WHP P01 REVISIT DATA BOOK

Collaboration between Sub-Arctic Gyre Experiment (SAGE) and Institute of Ocean Sciences (IOS)

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Edited by

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WHP P01 REVISIT

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SAGE & IOS

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Preface

An ocean science program entitled "Sub Arctic Gyre Experiment" (SAGE) began in April 1997 funded by the Japan Science and Technology Agency. The goals of the program were:

1. To detect decadal changes in the structure of the North Pacific Sub-Arctic gyre.
2. To describe an overturn in the Sub-arctic North Pacific which leads to the formation of North Pacific Intermediate Water in the Sub-Tropical North Pacific.
3. To develop ocean numerical model tools including the assimilation of hydrographic data.

As a part of the SAGE field operations, two WOCE Hydrographic Sections were re-occupied. One is WHP P01 along 47°N which was occupied by United States in 1985. The other is WHP P17N in the Gulf of Alaska, which was occupied also by United States in 1993. P01 was reoccupied in 1999 collaboratively between the SAGE P1 revisit group (Japan Fisheries Agency, Maritime Safety Agency, National Institute of Resource and Environment, Tokai University, Tohoku University, Shizuoka University and Japan Marine Science and Technology Center) and the Institute of Ocean Sciences, Sidney, B.C., Canada. P17N was reoccupied in 2001 collaboratively between the Japan Marine Science and Technology Center and the Fisheries Agency on R/V Mirai of the Japan Marine Science and Technology Center during the same period that IOS scientists were occupying Line-P in the Gulf of Alaska. These two revisit cruises were planned to follow WOCE standards for sampling including measurements of carbon related variables.

This booklet contains short cruise reports, metadata and data collected from the P1 revisit cruises, because we hope and believe that the result of P1 revisit is useful for not only SAGE and IOS scientists but also many other researchers in the world. Ultimately, to make the hydrographic data public, it may be the best way to deposit reports and data with the WOCE Hydrographic Program Office (WHPO). But the complexities stemming from having so many institutions and universities collaborating made it difficult to deposit the entire reports and data with the WHPO even in 2001, two years after the cruise. So, we decided to publish this booklet to effect a faster utilization of the data from the P1 revisit, even though some data have yet to be reported. We believe that all of PIs will continue to finish their duties so that a complete data set may be deposited with the WHPO as soon as possible.

Finally, we would like to express our gratitude to all participants and crews of the Kaiyo-maru of Japan Fisheries Agency, Mirai of the Japan Marine Science and Technology agency and the John P. Tully of the Canadian Coast Guard, for their assistance in carrying out these cruises.

This booklet is published under funding for the "Sub-Arctic Gyre Experiment" from the Japan Science and Technology Agency, which was reconstructed into the Ministry of Education, Culture, Sports, Science and Technology in 2001.

Masao Fukasawa
SAGE Principal Investigator
Japan Marine Science and
Technology Center
Yokosuka, Kanagawa, Japan

It was a great honour to be asked by Dr. Masao Fukasawa to collaborate with our esteemed Japanese colleagues to assist in the re-occupation of the WOCE Line P1, and we agree that the data should be made available to scientists as soon as possible. We would like to thank Fukasawa-san and his colleagues with the various Japanese agencies involved for this opportunity.

We also would like to express our gratitude to the officers and crews of all vessels involved in the P1 reoccupation project, their generous assistance is much appreciated. The Canadian contribution was funded by the Department of Fisheries and Oceans under the auspices of the Strategic Science Fund.

Howard Freeland
Institute of Ocean Science
Sidney, British Columbia., Canada

P1W

I. Cruise Narrative

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

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

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

After finishing the CTD+RMS observation at P01_#74 on June 7, we changed the course and started to the west to reoccupy the station P01_#35. We did 75 XBT observations on the course from 166W to 157E every 0.5-degree longitude by the request of the hydrographic division of Japan Meteorological Agency on SAGE. We left the last station CTD-RMS station P01_#35 at 12:00 JST June 11 and we turned the bow to Kushiro. We arrived in the Kushiro harbor on June 13.

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

II. Cruise summary

1. Ship name
   Kaiyo-maru (Japan Fisheries Agency)
2. Cruise period
   From 23 May 1999 to 6 June 1999
3. Observation
   49 stations along WHP P1 from 148E to 172W
4. Chief Scientist
   Tomowo Watanabe (Far Fisheries Laboratory, Japan Fisheries Agency):
   wattom@affrc.go.jp
5. Observation Item and PI

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

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

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

III. Sample water salinity measurements

(1) Personal

Ayako Nishina (Kagoshima University)

Tomowo Watanabe (Fisheries Agency)

Masao Fukasawa (Tokai University)

(2) Objective

Calibration of salinity measured by CTD.

(3) Measured Parameter

Sample water salinity

(4) Instruments and Method

The salinity analysis was carried out by two Guildline Autosal salinometers model 8400B, which were modified by addition of an Ocean Science International peristaltic-type sample intake pump. One salinometer was operated in an air-conditioned ship's laboratory and in a laboratory of Far Fisheries Laboratory JFA. The other one was operated also in an air-conditioned room at Kagoshima University.

i) Standard Sea Water

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

ii) Salinity Sample Collection

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

iii) Replicate Samples

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

IV. Sample Dissolved Oxygen Measurements

(1) Personel

Ayako Nishina (Kagoshima University)

Hiroyuki Nakajima (Tokai University)

Masao Fukasawa (Tokai University)

(2) Objective

To describe changes in DO transect between 1985 and 1999.

(3) Equipment and techniques

Bottle oxygen samples were taken in calibrated clear glass bottle of 100 ml capacity before other samples were drawn. To check and to allow corrections for change in capacity of the sample between the closure of the rosette bottle and fixing of the dissolved oxygen, the potential temperature calculated from CTD results was used after a correction based on the measured temperature data. Analysis followed the whole bottle method. The thiosulfate titration was carried out in a controlled environmental laboratory maintained at temperature between 20 deg.C and 28deg.C. The normality of thiosulfate was set to be 0.05 when the regents were made up, and checked their changes 7 times during a cruise. Replicate samples were taken from bottles of fixed number (2, 7, 12, 17, 22) on every cast ; usually these were included deepest bottle and DO minimum bottle.

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

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

(4) Reproducibility of measurement

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

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

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

V. Carbonate species and Chemical transient tracers

(1) Personnel

Yutaka Watanabe (National Institute of Resource and Environment)

Tsuneo Ono (National Research Institute of Fisheries Laboratory)

Yoshiyuki Nakano (Hokkaido University)

Masahide Wakita (Hokkaido University)

(2) Objectives

Total dissolved inorganic carbon (DIC), titration Alkalinity (TA) and pH are the main parameters of oceanic carbon cycle, which owes significant importance recently for understanding of the fate of human-released CO_2. On the other hand, CFC11, CFC12, CFC113 and SF_6 as chemical transient tracers are very useful to clarify the water movement and/or the fate of human-released CO_2. If we observed the above parameters simultaneously, it will allow us to get more information about oceanic carbon cycle.

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

(3) Sampling and Methods

(a) DIC

Method: Extraction/Coulometry (Ono et al., 1998)

Analyzer: UIC CM5012 coulometer & KIMOTO EN-501 auto-coulometer

Standard: Primary standard grade Na_2CO_3 (Asahi grass Co.)

Precision: +/- 2.7 µmol/kg

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

(b) TA

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

Analyzer: Manual measurement

Standard: Primary standard grade Na_2CO_3 (Asahi grass Co.)

Precision: +/- 3.5 µmol/kg

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

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

(c) pH

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

(The pH indicator is m-cresol purple)

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

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

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

Precision: +/- 0.002pH

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

(d) CFC11, CFC12 & CFC113

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

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

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.01 pmole/kg

Sub-samples were drawn into a 120 ml grass syringe. Duplicate samples were taken on every station. We used 30 ml as a sample. All samples were stored within 12 hours after the sampling followed by the modified purged and trapped ECD-GC method (Bullister and Weiss, 1988). We measured water sample of 30 ml. All data were normalized to SIO '93 scale.

(e) SF_6

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

Analyzer: ECD-GC (Hitachi 5000A)

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.03 fmole/kg

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

(4) Preliminary results

Measurements of DIC, TA, pH, CFC11, CFC12, CFC113 and SF_6 were made with the above precision. This was the first result of the east-west cross section where precise carbonate species and chemical transient tracers were simultaneously observed in the North Pacific subpolar region. We will try to get these detailed spatial distributions with the results of SAGE-P1revisit first leg by R/V Kaiyo-maru of Japan Fisheires Agancy during May-June 1999. We also will do the time change of carbonate species and water movement by comparing the 1985 WOCE/WHP P01 data with our data in the future.

