49MR0505_2   P03     305       1  ROS 010406 1728    BO 24 14.62 N 141 33.54 E GPS   1324   1329        14   1353   1359      16 1-8,23,24,26,27
49MR0505_2   P03     305       1  ROS 010406 1821    EN 24 14.45 N 141 33.37 E GPS   1349   1342
49MR0505_2   P03     306       1  ROS 010406 2019    BE 24 14.57 N 141 24.39 E GPS    892    888
49MR0505_2   P03     306       1  BUC 010406 2025    UN 24 14.56 N 141 24.37 E GPS    892    892                                 1                                               24.1C
49MR0505_2   P03     306       1  ROS 010406 2038    BO 24 14.52 N 141 24.35 E GPS    872    885        10    876    880      13 1-8,23,24,26,27
49MR0505_2   P03     306       1  ROS 010406 2112    EN 24 14.45 N 141 24.29 E GPS    884    886
49MR0505_2   P03     308       1  ROS 010406 2313    BE 24 15.01 N 141 11.99 E GPS   1864   1865
49MR0505_2   P03     308       1  BUC 010406 2320    UN 24 15.09 N 141 11.97 E GPS   1846   1844                                 1,33                                            23.4C
49MR0505_2   P03     308       1  UNK 010406 2328    UN 24 15.13 N 141 11.99 E GPS   1839   1836                                                                                 AIR N2O SMPL
49MR0505_2   P03     308       1  ROS 010406 2345    BO 24 15.15 N 141 12.04 E GPS   1835   1834         9   1833   1841      18 1-8,27
49MR0505_2   P03     308       1  ROS 010506 0041    EN 24 15.46 N 141 12.24 E GPS   1833   1832
49MR0505_2   P03     310       1  ROS 010506 0241    BE 24 15.83 N 140 47.81 E GPS   2695   2693
49MR0505_2   P03     310       1  BUC 010506 0249    UN 24 15.91 N 140 47.74 E GPS   2679   2678                                 1                                               23.9C
49MR0505_2   P03     310       1  ROS 010506 0325    BO 24 15.99 N 140 47.56 E GPS   2681   2680        10   2680   2697      23 1-8,23,24,26,27
49MR0505_2   P03     310       1  ROS 010506 0445    EN 24 16.11 N 140 47.38 E GPS   2678   2676
49MR0505_2   P03     312       1  ROS 010506 0727    BE 24 15.67 N 140 15.98 E GPS   4024   4015
49MR0505_2   P03     312       1  BUC 010506 0733    UN 24 15.65 N 140 16.00 E GPS   4016   4016                                 1,33                                            23.0C
49MR0505_2   P03     312       1  UNK 010506 0742    UN 24 15.61 N 140 16.00 E GPS   4019   4022                                                                                 AIR N2O SMPL
49MR0505_2   P03     312       1  ROS 010506 0829    BO 24 15.44 N 140 16.17 E GPS   4015   4014        10   4034   4070      28 1-8,27
49MR0505_2   P03     312       1  ROS 010506 1026    EN 24 15.29 N 140 16.76 E GPS   4027   4026
49MR0505_2   P03     314       1  ROS 010506 1429    BE 24 13.88 N 139 24.75 E GPS   4793   4792
49MR0505_2   P03     314       1  BUC 010506 1436    UN 24 13.84 N 139 24.74 E GPS   4786   4789                                 1,31,33,82                                      22.5C
49MR0505_2   P03     314       1  UNK 010506 1447    UN 24 13.80 N 139 24.75 E GPS   4787   4787                                                                                 AIR CH4 & N2O SMPL
49MR0505_2   P03     314       1  ROS 010506 1543    BO 24 13.61 N 139 24.89 E GPS   4792   4784        10   4802   4854      32 1-8,23,24,26,27,31,33,64,82
49MR0505_2   P03     314       1  ROS 010506 1742    EN 24 12.56 N 139 24.87 E GPS   4633   4636
49MR0505_2   P03     316       1  ROS 010506 2150    BE 24 15.54 N 138 34.41 E GPS   5027   5026
49MR0505_2   P03     316       1  BUC 010506 2156    UN 24 15.55 N 138 34.35 E GPS   5026   5027                                 1,33                                            21.3C
49MR0505_2   P03     316       1  UNK 010506 2206    UN 24 15.52 N 138 34.27 E GPS   5026   5027                                                                                 AIR N2O SMPL
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49MR0505_2   P03     316      1  ROS 010506 2307    BO 24 15.27 N 138 33.80 E GPS   5027   5028         9   5061   5103      33 1-8,27
49MR0505_2   P03     316      1  ROS 010606 0116    EN 24 15.17 N 138 33.37 E GPS   5028   5028
49MR0505_2   P03     318      1  ROS 010606 0501    BE 24 14.69 N 137 48.26 E GPS   5124   5125
49MR0505_2   P03     318      1  BUC 010606 0508    UN 24 14.60 N 137 48.23 E GPS   5122   5122                                 1,33                                            21.9C
49MR0505_2   P03     318      1  UNK 010606 0517    UN 24 14.47 N 137 48.18 E GPS   5100   5106                                                                                     AIR N2O SMPL
49MR0505_2   P03     318      1  ROS 010606 0621    BO 24 14.07 N 137 47.83 E GPS   5027   5031         9   5153   5173      36 1-8,22,27                                       #2-4 FOR R.N.
49MR0505_2   P03     318      2  UNK 010606 0628    BE 24 14.04 N 137 47.79 E GPS   5029   5021                                                                                     80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03     318      2  UNK 010606 0644    EN 24 13.99 N 137 47.69 E GPS   5007   5007
49MR0505_2   P03     318      1  ROS 010606 0836    EN 24 13.47 N 137 47.40 E GPS   5060   5065
49MR0505_2   P03     X09      1  ROS 010606 1514    BE 23 59.82 N 136 59.77 E GPS   4045   4046
49MR0505_2   P03     X09      1  BUC 010606 1522    UN 23 59.77 N 136 59.78 E GPS   4045   4040                                 1,33                                            22.1C
49MR0505_2   P03     X09      1  UNK 010606 1531    UN 23 59.64 N 136 59.79 E GPS   4071   4072                                                                                     AIR N2O SMPL
49MR0505_2   P03     X09      1  ROS 010606 1622    BO 23 59.22 N 136 59.60 E GPS   4091   4100        10   4163   4166      30 1-8,12,13,23,24,26,27                           #2 DUPL FOR SALNTY
49MR0505_2   P03     X09      1  ROS 010606 1808    EN 23 58.37 N 136 59.05 E GPS   4128   4128
49MR0505_2   P03     322      1  ROS 010606 2241    BE 24 14.84 N 136 12.03 E GPS   3925   3925
49MR0505_2   P03     322      1  BUC 010606 2249    UN 24 14.65 N 136 11.97 E GPS   3948   3969                                 1,33                                            21.9C
49MR0505_2   P03     322      1  UNK 010606 2258    UN 24 14.51 N 136 11.89 E GPS   3987   3988                                                                                     AIR N2O SMPL
49MR0505_2   P03     322      1  ROS 010606 2347    BO 24 14.15 N 136 11.41 E GPS   4368   4363        10   4181   4154      29 1-8,23,24,26,27                                 #2 DUPL FOR SALNTY, #18 MISS FIRE
49MR0505_2           566      1  UNK 010706 0030    UN 24 13.93 N 136 11.10 E GPS   4539   4539                                                                                     RAIN SMPL (1.5MM/HR)
49MR0505_2   P03     322      1  ROS 010706 0136    EN 24 13.55 N 136 10.77 E GPS   4748   4765
49MR0505_2   P03     324      1  ROS 010706 0444    BE 24 15.56 N 135 36.84 E GPS   5309   5309
49MR0505_2   P03     324      1  BUC 010706 0453    UN 24 15.42 N 135 36.73 E GPS   5314   5316                                 1,33                                            22.3C
49MR0505_2   P03     324      1  UNK 010706 0503    UN 24 15.27 N 135 36.58 E GPS   5322   5320                                                                                     AIR N2O SMPL
49MR0505_2   P03     324      1  ROS 010706 0607    BO 24 14.98 N 135 36.17 E GPS   5326   5326         9   5367   5403      34 1-8,23,24,26,27
49MR0505_2   P03     324      1  ROS 010706 0820    EN 24 14.33 N 135 34.96 E GPS   5329   5330
49MR0505_2   P03     326      1  ROS 010706 1116    BE 24 14.17 N 135  2.04 E GPS   5174   5175
49MR0505_2   P03     326      1  BUC 010706 1124    UN 24 14.19 N 135  1.88 E GPS   5167   5167                                 1,33                                            22.2C
49MR0505_2   P03     326      1  UNK 010706 1134    UN 24 14.25 N 135  1.79 E GPS   5172   5176                                                                                     AIR N2O SMPL
49MR0505_2   P03     326      1  ROS 010706 1234    BO 24 14.30 N 135  1.37 E GPS   5171   5172         9   5200   5250      33 1-8,27
49MR0505_2   P03     326      1  ROS 010706 1443    EN 24 14.35 N 135  0.61 E GPS   5169   5174
49MR0505_2   P03     328      1  ROS 010706 1728    BE 24 13.89 N 134 30.70 E GPS   5034   5038
49MR0505_2   P03     328      1  BUC 010706 1738    UN 24 13.91 N 134 30.68 E GPS   5040   5041                                 1                                               23.7C
49MR0505_2   P03     328      1  ROS 010706 1848    BO 24 13.42 N 134 30.90 E GPS   5021   5022         8   5076   5108      33 1-8,23,24,26,27                                 JELLYFISH IN PRI TC DUCT(UP CAST ABOVE 1200M)
49MR0505_2   P03     328      1  ROS 010706 2055    EN 24 12.34 N 134 30.22 E GPS   5032   5030
49MR0505_2   P03     329      1  ROS 010706 2347    BE 24 12.60 N 133 59.39 E GPS   4952   4951
49MR0505_2   P03     329      1  BUC 010706 2357    UN 24 12.53 N 133 59.37 E GPS   4949   4949                                 1,33                                            22.3C
49MR0505_2   P03     329      1  UNK 010806 0007    UN 24 12.54 N 133 59.35 E GPS   4951   4949                                                                                     AIR N2O SMPL
49MR0505_2   P03     329      1  ROS 010806 0102    BO 24 12.42 N 133 59.12 E GPS   4948   4948         8   4957   5017      32 1-8,27
49MR0505_2   P03     329      1  ROS 010806 0306    EN 24 12.13 N 133 58.38 E GPS   4947   4947
49MR0505_2   P03     331      1  ROS 010806 0628    BE 24 15.81 N 133 21.58 E GPS   4645   4646
49MR0505_2   P03     331      1  BUC 010806 0636    UN 24 15.66 N 133 21.53 E GPS   4641   4642                                 1,33                                            21.9C
49MR0505_2   P03     331      1  UNK 010806 0646    UN 24 15.58 N 133 21.45 E GPS   4640   4637                                                                                     AIR N2O SMPL
49MR0505_2   P03     331      1  ROS 010806 0742    BO 24 15.33 N 133 21.01 E GPS   4642   4642         9   4700   4707      31 1-8,27
49MR0505_2   P03     331      1  ROS 010806 0941    EN 24 14.60 N 133 20.52 E GPS   4640   4641
49MR0505_2   P03     333      1  ROS 010806 1219    BE 24 16.93 N 132 49.97 E GPS   4037   4038
49MR0505_2   P03     333      1  BUC 010806 1226    UN 24 16.99 N 132 49.80 E GPS   4042   4043                                 1,31,33                                         23.7C
49MR0505_2   P03     333      1  UNK 010806 1242    UN 24 17.17 N 132 49.61 E GPS   4042   4040                                                                                     AIR N2O SMPL
49MR0505_2   P03     333      1  ROS 010806 1322    BO 24 17.38 N 132 49.35 E GPS   4047   4048        10   4097   4091      33 1-8,23,24,26,27,31,33,81                        #2-5 FOR POM
49MR0505_2   P03     333      1  ROS 010806 1510    EN 24 18.18 N 132 48.54 E GPS   4001   4001
49MR0505_2   P03     335      1  ROS 011006 0958    BE 24 15.32 N 132 12.50 E GPS   3015   3013
49MR0505_2   P03     335      1  BUC 011006 1005    UN 24 15.56 N 132 12.36 E GPS   3073   3074                                 1,33                                            23.4C
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49MR0505_2   P03      335       1  UNK 011006 1014    UN 24 15.71 N 132 12.38 E GPS   3133   3130                                                                     AIR N2O SMPL
49MR0505_2   P03      335       1  ROS 011006 1051    BO 24 16.22 N 132 12.42 E GPS   3220   3220        10   3256   3194      25 1-8,27
49MR0505_2   P03      335       1  ROS 011006 1229    EN 24 17.31 N 132 12.66 E GPS   3340   3338
49MR0505_2   P03      337       1  ROS 011006 1457    BE 24 15.05 N 131 35.86 E GPS   2380   2378
49MR0505_2   P03      337       1  BUC 011006 1504    UN 24 15.09 N 131 35.89 E GPS   2379   2379                                 1                                    23.1C
49MR0505_2   P03      337       1  ROS 011006 1537    BO 24 15.22 N 131 35.77 E GPS   2381   2381         9   2385   2396      21 1-8,23,24,26,27
49MR0505_2   P03      337       1  ROS 011006 1648    EN 24 15.36 N 131 35.27 E GPS   2375   2373
49MR0505_2   P03      339       1  ROS 011006 1918    BE 24 15.90 N 130 58.98 E GPS   3349   3351
49MR0505_2   P03      339       1  BUC 011006 1925    UN 24 16.01 N 130 58.88 E GPS   3370   3373                                 1,33                                 23.3C
49MR0505_2   P03      339       1  UNK 011006 1934    UN 24 16.09 N 130 58.75 E GPS   3358   3358                                                                     AIR N2O SMPL
49MR0505_2   P03      339       1  ROS 011006 2013    BO 24 16.25 N 130 58.14 E GPS   3489   3489        14   3486   3418      28 1-8,22,27                            #2,3 FOR R.N.
49MR0505_2   P03      339       2  UNK 011006 2017    BE 24 16.23 N 130 58.08 E GPS   3496   3495                                                                     80L THROUGH HULL PUMP FOR R.N.