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

(1) Personnel

Masao Fukasawa (Tokai University): collecting sample

Robert Key (Princeton University): analyzing sample

(2) Objective

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

(3) Sample collection

Sampling stations of 14C are planned to be every five degrees except the western boundary area. Samples were collected from depth using 12 liter Niskin bottles. Sampling glass bottles of c.a. 500ml were baked at 450 degree C for tow hours after dipped into 1 N of HCl solution. After baking, each bottle was capped with an aluminum foil until the sampling on the shipboard. The seawater sample was siphoned into the glass bottle with enough seawater to fill the glass. Immediately after the collection, about 10 ml of seawater was removed from the bottle and poisoned by 1 ml of saturated $HgCl_2$ solution. The bottle was put a screwed plastic cap on and sealed with butyl tape. Then the bottle was put in a wooden container.

295 samples were collected from 12 stations.

(4) Sample measurements

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

VII. CTD measurement

(1) Personnel

Masao Fukasawa (Tokai University)

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

Tkahiko Kameda (National Research Institute of Far Seas Fisheries Laboratory)

(2) Objective

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

(3) Apparatus

Body and Circuit

Sea-Bird CTD9 s/n 09P13830-0429

Sensors

Temperature sensor: 2109

Conductivity sensor: 041723,042256

Pressure sensor: Digiquartz 410k-105 s/n 59935

DO sensor: s/n 130207, Beckman s/n 7-05-19

(3) Sensor calibration

(3)-1 Temperature sensor

Temperature sensor was calibrated before and after the cruise on 3 Apr. 99 and 29 Jun. 99, respectively at Sea-Bird Electronics. Post-cruise residuals defined as differences between the bath temperature and the instrument temperature were checked at eleven temperature points of -1.4108, 1.0995, 4.5914, 8.1890, 11.6230, 15.1795, 18.6833, 22.1824, 25.7416. 29.1567 and 32.6894 ITS-90 degree C. The largest sensor drift during the period from the pre-cruise calibration to the post-cruise calibration was found to be 0.00003 deg C at around 1.0995 deg C. On the other hand, the absolute temperature difference between the bath and the instrument temperature was found to be largest as 0.0007deg C at around 15.1770 deg C using coefficients decided at the time of pre-cruise.

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

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

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

(3)-2 Conductivity sensors

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

(3)-3 Pressure sensor

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

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

(3)-4 DO sensor

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

(4) Data calibration

(4)-1 Temperature

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

(4)-2 Salinity

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

stn	cast	SD(0-1000) PSS-78	SD(1000-bottom) PSS-78
1	1	4.6181239e-003	N/A
2	1	1.4421889e-002	N/A
3	1	4.4185086e-003	N/A
4	1	4.2680562e-003	2.1874343e-004
20	1	3.8094293e-003	6.8252835e-004
22	1	2.8298779e-003	6.6035513e-004
24	1	1.7978313e-003	6.3866350e-004
26	1	1.8037580e-003	1.5259117e-003
27	1	1.9352809e-003	5.1124454e-004
28	1	2.1721584e-003	1.5042862e-003
29	1	1.2927151e-003	1.4045676e-003
30	1	2.1852552e-003	5.6407853e-004
31	1	1.6322545e-003	1.5007146e-003
32	1	2.2444854e-003	1.2699376e-003
33	1	2.5252833e-003	6.4161291e-004
34	1	1.5195429e-003	1.2669956e-003
35	1	N/A	N/A
36	1	1.4124021e-003	1.0463125e-003
37	1	1.6730462e-003	5.9182014e-004
38	1	1.0860671e-003	3.8176772e-004
39	1	1.4468418e-003	4.1070157e-004
40	1	1.9508624e-003	4.0846259e-004
41	1	1.1322033e-003	5.4830744e-004
X13	1	1.1533325e-003	5.5110814e-004
44	1	2.5624161e-003	9.8279168e-004
45	1	1.2238404e-003	2.3456222e-004
46	1	2.5344814e-003	8.9530163e-004
47	1	1.4346796e-003	1.2657885e-003
48	1	1.6048432e-003	6.9112603e-004
50	1	2.1409360e-003	4.1719428e-004
51	1	1.2464234e-003	9.7123702e-004
52	1	2.0123110e-003	5.5598393e-004

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

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

(4)-3 Pressure

CTD outputs were re-produced using coefficients noted above.

(4)-4 Oxygen

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

P1W .sum file

P1W R/V KAIYO-MARU CRUISE KY9901 LEG 1

SHIP/CRS EXPOCODE	WOCE SECT	STNNBR	CASTNO	CAST TYPE	DATE	UTC TIME	EVENT CODE	POSITION LATITUDE	LONGITUDE	NAV	UNC DEPTH	HT ABOVE BOTTOM	WIRE OUT	MAX PRESS	NO. OF BOTTLES	PARAMETERS	COMMENTS
49KY9901/1	P1W	1	1	ROS	052399	0110	BE	42 58.58 N	145 26.99 E	GPS	96				4	1-6	
49KY9901/1	P1W	1	1	ROS	052399		BO	N	E	GPS	95	15	96	81			
49KY9901/1	P1W	1	1	ROS	052399	0122	EN	42 58.59 N	145 26.90 E	GPS	95						
49KY9901/1	P1W	2	1	ROS	052399	0223	BE	42 53.16 N	145 31.10 E	GPS	407				9	1-8,13,23,26,27,34	#21 No Water
49KY9901/1	P1W	2	1	ROS	052399	0237	BO	42 53.15 N	145 30.95 E	GPS	423	40	396	392			
49KY9901/1	P1W	2	1	ROS	052399	0258	EN	42 53.07 N	145 30.70 E	GPS	415						
49KY9901/1	P1W	3	1	ROS	052399	0437	BE	42 51.40 N	145 32.40 E	GPS	901				14	1-6,13,46,47	
49KY9901/1	P1W	3	1	ROS	052399	0458	BO	42 51.20 N	145 32.30 E	GPS	918	20	912	902			
49KY9901/1	P1W	3	1	ROS	052399	0524	EN	42 51.10 N	145 32.00 E	GPS	925						
49KY9901/1	P1W	4	1	ROS	052399	0628	BE	42 48.40 N	145 34.80 E	GPS	1488				18	1-6,13	#1,21 No Water
49KY9901/1	P1W	4	1	ROS	052399	0703	BO	42 48.30 N	145 33.90 E	GPS	1524	-9	1556	1503			
49KY9901/1	P1W	4	1	ROS	052399	0743	EN	42 48.30 N	145 33.20 E	GPS	1424						
49KY9901/1	P1W	20	1	ROS	052499	0148	BE	39 41.48 N	147 55.60 E	GPS	5343				24	1-8,12,13,23,24,26,27,34,39	
49KY9901/1	P1W	20	1	ROS	052499	0331	BO	39 41.39 N	147 57.05 E	GPS	5367	-9	5488	5441			
49KY9901/1	P1W	20	1	ROS	052499	0528	EN	39 41.27 N	147 58.43 E	GPS	5358						
49KY9901/1	P1W	22	1	ROS	052499	0913	BE	40 19.21 N	148 52.41 E	GPS	5460				24	1-8,13,23,24,26,27	
49KY9901/1	P1W	22	1	ROS	052499	1101	BO	40 20.07 N	148 53.39 E	GPS	5488	7	5654	5577			
49KY9901/1	P1W	22	1	ROS	052499	1308	EN	40 20.21 N	148 53.57 E	GPS	5488						
49KY9901/1	P1W	24	1	ROS	052499	1644	BE	40 55.77 N	149 51.68 E	GPS	5370				24	1-8,13,23,24,26,27,39,46,47	#11 No Water, without LADCP
49KY9901/1	P1W	24	1	ROS	052499	1830	BO	40 55.73 N	149 52.43 E	GPS	5362	-9	5462	5442			
49KY9901/1	P1W	24	1	ROS	052499	2052	EN	40 55.92 N	149 53.68 E	GPS	5343						
49KY9901/1	P1W	26	1	ROS	052599	0029	BE	41 33.68 N	150 52.38 E	GPS	5208				24	1-8,13,23,24,26,27	
49KY9901/1	P1W	26	1	ROS	052599	0207	BO	41 34.08 N	150 52.53 E	GPS	5210	25	5298	5283			
49KY9901/1	P1W	26	1	ROS	052599	0453	EN	41 35.00 N	150 52.90 E	GPS	5220						
49KY9901/1	P1W	27	1	ROS	052599	0712	BE	41 56.56 N	151 27.89 E	GPS	5151				24	1-6,46,47	
49KY9901/1	P1W	27	1	ROS	052599	0854	BO	41 57.48 N	151 27.81 E	GPS	5261	13	5261	5220			
49KY9901/1	P1W	27	1	ROS	052599	1042	EN	41 58.37 N	151 28.00 E	GPS	5111						
49KY9901/1	P1W	28	1	ROS	052599	1308	BE	42 20.06 N	152 05.53 E	GPS	5113				24	1-8,12,13,23,24,26,27,34,39	#21 leak
49KY9901/1	P1W	28	1	ROS	052599	1532	BO	42 21.27 N	152 05.92 E	GPS	5127	15	5253	5200			
49KY9901/1	P1W	28	1	ROS	052599	1718	EN	42 21.58 N	152 07.00 E	GPS	5145						
49KY9901/1	P1W	29	1	ROS	052599	1945	BE	42 40.54 N	152 41.31 E	GPS	5309				24	1-6	#7 No water (broken)
49KY9901/1	P1W	29	1	ROS	052599	2124	BO	42 40.48 N	152 42.44 E	GPS	5297	21	5407	5387			
49KY9901/1	P1W	29	1	ROS	052599	2309	EN	42 40.11 N	152 43.48 E	GPS	5287						
49KY9901/1	P1W	30	1	ROS	052699	0148	BE	43 05.49 N	153 19.47 E	GPS	5164				24	1-8,13,23,24,26,27,34,39,46,47	
49KY9901/1	P1W	30	1	ROS	052699	0346	BO	43 05.39 N	153 19.87 E	GPS	5174	-9	5262	5246			
49KY9901/1	P1W	30	1	ROS	052699	0533	EN	43 05.42 N	153 19.98 E	GPS	5174						
49KY9901/1	P1W	31	1	ROS	052699	1058	BE	43 34.09 N	154 09.17 E	GPS	5434				24	1-6	
49KY9901/1	P1W	31	1	ROS	052699	1338	BO	43 35.46 N	154 08.41 E	GPS	5395	-9	5488	5474			
49KY9901/1	P1W	31	1	ROS	052699	1533	EN	43 35.60 N	154 08.20 E	GPS	5391						
49KY9901/1	P1W	32	1	ROS	052699	1914	BE	44 04.68 N	154 57.64 E	GPS	5364				24	1-8,12,13,23,24,26,27,34,39,45	#13 Leak, #12 No Water
49KY9901/1	P1W	32	1	ROS	052699	2052	BO	44 04.61 N	154 57.47 E	GPS	5366	28	5457	5445			
49KY9901/1	P1W	32	1	ROS	052699	2238	EN	44 04.88 N	154 57.60 E	GPS	5360						
49KY9901/1	P1W	33	1	ROS	052799	0147	BE	44 34.37 N	155 47.34 E	GPS	5131				24	1-6,46,47	#13Leak, #24 Leak,#8 No Water(Broken)
49KY9901/1	P1W	33	1	ROS	052799	0324	BO	44 34.25 N	155 47.77 E	GPS	5114	-9	5197	5186			