49MR0505_2   P03      339       2  UNK 011006 2035    EN 24 16.25 N 130 57.80 E GPS   3563   3565
49MR0505_2   P03      339       1  ROS 011006 2144    EN 24 16.61 N 130 57.62 E GPS   3485   3486
49MR0505_2   P03      341       1  ROS 011106 0048    BE 24 14.88 N 130 22.47 E GPS   4586   4569
49MR0505_2   P03      341       1  BUC 011106 0056    UN 24 14.95 N 130 22.43 E GPS   4605   4608                                 1                                    22.2C
49MR0505_2   P03      341       1  ROS 011106 0159    BO 24 15.37 N 130 22.21 E GPS   4479   4474         9   4577   4596      31 1-8,12,13,23,24,26,27
49MR0505_2   P03      341       1  ROS 011106 0355    EN 24 16.31 N 130 21.89 E GPS   4617   4618
49MR0505_2   P03      343       1  ROS 011106 0654    BE 24 15.84 N 129 47.35 E GPS   4101   4101
49MR0505_2   P03      343       1  BUC 011106 0701    UN 24 15.89 N 129 47.25 E GPS   4089   4089                                 1,33                                 22.3C
49MR0505_2   P03      343       1  UNK 011106 0710    UN 24 15.94 N 129 47.22 E GPS   4078   4079                                                                     AIR N2O SMPL
49MR0505_2   P03      343       1  ROS 011106 0759    BO 24 16.23 N 129 47.11 E GPS   4156   4159        10   4118   4139      29 1-8,27
49MR0505_2   P03      343       1  ROS 011106 0950    EN 24 16.90 N 129 46.62 E GPS   4192   4192
49MR0505_2   P03      345       1  ROS 011106 1220    BE 24 15.66 N 129 17.33 E GPS   4385   4387
49MR0505_2   P03      345       1  BUC 011106 1229    UN 24 15.78 N 129 17.36 E GPS   4356   4357                                 1,33                                 23.1C
49MR0505_2   P03      345       1  UNK 011106 1237    UN 24 15.87 N 129 17.32 E GPS   4358   4358                                                                     AIR N2O SMPL
49MR0505_2   P03      345       1  ROS 011106 1328    BO 24 16.31 N 129 17.42 E GPS   4335   4338         9   4412   4412      30 1-8,23,24,26,27
49MR0505_2   P03      345       1  ROS 011106 1524    EN 24 17.33 N 129 17.52 E GPS   4269   4274
49MR0505_2   P03      347       1  ROS 011106 1731    BE 24 15.20 N 128 53.67 E GPS   5125   5125
49MR0505_2   P03      347       1  BUC 011106 1741    UN 24 15.29 N 128 53.69 E GPS   5129   5129                                 1                                    22.8C
49MR0505_2   P03      347       1  ROS 011106 1853    BO 24 15.98 N 128 53.75 E GPS   5169   5172        10   5225   5216      33 1-8,27
49MR0505_2   P03      347       1  ROS 011106 2115    EN 24 17.17 N 128 53.90 E GPS   5146   5146
49MR0505_2   P03      349       1  ROS 011106 2357    BE 24 15.05 N 128 24.28 E GPS   5817   5818
49MR0505_2   P03      349       1  BUC 011206 0007    UN 24 15.16 N 128 24.33 E GPS   5819   5820                                 1,31,33,82                           21.8C
49MR0505_2   P03      349       1  UNK 011206 0019    UN 24 15.27 N 128 24.37 E GPS   5817   5817                                                                     AIR N2O SMPL
49MR0505_2   P03      349       1  ROS 011206 0126    BO 24 15.52 N 128 24.46 E GPS   5838   5834         8   5835   5915      36 1-8,23,24,26,27,31,33,82
49MR0505_2   P03      349       1  ROS 011206 0352    EN 24 16.38 N 128 24.83 E GPS   5817   5819
49MR0505_2   P03      351       1  ROS 011206 0601    BE 24 33.10 N 128 13.64 E GPS   5960   5954
49MR0505_2   P03      351       1  BUC 011206 0612    UN 24 33.16 N 128 13.69 E GPS   5975   5977                                 1,33                                 21.9C
49MR0505_2   P03      351       1  UNK 011206 0620    UN 24 33.19 N 128 13.69 E GPS   5993   5993                                                                     AIR N2O SMPL
49MR0505_2   P03      351       1  ROS 011206 0734    BO 24 33.53 N 128 13.69 E GPS   5988   5988         9   6010   6082      36 1-8,27
49MR0505_2   P03      351       1  ROS 011206 1012    EN 24 34.92 N 128 13.35 E GPS   6036   6036
49MR0505_2            567       1  UNK 011306 0057    UN 24 48.77 N 128  1.59 E GPS   6920   6920                                                                     RAIN SMPL (55MM/HR)
49MR0505_2   P03      369       1  ROS 011306 0755    BE 25 54.97 N 127 11.66 E GPS     94     95
49MR0505_2   P03      369       1  BUC 011306 0758    UN 25 55.04 N 127 11.65 E GPS     95     94                                 1,33                                 21.9C
49MR0505_2   P03      369       1  ROS 011306 0800    BO 25 55.13 N 127 11.64 E GPS     93     94        11     79     82       3 1-8,23,24,26,27
49MR0505_2   P03      369       1  UNK 011306 0805    UN 25 55.22 N 127 11.66 E GPS     93     94                                                                     AIR N2O SMPL
49MR0505_2   P03      369       1  ROS 011306 0808    EN 25 55.26 N 127 11.68 E GPS     89     91
49MR0505_2   P03      367       1  ROS 011306 0956    BE 25 45.90 N 127 17.63 E GPS   1123   1123
49MR0505_2   P03      367       1  BUC 011306 1005    UN 25 45.79 N 127 17.57 E GPS   1124   1131                                 1,33                                 22.3C
49MR0505_2   P03      367       1  UNK 011306 1014    UN 25 45.73 N 127 17.45 E GPS   1174   1168                                                                     AIR N2O SMPL
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49MR0505_2	P03	367	1	ROS	011306	1021	BO	25 45.65 N	127 17.45 E	GPS	1191	1187	10	1158	1145	15	1-8,27	
49MR0505_2	P03	367	1	ROS	011306	1110	EN	25 45.25 N	127 16.88 E	GPS	1281	1290						
49MR0505_2	P03	365	1	ROS	011306	1245	BE	25 37.37 N	127 24.79 E	GPS	2155	2153						
49MR0505_2	P03	365	1	BUC	011306	1256	UN	25 37.32 N	127 24.66 E	GPS	2149	2150					1,31,33	22.1C
49MR0505_2	P03	365	1	UNK	011306	1307	UN	25 37.30 N	127 24.57 E	GPS	2139	2138						AIR N2O SMPL
49MR0505_2	P03	365	1	ROS	011306	1325	BO	25 37.20 N	127 24.46 E	GPS	2138	2140	9	2151	2150	20	1-8,23,24,26,27,31,33	
49MR0505_2	P03	365	1	ROS	011306	1438	EN	25 37.10 N	127 24.25 E	GPS	2132	2134						
49MR0505_2	P03	363	1	ROS	011306	1638	BE	25 27.96 N	127 30.96 E	GPS	2344	2343						
49MR0505_2	P03	363	1	BUC	011306	1648	UN	25 27.99 N	127 30.78 E	GPS	2343	2343					1	22.1C
49MR0505_2	P03	363	1	ROS	011306	1720	BO	25 27.93 N	127 30.72 E	GPS	2343	2344	10	2340	2356	21	1-8,27	
49MR0505_2	P03	363	1	ROS	011306	1834	EN	25 27.95 N	127 30.22 E	GPS	2470	2472						
49MR0505_2	P03	361	1	ROS	011306	2009	BE	25 19.87 N	127 37.84 E	GPS	2187	2184						
49MR0505_2	P03	361	1	BUC	011306	2016	UN	25 19.96 N	127 37.71 E	GPS	2171	2169					1,33	22.2C
49MR0505_2	P03	361	1	UNK	011306	2025	UN	25 20.02 N	127 37.57 E	GPS	2139	2142						AIR N2O SMPL
49MR0505_2	P03	361	1	ROS	011306	2044	BO	25 20.09 N	127 37.44 E	GPS	2176	2175	10	2143	2154	20	1-8,23,24,26,27	
49MR0505_2	P03	361	1	ROS	011306	2156	EN	25 20.32 N	127 36.83 E	GPS	2186	2177						
49MR0505_2	P03	359	1	ROS	011306	2357	BE	25 10.03 N	127 45.47 E	GPS	3655	3647						
49MR0505_2	P03	359	1	BUC	011406	0006	UN	25 10.16 N	127 45.36 E	GPS	3632	3632					1	22.0C
49MR0505_2	P03	359	1	ROS	011406	0057	BO	25 10.50 N	127 45.34 E	GPS	3643	3652	9	3674	3698	27	1-8,27	
49MR0505_2	P03	359	1	ROS	011406	0241	EN	25 10.98 N	127 45.51 E	GPS	3645	3651						
49MR0505_2	P03	357	1	ROS	011406	0417	BE	25 3.90 N	127 49.19 E	GPS	5184	5182						
49MR0505_2	P03	357	1	BUC	011406	0424	UN	25 3.85 N	127 49.20 E	GPS	5189	5189					1,33	22.4C
49MR0505_2	P03	357	1	UNK	011406	0434	UN	25 3.82 N	127 49.15 E	GPS	5193	5191						AIR N2O SMPL
49MR0505_2	P03	357	1	ROS	011406	0538	BO	25 3.50 N	127 48.98 E	GPS	5228	5225	11	5214	5269	33	1-8,23,24,26,27	#17 MISS TRIP
49MR0505_2	P03	357	1	ROS	011406	0751	EN	25 2.37 N	127 48.35 E	GPS	5245	5243						
49MR0505_2	P03	355	1	ROS	011406	0958	BE	24 58.38 N	127 55.03 E	GPS	6708	6713						
49MR0505_2	P03	355	1	BUC	011406	1005	UN	24 58.35 N	127 54.99 E	GPS	6703	6703					1,33	22.8C
49MR0505_2	P03	355	1	UNK	011406	1015	UN	24 58.33 N	127 54.94 E	GPS	6677	6674						AIR N2O SMPL
49MR0505_2	P03	355	1	ROS	011406	1136	BO	24 58.10 N	127 54.14 E	GPS	6571	6558	-9	6489	6502	36	1-8,27	
49MR0505_2	P03	355	1	ROS	011406	1433	EN	24 58.29 N	127 52.45 E	GPS	6283	6293						
49MR0505_2	P03	353	1	ROS	011406	1609	BE	24 49.00 N	128 1.25 E	GPS	6996	7006						
49MR0505_2	P03	353	1	BUC	011406	1617	UN	24 49.11 N	128 1.13 E	GPS	7053	7052					1,33	23.2C
49MR0505_2	P03	353	1	UNK	011406	1626	UN	24 49.20 N	128 1.07 E	GPS	7111	7094						AIR N2O SMPL
49MR0505_2	P03	353	1	ROS	011406	1751	BO	24 49.87 N	128 0.92 E	GPS	7412	7411	-9	6438	6501	36	1-8,23,24,26,27	
49MR0505_2	P03	353	1	ROS	011406	2054	EN	24 51.54 N	128 0.68 E	GPS	7303	7303						
49MR0505_2	P03	351	2	ROS	011406	2309	BE	24 33.00 N	128 13.49 E	GPS	5968	5969						
49MR0505_2	P03	351	2	BUC	011406	2316	UN	24 33.05 N	128 13.52 E	GPS	5948	5949					1,33	22.7C
49MR0505_2	P03	351	2	UNK	011406	2325	UN	24 33.08 N	128 13.51 E	GPS	5972	5961						AIR N2O SMPL
49MR0505_2	P03	351	2	ROS	011506	0038	BO	24 33.35 N	128 13.63 E	GPS	5972	5972	11	5975	6062	35	1,2	#14 MISS FIRE, #21 MISS TRIP
49MR0505_2	P03	351	2	ROS	011506	0311	EN	24 33.88 N	128 13.88 E	GPS	6031	6020						

Parameter

1=Salinity, 2=Oxygen, 3=Silicate, 4=Nitrate, 5=Nitrite, 6=PHOSPHATE, 7=CFC-11, 8=CFC-12, 12=Δ^{14}C, 13=δ^{13}C, 22=^{137}CS, 23= Total carbon, 24=Alkalinity, 26=PH, 27=CFC-113, 31= CH_4, 33=N_2O, 42= Abundance of bacteria, 64= Incubation, 81= Particulate organic matter, 82=$^{15}NO_3$

49MR0505_3.sum file

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P03 REV R/V MIRAI CRUISE MR0505 LEG 3
SHIP/CRS    WOCE                CAST         UTC EVENT          POSITION             UNC    COR HT ABOVE   WIRE    MAX  NO. OF
EXPOCODE    SECT  STNNBR CASTNO TYPE DATE   TIME  CODE LATITUDE    LONGITUDE  NAV  DEPTH  DEPTH   BOTTOM    OUT  PRESS BOTTLES PARAMETERS                                    COMMENTS
49MR0505_3   P03     370      1  ROS 012006 0650    BE 26 23.41 N 126 42.26 E GPS    406    406
49MR0505_3   P03     370      1  BUC 012006 0651    UN 26 23.40 N 126 42.26 E GPS    397    398                                1,33,42                                       22.3C
49MR0505_3   P03     370      1  ROS 012006 0659    BO 26 23.31 N 126 42.22 E GPS    328    328       16    304    308       9 1-8,27,42
49MR0505_3   P03     370      1  UNK 012006 0703    UN 26 23.27 N 126 42.20 E GPS    311    311                                                                              AIR N2O SMPL
49MR0505_3   P03     370      1  ROS 012006 0725    EN 26 23.03 N 126 42.10 E GPS    194    194
49MR0505_3   P03     372      1  ROS 012006 0831    BE 26 27.07 N 126 37.50 E GPS   1400   1402
49MR0505_3   P03     372      1  BUC 012006 0839    UN 26 27.04 N 126 37.53 E GPS   1387   1387                                1,31,33,42                                    22.3C
49MR0505_3   P03     372      1  UNK 012006 0852    UN 26 27.03 N 126 37.55 E GPS   1371   1370                                                                              AIR N2O SMPL
49MR0505_3   P03     372      1  ROS 012006 0858    BO 26 27.02 N 126 37.54 E GPS   1366   1365       13   1369   1376      18 1-8,23,24,26,27,31,33,42,81
49MR0505_3   P03     372      1  ROS 012006 1006    EN 26 26.81 N 126 37.58 E GPS   1324   1325
49MR0505_3   P03     374      1  ROS 012006 1205    BE 26 36.26 N 126 31.57 E GPS   1488   1489
49MR0505_3   P03     374      1  BUC 012006 1213    UN 26 36.21 N 126 31.53 E GPS   1488   1489                                1,33,42                                       22.2C
49MR0505_3   P03     374      1  UNK 012006 1223    UN 26 36.17 N 126 31.47 E GPS   1491   1491                                                                              AIR N2O SMPL
49MR0505_3   P03     374      1  ROS 012006 1234    BO 26 36.29 N 126 31.34 E GPS   1516   1516       14   1509   1489      19 1-8,27,42
49MR0505_3   P03     374      1  ROS 012006 1342    EN 26 36.73 N 126 30.46 E GPS   1513   1516
49MR0505_3   P03     376      1  ROS 012006 1519    BE 26 44.02 N 126 20.27 E GPS   1900   1903
49MR0505_3   P03     376      1  BUC 012006 1528    UN 26 44.07 N 126 20.13 E GPS   1912   1913                                1,42                                          22.5C
49MR0505_3   P03     376      1  ROS 012006 1557    BO 26 44.38 N 126 19.77 E GPS   1910   1913       14   1946   1891      22 1-8,12,13,23,24,26,27,42                      #17=#19 DUPL SMPLS (1800DB)
49MR0505_3   P03     376      1  ROS 012006 1718    EN 26 45.27 N 126 18.91 E GPS   1897   1897
49MR0505_3   P03     378      1  ROS 012006 1906    BE 26 53.17 N 126 11.44 E GPS   1536   1536
49MR0505_3   P03     378      1  BUC 012006 1914    UN 26 53.25 N 126 11.36 E GPS   1532   1533                                1,33,42                                       22.7C
49MR0505_3   P03     378      1  UNK 012006 1927    UN 26 53.42 N 126 11.24 E GPS   1532   1532                                                                              AIR N2O SMPL
49MR0505_3   P03     378      1  ROS 012006 1935    BO 26 53.48 N 126 11.18 E GPS   1535   1535       10   1540   1530      19 1-8,27,42
49MR0505_3   P03     378      1  ROS 012006 2044    EN 26 54.11 N 126 10.73 E GPS   1554   1553
49MR0505_3   P03     380      1  ROS 012006 2220    BE 26 57.86 N 126  5.07 E GPS   1417   1417