49KY9901/1	P1W	33	1	ROS	052799	0518	EN	44 33.66 N	155 47.40 E	GPS	5122						
49KY9901/1	P1W	34	1	ROS	052799	0840	BE	45 04.22 N	156 37.99 E	GPS	4775				24	1-8,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	34	1	ROS	052799	1012	BO	45 03.79 N	156 37.55 E	GPS	4777	36	4872	4844			
49KY9901/1	P1W	34	1	ROS	052799	1216	EN	45 03.40 N	156 36.40 E	GPS	4799						
49KY9901/1	P1W	35	1	ROS	052799	1532	BE	45 33.46 N	157 28.67 E	GPS	5038				24	1-6	A large jerry fish was in the pump
49KY9901/1	P1W	35	1	ROS	052799	1705	BO	45 33.38 N	157 28.11 E	GPS	5036	12	5135	5121			and C sensor.
49KY9901/1	P1W	35	1	ROS	052799	1849	EN	45 33.23 N	157 27.52 E	GPS	5036						Will be re-occupied
49KY9901/1	P1W	36	1	ROS	052799	2202	BE	46 04.10 N	158 20.04 E	GPS	4834				24	1-8,13,23,24,26,27,34,39,45-47	#6 Leak
49KY9901/1	P1W	36	1	ROS	052799	2330	BO	46 04.34 N	158 19.86 E	GPS	4837	14	4938	4915			
49KY9901/1	P1W	36	1	ROS	052899	0105	EN	46 04.62 N	158 20.24 E	GPS	4839						
49KY9901/1	P1W	37	1	ROS	052899	0417	BE	46 33.86 N	159 12.87 E	GPS	5107				24	1-6	#13 Leak
49KY9901/1	P1W	37	1	ROS	052899	0551	BO	46 33.87 N	159 12.35 E	GPS	5104	10	5212	5196			
49KY9901/1	P1W	37	1	ROS	052899	0740	EN	46 34.19 N	159 11.92 E	GPS	5111						
49KY9901/1	P1W	38	1	ROS	052899	1026	BE	46 59.97 N	160 00.93 E	GPS	5210				24	1-8,12,13,23,24,26,27,34,39,45	#13 Leak
49KY9901/1	P1W	38	1	ROS	052899	1203	BO	47 00.23 N	160 00.66 E	GPS	5188	18	5294	5280			
49KY9901/1	P1W	38	1	ROS	052899	1351	EN	47 00.09 N	160 00.31 E	GPS	5184						
49KY9901/1	P1W	39	1	ROS	052899	1710	BE	47 00.00 N	161 08.29 E	GPS	5345				24	1-6,46,47	#13 Leak
49KY9901/1	P1W	39	1	ROS	052899	1850	BO	47 00.60 N	161 08.69 E	GPS	-9	11	5464	5435			
49KY9901/1	P1W	39	1	ROS	052899	2035	EN	47 00.69 N	161 09.09 E	GPS	5333						
49KY9901/1	P1W	40	1	ROS	052899	2351	BE	46 59.97 N	162 15.31 E	GPS	5673				24	1-8,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	40	1	ROS	052999	0134	BO	47 00.42 N	162 15.65 E	GPS	5685	18	5794	5784			
49KY9901/1	P1W	40	1	ROS	052999	0333	EN	47 01.00 N	162 15.80 E	GPS	5632						
49KY9901/1	P1W	41	1	ROS	052999	0724	BE	47 00.10 N	163 21.75 E	GPS	5761				24	1-6	#24 Leak
49KY9901/1	P1W	41	1	ROS	052999	0910	BO	47 00.68 N	163 21.41 E	GPS	5729	24	5902	5888			
49KY9901/1	P1W	41	1	ROS	052999	1117	EN	47 00.19 N	163 20.90 E	GPS	5784						
49KY9901/1	P1W	X13	1	ROS	052999	1612	BE	47 00.04 N	164 57.75 E	GPS	5873				24	1-8,12,13,23,24,26,27,34,39,45-47	#24 Leak, The cross point with P13
49KY9901/1	P1W	X13	1	ROS	052999	1757	BO	47 00.37 N	164 57.67 E	GPS	5851	20	5970	5963			
49KY9901/1	P1W	X13	1	ROS	052999	1947	EN	47 00.74 N	164 57.97 E	GPS	5846						
49KY9901/1	P1W	44	1	ROS	053099	0037	BE	46 59.86 N	166 44.80 E	GPS	5948				24	1-8,13,23,24,27,34,39,45	
49KY9901/1	P1W	44	1	ROS	053099	0223	BO	46 59.50 N	166 45.59 E	GPS	5959	45	6044	6037			
49KY9901/1	P1W	44	1	ROS	053099	0420	EN	46 59.44 N	166 45.98 E	GPS	5963						
49KY9901/1	P1W	45	1	ROS	053099	0721	BE	47 00.00 N	167 49.75 E	GPS	6246				24	1-6	
49KY9901/1	P1W	45	1	ROS	053099	0901	BO	47 00.38 N	167 50.28 E	GPS	6248	-9	6025	6002			
49KY9901/1	P1W	45	1	ROS	053099	1054	EN	47 00.56 N	167 50.60 E	GPS	6249						
49KY9901/1	P1W	46	1	ROS	053099	1237	BE	46 59.93 N	168 22.16 E	GPS	6256				24	1-8,12,13,23,24,26,27,34,39,45-47	#24 Leak
49KY9901/1	P1W	46	1	ROS	053099	1421	BO	47 00.23 N	168 22.59 E	GPS	6187	-9	6022	6010			
49KY9901/1	P1W	46	1	ROS	053099	1617	EN	47 00.22 N	168 23.28 E	GPS	6176						
49KY9901/1	P1W	47	1	ROS	053099	1814	BE	46 59.94 N	168 59.54 E	GPS	5181				24	1,2	#24 Leak
49KY9901/1	P1W	47	1	ROS	053099	1946	BO	46 59.80 N	168 59.82 E	GPS	5163	36	5275	5261			
49KY9901/1	P1W	47	1	ROS	053099	2125	EN	46 59.55 N	169 00.22 E	GPS	5161						
49KY9901/1	P1W	48	1	ROS	053099	2207	BE	46 59.96 N	169 05.97 E	GPS	3954				24	1-8,12,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	48	1	ROS	053099	2321	BO	46 59.44 N	169 06.27 E	GPS	-9	30	3972	3934			13C surface no sample
49KY9901/1	P1W	48	1	ROS	053199	0042	EN	46 59.25 N	169 06.76 E	GPS	3521						
49KY9901/1	P1W	50	1	ROS	053199	0246	BE	47 00.01 N	169 34.57 E	GPS	2334				24	1-6,13,23,24,26,34,39,46,47	#5, #21 No water (broken)
49KY9901/1	P1W	50	1	ROS	053199	0336	BO	46 59.93 N	169 34.84 E	GPS	2310	12	2362	2343			
49KY9901/1	P1W	50	1	ROS	053199	0427	EN	46 59.77 N	169 35.13 E	GPS	2271						
49KY9901/1	P1W	51	1	ROS	053199	0551	BE	47 00.00 N	169 48.65 E	GPS	3292				24	1,2	#24 Leak
49KY9901/1	P1W	51	1	ROS	053199	0702	BO	46 59.89 N	169 48.75 E	GPS	-9	-9	3449	3427			
49KY9901/1	P1W	51	1	ROS	053199	0815	EN	46 59.71 N	169 48.84 E	GPS	3484						
49KY9901/1	P1W	52	1	ROS	053199	0903	BE	47 00.03 N	169 59.85 E	GPS	4945				24	1-8,12,13,23,24,26,27,34,39,45	#24 Leak
49KY9901/1	P1W	52	1	ROS	053199	1034	BO	46 59.85 N	170 00.01 E	GPS	4958	33	5047	5032			