49MR0505_3   P03     380      1  BUC 012006 2229    UN 26 57.99 N 126  5.03 E GPS   1417   1417                                1,42                                          23.2C
49MR0505_3   P03     380      1  ROS 012006 2248    BO 26 58.19 N 126  4.94 E GPS   1357   1356       10   1349   1353      19 1-8,23,24,26,27,42                            #23 MISS TRIP, SEAWATER SAMPLE (#23)
                                                                                                                                                                             COLLECTED FROM #5

49MR0505_3   P03     380      1  ROS 012006 2356    EN 26 58.84 N 126  4.54 E GPS    977    977
49MR0505_3   P03     382      1  ROS 012106 0147    BE 27  4.27 N 125 58.71 E GPS    863    863
49MR0505_3   P03     382      1  BUC 012106 0156    UN 27  4.38 N 125 58.66 E GPS    853    853                                1,31,33,42                                    22.6C
49MR0505_3   P03     382      1  ROS 012106 0206    BO 27  4.44 N 125 58.56 E GPS    837    836       11    835    838      18 1-8,23,24,26,27,31,33,42,81                   #23=#25 DUPL SMPLS (800DB)
49MR0505_3   P03     382      1  UNK 012106 0211    UN 27  4.45 N 125 58.53 E GPS    829    830                                                                              AIR CH4 & N2O SMPL
49MR0505_3   P03     382      1  ROS 012106 0251    EN 27  4.91 N 125 58.36 E GPS    780    780
49MR0505_3   P03     382      2  ROS 012106 2254    BE 27  4.34 N 125 58.63 E GPS    851    851
49MR0505_3   P03     382      2  BUC 012106 2303    UN 27  4.45 N 125 58.56 E GPS    838    838                                1,33                                          23.2C
49MR0505_3   P03     382      2  UNK 012106 2312    UN 27  4.46 N 125 58.54 E GPS    829    829                                                                              AIR N2O SMPL
49MR0505_3   P03     382      2  ROS 012106 2315    BO 27  4.46 N 125 58.53 E GPS    829    829       12    819    826      15 1,2
49MR0505_3   P03     382      2  ROS 012206 0002    EN 27  4.68 N 125 58.27 E GPS    790    790
49MR0505_3   P03     384      1  ROS 012206 0052    BE 27  9.92 N 125 52.99 E GPS    307    307
49MR0505_3   P03     384      1  BUC 012206 0054    UN 27  9.91 N 125 52.98 E GPS    301    301                                1,42                                          22.5C
49MR0505_3   P03     384      1  ROS 012206 0100    BO 27  9.90 N 125 52.96 E GPS    303    304       12    282    288       9 1-8,23,24,26,27,42
49MR0505_3   P03     384      1  ROS 012206 0124    EN 27  9.86 N 125 52.89 E GPS    296    296
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49MR0505_3   P03      385      1  ROS 012206 0239    BE 27 18.81 N 125 44.22 E GPS    145    145
49MR0505_3   P03      385      1  BUC 012206 0241    UN 27 18.81 N 125 44.22 E GPS    146    146                                1,33,42                             22.2C
49MR0505_3   P03      385      1  ROS 012206 0244    BO 27 18.85 N 125 44.24 E GPS    145    145      9    128    135       6 1-8,27,42
49MR0505_3   P03      385      1  UNK 012206 0251    UN 27 18.93 N 125 44.25 E GPS    146    146                                                                    AIR N2O SMPL
49MR0505_3   P03      385      1  ROS 012206 0255    EN 27 18.99 N 125 44.26 E GPS    145    145
49MR0505_3   P03      386      1  ROS 012206 0403    BE 27 27.13 N 125 35.26 E GPS    124    124
49MR0505_3   P03      386      1  BUC 012206 0406    UN 27 27.17 N 125 35.27 E GPS    121    121                                1,42                                20.3C
49MR0505_3   P03      386      1  ROS 012206 0409    BO 27 27.21 N 125 35.28 E GPS    122    122      9    111    111       6 1-8,27,42
49MR0505_3   P03      386      1  ROS 012206 0421    EN 27 27.41 N 125 35.28 E GPS    122    122
49MR0505_3   P03      387      1  ROS 012206 0537    BE 27 36.34 N 125 26.30 E GPS    117    117
49MR0505_3   P03      387      1  BUC 012206 0539    UN 27 36.35 N 125 26.29 E GPS    117    117                                1,33,42                             19.4C
49MR0505_3   P03      387      1  ROS 012206 0542    BO 27 36.36 N 125 26.27 E GPS    118    118     11    100    102       5 1-8,27,42
49MR0505_3   P03      387      1  UNK 012206 0548    UN 27 36.39 N 125 26.26 E GPS    114    115                                                                    AIR N2O SMPL
49MR0505_3   P03      387      1  ROS 012206 0554    EN 27 36.40 N 125 26.25 E GPS    115    115
49MR0505_3   P03      388      1  ROS 012206 0727    BE 27 44.96 N 125 12.93 E GPS    111    111
49MR0505_3   P03      388      1  BUC 012206 0729    UN 27 44.96 N 125 12.93 E GPS    112    112                                1,42                                17.1C
49MR0505_3   P03      388      1  ROS 012206 0732    BO 27 44.96 N 125 12.92 E GPS    112    112     11     95     98       5 1-8,27,42
49MR0505_3   P03      388      1  ROS 012206 0743    EN 27 44.94 N 125 12.89 E GPS    111    111
49MR0505_3   P03      389      1  ROS 012206 0949    BE 28  0.18 N 124 59.36 E GPS    102    103
49MR0505_3   P03      389      1  BUC 012206 0949    UN 28  0.18 N 124 59.36 E GPS    102    103                                1,31,33,42                          16.9C
49MR0505_3   P03      389      1  ROS 012206 0955    BO 28  0.11 N 124 59.32 E GPS    104    104     11     87     92       6 1-8,27,31,33,42,81
49MR0505_3   P03      389      1  UNK 012206 1004    UN 28  0.06 N 124 59.27 E GPS    103    103                                                                    AIR N2O SMPL
49MR0505_3   P03      389      1  ROS 012206 1006    EN 28  0.06 N 124 59.27 E GPS    104    104
49MR0505_3   P03      390      1  ROS 012306 0429    BE 28 51.44 N 129 49.87 E GPS    215    215
49MR0505_3   P03      390      1  BUC 012306 0431    UN 28 51.44 N 129 49.85 E GPS    215    215                                1,31,33,42                          20.6C
49MR0505_3   P03      390      1  UNK 012306 0432    UN 28 51.44 N 129 49.84 E GPS    213    213                                                                    AIR N2O SMPL
49MR0505_3   P03      390      1  ROS 012306 0435    BO 28 51.41 N 129 49.83 E GPS    215    215     10    200    201       7 1-8,23,24,26,27,31,33,42,81
49MR0505_3   P03      390      1  ROS 012306 0450    EN 28 51.30 N 129 49.79 E GPS    207    207
49MR0505_3   P03      392      1  ROS 012306 0606    BE 29  0.43 N 129 54.47 E GPS    654    654
49MR0505_3   P03      392      1  BUC 012306 0613    UN 29  0.32 N 129 54.49 E GPS    660    660                                1,42                                20.7C