49KY9901/1	P1W	52	1	ROS	053199	1211	EN	46	59.64	N	170	00.13	E	GPS	4951								
49KY9901/1	P1W	53	1	ROS	053199	1411	BE	46	59.96	N	170	28.50	E	GPS	6337						24	1-6	#16 Leak
49KY9901/1	P1W	53	1	ROS	053199	1600	BO	46	59.42	N	170	28.69	E	GPS	6330	-9	6013	6000					
49KY9901/1	P1W	53	1	ROS	053199	1747	EN	46	58.90	N	170	28.45	E	GPS	6331								
49KY9901/1	P1W	54	1	ROS	053199	2218	BE	46	59.97	N	171	36.93	E	GPS	6110						24	1-8,13,23,24,26,27,34,39,45-47	
49KY9901/1	P1W	54	1	ROS	060199	0003	BO	46	59.92	N	171	37.42	E	GPS	5966	135	6016	6004					
49KY9901/1	P1W	54	1	ROS	060199	0230	EN	46	59.87	N	171	38.13	E	GPS	5917								
49KY9901/1	P1W	55	1	ROS	060199	0528	BE	46	59.95	N	172	42.57	E	GPS	5588						24	1-6	
49KY9901/1	P1W	55	1	ROS	060199	0834	BO	47	00.04	N	172	43.57	E	GPS	5621	15	5746	5727					
49KY9901/1	P1W	55	1	ROS	060199	1023	EN	47	00.51	N	172	43.57	E	GPS	5586								
49KY9901/1	P1W	56	1	ROS	060199	1740	BE	47	00.04	N	173	50.03	E	GPS	5809						24	1-8,12,13,23,24,26,27,34,39,45	#9 No Water
49KY9901/1	P1W	56	1	ROS	060199	1927	BO	47	00.59	N	173	50.30	E	GPS	5708	-9	5885	5850					
49KY9901/1	P1W	56	1	ROS	060199	2134	EN	47	00.55	N	173	50.72	E	GPS	5746								
49KY9901/1	P1W	57	1	ROS	060299	0132	BE	47	00.00	N	174	58.28	E	GPS	5669						24	1-6,46,47	#14 No Water
49KY9901/1	P1W	57	1	ROS	060299	0356	BO	47	00.08	N	174	59.00	E	GPS	5655	55	5786	5748					#24 Leak
49KY9901/1	P1W	57	1	ROS	060299	0551	EN	47	00.20	N	174	59.10	E	GPS	5682								
49KY9901/1	P1W	58	1	ROS	060299	1228	BE	47	00.32	N	176	06.11	E	GPS	5670						24	1-8,13,23,24,26,27,34,39,45	C sensor and the pump were replaced.
49KY9901/1	P1W	58	1	ROS	060299	1410	BO	47	00.21	N	176	06.78	E	GPS	5690	13	5807	5793					
49KY9901/1	P1W	58	1	ROS	060299	1545	EN	47	00.23	N	176	07.37	E	GPS	5693								
49KY9901/1	P1W	59	1	ROS	060299	1836	BE	47	00.00	N	177	11.55	E	GPS	5664						24	1-6	
49KY9901/1	P1W	59	1	ROS	060299	2025	BO	46	59.59	N	177	12.89	E	GPS	5670	16	5842	5781					
49KY9901/1	P1W	59	1	ROS	060299	2205	EN	46	59.28	N	177	13.29	E	GPS	5684								
49KY9901/1	P1W	X14	1	ROS	060399	0248	BE	47	00.03	N	179	00.03	E	GPS	5654						24	1-8,12,13,23,24,26,27,34,39,45-47	#24 Leak, The cross point with P14
49KY9901/1	P1W	X14	1	ROS	060399	0429	BO	46	59.90	N	179	00.10	E	GPS	5655	9	5773	5765					
49KY9901/1	P1W	X14	1	ROS	060399	0554	EN	46	59.88	N	179	00.12	E	GPS	5655								
49KY9901/1	P1W	62	1	ROS	060399	1013	BE	46	59.91	N	179	25.55	W	GPS	5639						24	1-8,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	62	1	ROS	060399	1159	BO	46	59.87	N	179	25.51	W	GPS	5641	67	5739	5729					
49KY9901/1	P1W	62	1	ROS	060399	1333	EN	46	59.30	N	179	25.49	W	GPS	5726								
49KY9901/1	P1W	63	1	ROS	060399	1640	BE	47	00.00	N	178	18.40	W	GPS	5499						24	1-6,46,47	
49KY9901/1	P1W	63	1	ROS	060399	1817	BO	47	00.23	N	178	19.20	W	GPS	5521	10	5636	5622					
49KY9901/1	P1W	63	1	ROS	060399	1953	EN	47	00.32	N	178	19.13	W	GPS	5507								
49KY9901/1	P1W	64	1	ROS	060399	2254	BE	47	00.07	N	177	13.11	W	GPS	5702						24	1-8,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	64	1	ROS	060499	0037	BO	47	00.24	N	177	12.76	W	GPS	5715	10	5832	5825					
49KY9901/1	P1W	64	1	ROS	060499	0227	EN	47	00.63	N	177	12.69	W	GPS	5721								
49KY9901/1	P1W	65	1	ROS	060499	0545	BE	47	00.09	N	176	02.47	W	GPS	5649						24	1-6	#16 No Water
49KY9901/1	P1W	65	1	ROS	060499	0726	BO	47	00.43	N	176	02.84	W	GPS	5627	5	5782	5762					#24 Leak
49KY9901/1	P1W	65	1	ROS	060499	0915	EN	47	00.84	N	176	03.16	W	GPS	5619								
49KY9901/1	P1W	66	1	ROS	060499	1221	BE	46	59.90	N	174	57.00	W	GPS	5789						24	1-8,12,13,23,24,26,27,34,39,45-47	
49KY9901/1	P1W	66	1	ROS	060499	1408	BO	46	59.62	N	174	57.07	W	GPS	5788	14	5902	5898					
49KY9901/1	P1W	66	1	ROS	060499	1604	EN	46	59.25	N	174	57.46	W	GPS	5688								
49KY9901/1	P1W	67	1	ROS	060499	1914	BE	47	00.00	N	173	48.46	W	GPS	5714						24	1-6	
49KY9901/1	P1W	67	1	ROS	060499	2055	BO	47	00.11	N	173	48.98	W	GPS	5688	9	5835	5822					
49KY9901/1	P1W	67	1	ROS	060499	2250	EN	47	00.76	N	173	48.71	W	GPS	5628								
49KY9901/1	P1W	68	1	ROS	060599	0157	BE	46	59.95	N	172	42.68	W	GPS	5761						24	1-8,13,23,24,26,27,34,39,45	#8 No Water
49KY9901/1	P1W	68	1	ROS	060599	0341	BO	47	00.02	N	172	42.68	W	GPS	5765	14	5875	5870					
49KY9901/1	P1W	68	1	ROS	060599	0524	EN	46	59.87	N	172	42.80	W	GPS	5763								
49KY9901/1	P1W	69	1	ROS	060599	0848	BE	47	00.04	N	171	32.57	W	GPS	5779						24	1-6,46,47	
49KY9901/1	P1W	69	1	ROS	060599	1033	BO	47	00.20	N	171	32.85	W	GPS	5773	12	5895	5889					
49KY9901/1	P1W	69	1	ROS	060599	1216	EN	47	00.29	N	171	33.08	W	GPS	5761								
49KY9901/1	P1W	70	1	ROS	060599	1537	BE	47	00.04	N	170	25.94	W	GPS	5480						24	1-8,13,23,24,26,27,34,39,45	
49KY9901/1	P1W	70	1	ROS	060599	1719	BO	47	00.35	N	170	25.85	W	GPS	5539	-9	5625	5612					

49KY9901/1	P1W	70	1	ROS	060599	1902	EN	47	00.33	N	170	25.98	W	GPS	5570						
49KY9901/1	P1W	71	1	ROS	060599	2213	BE	47	00.09	N	169	20.02	W	GPS	5615					24	1-6
49KY9901/1	P1W	71	1	ROS	060599	2358	BO	47	00.30	N	169	20.83	W	GPS	5615	10	5728	5722			
49KY9901/1	P1W	71	1	ROS	060699	0157	EN	47	00.43	N	169	20.43	W	GPS	5620						
49KY9901/1	P1W	72	1	ROS	060699	0510	BE	46	59.90	N	168	12.81	W	GPS	5402					24	1-8,12,13,23,24,26,27,34,39,45-47
49KY9901/1	P1W	72	1	ROS	060699	0650	BO	47	00.11	N	168	13.31	W	GPS	5389	14	5508	5493			
49KY9901/1	P1W	72	1	ROS	060699	0832	EN	47	00.40	N	168	13.66	W	GPS	5381						
49KY9901/1	P1W	73	1	ROS	060699	1153	BE	47	00.05	N	167	05.01	W	GPS	5420					24	1-6
49KY9901/1	P1W	73	1	ROS	060699	1336	BO	47	00.16	N	167	04.95	W	GPS	5421	14	5526	5520			
49KY9901/1	P1W	73	1	ROS	060699	1519	EN	47	00.12	N	167	04.93	W	GPS	5420						
49KY9901/1	P1W	74	1	ROS	060699	1922	BE	46	59.96	N	165	58.17	W	GPS	5336					24	1-8,13,23,24,26,27,34,39,45
49KY9901/1	P1W	74	1	ROS	060699	2102	BO	47	00.45	N	165	58.34	W	GPS	5468	8	5468	5434			
49KY9901/1	P1W	74	1	ROS	060699	2248	EN	47	00.87	N	165	57.29	W	GPS	5325						
49KY9901/1	P1W	35	2	ROS	061099	2345	BE	45	33.52	N	157	28.77	E	GPS	5036					23	1,2,13
49KY9901/1	P1W	35	2	ROS	061199	0124	BO	45	33.45	N	157	29.09	E	GPS	5040	13	5137	5123			
49KY9901/1	P1W	35	2	ROS	061199	0257	EN	45	33.29	N	157	29.45	E	GPS	5029						

1=Sal, 2=DO, 3=SiO2, 4=NO2, 5=NO3, 6=PO4, 7=CFC11, 8=CFC12, 12=C14, 13=C13, 23=DIC, 24=Alk, 26=pH, 27=CFC113, 34=Chla, 39=Ba, 45=SF6, 46=Cu, 47=Ni

P1C

I. Cruise Narrative

Masao Fukasawa (Tokai University)

P1C cruise was a leg of MR99K05 on the board of Mirai of JAMSTEC, and was planned as part of the collaboration program between SAGE (Sub-Arctic Gyre Experiment: a Japanese ocean science program funded by the Science and Technology Agency) and IOS (Institute of Ocean Sciences, Canada) to re-visit WHP P1 which was previously occupied by United States in 1985. As it has been 15 years since P1 was observed last, any possible climatological change may occur in the water column structure. Thus, P1 revisit cruises were called for.

The original purpose of the cruise was to back-up WHP P1 revisit stations located between 166 deg. W and 143.5 deg. W. But Kaiyo-maru cruise (P1W), which has planed to occupy stations in the west of 160 deg. W, could not occupy planned stations in the south of Hokkaido because of the temporal activity of the salmon fisheries there. As the result, those stations not occupied by Kaiyo-maru were added to this cruise forming our duty to visit sixteen extra stations in the south of Hokkaido and twenty two stations between 166 deg. W and 143.5 deg. W.

We set sail on August 24, 1999 at Sekinehama, Japan. The first station of the cruise was located at 42.81 deg. N, 145.56 deg. E where the CTD+RMS observation began at 08:31 JST on August 25. At the fourth station of P1_#7, we lost whole CTD+RMS system and LADCP system with CTD cable of 4000m long. As the back up CTD+RMS system did not work properly, we made a port at Hachinohe on August 27 for another new ROSETTE system and started the cruise again. However, it was estimated that the preparation of new CTD+RMS system on the board would force us to spend more than 72 hours. Then we gave up our duty off Hokkaido for the most important objective of the cruise, i.e. to occupy stations between Japanese efforts and Canadian efforts. P1_#74 located 47 deg. N, 165.96 deg. W was set ahead.

On the course to P1_#74, 47 XBTS and 47 XCTDs were casted by Hydrographic department of Japan Maritime Safety Agency. We arrived at P1_#74 on September 3 1999 UTC. We occupied seventeen stations before we left the easternmost station of P1_#92 located at 46.99 deg N, 145.80 deg W on September 8. Four SVP drifters were deployed in the center of the Alaskan Gyre and in the Alaskan stream on the way to Dutch Harbor.

The cruise experienced very rare but fatal accidents. But 2/3 of planned stations were occupied and 1/2 of planned water samplings were carried out.

We heartily hope that our data will be useful for studies on climate changes in the ocean. Raw data including underway observations e.g. the multi-narrow beam and meteorology are kept in DMO of JAMSTEC, however, the ship board ADCP did not work properly.

II. Cruise summary

1. Ship name

   Mirai (Japan Marine Science and Technology Center)

2. Cruise period

   From 24 August 1999 to 10 September 1999

3. Observation

   4 stations of WHP P1 in the south of Hokkaido and 17 stations along WHP P1 from 172 deg. W to 145 deg W

4. Chief Scientist

   Masao Fukasawa (Tokai University): fksw@jamstec.go.jp

5. Observation Item and PI

CTD/DO	Masao Fukasawa (Tokai University): fksw@jamstec.go.jp
Bottle Salinity	Hiroyuki Yoritaka (Hydrographic Department Japan Maritime Safety Agency): yoritaka@jodc.go.jp
Bottle Oxygen	Masao Fukasawa (Tokai University): fksw@jamstec.go.jp
Nutrients	Chizuru Saitoh (Japan Marine Science and Technology Center): saitoc@jamstec.go.jp
CFC11,12,133	Yutaka Watanabe (National Institute for Resource and Environment): yywata@ees.hokudai.ac.jp
SF6	Yutaka Watanabe (National Institute for Resource and Environment): yywata@ees.hokudai.ac.jp
DIC, pH, TAlk	Tsuneo Ono (National Research Institute of Fisheries Laboratory): onot@jamstec.go.jp
delta 14C	Robert Key (Princeton University): key@Princeton.EDU Masao Fukasawa (Tokai University): fksw@jamstec.go.jp

delta 13C	Yutaka Watanabe (National Institute for Resource and Environment): yywata@ees.hokudai.ac.jp
Barium,Calcium	Yoshihisa Kato (Tokai University): ykato@scc.u-tokai.ac.jp
Chlorophyll_a	Yoshimi Suzuki (Shizuoka University): ysuzu@shizuoka-u.ac.jp
Total Organic Carbon	Yoshimi Suzuki (Shizuoka University): ysuzu@shizuoka-u.ac.jp
Cu, Ni	Chizuru Saitoh (Japan Marine Science and Technology Center): saitoc@jamstec.go.jp

III. Sample water salinity measurements

(1) Personal

Hiroyuki Yoritaka (Hydrographic Department, Maritime Safety Agency)
Satoshi Ozawa (Marine Works Japan)
Toru Idai (Marine Works Japan)
Hitoshi Yamanobe (Marine Works Japan)
Hiroyuki Nakajima (Tokai University)
Satoko Katsuyama (Tokai University)
Fujio Kobayashi (Marine Works Japan)

(2) Objective

Calibration of salinity measured by CTD.

(3) Measured Parameter

Sample water salinity

(4) Instruments and Method

The salinity analysis was carried out by a Guildline Autosal salinometer model 8400B, which was modified by addition of an Ocean Science International peristaltic-type sample intake pump. Data of salinometer was collected simultaneously by a personal computer. A double conductivity ratio was defined as a median of 15 readings of the salinometer. Data collection was started after 5 seconds and it took about 5 seconds to collect 15 readings by a personal computer.

The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 degree C. An ambient temperature varied from approximately 23 to 24 degree C.

i) Standard Sea Water

Autosal model 8400B was standardized only before sequence of measurements by use of IAPSO Standard Seawater batch P135 whose conductivity ratio was 0.99992. After the standardization, 8400B was monitored by SSW ampoule before and after the measurements for samples of one station. Total 23 ampoules of SSW were measured for monitoring, whose standard deviation was 0.0004 psu.

ii) Salinity Sample Collection

The bottles in which the salinity samples are collected and stored are 250ml clear glass bottles with inner caps and outer screw caps. Each bottle were rinsed twice and filled with sample water. Salinity samples were stored by the end of leg 1 in the same laboratory as the salinity measurement was made.

iii) Replicate Samples

Replicate samples were drawn from several Niskin bottles for each station. Standard deviation in the measurements of replicate samples was 0.0013 psu for 54 pairs.

iv) Quality Flag

Quality flag was made according to difference from corrected salinity measured with CTD. CTD salinity was corrected by linear fitting with bottle salinity for pressure in the upper layer (<1000db) and the deep layer (>1000db) at each station (see CTD). For the bottle salinity exceeded double standard deviation, bad (4) or doubt (3) flag was made. Rms of residual difference was 0.001 between CTD salinity and good bottle salinity for deeper layer.

IV. Sample water oxygen measurements

(1) Personal

Masao Fukasawa (Tokai University)
Fuyuku Shibata (Marine Works Japan)
Katsunori Sagishima (Marine Works Japan)

(3) Objective

To describe changes in DO transect between 1985 and 1999.