49MR0505_3   P03      392      1  ROS 012306 0623    BO 29  0.26 N 129 54.49 E GPS    664    664      9    676    659      13 1-8,23,24,26,27,42
49MR0505_3   P03      392      1  ROS 012306 0656    EN 29  0.01 N 129 54.64 E GPS    671    671
49MR0505_3   P03      394      1  ROS 012306 0830    BE 29  6.77 N 129 57.62 E GPS   1198   1198
49MR0505_3   P03      394      1  BUC 012306 0838    UN 29  6.65 N 129 57.70 E GPS   1167   1168                                1,33,42                             21.0C
49MR0505_3   P03      394      1  UNK 012306 0849    UN 29  6.49 N 129 57.86 E GPS   1148   1148                                                                    AIR N2O SMPL
49MR0505_3   P03      394      1  ROS 012306 0857    BO 29  6.45 N 129 57.93 E GPS   1134   1135     10   1143   1143      17 1-8,23,24,26,27,42
49MR0505_3   P03      394      1  ROS 012306 0946    EN 29  5.76 N 129 58.50 E GPS   1026   1027
49MR0505_3   P03      396      1  ROS 012306 1148    BE 29 17.98 N 130  2.78 E GPS   1186   1186
49MR0505_3   P03      396      1  BUC 012306 1156    UN 29 17.88 N 130  2.77 E GPS   1188   1187                                1,31,33,42                          20.8C
49MR0505_3   P03      396      1  UNK 012306 1207    UN 29 17.71 N 130  2.77 E GPS   1199   1198                                                                    AIR N2O SMPL
49MR0505_3   P03      396      1  ROS 012306 1211    BO 29 17.67 N 130  2.77 E GPS   1204   1199      9   1182   1182      20 1-8,23,24,26,27,31,33,42,81
49MR0505_3   P03      396      1  ROS 012306 1305    EN 29 17.04 N 130  2.69 E GPS   1214   1214
49MR0505_3   P03      398      1  ROS 012306 1506    BE 29 24.97 N 130  7.35 E GPS    424    424
49MR0505_3   P03      398      1  BUC 012306 1511    UN 29 25.00 N 130  7.38 E GPS    425    425                                1,42                                20.8C
49MR0505_3   P03      398      1  ROS 012306 1519    BO 29 24.97 N 130  7.43 E GPS    425    425     10    413    415      10 1-8,23,24,26,27,42
49MR0505_3   P03      398      1  ROS 012306 1541    EN 29 24.93 N 130  7.60 E GPS    419    418
49MR0505_3   P03      400      1  ROS 012306 1718    BE 29 35.23 N 130 11.22 E GPS    484    484
49MR0505_3   P03      400      1  BUC 012306 1721    UN 29 35.21 N 130 11.30 E GPS    482    482                                1,33,42                             20.9C
49MR0505_3   P03      400      1  ROS 012306 1730    BO 29 35.19 N 130 11.47 E GPS    484    484     13    468    472      11 1-8,23,24,26,27,42
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49MR0505_3   P03      400      1  UNK 012306 1732    UN 29 35.17 N 130 11.49 E GPS     485    484                                                                                 AIR N2O SMPL
49MR0505_3   P03      400      1  ROS 012306 1758    EN 29 34.98 N 130 11.89 E GPS     486    487
49MR0505_3   P03      402      1  ROS 012306 1930    BE 29 44.63 N 130 16.52 E GPS     307    307
49MR0505_3   P03      402      1  BUC 012306 1934    UN 29 44.59 N 130 16.52 E GPS     304    304                                 1,31,33,42                                      20.4C
49MR0505_3   P03      402      1  ROS 012306 1938    BO 29 44.55 N 130 16.52 E GPS     304    304       10     291    296       9 1-8,23,24,26,27,31,33,42,81
49MR0505_3   P03      402      1  UNK 012306 1946    UN 29 44.48 N 130 16.53 E GPS     307    307                                                                                 AIR CH4 & N2O SMPL
49MR0505_3   P03      402      1  ROS 012306 2000    EN 29 44.35 N 130 16.57 E GPS     310    310
49MR0505_3   P03      404      1  ROS 012306 2129    BE 29 56.77 N 130 22.55 E GPS     417    417
49MR0505_3   P03      404      1  BUC 012306 2130    UN 29 56.76 N 130 22.55 E GPS     418    418                                 1,42                                            20.3C
49MR0505_3   P03      404      1  ROS 012306 2140    BO 29 56.63 N 130 22.59 E GPS     417    416        9     406    405      10 1-8,23,24,26,27,42
49MR0505_3   P03      404      1  ROS 012306 2205    EN 29 56.23 N 130 22.71 E GPS     401    401
49MR0505_3   P03      406      1  ROS 012306 2335    BE 30  1.86 N 130 24.71 E GPS     408    410
49MR0505_3   P03      406      1  BUC 012306 2337    UN 30  1.84 N 130 24.72 E GPS     416    417                                 1,33,42                                         20.2C
49MR0505_3   P03      406      1  ROS 012306 2345    BO 30  1.72 N 130 24.78 E GPS     415    415       11     406    407      10 1-8,23,24,26,27,42
49MR0505_3   P03      406      1  UNK 012306 2349    UN 30  1.67 N 130 24.80 E GPS     423    423                                                                                 AIR N2O SMPL
49MR0505_3   P03      406      1  ROS 012406 0009    EN 30  1.33 N 130 24.91 E GPS     421    421
49MR0505_3   P03      408      1  ROS 012406 0140    BE 30  6.89 N 130 28.16 E GPS     239    239
49MR0505_3   P03      408      1  BUC 012406 0142    UN 30  6.85 N 130 28.18 E GPS     238    238                                 1,31,33,42                                      20.0C
49MR0505_3   P03      408      1  ROS 012406 0147    BO 30  6.79 N 130 28.23 E GPS     241    241       10     226    229      10 1-8,23,24,26,27,31,33,42,81
49MR0505_3   P03      408      1  UNK 012406 0154    UN 30  6.72 N 130 28.25 E GPS     242    242                                                                                 AIR N2O SMPL
49MR0505_3   P03      408      1  ROS 012406 0203    EN 30  6.63 N 130 28.27 E GPS     246    246
49MR0505_3   P03      TS7      1  ROS 012506 1859    BE 34 25.46 N 130 43.74 E GPS     100    100
49MR0505_3   P03      TS7      1  UNK 012506 1900    UN 34 25.45 N 130 43.74 E GPS     101    101                                                                                 AIR N2O SMPL
49MR0505_3   P03      TS7      1  BUC 012506 1902    UN 34 25.43 N 130 43.71 E GPS     100    100                                 1,31,33,42                                      14.3C
49MR0505_3   P03      TS7      1  ROS 012506 1905    BO 34 25.39 N 130 43.68 E GPS     102    101       10      84     86       6 1-8,27,31,33,42,81
49MR0505_3   P03      TS7      1  ROS 012506 1915    EN 34 25.22 N 130 43.61 E GPS      96     95
49MR0505_3   P03      TS6      1  ROS 012506 2029    BE 34 30.23 N 130 38.85 E GPS     121    121
49MR0505_3   P03      TS6      1  BUC 012506 2030    UN 34 30.23 N 130 38.84 E GPS     121    121                                 1,42                                            14.2C
49MR0505_3   P03      TS6      1  ROS 012506 2035    BO 34 30.17 N 130 38.83 E GPS     119    119       10     105    108       5 1-8,27,42
49MR0505_3   P03      TS6      1  ROS 012506 2045    EN 34 30.07 N 130 38.72 E GPS     121    120
49MR0505_3   P03      TS5      1  BUC 012506 2216    UN 34 39.84 N 130 26.12 E GPS     134    134                                 1,33,42                                         14.6C
49MR0505_3   P03      TS5      1  ROS 012506 2216    BE 34 39.84 N 130 26.11 E GPS     133    134
49MR0505_3   P03      TS5      1  UNK 012506 2218    UN 34 39.83 N 130 26.08 E GPS     133    133                                                                                 AIR N2O SMPL
49MR0505_3   P03      TS5      1  ROS 012506 2222    BO 34 39.81 N 130 26.02 E GPS     133    133       11     117    119       5 1-8,27,42
49MR0505_3   P03      TS5      1  ROS 012506 2234    EN 34 39.77 N 130 25.96 E GPS     133    133
49MR0505_3   P03      TS4      1  ROS 012606 0000    BE 34 50.05 N 130 11.83 E GPS     126    126
49MR0505_3   P03      TS4      1  BUC 012606 0003    UN 34 50.04 N 130 11.82 E GPS     126    126                                 1,31,33,42                                      14.2C
49MR0505_3   P03      TS4      1  UNK 012606 0004    UN 34 50.04 N 130 11.82 E GPS     126    126                                                                                 AIR CH4 & N2O SMPL
49MR0505_3   P03      TS4      1  ROS 012606 0006    BO 34 50.04 N 130 11.82 E GPS     126    126       10     111    113       6 1-8,27,31,33,42,81
49MR0505_3   P03      TS4      1  ROS 012606 0017    EN 34 50.01 N 130 11.80 E GPS     126    126
49MR0505_3   P03      TS3      1  ROS 012606 0144    BE 35  0.55 N 129 58.65 E GPS     134    134
49MR0505_3   P03      TS3      1  BUC 012606 0146    UN 35  0.55 N 129 58.67 E GPS     135    135                                 1,33                                            14.0C
49MR0505_3   P03      TS3      1  UNK 012606 0148    UN 35  0.55 N 129 58.67 E GPS     133    133                                                                                 AIR N2O SMPL
49MR0505_3   P03      TS3      1  ROS 012606 0149    BO 35  0.55 N 129 58.68 E GPS     135    135       10     121    124       5 1-8,27
49MR0505_3   P03      TS3      1  ROS 012606 0201    EN 35  0.54 N 129 58.74 E GPS     134    134
49MR0505_3   P03      TS2      1  ROS 012606 0335    BE 35 11.74 N 129 44.03 E GPS     141    141
49MR0505_3   P03      TS2      1  BUC 012606 0337    UN 35 11.72 N 129 44.01 E GPS     142    142                                 1                                               13.8C
49MR0505_3   P03      TS2      1  ROS 012606 0341    BO 35 11.68 N 129 43.97 E GPS     142    142       10     129    130       6 1-8,27
49MR0505_3   P03      TS2      1  ROS 012606 0351    EN 35 11.61 N 129 43.89 E GPS     143    143
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49MR0505_3   P03     TS1      1  ROS 012606 0457    BE 35 16.21 N 129 39.00 E GPS    146    146
49MR0505_3   P03     TS1      1  BUC 012606 0500    UN 35 16.21 N 129 39.00 E GPS    148    148                                1,31,33                                14.2C
49MR0505_3   P03     TS1      1  UNK 012606 0501    UN 35 16.22 N 129 39.00 E GPS    146    146                                                                       AIR N2O SMPL
49MR0505_3   P03     TS1      1  ROS 012606 0504    BO 35 16.22 N 129 39.03 E GPS    144    144      10    132    135       7 1-8,27,31,33,81
49MR0505_3   P03     TS1      1  ROS 012606 0516    EN 35 16.29 N 129 39.06 E GPS    147    147
49MR0505_3           568      1  XCT 012706 0955    DE 37 18.81 N 133 47.52 E GPS   1670   1672
49MR0505_3           569      1  UNK 012806 0825    BE 39 13.68 N 138 29.13 E GPS    988    988                                                                       FIGURE-OF-EIGHT SAILING FOR MAGNETOMETER
49MR0505_3           569      1  UNK 012806 0850    EN 39 14.42 N 138 29.28 E GPS    990    990
```

Parameter

1=Salinity, 2=Oxygen, 3=Silicate, 4=Nitrate, 5=Nitrite, 6=PHOSPHATE, 7=CFC-11, 8=CFC-12, 12=$\Delta^{14}C$, 13=$\delta^{13}C$, 22=^{137}CS, 23= Total carbon, 24=Alkalinity, 26=PH, 27=CFC-113, 31= CH_4, 33=N_2O, 42= Abundance of bacteria, 64= Incubation, 81= Particulate organic matter, 82=$^{15}NO_3$

Figure 1

Station locations for WHP P03 cruise

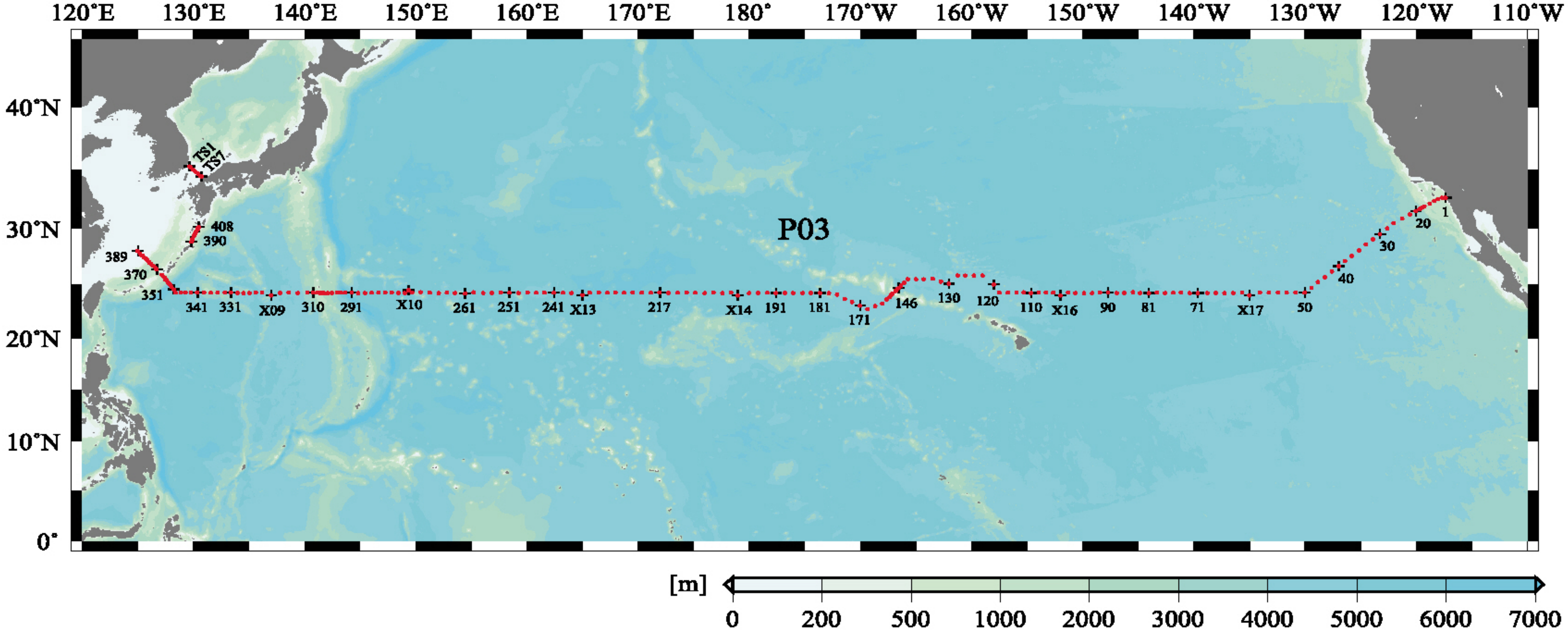

Figure 2

Bathymetry measured by Multi Narrow Beam Echo Sounding System

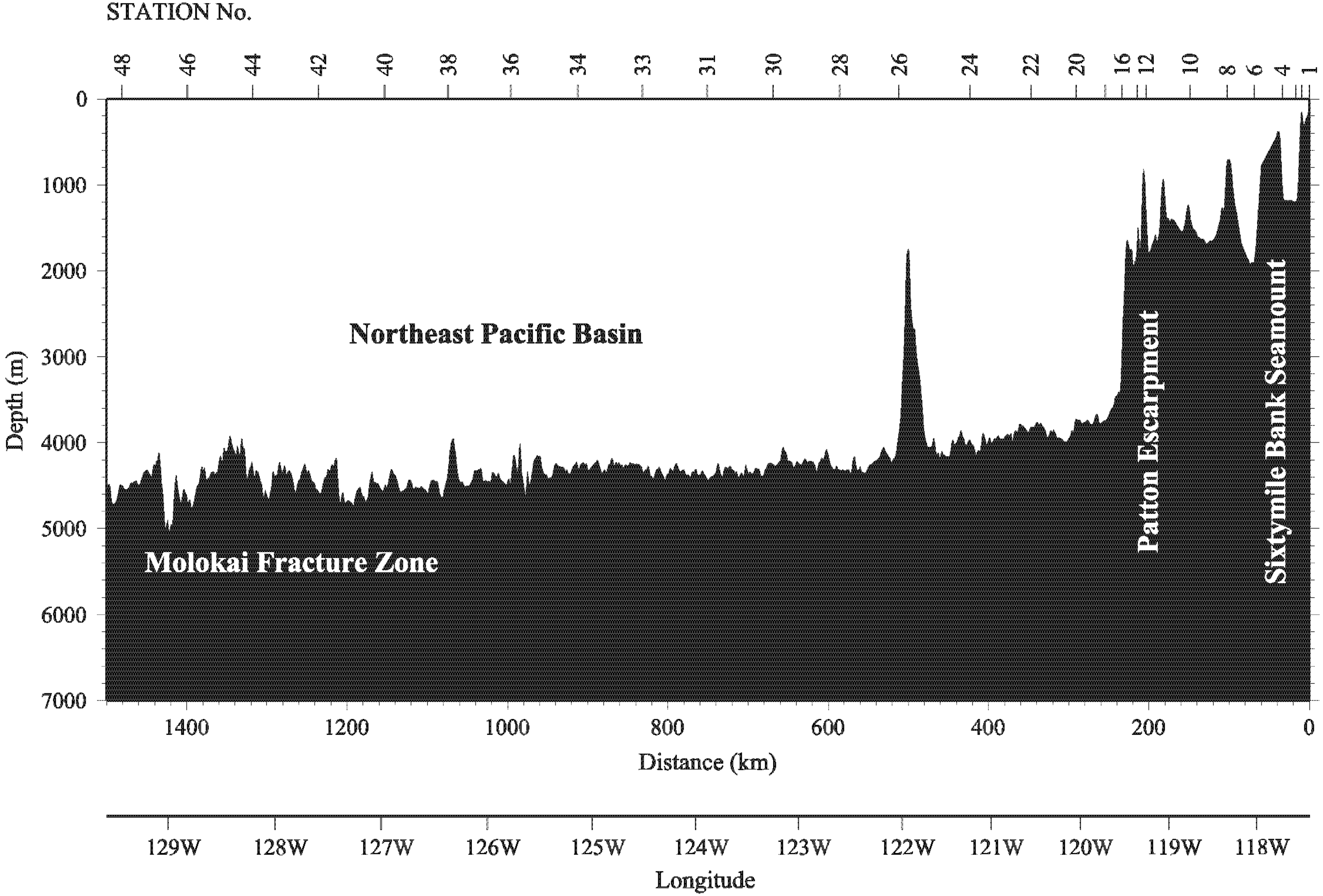

Figure 2
Continued

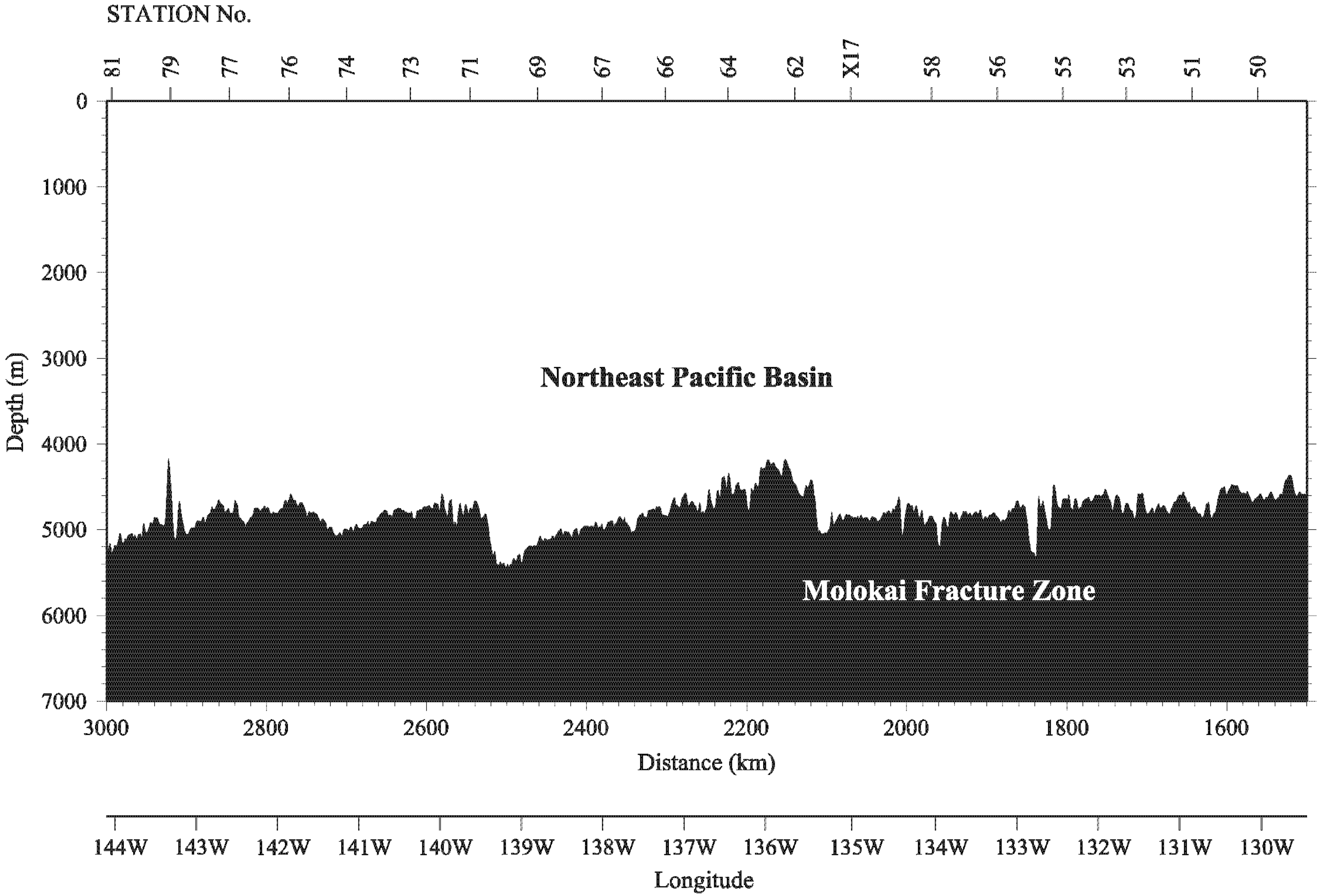

Figure 2
Continued

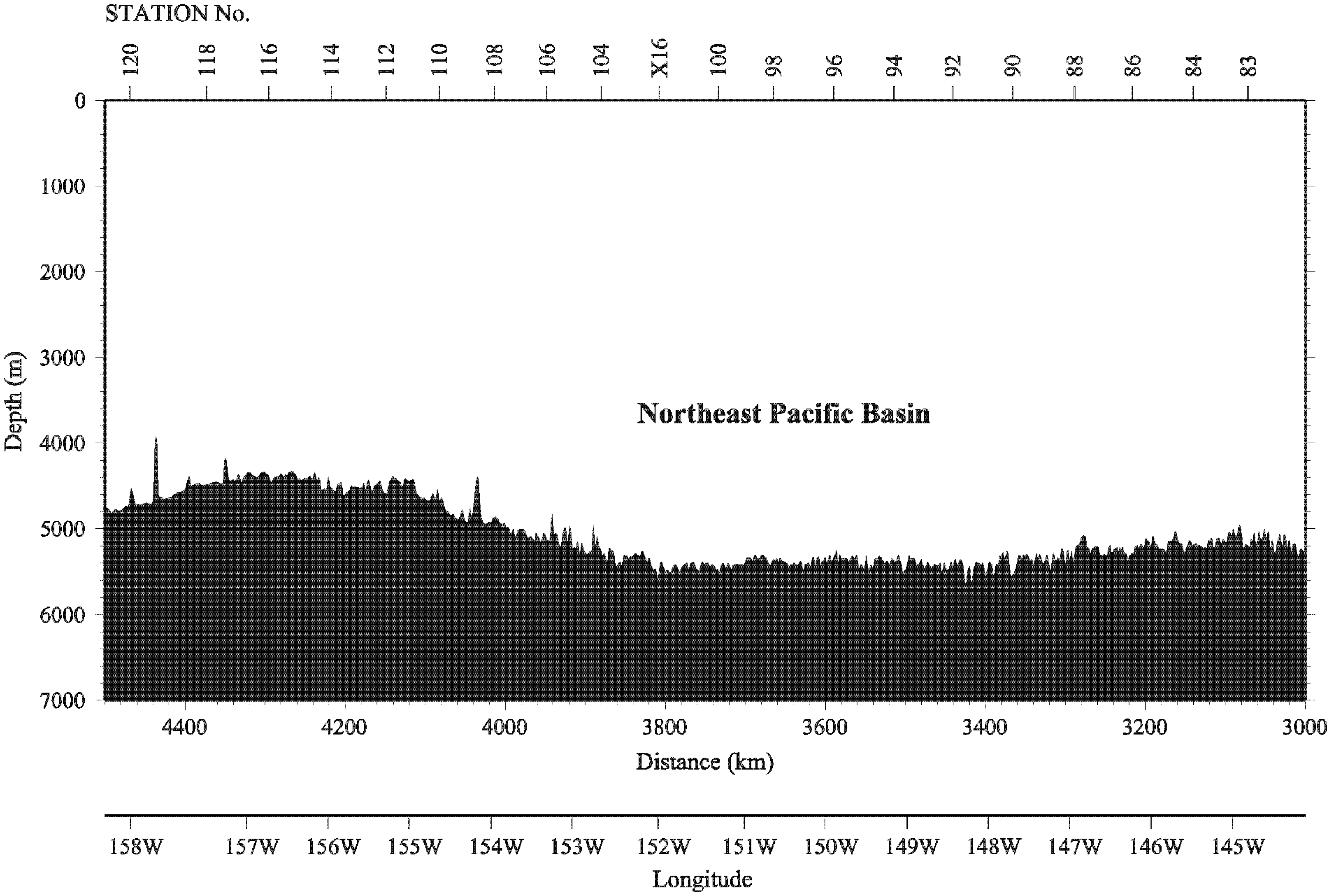

Figure 2
Continued

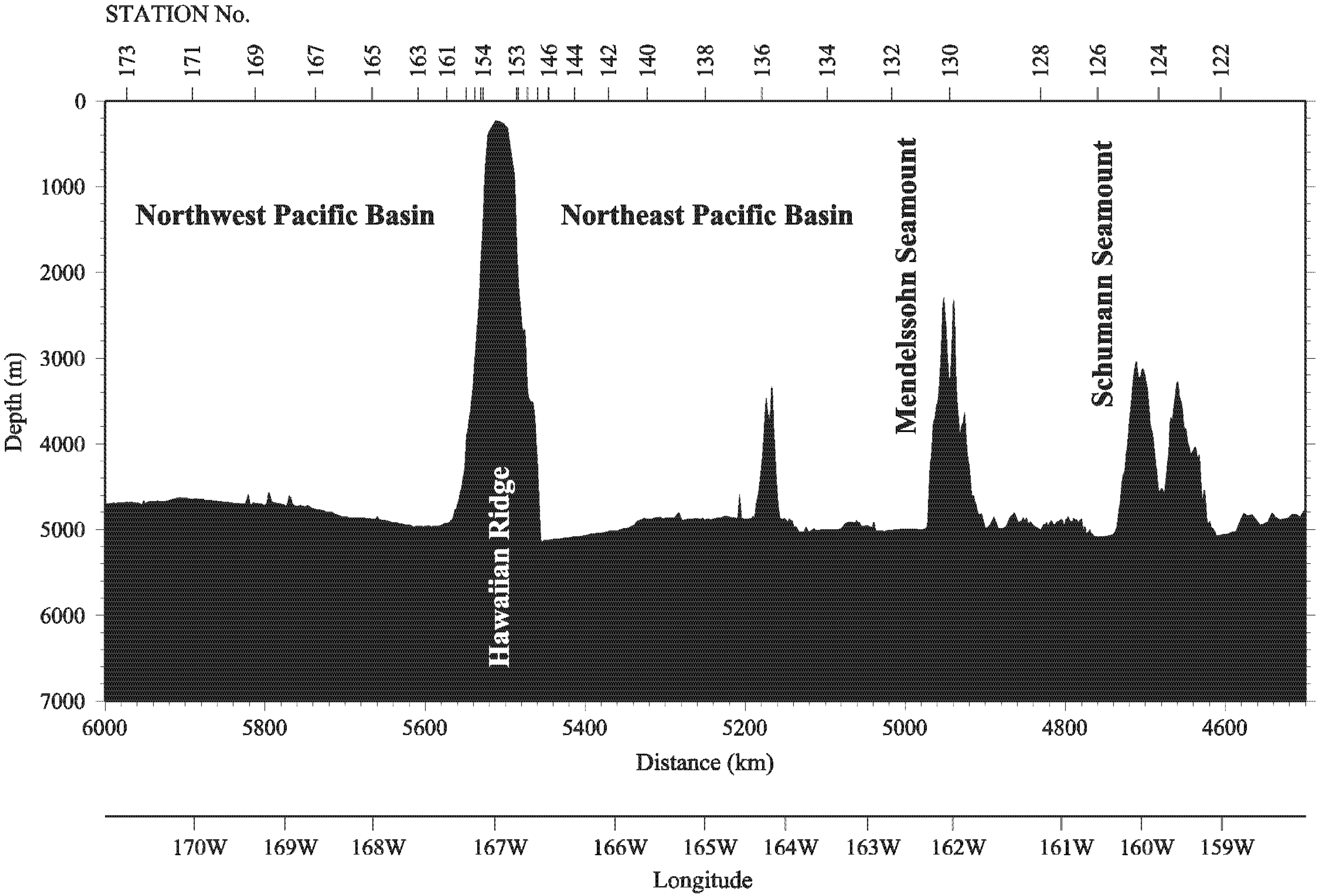

Figure 2
Continued

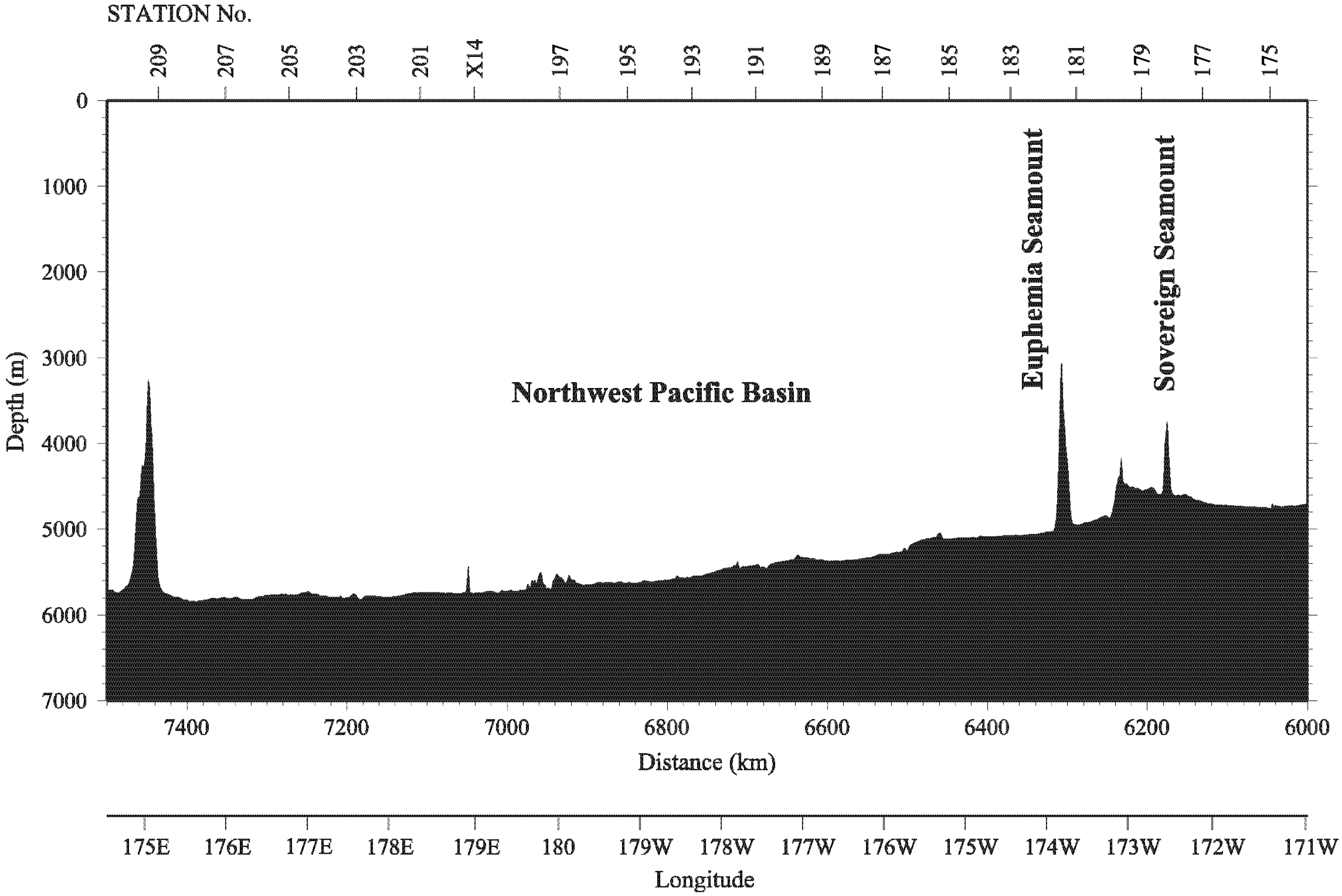

Figure 2
Continued

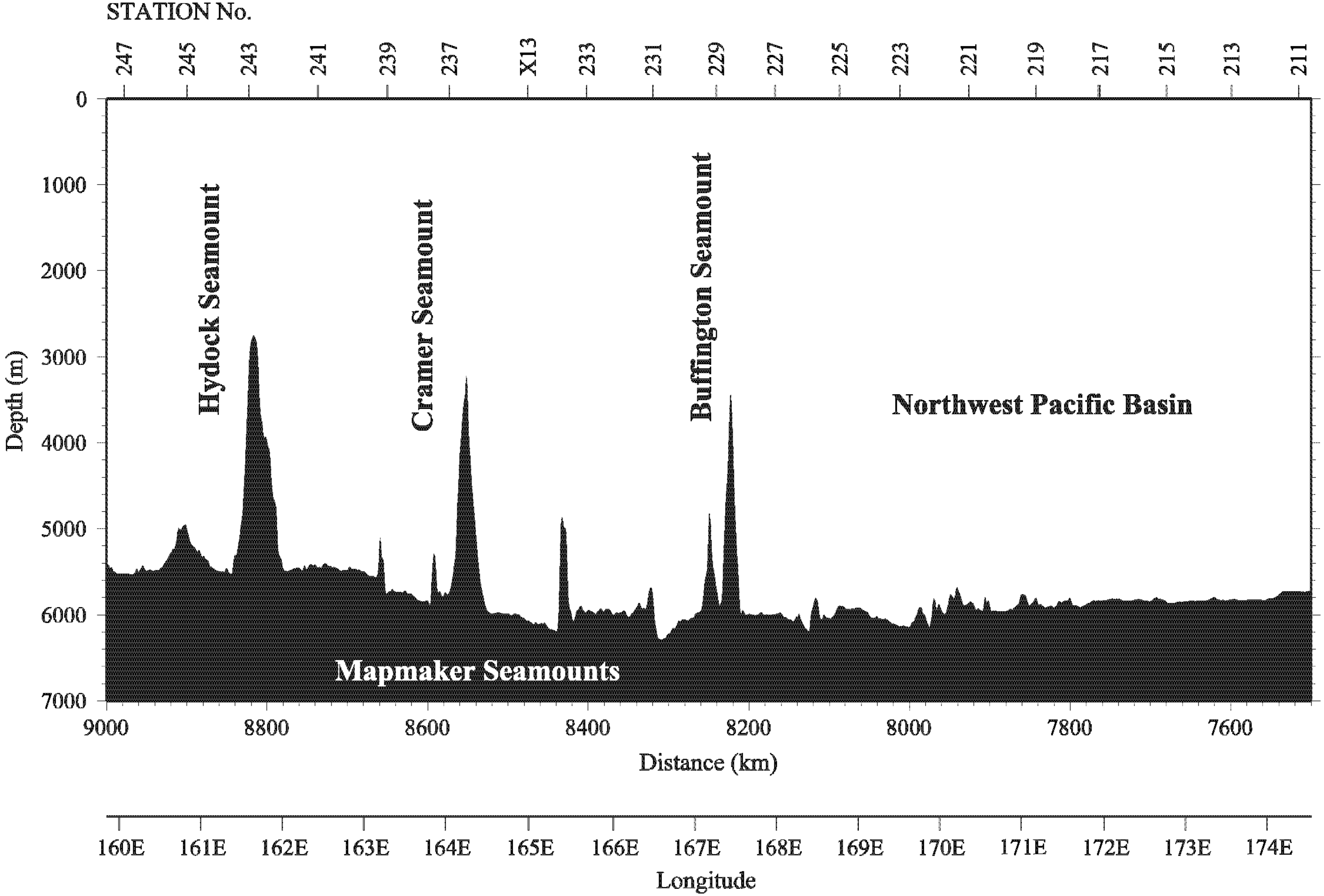

Figure 2
Continued

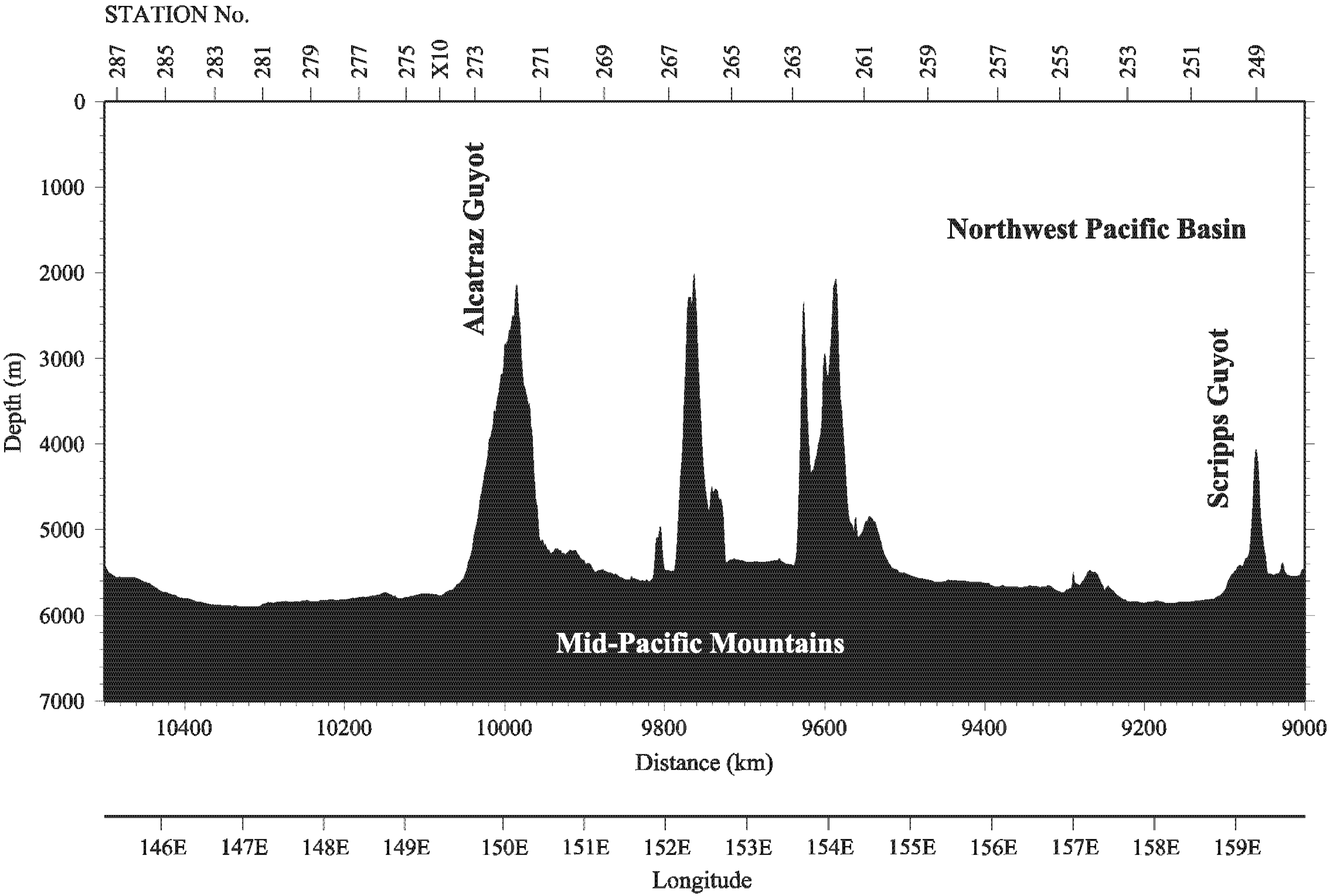

Figure 2
Continued

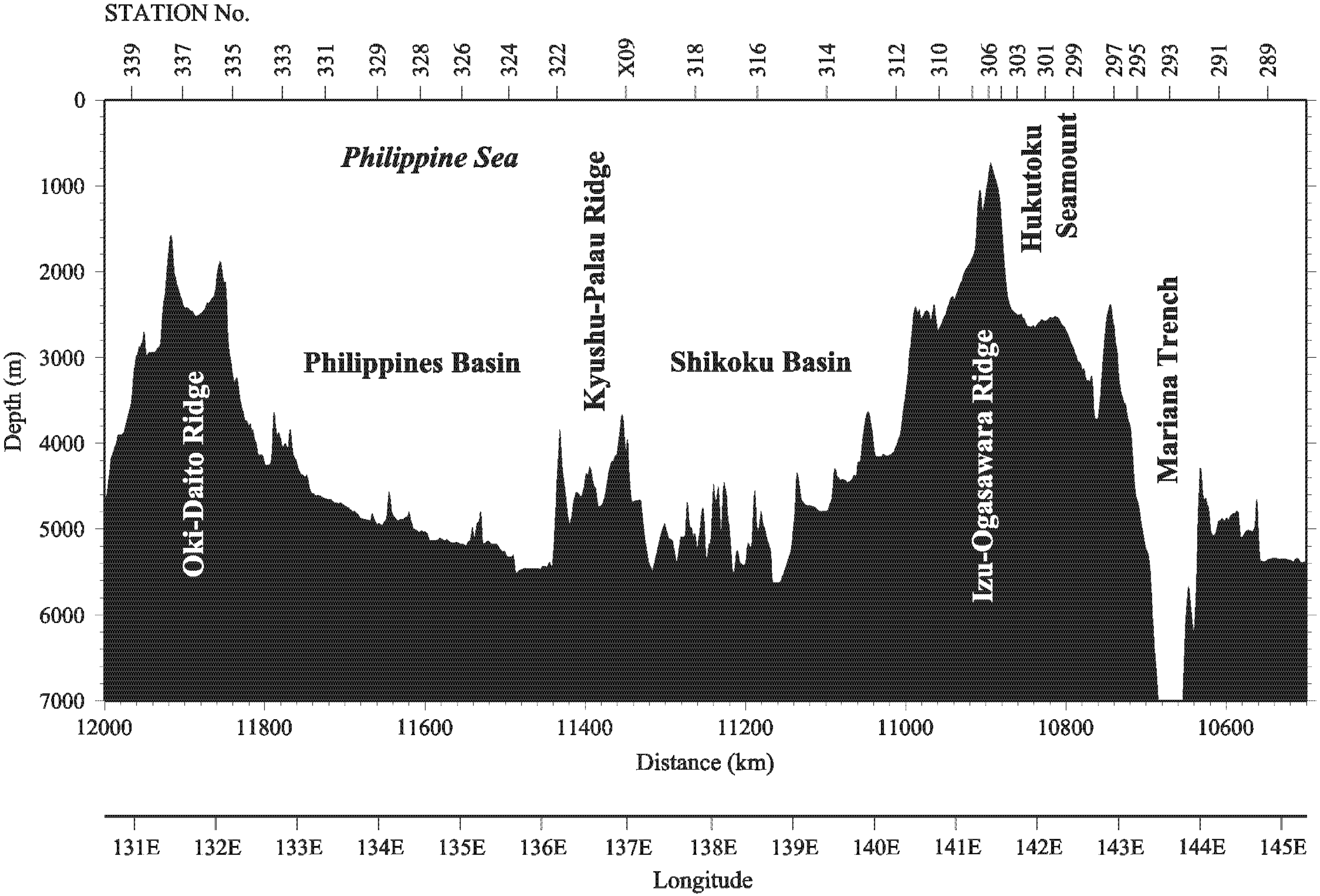

Figure 2
Continued

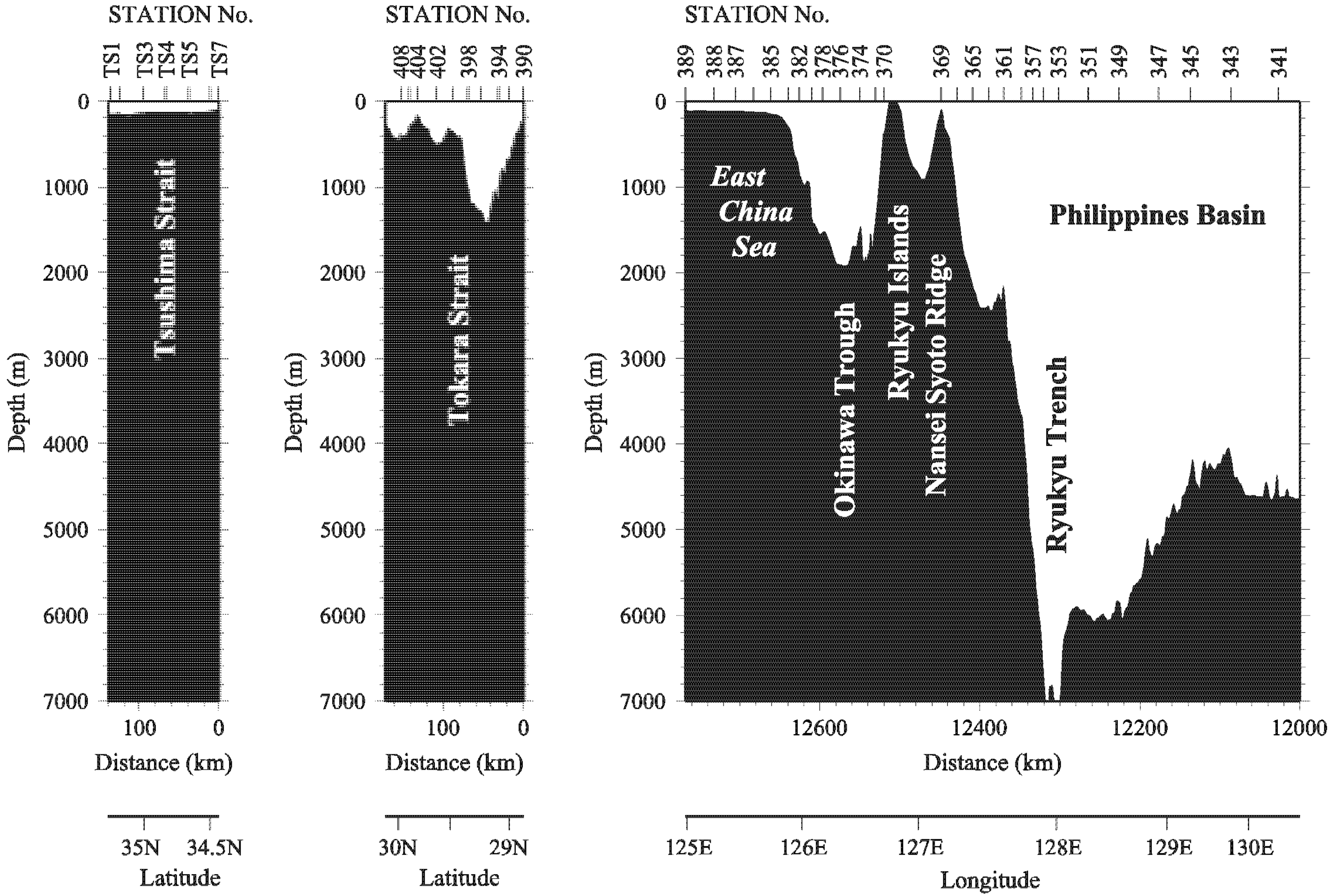

Figure 3

Surface wind measured at 25 m above sea level

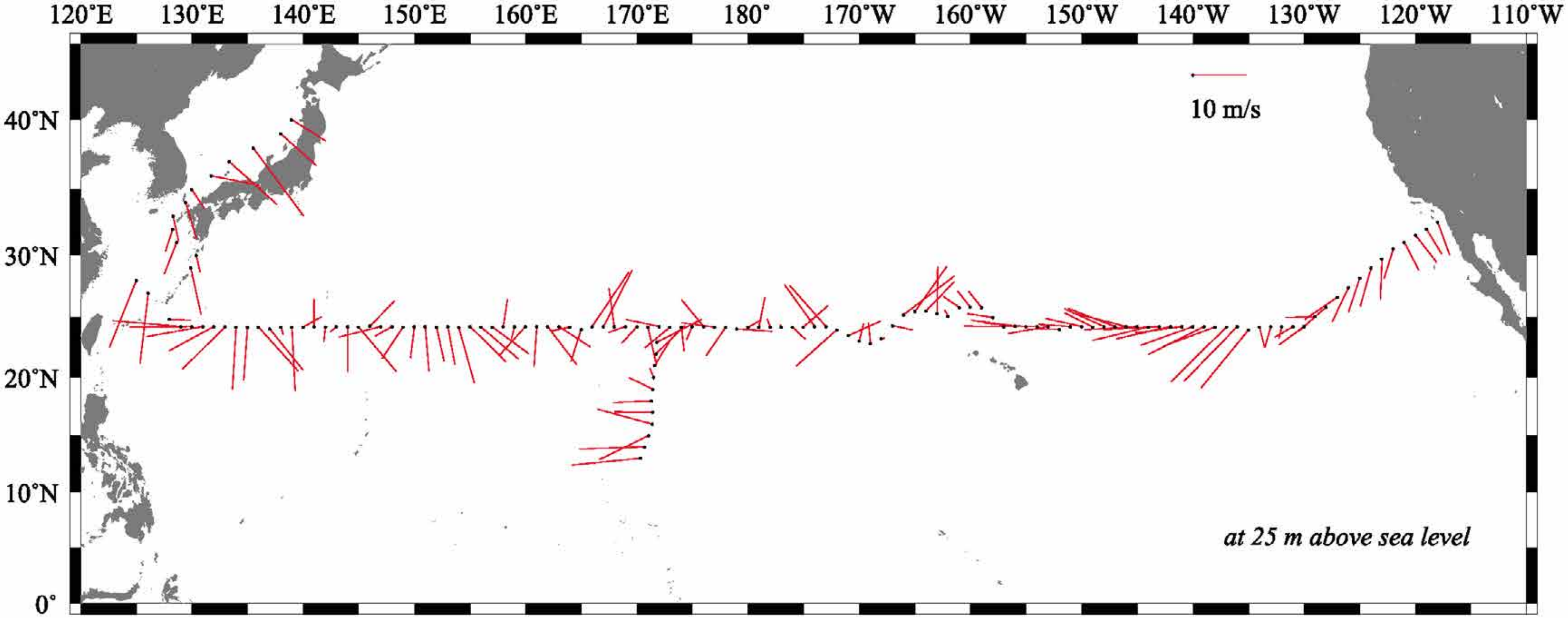

Figure 4
Sea surface temperature (SST)

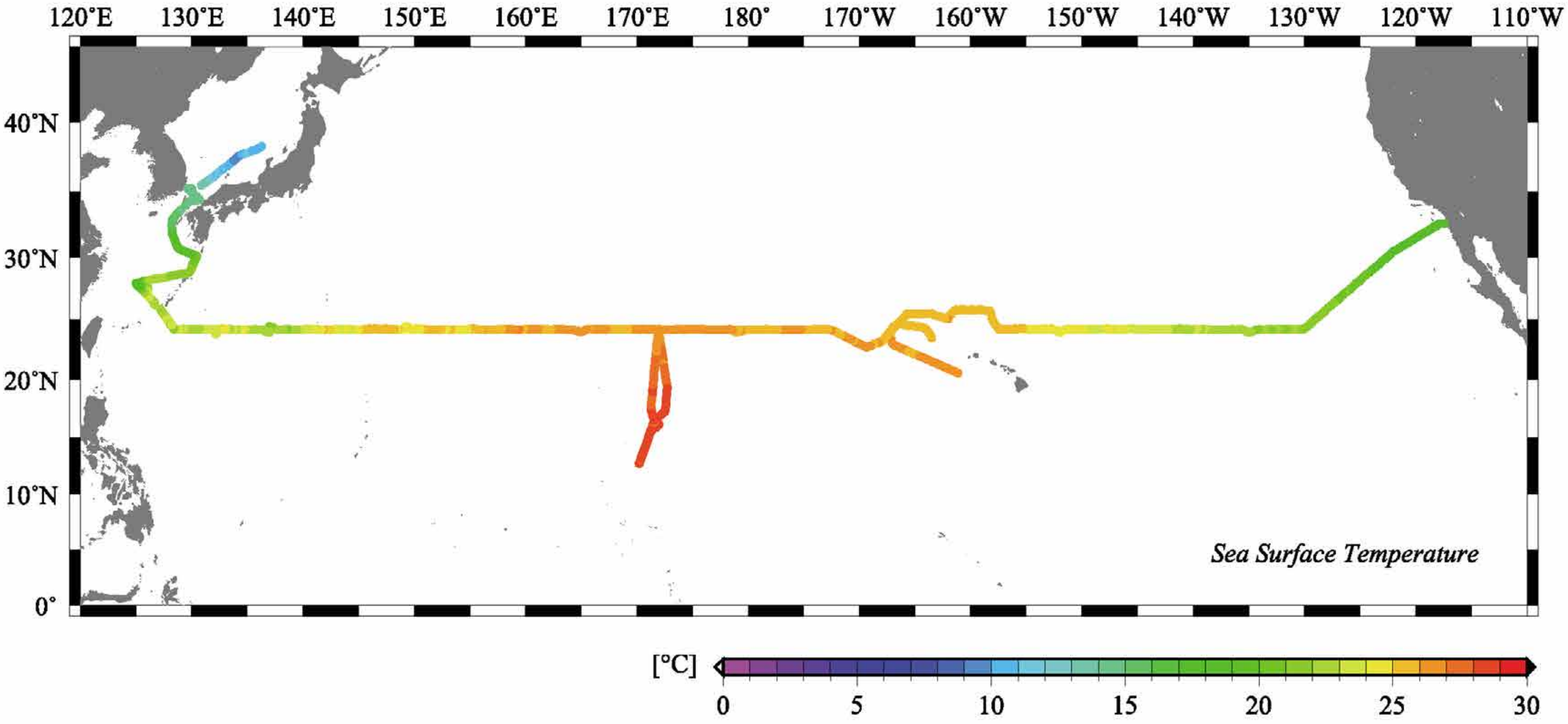

Figure 5
Sea surface salinity (SSS)

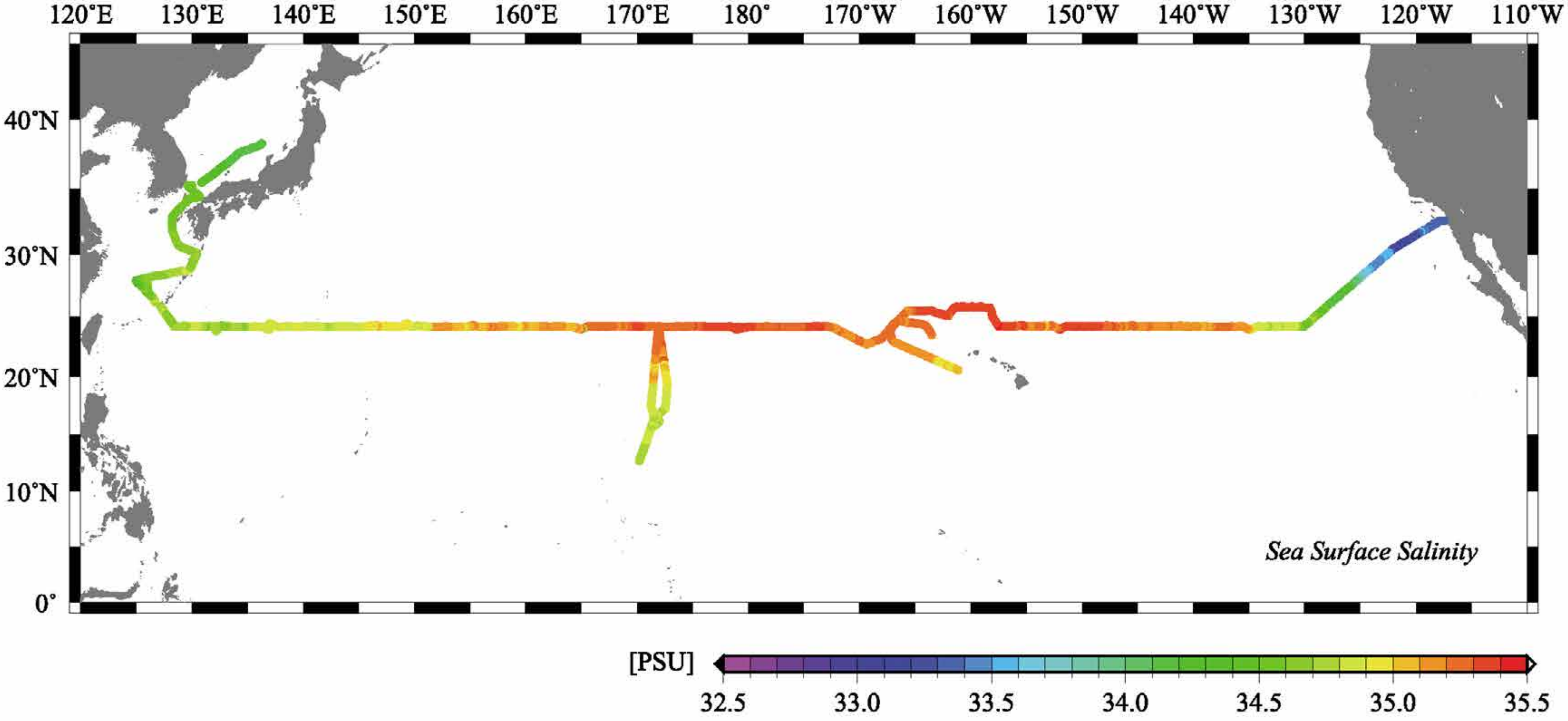

Figure 6
ΔpCO_2

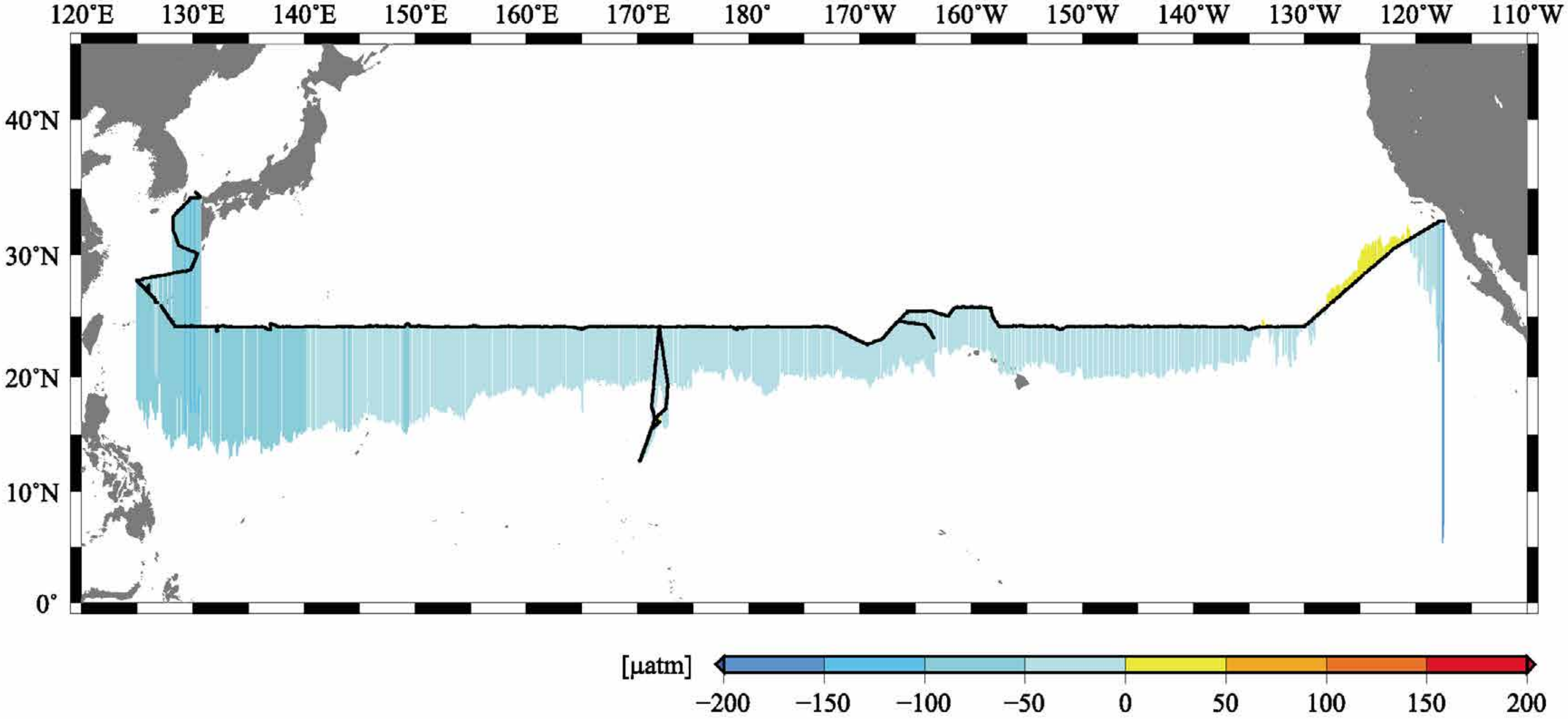

Figure 7
Surface current measured by shipboard ADCP

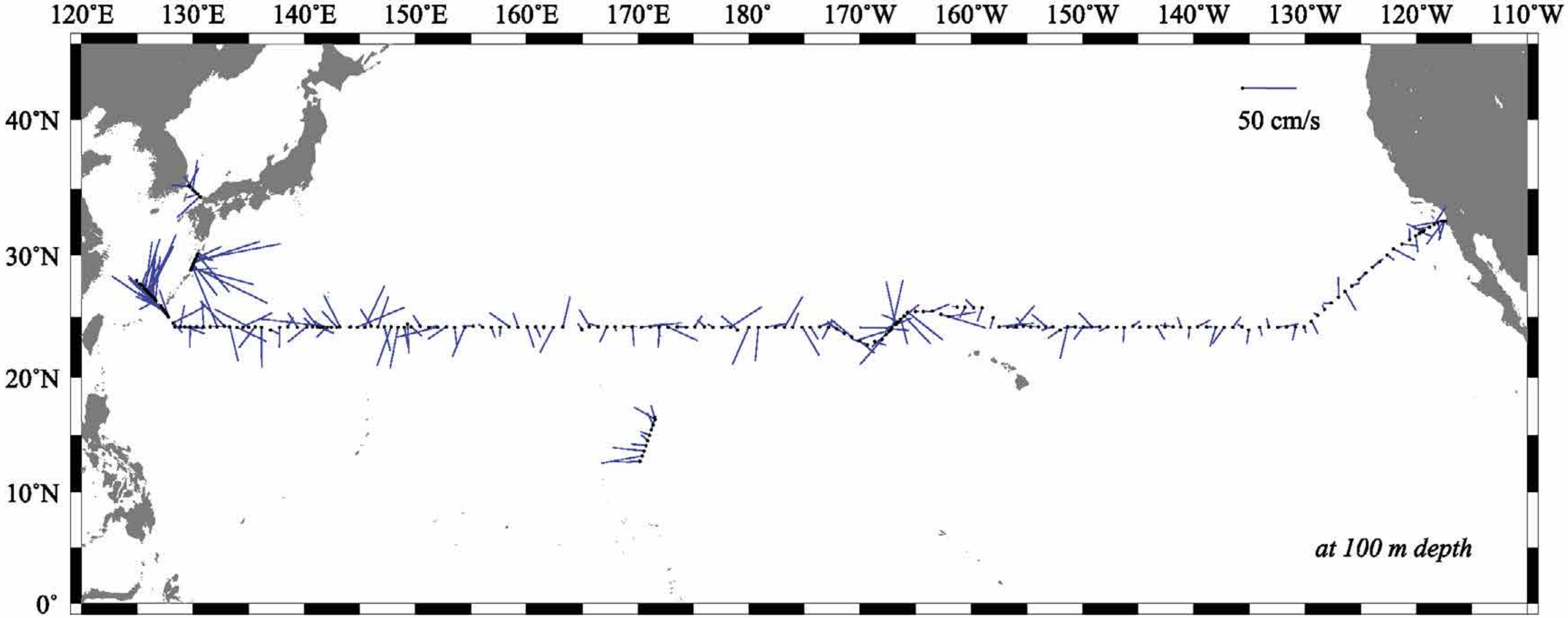

Figure 8

Potential temperature (°C)

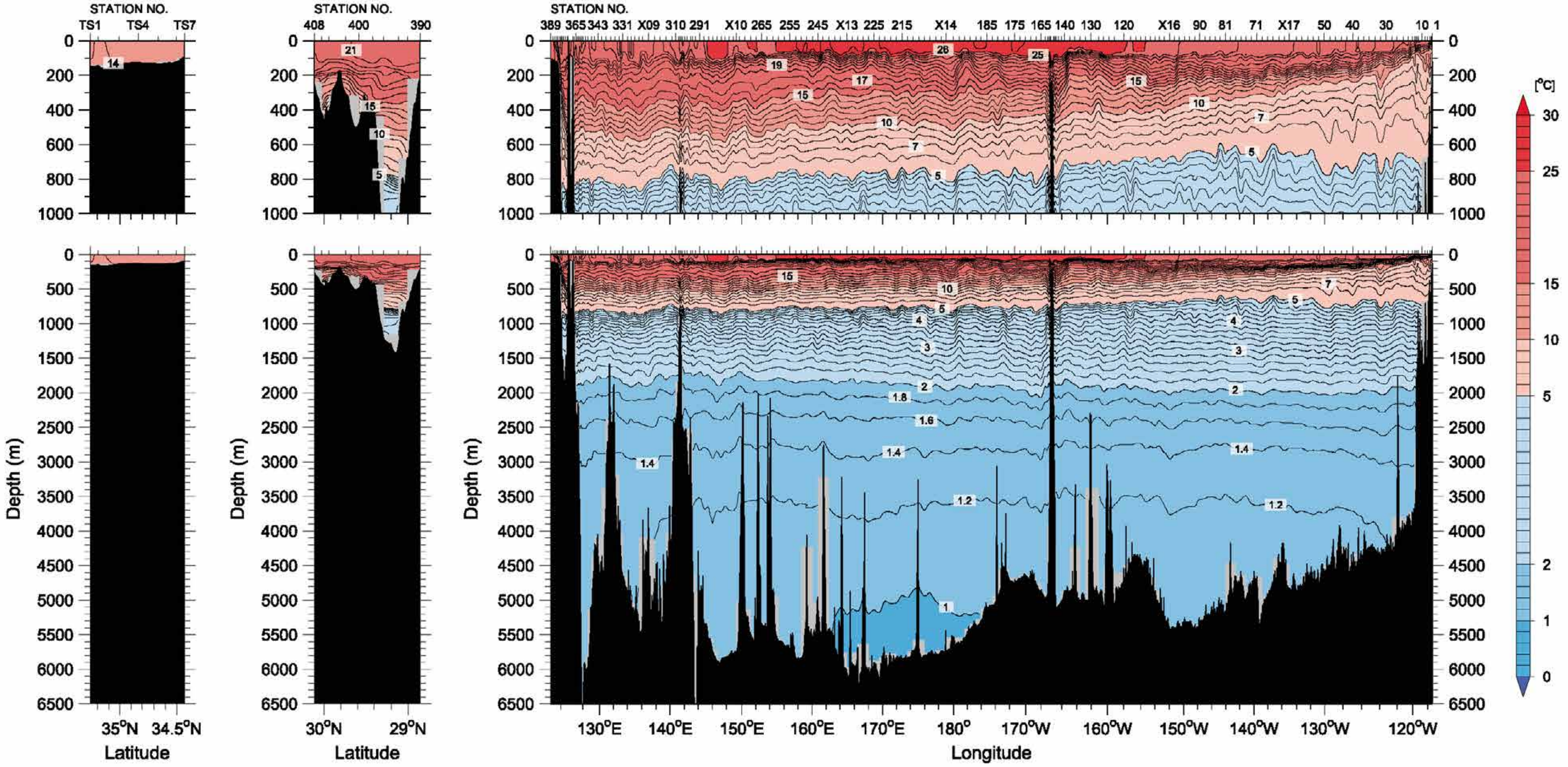

Figure 9
CTD salinity (psu)

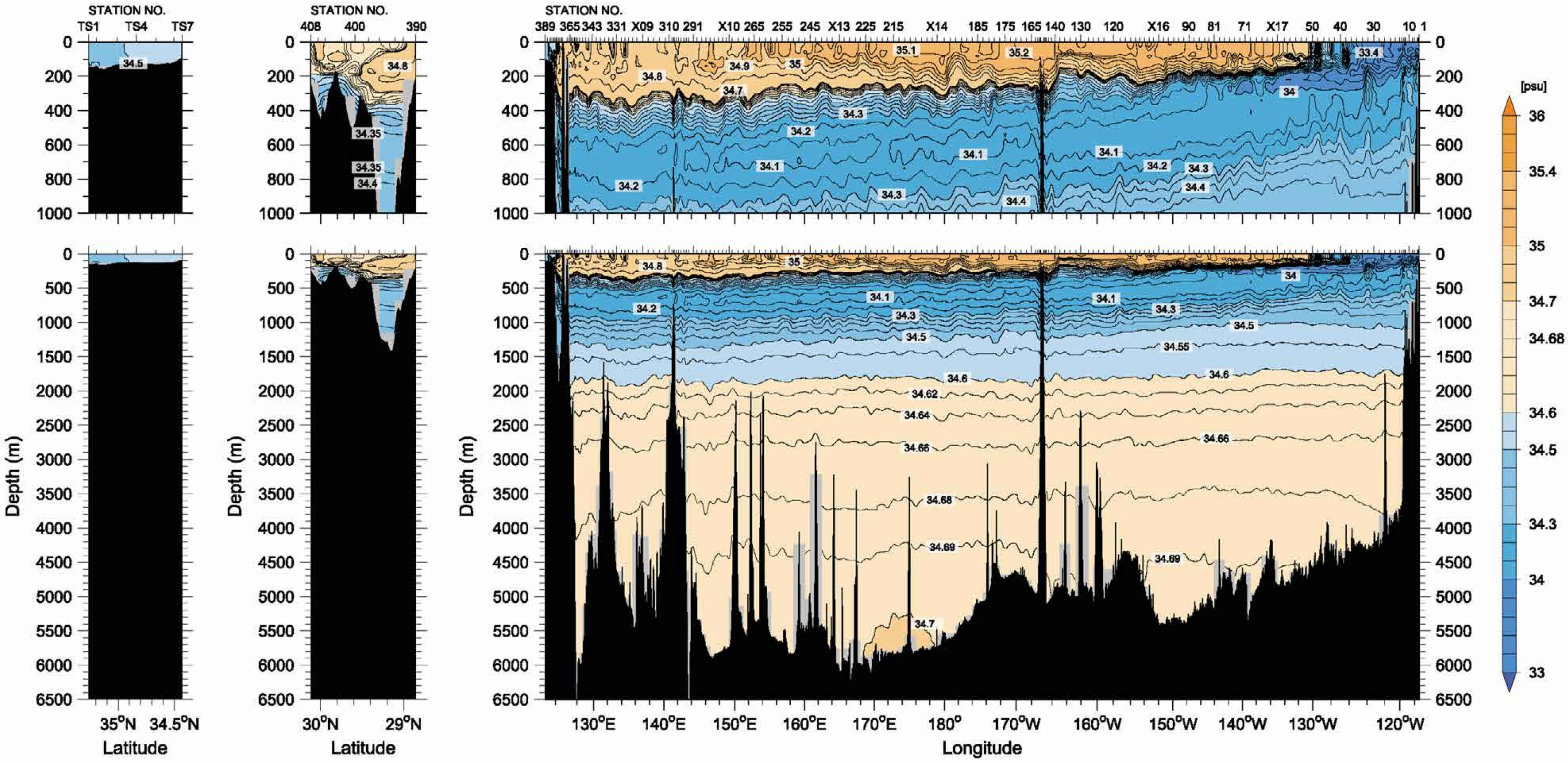

Figure 10
CTD salinity (psu) with SSW batch correction

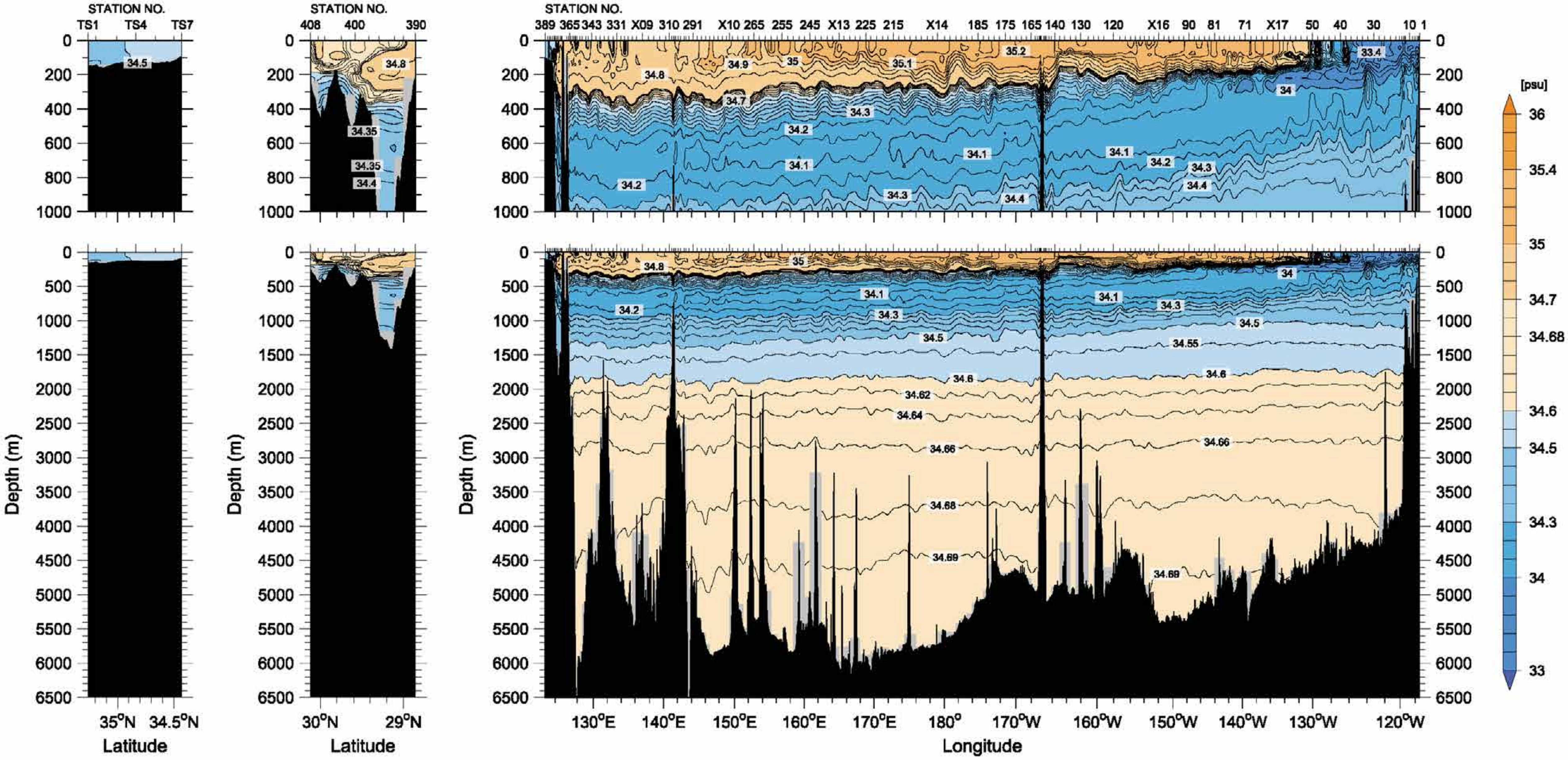

Figure 11

Density (σ_0) (kg/m^3)

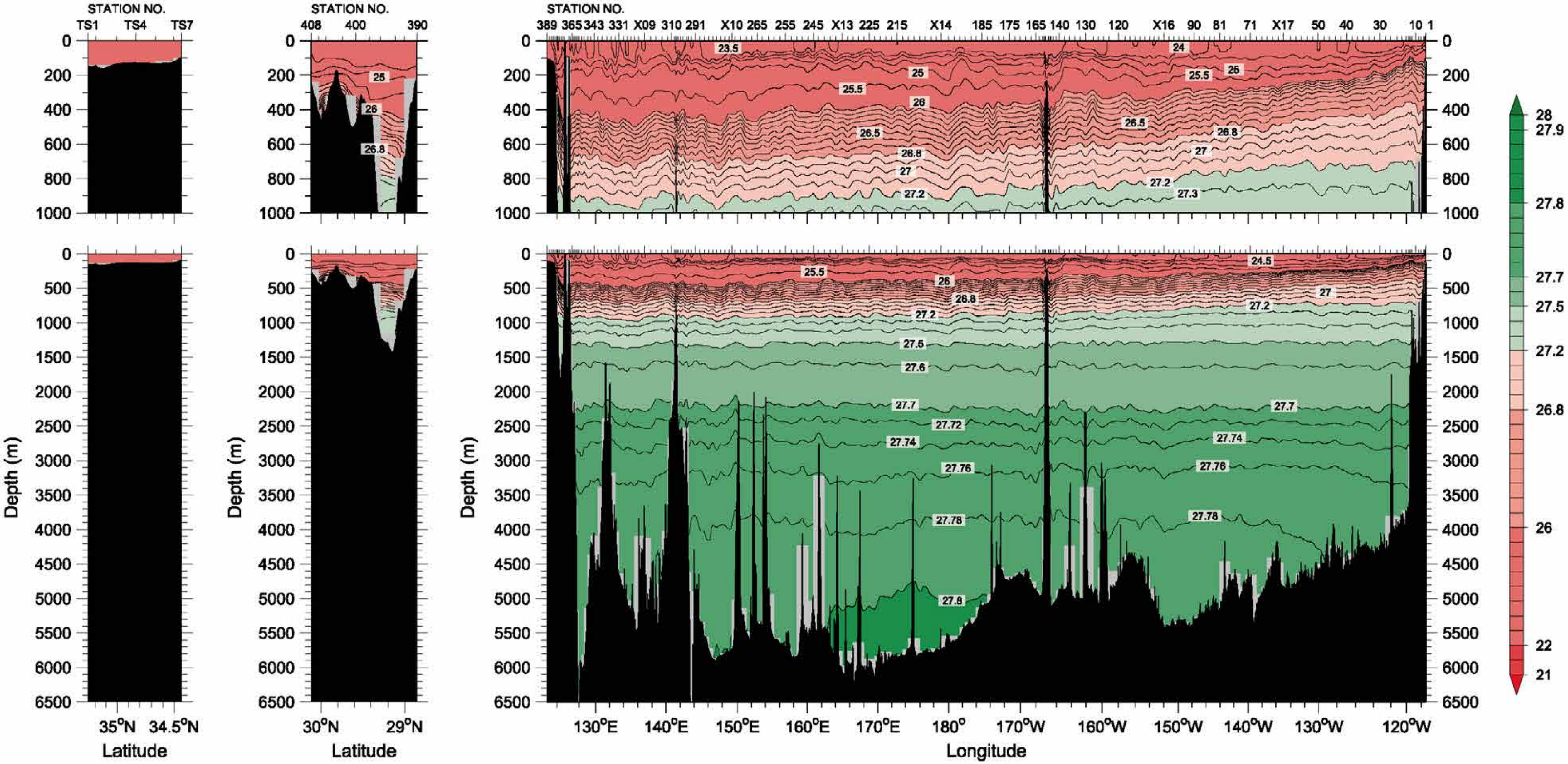

Figure 12
Density (σ_4) (kg/m^3)

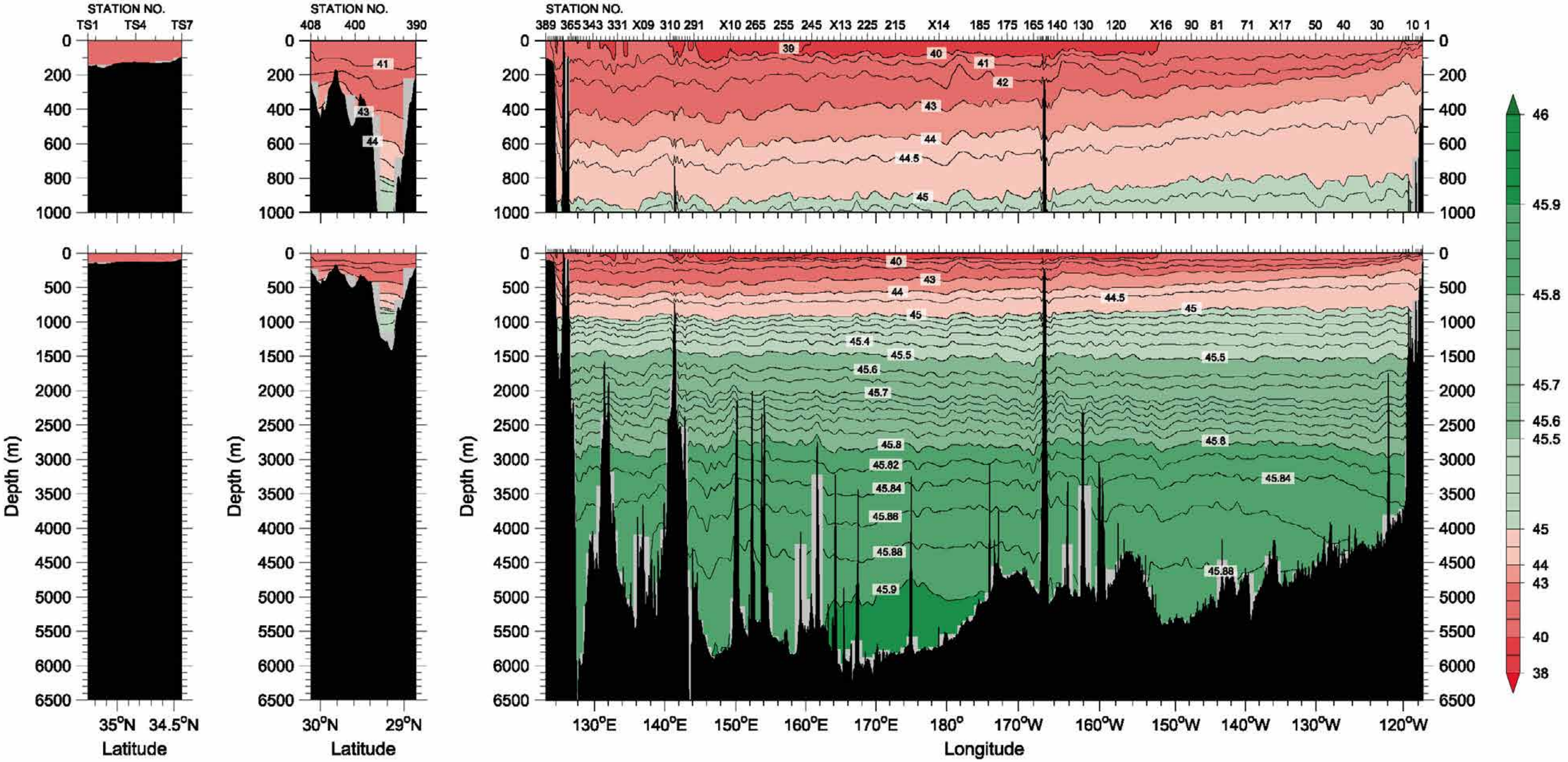

Figure 13

Density (γ^n) (kg/m^3)

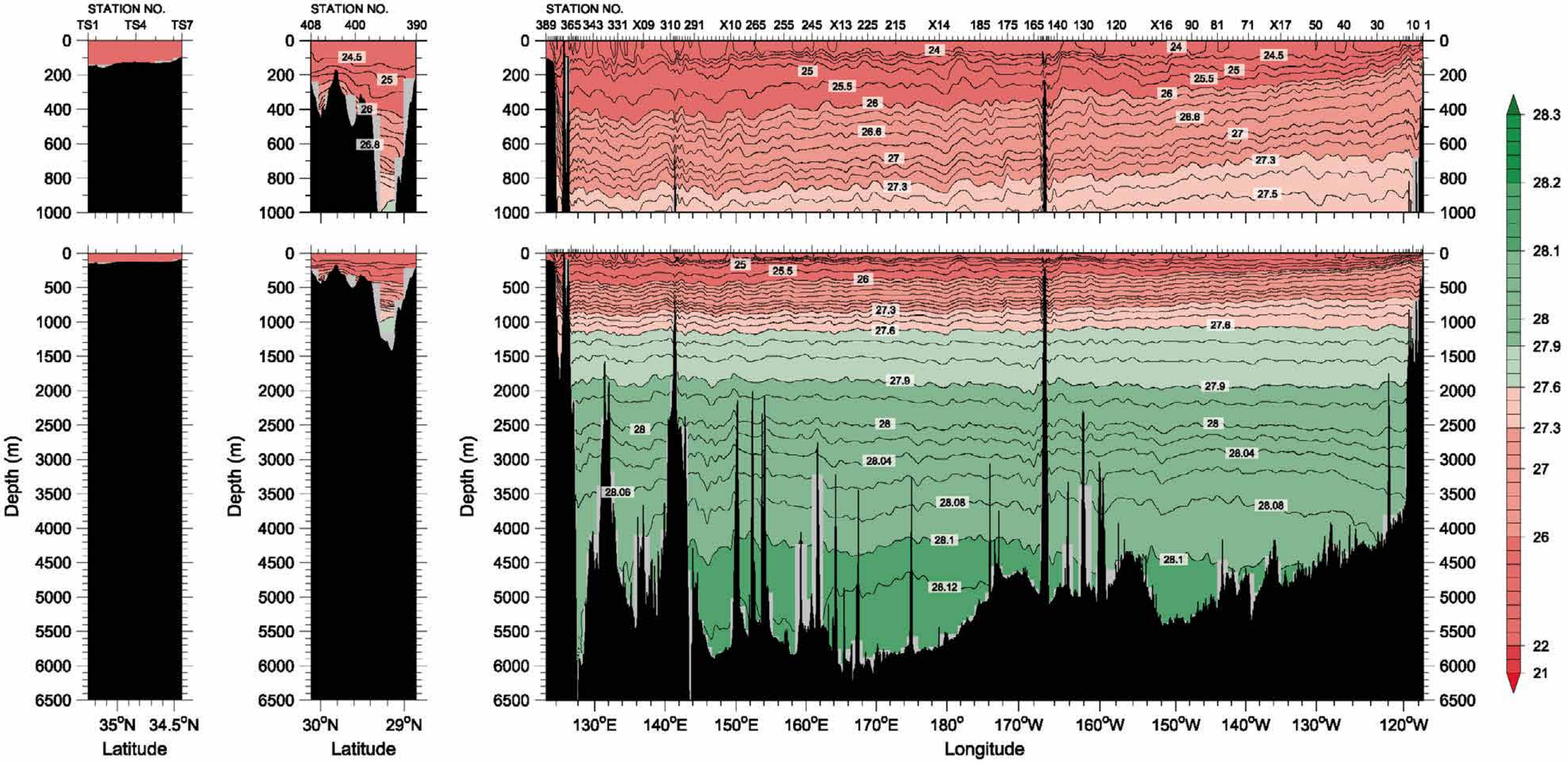

Figure 14
Bottle sampled dissolved oxygen (μmol/kg)

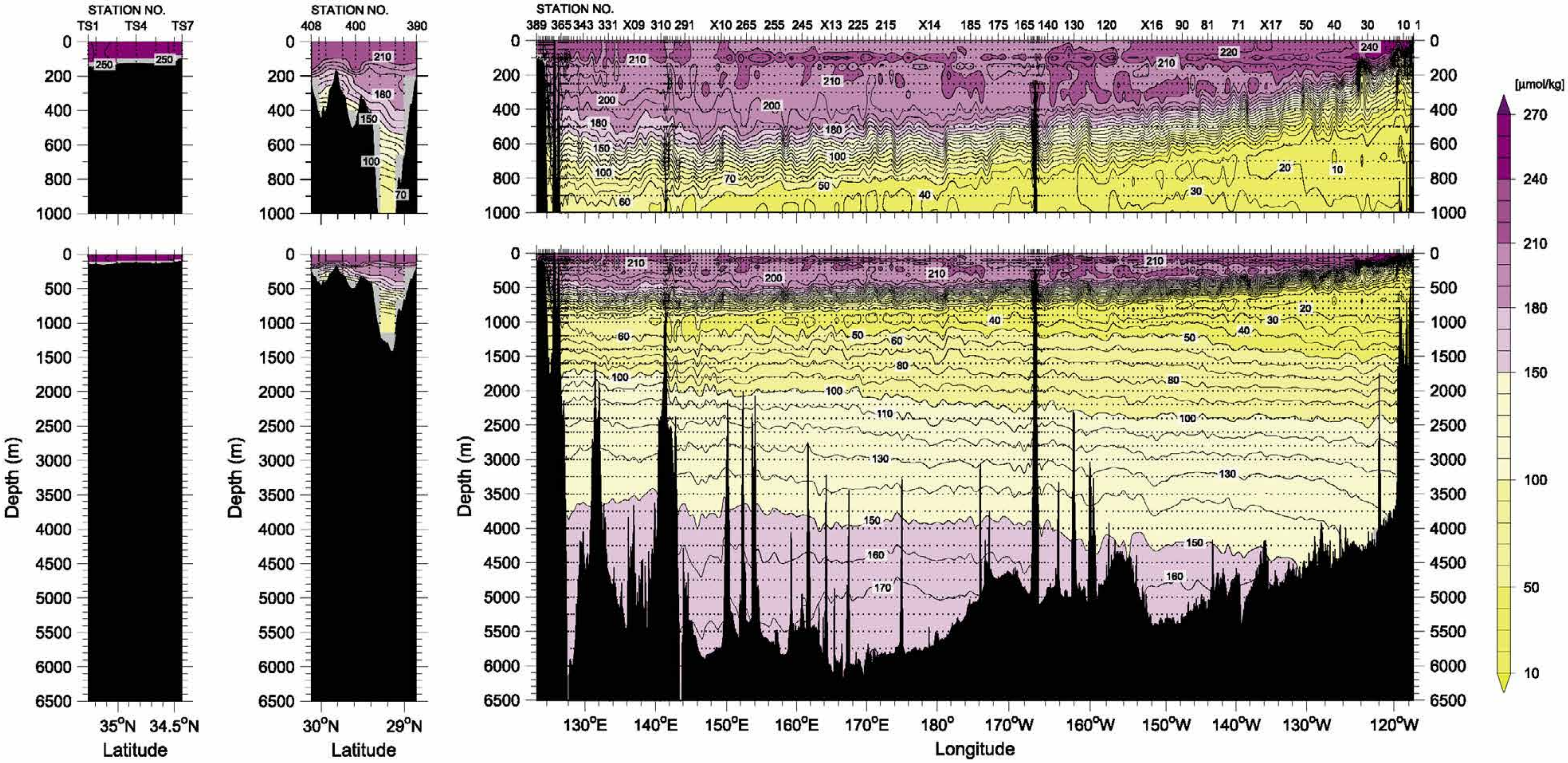

Figure 15
Silicate (μmol/kg)

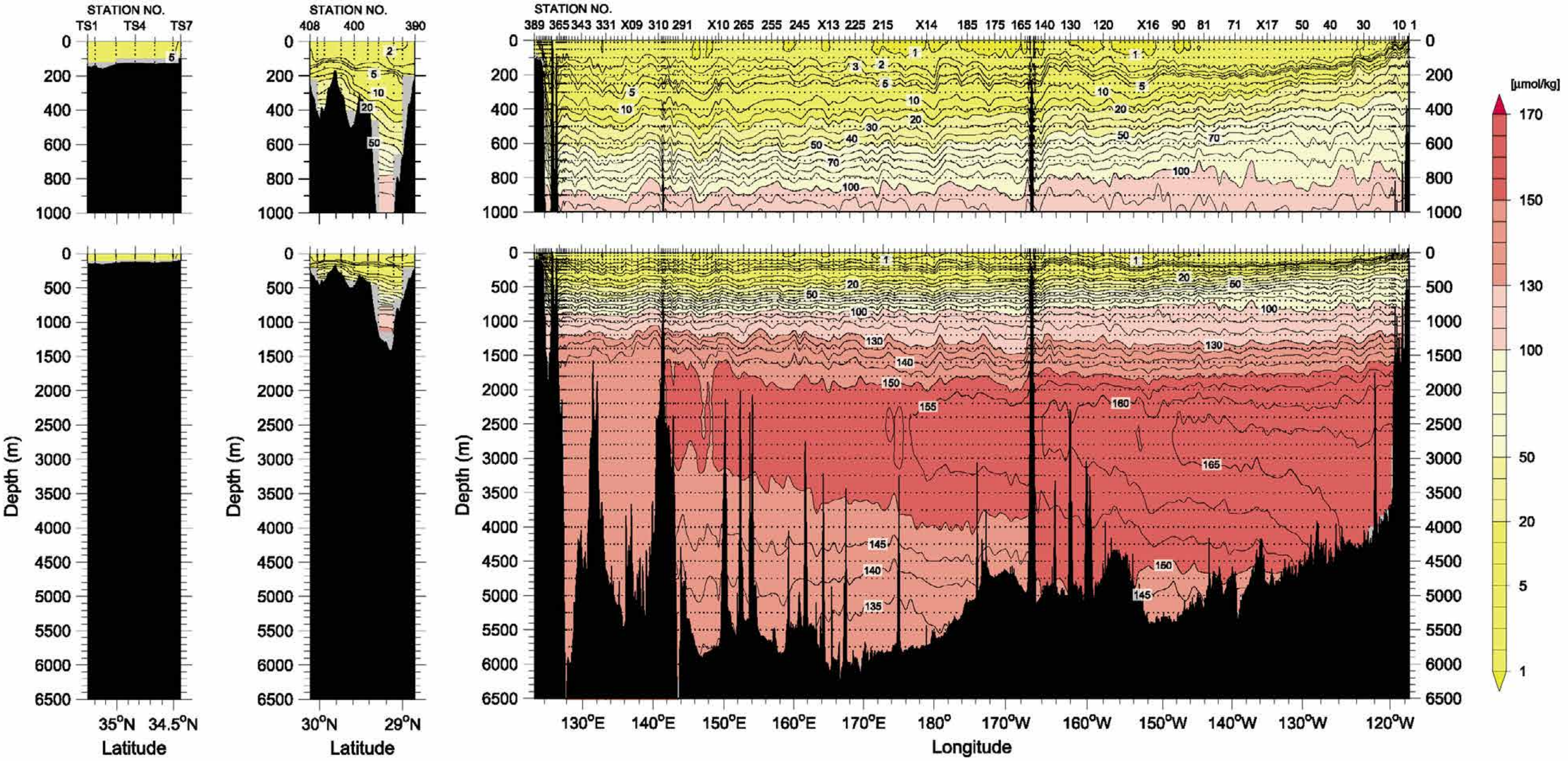

Figure 16

Nitrate (μmol/kg)

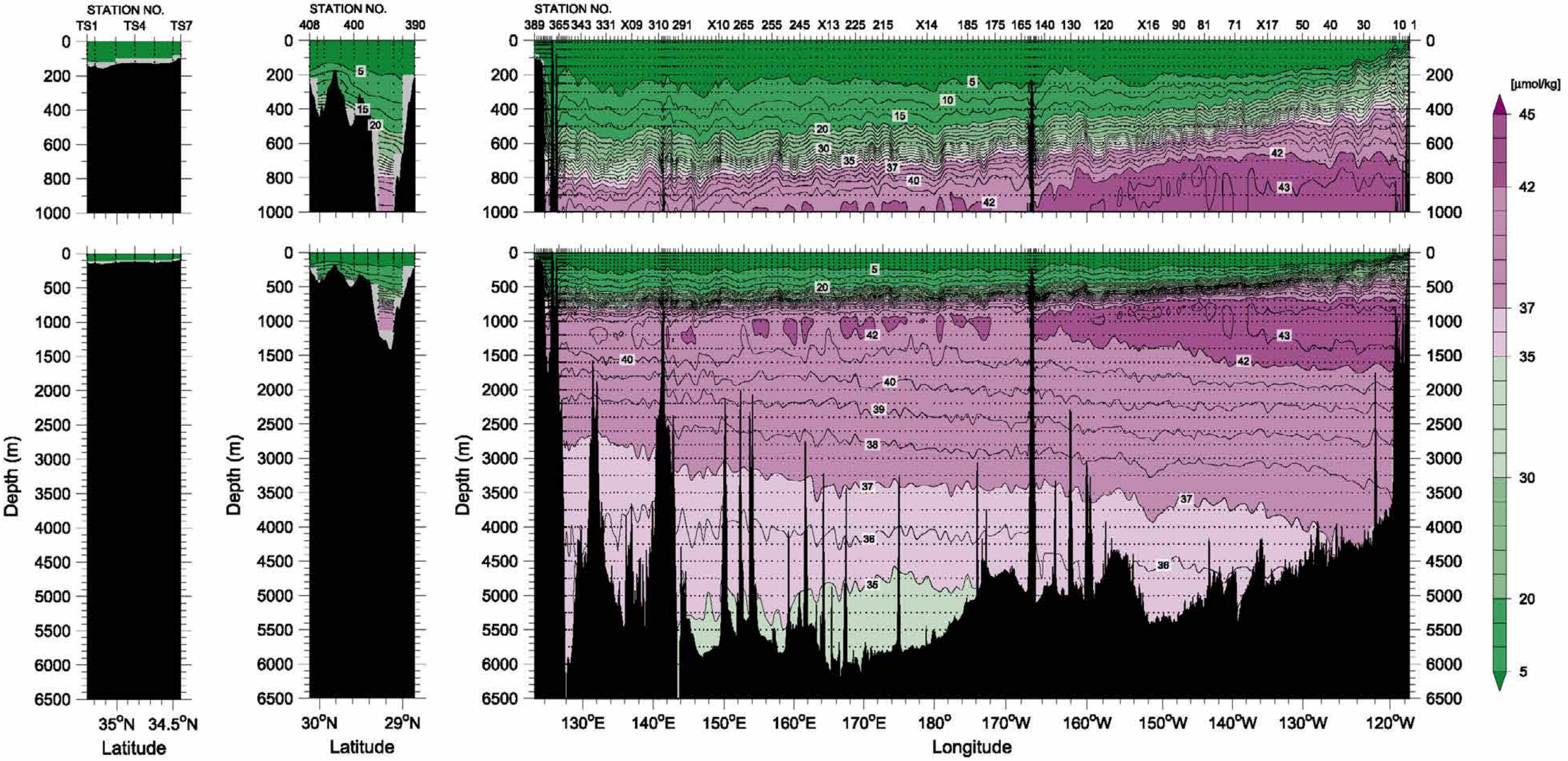

Figure 17

Nitrate (μmol/kg)

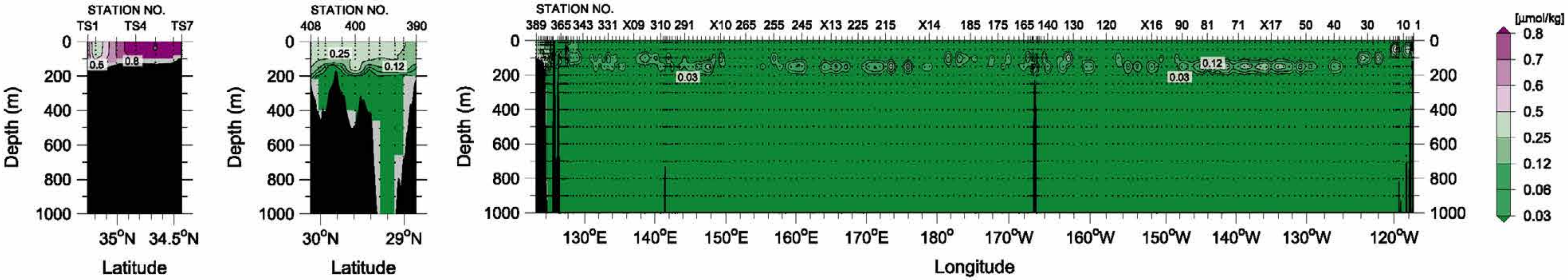

Figure 18
Phosphate (μmol/kg)

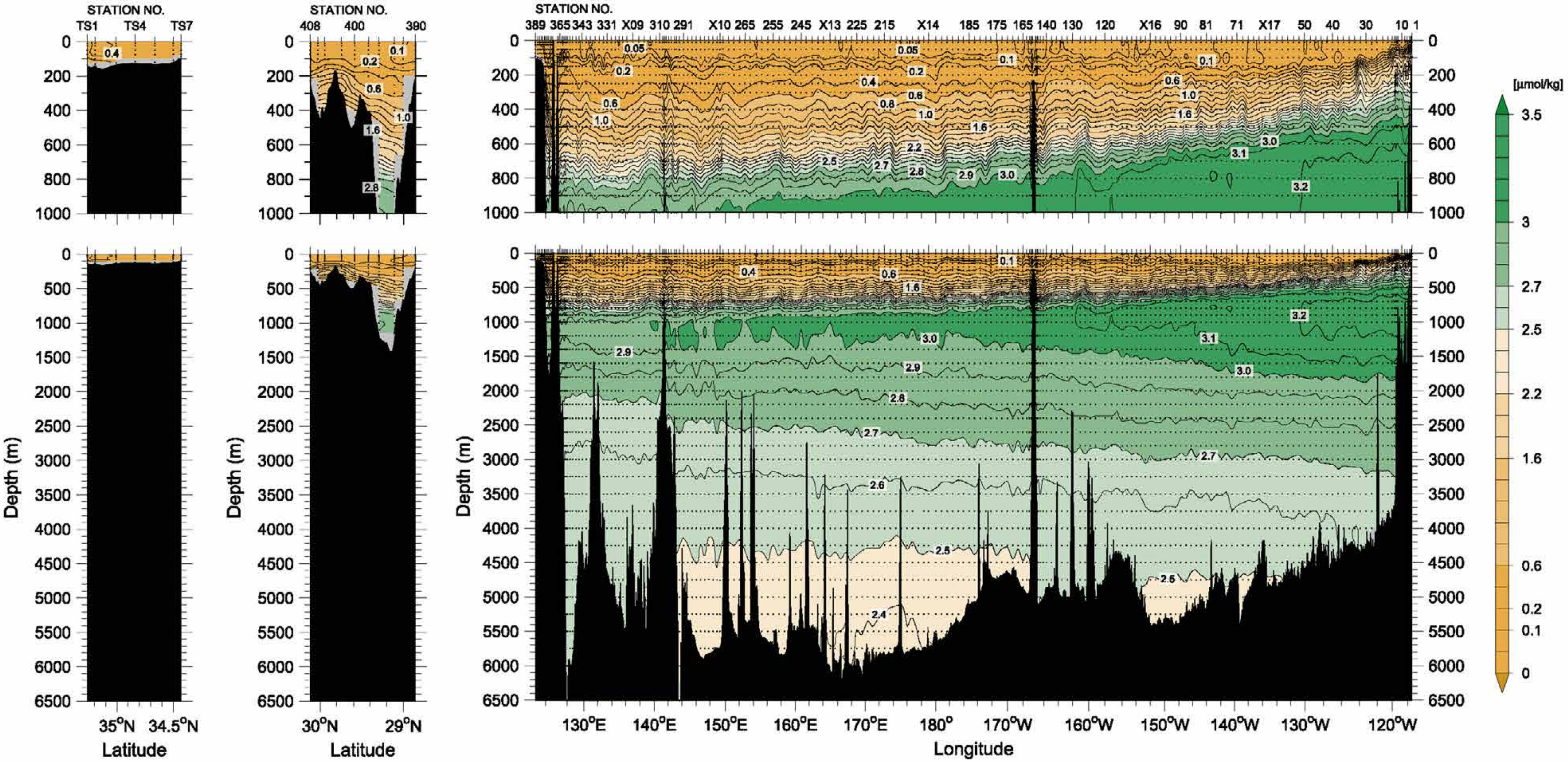

Figure 19
Dissolved inorganic carbon (μmol/kg)

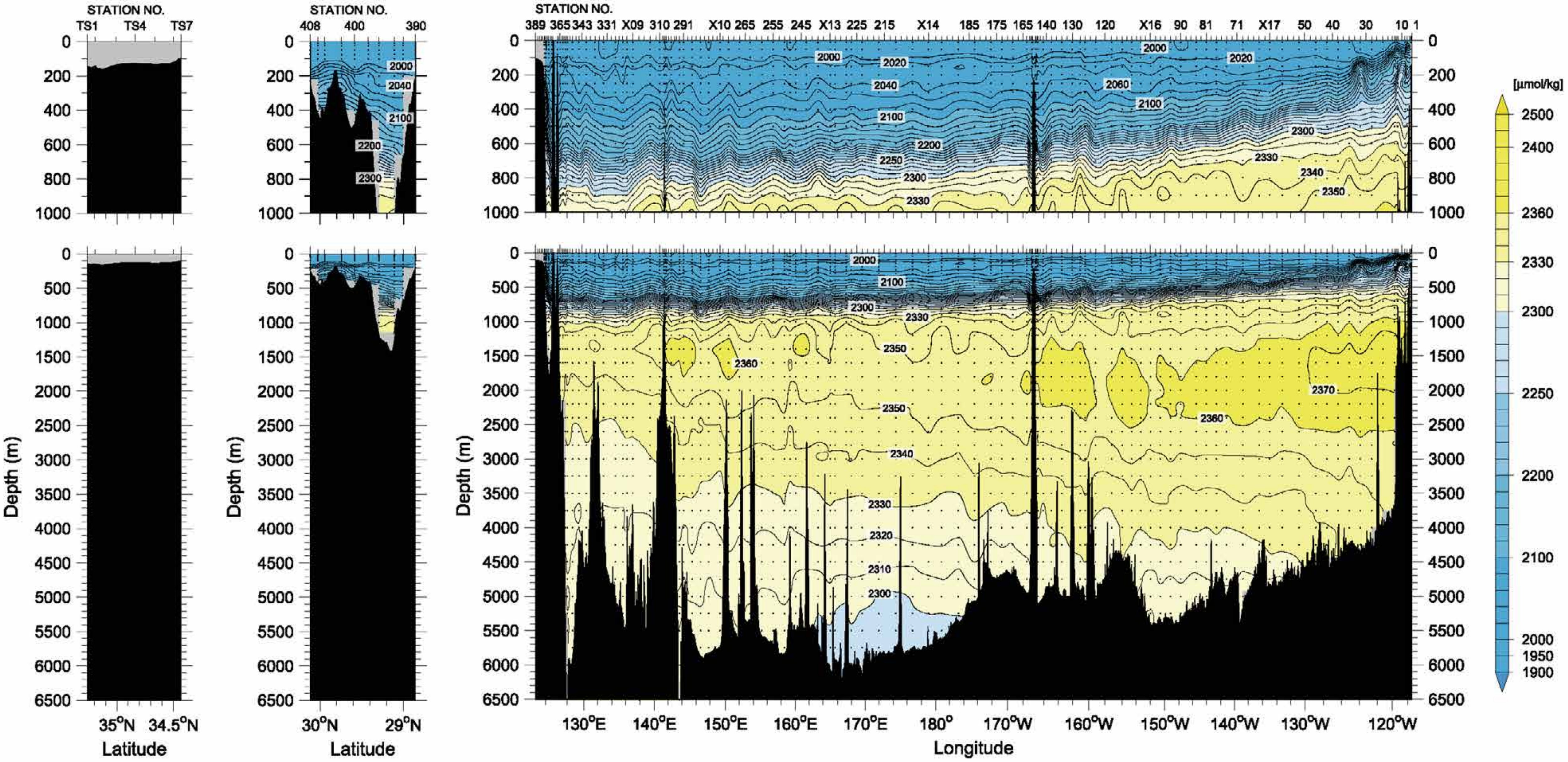

Figure 20

Total alkalinity (μmol/kg)

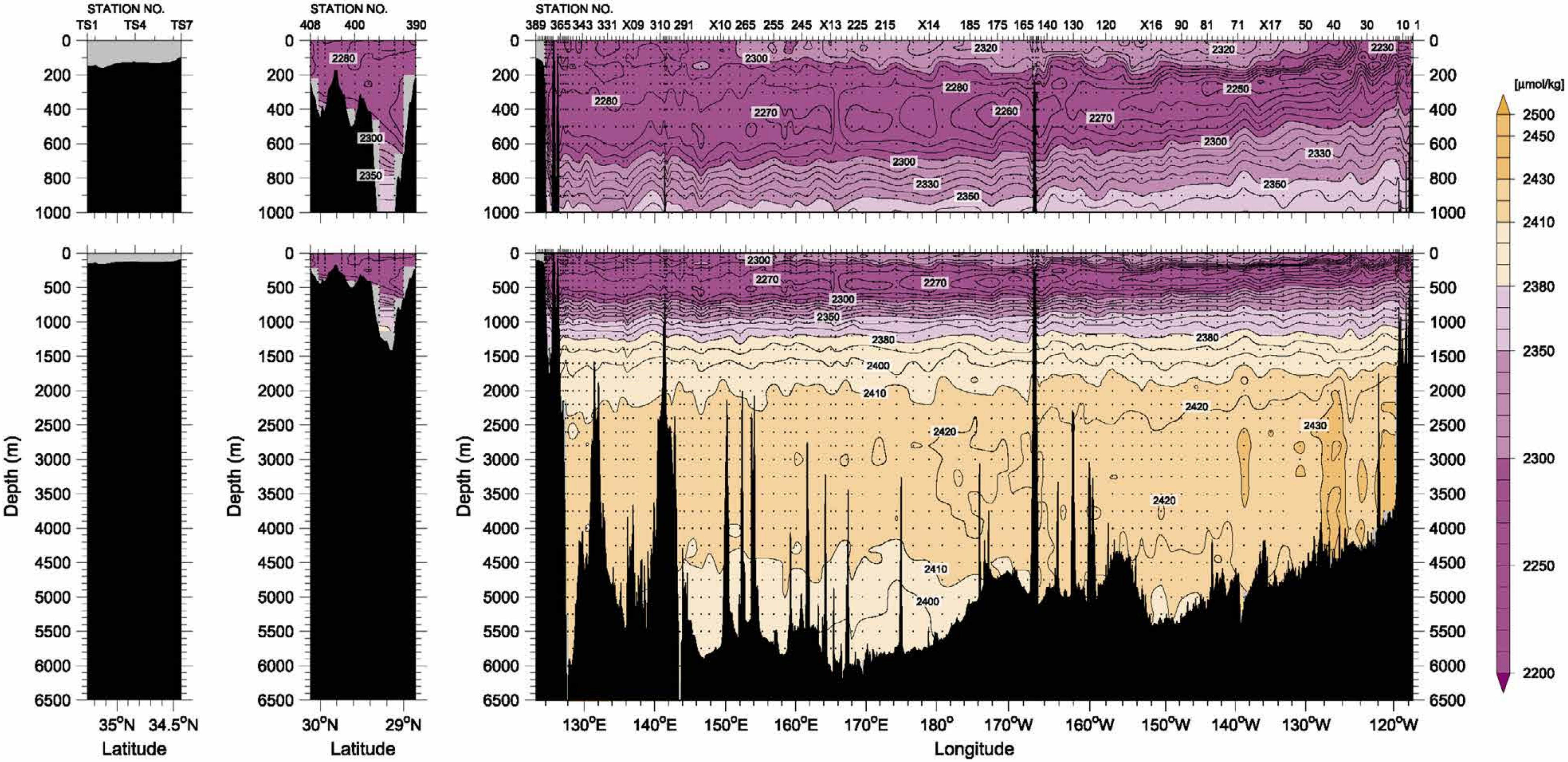

Figure 21
pH

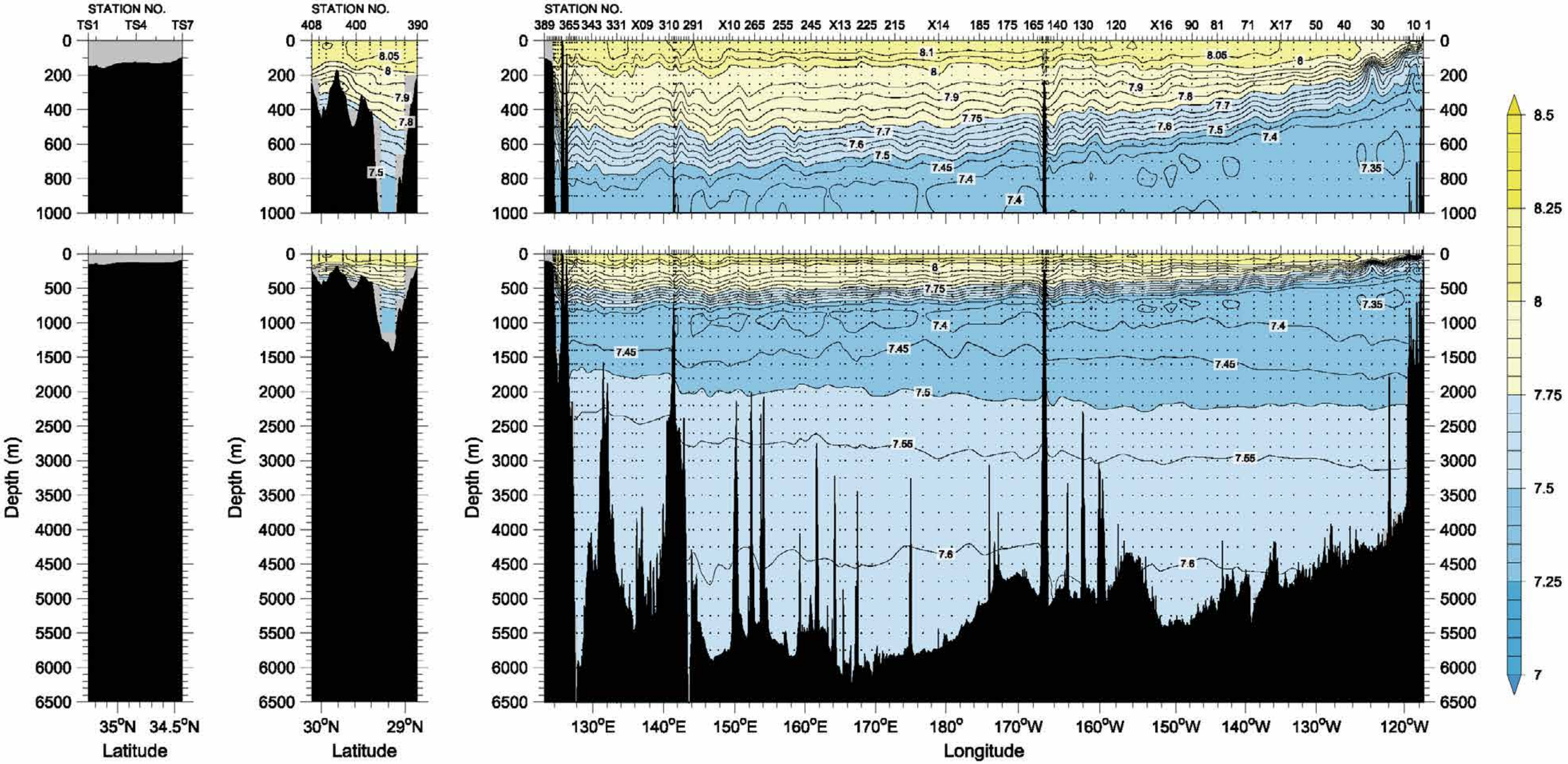
STATION NO.
TS1
TS4
TS7
STATION NO.
408
400
390
STATION NO.