(3) Measured Parameter

Sample water dissolved oxygen

(4) Instruments and Method

(a) Instruments and Apparatus

Dispenser:	Eppendorf Comforpette 480/ 1000µl.
	OPTIFIX/ 2ml
	Metrohm Model 725 Multi Dosimat/ 20ml
Titrator:	Metrohm Model 716 DMS Titrino / 10ml of titration vesswl
	Pt electrode/ 6.0403.100(NC)
Software:	Data acquisition / Metrohm, METRODATA / 606013/000
	Endpoint evaluation

(b) Methods

Samples were colleted from 12L Niskin bottles and a bucked for the surface into the volumetrically calibrated dry grass bottles. At least two times of bottle volumes of sample water were overflowed before each sampling. Sampling water temperatures for 4 or 5 bottles were measured by a thermister-thermometer to calculate the change in the volume of sampled water at the time of the titration. For other samples of which temperature were not measured, potential temperatures derived from CTD data were used. The sampling bottles consist of ordinary BOD flask (ca. 180ml) and glass stopper with long nipple inside which is modified from the nipple in Green and Carritt (1966). Oxygen in the sample was fixed immediately after the collection. Bottles were kept in a wooden box in the temperature-controlled laboratory until the titration.

The analytical method and the preparation of regents were carried out in the same way as described in WHP Operations and Methods (Culberson, 1991). A 0.05N thiosulfateof titrant was adopted during the cruise. Volumetric apparatus except titrator were calibrated before the cruise. A titration was started about one hour after the fixation of dissolved oxygen. Two sets of Metrohm titrators with the automatic piston burette of 10ml and Pt electrode were used for the titration in the temperature-controlled laboratory. The temperature of samples which had been stored was 21 deg. C +/- 1 deg. C during the cruise. The end point was determined by the potentiometric method and evaluated by the second-derivative curve method. Concentration of dissolved oxygen was computed using the equation in WHP Operation and Methods (Culberson, 1991).

(5) Results

We carried out 366 analyses of DO. Results are shown in .sea file.

(a) Thiosulfate Standardization

Thiosulfate regent was standardized when thiosulfate bottles of titrator were empty. Two kinds of 0.0100N KIO3 standard solutions were used for the standardization e.g. Lot 990420b(0.01003N) and Lot 990421(0.01002N). The averaged volumes of thiosulfate for the standardization were 1.969ml (titrator #1) and 1.973ml (titrator #2), with standard deviation of 0.007ml and 0.001ml, respectively.

(b) Pure water blank

The blank value comes from the presence of redox species aparted from oxygen in the regents, which behaves equivalently to oxygen to be analysed. The pure water blank or the titration blank was determined using deionaized water (Milli-Q SP, Millipore) at each thiosulfate standardization. The average of pure water blanks was -0.015ml (#1) and -0.015ml (#2) with standard deviation of 0.003ml and 0.004ml, respectively.

(c) Reproducibility

In the cruise, replicate samples were drawn from some Niskin bottles at each station to estimate the precision of the analysis. 85 pair of replicate samples are analyzed to show the standard deviation (2 sigma) of 0.016ml/l or 0.2% of maximum value of DO concentration of 7.843ml/l in the cruise.

V. Carbonate species and Chemical transient tracers

(1) Personnel

Yutaka Watanabe (National Institute of Resource and Environment)

Tsuneo Ono (National Research Institute of Fishery Laboratory)

Yoshiyuki Nakano (Hokkaido University)

Masahide Wakita (Hokkaido University)

(2) Objectives

Total dissolved inorganic carbon (DIC), titration Alkalinity (TA) and pH are the main parameters of oceanic carbon cycle, which owes significant importance recently for understanding of the fate of human-released CO_2. On the other hand, CFC11, CFC12, CFC113 and SF_6 as chemical transient tracers are very useful to clarify the water movement and/or the fate of human-released CO_2. If we observed the above parameters simultaneously, it will allow us to get more information about oceanic carbon cycle.

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

(3) Sampling and Methods

(a) DIC

Method: Extraction/Coulometry (Ono et al., 1998)

Analyzer: UIC CM5012 coulometer & KIMOTO EN-501 auto-coulometer

Standard: Primary standard grade Na_2CO_3 (Asahi grass Co.)

Precision: +/- 2.7 μmol/kg

Sub-samples were drawn into a 150 ml grass salinity bottle and closed after 5 seconds of overflow. Duplicate samples were taken on every station. All samples were stored under room temperature and analyzed within 12 hours after the sampling followed by a coulometric method (Ono et al., 1998). In some stations, measurement was also done by the automatic DIC measurement system by coulometry (KIMOTO EN-501, KIMOTO Electronic CO.).

Two solutions of standard grade sodium carbonate were used as the primary standard. Two concentrations of the seawater standards containing a constant amount of DIC were made in laboratory as working standard in the cruise. The DIC content of this working standard was determined on board using the primary standard sodium carbonate solutions. The Certified Reference materials distributed by Scripps Institution of Oceanography was measured together with the measurement at several stations.

(b) TA

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

Analyzer: Manual measurement

Standard: Primary standard grade Na_2CO_3 (Asahi grass Co.)

Precision: +/- 3.5 μmol/kg

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

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

(c) pH

Method: Continuous-flow Spectrophotometric pH measurements (Clayton et al., 1993) (The pH indicator is m-cresol purple)

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

Standard: 2-amino-2-hydroxymethyl-1, 3-propanediol (tris) buffer in synthetic seawater, 2-aminopyridine buffer in synthetic seawater (Dickson, Goyet, DOE, 1994)

Precision: +/- 0.002pH

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

(d) CFC11, CFC12 & CFC113

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

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

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.01 pmole/kg

Sub-samples were drawn into a 120 ml grass syringe. Duplicate samples were taken on every station. We used 30 ml as a sample. All samples were stored within 12 hours after the sampling followed by the modified purged and trapped ECD-GC method (Bullister and Weiss, 1988). We measured water sample of 30 ml. All data were normalized to SIO '93 scale.

(e) SF_6

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

Analyzer: ECD-GC (Hitachi 5000A)

Standard: Inter-calibrated gaseous bomb

Precision: +/- 0.03 fmole/kg

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

(4) Preliminary results

Measurements of DIC, TA, pH, CFC11, CFC12, CFC113 and SF_6 were made with the above precision. This was the first result of the east-west cross section where precise carbonate species and chemical transient tracers were simultaneously observed in the North Pacific subpolar region. We will try to get the these detailed spatial distributions with the results of SAGE-P1revisit first leg by R/V Kaiyo-maru of Japan Fisheires Agancy during May-June 1999. We also will do the time change of carbonate species and water movement by comparing the 1985 WOCE/WHP P01 data with our data in the future.

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

(1) Personel

Masao Fukasawa (Tokai University): sample collection

Robert Key (Princeton University): sample analysis

(2) Sample collection

Sampling stations of 14C are planned to be every five degrees except the western boundary area . Samples were collected from depth using 12 liter Niskin bottles. Sampling glass bottles of c.a. 500ml were baked at 450 degree C for two hours after dipped into 1 N of HCl solution. After baking, each bottle was capped with an aluminum foil until the sampling on the ship board. The seawater sample was siphoned into the glass bottle with enough seawater to fill the glass. Immediately after the collection, about 10 ml of seawater was removed from the bottle and poisoned by 1 ml of saturated $HgCl_2$ solution. The bottle was put a screwed plastic cap on and sealed with butyl tape. Then the bottle was put in a wooden container.

143 samples were collected from 7 stations.

(3) Sample measurement

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

VII. CTD measurement

(1) Personnel

Masao Fukasawa (Tokai University)

Satoshi Ozawa (Marine Works Japan)

(2) Apparatus

Body and Circuit: Sea-Bird CTD9 plus

Sensors

Temperature sensor (Primary): 2445

Conductivity sensor: 041723,041723

Pressure sensor: Digiquartz 410k-105 s/n 59985

(3) Sensor calibration

(3)-1 Temperature sensor

(3)-1-1 Primary sensor

Temperature sensor was calibrated before and after the cruise on 16 Apr. 99 and on 22 Sep. 99 at Sea-Bird Electronics and Marine Works Japan, respectively. Post-cruise residuals defined as differences between the bath temperature and the instrument temperature were checked at eleven temperature points of -1.4068, 1.0382, 4.5401, 8.1934, 11.6512, 15.1937, 18.6689, 22.1613, 25.6567. 29.1251 and 32.6239 ITS-90 degree C.

The largest sensor drift during the period from the pre-cruise calibration to the post-cruise calibration was found to be +0.00009 deg C at 8.1934 deg C. On the other hand, the absolute temperature difference between the bath and the instrument temperature was found to be largest as 0.00035 deg C also at +8.1934 deg C using coefficients decided at the time of pre-cruise. As the result the drift of the temperature sensor was found to be +0.00021 of average with 0.00010 of standard deviation.

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

bath temp (degC)	ambiguity (degC)
-1.4068	0.0001
1.0382	0.0003
4.5401	0.0004
8.1934	0.0004
11.6512	0.0004
15.1937	0.0000
18.6689	0.0001
22.1613	0.0000
25.6567	0.0000
29.1251	0.0000
32.6239	0.0000

(3)-2 Conductivity sensors

Sensor 041723 was used during P1W five months ago. It was not calibrated specially for this cruise.

(3)-3 Pressure sensor

Pressure sensor was calibrated in Aug. 98, one year before the cruise and on Jun. 00, a half a year after the cruise at Marine Works Japan using the Bunden Burge weight tester. Calibration was carried out on six pressure values from 14 psia to 10000 psia for both case of the calibration. Any apparent hysteresis were found. Coefficients were decided by linearly for pre- and post calibrations. Using the same coefficients, the slope value and intersect value were found to be shifted to 1.00010 and +1.54 psi or +1.0646 db.

The linearity of calibration line was so good that the largest offset of -0.12 db was found at around 2500 psi.

(3)-4 DO sensor

DO sensor was not used.

(4) Data calibration

(4)-1 Temperature

Residual which was detected at post-cruise sensor calibration at 14 temperature points were so large and it is impossible to know the history of the time drift. So, we gave up to add any artificial values to out put from CTD.

(4)-2 Salinity

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

	PSS78	PSS78
stn	SD(0-1000)	SD(1000-bottom)
74	2.7458379e-003	8.6143565e-004
X15	3.1117788e-003	6.7851397e-004
77	2.4775832e-003	1.1432165e-003
78	1.3604482e-003	4.2864640e-004
79	1.0595436e-003	5.3101096e-004
80	1.2087674e-003	9.6035486e-004
81	6.4672157e-004	4.4532393e-004
82	2.0460944e-003	3.9105123e-004
83	1.2817455e-003	9.2143370e-004
84	8.6565011e-004	3.6727151e-004
85	1.8649106e-003	5.5852840e-004

X16	1.7737935e-003	5.6941223e-004
88	1.6532946e-003	4.8886168e-004
89	1.2022222e-003	4.1798853e-004
90	1.5892371e-003	7.6844965e-004
91	5.7392606e-003	1.2130803e-003
92	1.6755848e-003	8.5333845e-004

As for the traceability of SSW P-135 was -15/10000 psu to Mantyla's value. Aoyama et al. (2002) also reported -16/10000, -14/10000, -14/10000 for P135. It must be noted that data calibration did not include the traceability.

(4)-3 Pressure

CTD outputs were re-produced using coefficients noted above.

P1C .sum file

P1C R/V MIRAI CRUISE MR99K05 LEG 1

SHIP/CRS EXPOCODE	WOCE SECT	STNNBR	CASTNO	CAST TYPE	DATE	UTC TIME	EVENT CODE	POSITION LATITUDE	LONGITUDE	NAV	UNC DEPTH	HT ABOVE BOTTOM	WIRE OUT	MAX PRESS	NO. OF BOTTLES	PARAMETERS	COMMENTS
49MR99K05/1	P1C	4	1	ROS	082599	0031	BE	42 48.42 N	145 33.70 E	GPS	1475				18	1-6,13,23,24,26,34,39,43,46-48	No T sensor calibration.
49MR99K05/1	P1C	4	1	ROS	082599	0111	BO	42 48.23 N	145 33.23 E	GPS	1470	10	-9	1470			
49MR99K05/1	P1C	4	1	ROS	082599	0204	EN	42 48.26 N	145 33.23 E	GPS	1485						
49MR99K05/1	P1C	5	1	ROS	082599	0455	BE	42 38.96 N	145 41.98 E	GPS	2386				24	1-6	No T sensor calibration.
49MR99K05/1	P1C	5	1	ROS	082599	0548	BO	42 38.98 N	145 41.97 E	GPS	2408	10	2376	2408			
49MR99K05/1	P1C	5	1	ROS	082599	0704	EN	42 38.83 N	145 41.64 E	GPS	2408						
49MR99K05/1	P1C	6	1	ROS	082599	0831	BE	42 29.26 N	145 50.50 E	GPS	3161				24	1-6	No T sensor calibration.
49MR99K05/1	P1C	6	1	ROS	082599	0931	BO	42 29.03 N	145 50.49 E	GPS	3165	10	3147	3199			
49MR99K05/1	P1C	6	1	ROS	082599	1059	EN	42 29.03 N	145 50.79 E	GPS	3165						
49MR99K05/1	P1C	7	1	ROS	082599	1228	BE	42 17.00 N	146 03.29 E	GPS	4193				24		Whole CTD system and
49MR99K05/1	P1C	7	1	ROS	082599	1348	BO	42 17.16 N	146 03.29 E	GPS	4167	10	4250	4228			LADCP system were lost.
49MR99K05/1	P1C	7	1	ROS	082599	1348	EN	42 17.16 N	146 03.29 E	GPS	4167						No SEA file.
49MR99K05/1	P1C	7	2	ROS	082599	1800	BE	42 17.12 N	146 03.38 E	GPS	4179				12		ROSSETTE did not work.
49MR99K05/1	P1C	7	2	ROS	082599	1814	BO	42 17.41 N	146 03.38 E	GPS	4201	-9	698	701			No SEA file.
49MR99K05/1	P1C	7	2	ROS	082599	1837	EN	42 17.23 N	146 03.38 E	GPS	4169						
49MR99K05/1	P1C	7	3	ROS	082799	2304	BE	42 17.11 N	146 03.43 E	GPS	4178				12	1-6,13,23,24,26,34,39,43,46-48	
49MR99K05/1	P1C	7	3	ROS	082799	2318	BO	42 17.12 N	146 03.49 E	GPS	4179	-9	-9	701			
49MR99K05/1	P1C	7	3	ROS	082799	2347	EN	42 17.26 N	146 03.51 E	GPS	4182						
49MR99K05/1	P1C	7	4	ROS	082899	0015	BE	42 17.23 N	146 03.67 E	GPS	4185				12	1-6,13,26,39,43,46-48	Rossette did not work
49MR99K05/1	P1C	7	4	ROS	082899	0131	BO	42 17.09 N	146 03.83 E	GPS	4206	10	4189	4252			properly.Only#7,#8,#11
49MR99K05/1	P1C	7	4	ROS	082899	9999	EN	42 17.95 N	146 03.90 E	GPS	4187						and#12 worked.
49MR99K05/1	P1C	10	1	ROS	082899	0647	BE	41 52.59 N	146 18.25 E	GPS	6727				12	1-6	Rossette did not work
49MR99K05/1	P1C	10	1	ROS	082899	0703	BO	41 52.17 N	146 18.27 E	GPS	6713	-9	793	801			properly.
49MR99K05/1	P1C	10	1	ROS	082899	0735	EN	41 52.75 N	146 18.33 E	GPS	5632						
49MR99K05/1	P1C	10	2	ROS	082599	0749	BE	41 52.81 N	146 18.39 E	GPS	6742				12	1-6	Rossette did not work
49MR99K05/1	P1C	10	2	ROS	082599	0922	BO	41 52.25 N	146 18.80 E	GPS	6840	-9	5895	6000			properly.
49MR99K05/1	P1C	10	2	ROS	082599	1107	EN	41 52.81 N	146 18.98 E	GPS	6836						
49MR99K05/1	P1C	74	1	ROS	090399	0433	BE	47 00.48 N	165 57.88 W	GPS	5334				12	1-8,13,23,24,26,27,34,39,43,45,48	Do sensor removed
49MR99K05/1	P1C	74	1	ROS	090399	0558	BO	47 00.40 N	165 57.14 W	GPS	5326	10	5351	5429			No sampling at 0m
49MR99K05/1	P1C	74	1	ROS	090399	0726	EN	47 00.53 N	165 57.76 W	GPS	5325						#2,#7 possible miss-trips.
49MR99K05/1	P1C	X15	1	ROS	090399	1401	BE	47 00.13 N	164 59.44 W	GPS	5329				12	1-8,12,13,23,24,26,27,34,39,43,45-48	#18,#21,#2 replaced
49MR99K05/1	P1C	X15	1	ROS	090399	1417	BO	47 00.10 N	164 59.30 W	GPS	5227	-9	-9	600			
49MR99K05/1	P1C	X15	1	ROS	090399	1436	EN	47 00.05 N	164 59.18 W	GPS	5333						
49MR99K05/1	P1C	X15	2	ROS	090399	1416	BE	47 00.04 N	164 59.38 W	GPS	5329				12	1-8,12,13,23,24,26,27,39,43,45-48	
49MR99K05/1	P1C	X15	2	ROS	090399	1624	BO	47 00.45 N	164 59.14 W	GPS	5332	20	5340	5413			
49MR99K05/1	P1C	X15	2	ROS	090399	1806	EN	46 58.76 N	164 58.83 W	GPS	5335						
49MR99K05/1	P1C	77	1	ROS	090499	1324	BE	46 59.92 N	162 37.13 W	GPS	5177				12	1-8,13,23,24,26,27,34,39,43,45-48	
49MR99K05/1	P1C	77	1	ROS	090499	1450	BO	46 59.73 N	162 37.25 W	GPS	5174	20	5167	5256			
49MR99K05/1	P1C	77	1	ROS	090499	1616	EN	46 59.41 N	162 37.40 W	GPS	5174						
49MR99K05/1	P1C	78	1	ROS	090499	1929	BE	47 00.26 N	161 29.32 W	GPS	5080				12	1-6	
49MR99K05/1	P1C	78	1	ROS	090499	2046	BO	47 00.05 N	161 30.01 W	GPS	5076	15	5163	5085			
49MR99K05/1	P1C	78	1	ROS	090499	2212	EN	47 00.32 N	161 31.12 W	GPS	5070						
49MR99K05/1	P1C	79	1	ROS	090599	0144	BE	46 59.80 N	160 21.91 W	GPS	5124				12	1-8,13,23,24,26,27,34,39,43,45,48	