389 365 343 331 X09 310 291 X10 265 255 245 X13 225 215 X14 185 175 165 140 130 120 X16 90 81 71 X17 50 40 30 10 1
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
Depth (m)
35°N
34.5°N
Latitude
30°N
29°N
Latitude
130°E
140°E
150°E
160°E
170°E
180°
170°W
160°W
150°W
140°W
130°W
120°W
Longitude
8.1
8.05
8
7.9
7.8
7.75
7.7
7.6
7.5
7.45
7.4
7.35
7.55
8.5
8.25
7.25
7

Figure 22
CFC-11 (pmol/kg)

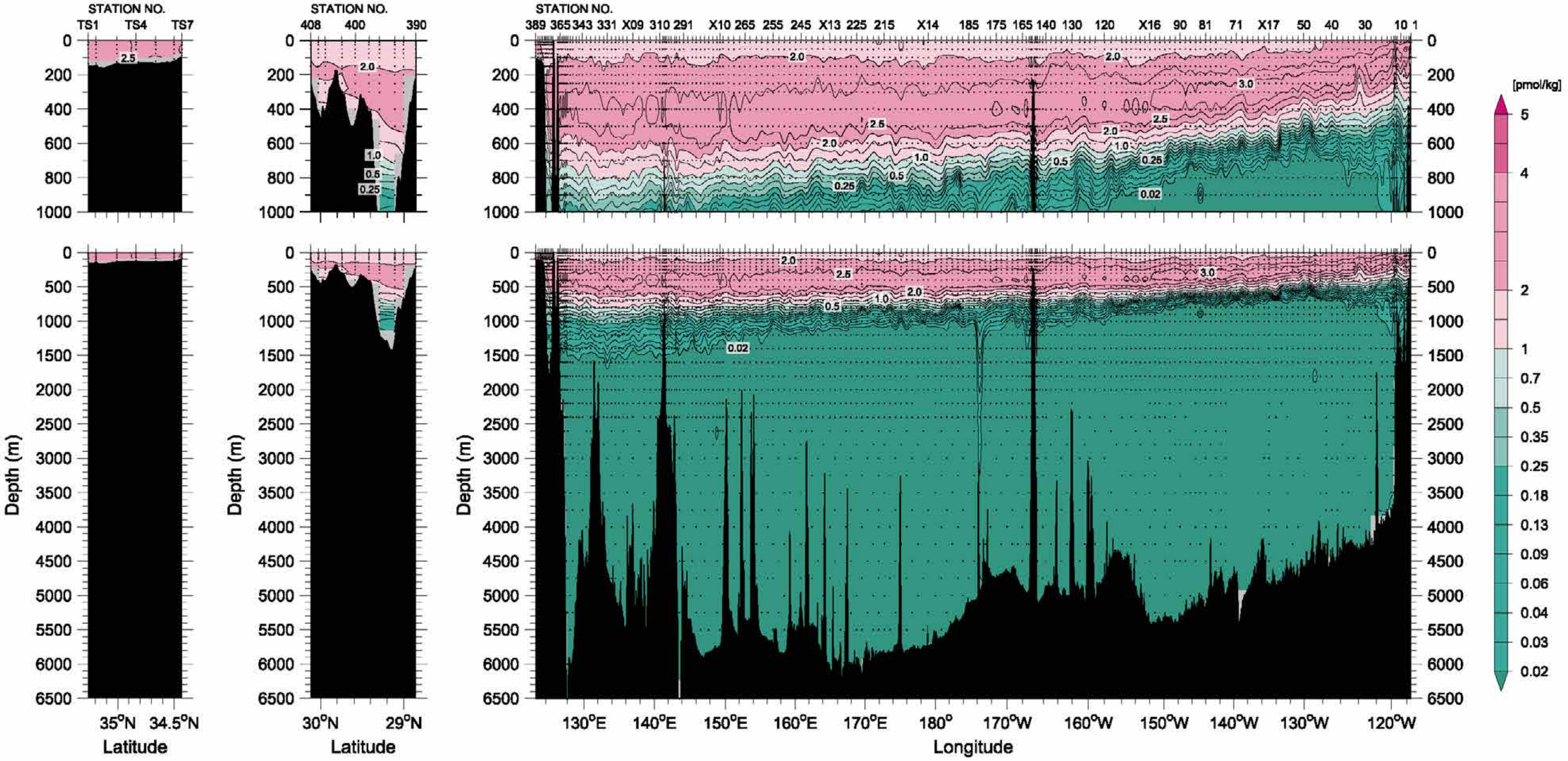

Figure 23

CFC-12 (pmol/kg)

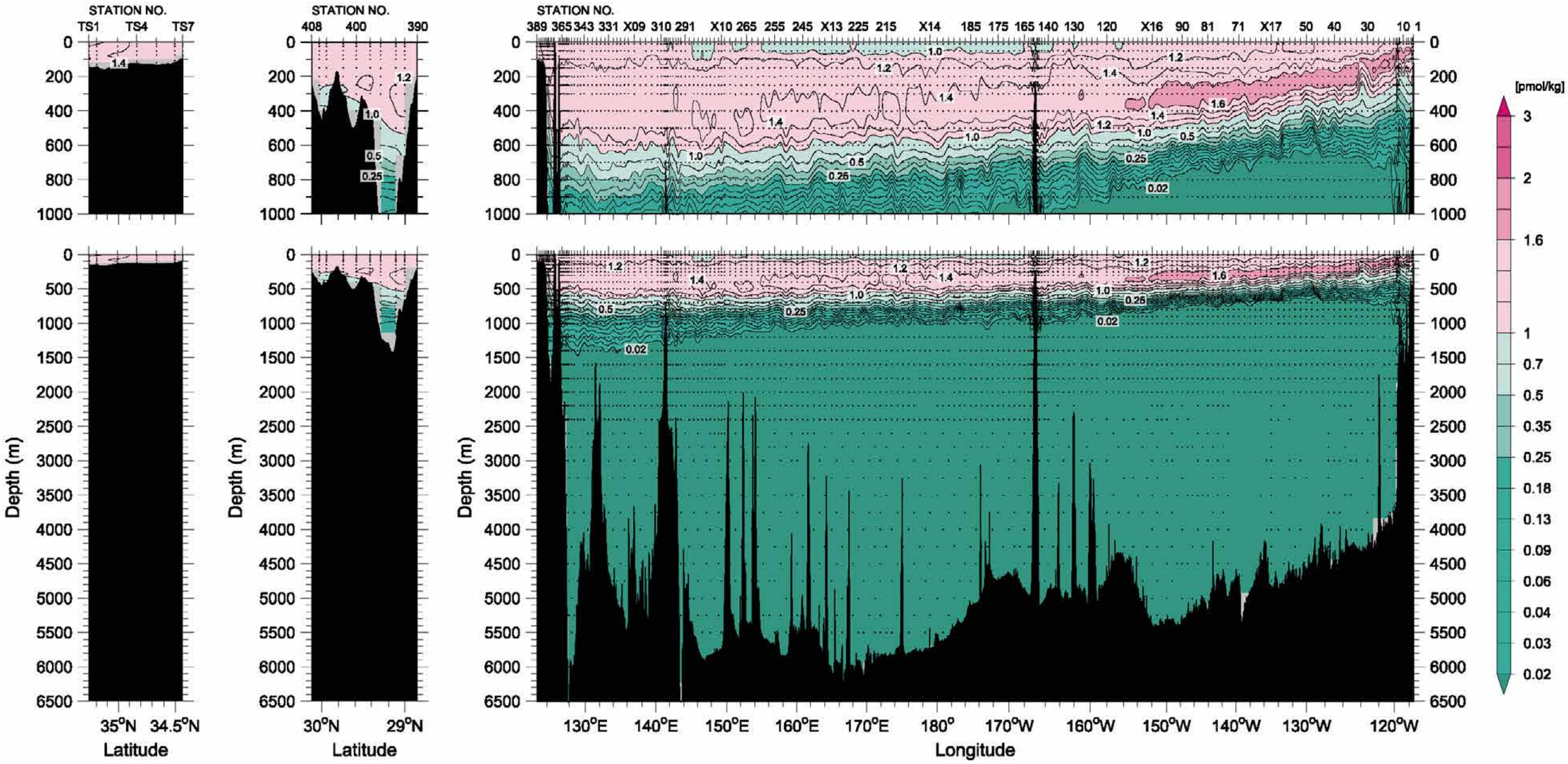

Figure 24
CFC-113 (pmol/kg)

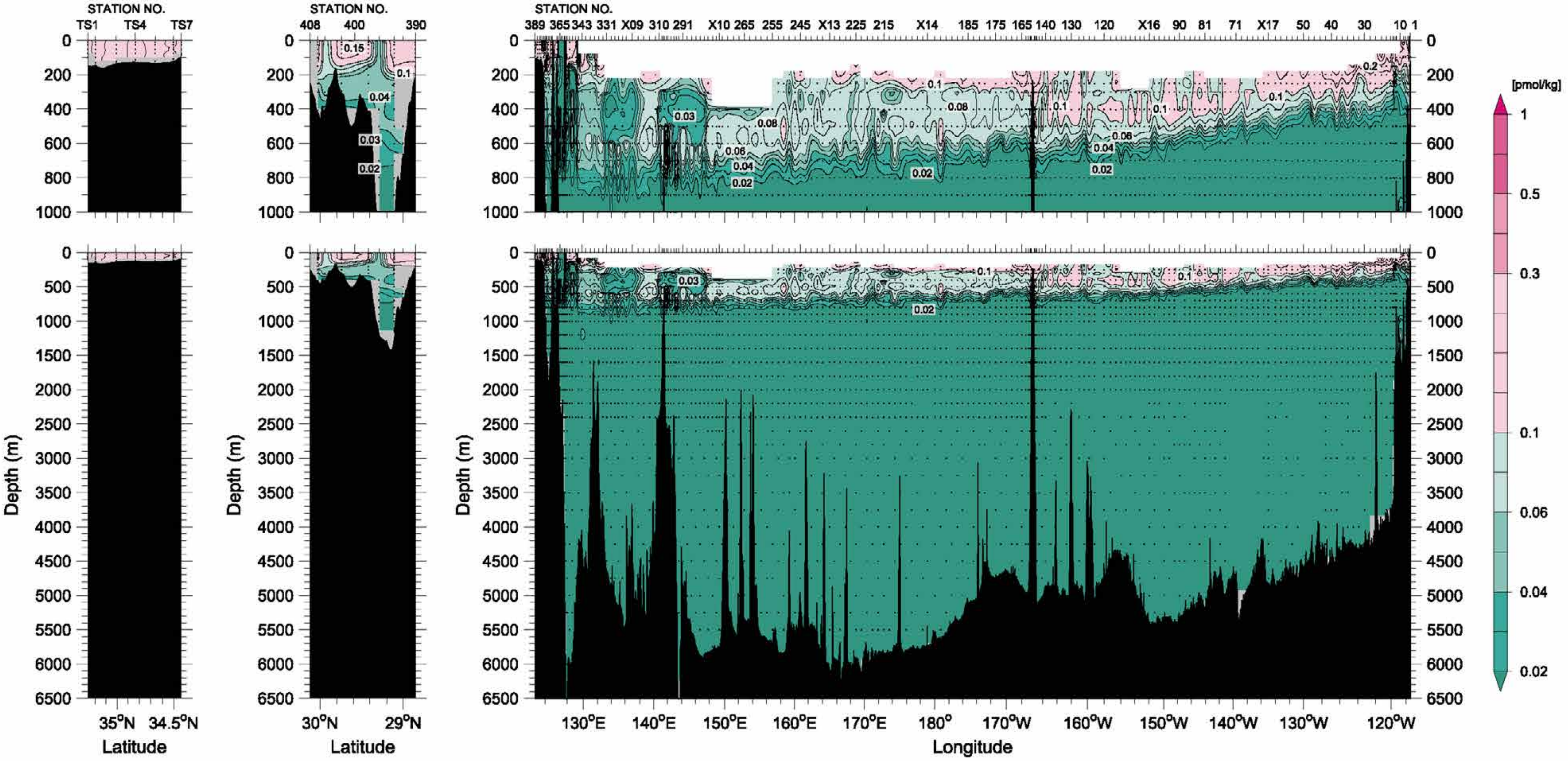

Figure 25

Current velocity (cm/s) normal to the cruise track measured by LADCP (northward is positive)

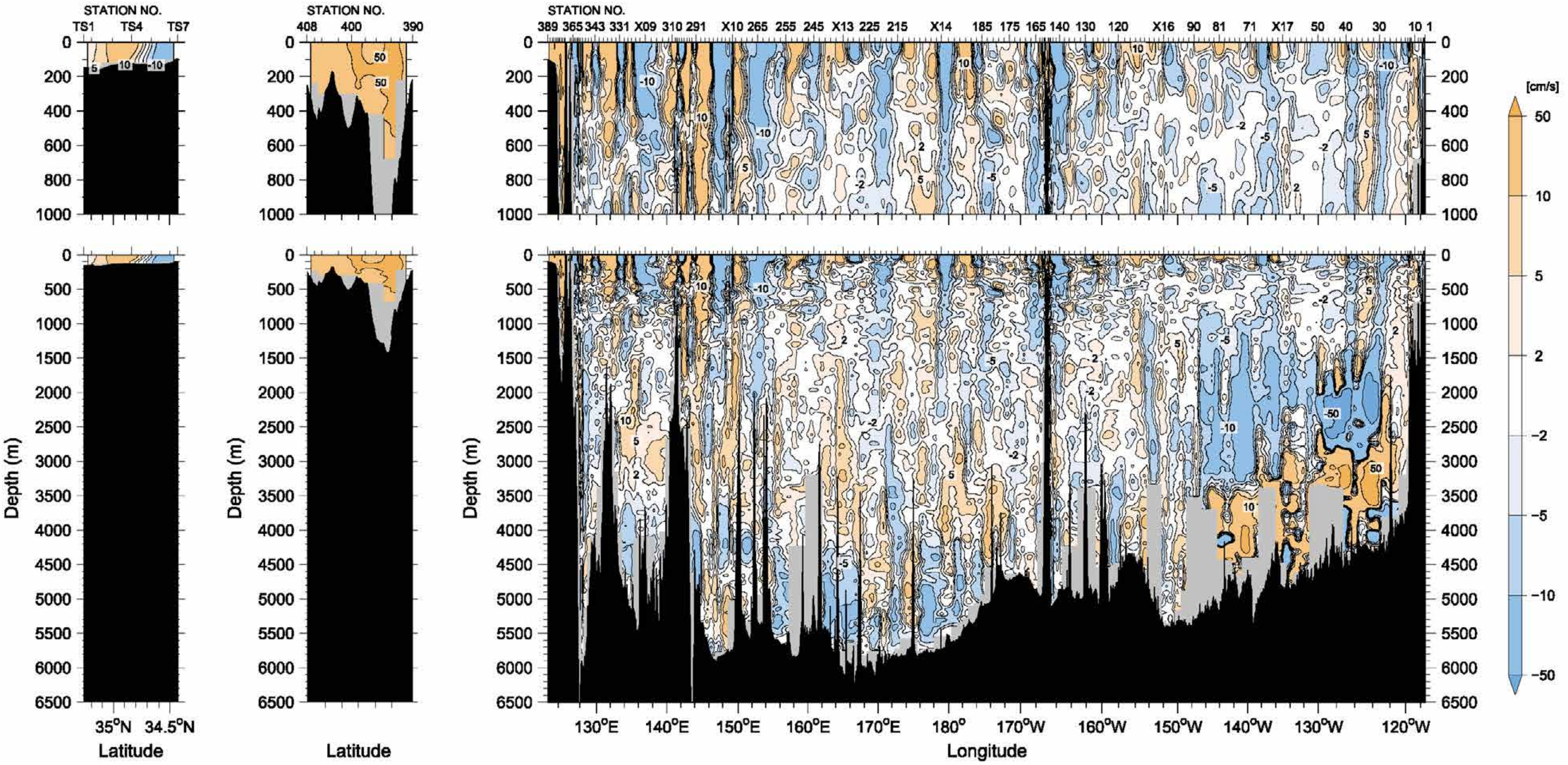

Figure 26

Difference in potential temperature (°C) between results from WOCE and the revisit cruise

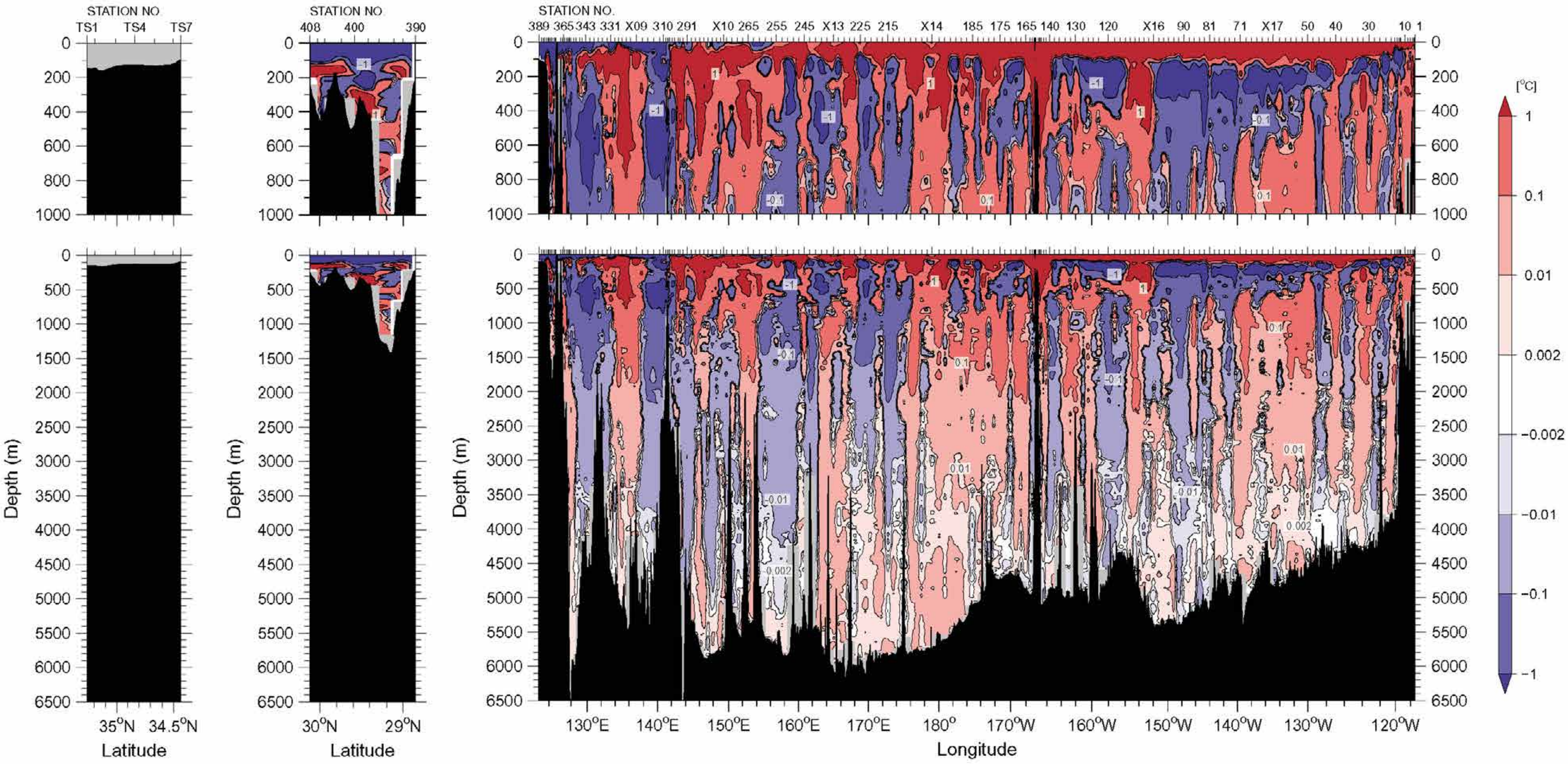

Figure 27

Difference in salinity (psu) between results from WOCE and the revisit cruise

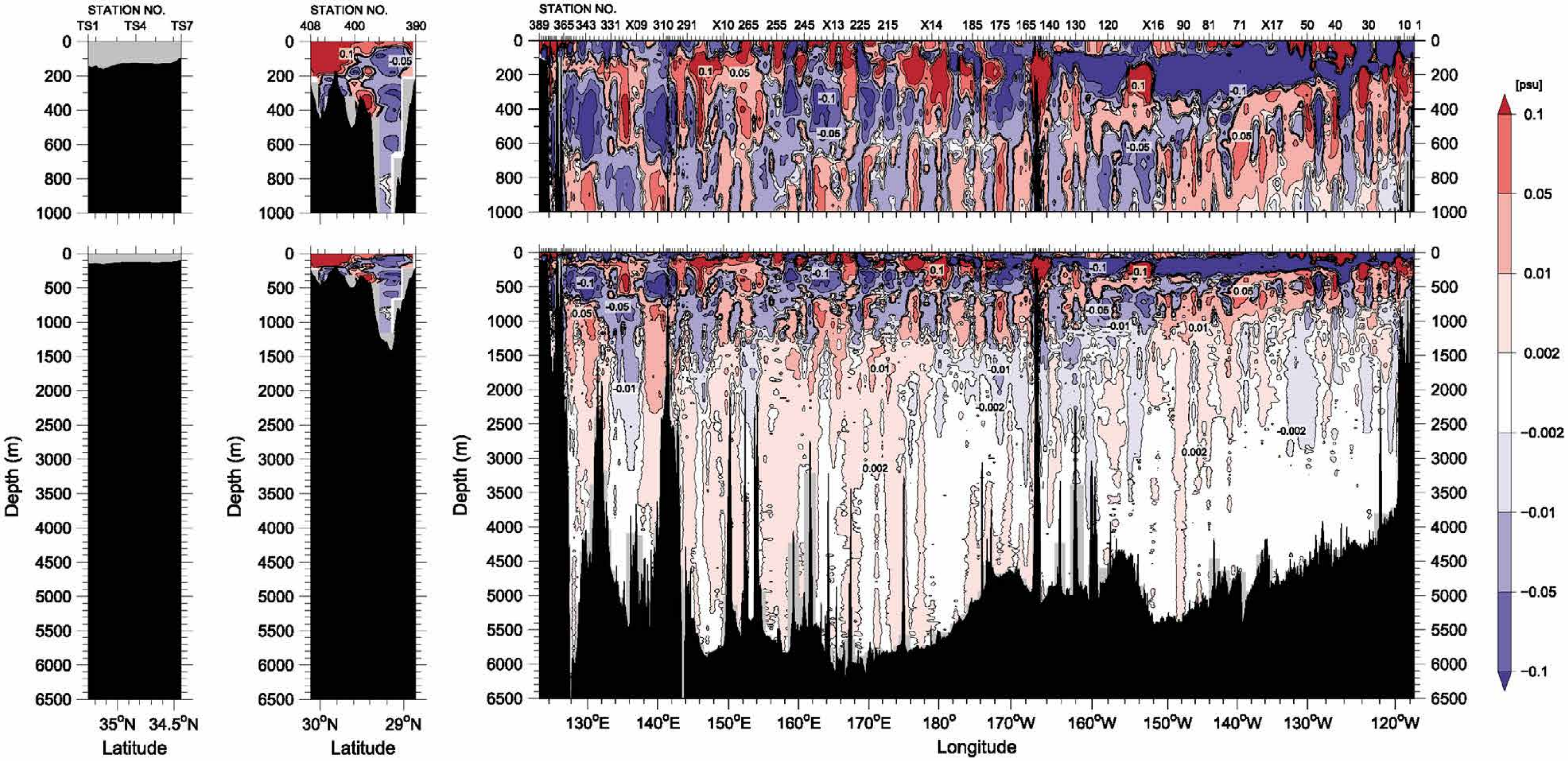

Figure 28

Difference in dissolved oxygen (μmol/kg) between results from WOCE and the revisit cruise