49MR99K05/1	P1C	79	1	ROS	090599	0300	BO	47 00.01 N	160 21.60 W	GPS	5122	15	5123	5211		
49MR99K05/1	P1C	79	1	ROS	090599	0421	EN	47 00.20 N	160 20.82 W	GPS	5124					
49MR99K05/1	P1C	80	1	ROS	090599	0726	BE	46 59.59 N	159 15.49 W	GPS	5189				12	1-6
49MR99K05/1	P1C	80	1	ROS	090599	0843	BO	46 59.40 N	159 14.43 W	GPS	5190	15	5246	5280		
49MR99K05/1	P1C	80	1	ROS	090599	1004	EN	46 59.09 N	159 13.74 W	GPS	5198					
49MR99K05/1	P1C	81	1	ROS	090599	1305	BE	47 00.49 N	158 07.58 W	GPS	5234				4	1-8,12,13,23,24,26,27,34,39,43,45-48
49MR99K05/1	P1C	81	1	ROS	090599	1311	BO	47 00.47 N	158 07.50 W	GPS	5235	-9	195	200		
49MR99K05/1	P1C	81	1	ROS	090599	1317	EN	47 00.45 N	158 07.41 W	GPS	5233					
49MR99K05/1	P1C	81	2	ROS	090599	1324	BE	47 00.46 N	158 07.52 W	GPS	5231				12	1-8,12,13,23,24,26,27,34,39,43,45-48
49MR99K05/1	P1C	81	2	ROS	090599	1447	BO	47 00.04 N	158 07.32 W	GPS	5234	10	5252	5326		
49MR99K05/1	P1C	81	2	ROS	090599	1602	EN	46 59.83 N	158 06.50 W	GPS	5237					
49MR99K05/1	P1C	82	1	ROS	090599	1909	BE	47 00.04 N	157 01.49 W	GPS	5229				12	1-6
49MR99K05/1	P1C	82	1	ROS	090599	2025	BO	47 00.26 N	157 01.09 W	GPS	5227	10	5224	5319		
49MR99K05/1	P1C	82	1	ROS	090599	2141	EN	47 00.52 N	157 00.68 W	GPS	5226					
49MR99K05/1	P1C	83	1	ROS	090699	0111	BE	46 59.51 N	155 51.87 W	GPS	5251				12	1-8,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	83	1	ROS	090699	0229	BO	46 59.34 N	155 50.96 W	GPS	5250	10	5307	5343		
49MR99K05/1	P1C	83	1	ROS	090699	0341	EN	46 59.18 N	155 50.47 W	GPS	5249					
49MR99K05/1	P1C	84	1	ROS	090699	0639	BE	46 59.51 N	154 45.88 W	GPS	5205				12	1-6
49MR99K05/1	P1C	84	1	ROS	090699	0756	BO	46 59.53 N	154 45.43 W	GPS	5210	10	5210	5301		
49MR99K05/1	P1C	84	1	ROS	090699	0912	EN	46 59.33 N	154 45.03 W	GPS	5206					
49MR99K05/1	P1C	85	1	ROS	090699	1215	BE	46 59.93 N	153 37.48 W	GPS	5226				4	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	85	1	ROS	090699	1222	BO	46 59.93 N	153 37.38 W	GPS	5226	-9	195	200		
49MR99K05/1	P1C	85	1	ROS	090699	1229	EN	46 59.90 N	153 37.40 W	GPS	5229					
49MR99K05/1	P1C	85	2	ROS	090699	1234	BE	46 59.87 N	153 37.52 W	GPS	5222				12	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	85	2	ROS	090699	1358	BO	46 59.50 N	153 38.03 W	GPS	5221	10	5249	5204		
49MR99K05/1	P1C	85	2	ROS	090699	1511	EN	46 59.17 N	153 38.42 W	GPS	5221					
49MR99K05/1	P1C	X16	1	ROS	090699	1959	BE	46 59.92 N	152 00.04 W	GPS	5127				12	1-8,12,13,23,24,26,27,34,39,43,45-48
49MR99K05/1	P1C	X16	1	ROS	090699	2013	BO	46 59.92 N	152 00.03 W	GPS	5132	-9	791	800		
49MR99K05/1	P1C	X16	1	ROS	090699	2034	EN	47 00.00 N	151 59.95 W	GPS	5139					
49MR99K05/1	P1C	X16	2	ROS	090699	2042	BE	47 00.01 N	152 00.00 W	GPS	5128				12	1-8,12,13,23,24,26,27,39,43,45-48
49MR99K05/1	P1C	X16	2	ROS	090699	2159	BO	46 59.77 N	151 59.72 W	GPS	5134	10	5134	5224		
49MR99K05/1	P1C	X16	2	ROS	090699	2315	EN	46 59.65 N	151 59.33 W	GPS	5181					
49MR99K05/1	P1C	88	1	ROS	090799	0352	BE	46 59.30 N	150 17.61 W	GPS	5055				4	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	88	1	ROS	090799	0358	BO	46 59.33 N	150 17.44 W	GPS	5057	-9	198	200		
49MR99K05/1	P1C	88	1	ROS	090799	0403	EN	46 59.29 N	150 17.38 W	GPS	5038					
49MR99K05/1	P1C	88	2	ROS	090799	0413	BE	46 59.23 N	150 17.26 W	GPS	5016				12	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	88	2	ROS	090799	0528	BO	46 58.87 N	150 16.91 W	GPS	5014	10	4982	5054		
49MR99K05/1	P1C	88	2	ROS	090799	0638	EN	46 58.57 N	150 16.36 W	GPS	5085					
49MR99K05/1	P1C	89	1	ROS	090799	0938	BE	46 59.87 N	149 08.86 W	GPS	5054				4	1-6
49MR99K05/1	P1C	89	1	ROS	090799	0945	BO	46 59.79 N	149 08.72 W	GPS	5054	-9	198	199		
49MR99K05/1	P1C	89	1	ROS	090799	0952	EN	46 59.73 N	149 08.70 W	GPS	5058					
49MR99K05/1	P1C	89	2	ROS	090799	0957	BE	46 59.78 N	149 08.72 W	GPS	5056				12	1-6
49MR99K05/1	P1C	89	2	ROS	090799	1115	BO	46 59.47 N	149 08.95 W	GPS	5056	10	5054	5140		
49MR99K05/1	P1C	89	2	ROS	090799	1227	EN	46 59.31 N	149 09.36 W	GPS	5058					
49MR99K05/1	P1C	90	1	ROS	090799	1540	BE	47 00.48 N	148 02.39 W	GPS	5012				4	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	90	1	ROS	090799	1546	BO	47 00.46 N	148 02.41 W	GPS	5002	-9	196	201		
49MR99K05/1	P1C	90	1	ROS	090799	1552	EN	47 00.44 N	148 02.44 W	GPS	5002					
49MR99K05/1	P1C	90	2	ROS	090799	1557	BE	47 00.44 N	148 02.48 W	GPS	5004				12	1-8,12,13,23,24,26,27,34,39,43,45,48
49MR99K05/1	P1C	90	2	ROS	090799	1713	BO	47 00.39 N	148 03.19 W	GPS	5001	10	5021	5087		
49MR99K05/1	P1C	90	2	ROS	090799	1821	EN	47 00.32 N	148 03.76 W	GPS	5012					
49MR99K05/1	P1C	91	1	ROS	090799	2144	BE	47 00.05 N	146 56.05 W	GPS	4909				4	1-6

49MR99K05/1	P1C	91	1	ROS	090799	2150	BO	47 00.07	N	146 56.11	W	GPS	4909	-9	194	199		
49MR99K05/1	P1C	91	1	ROS	090799	2157	EN	47 00.09	N	146 56.15	W	GPS	4909					
49MR99K05/1	P1C	91	2	ROS	090799	2205	BE	47 00.08	N	146 56.11	W	GPS	4909				12	1-6
49MR99K05/1	P1C	91	2	ROS	090799	2319	BO	46 59.92	N	146 56.08	W	GPS	4906	10	4900	4991		
49MR99K05/1	P1C	91	2	ROS	090899	0026	EN	46 59.79	N	146 56.08	W	GPS	4908					
49MR99K05/1	P1C	92	1	ROS	090899	0341	BE	47 00.17	N	145 48.36	W	GPS	4808				12	1-8,12,13,23,24,26,27,34,39,43,45-48
49MR99K05/1	P1C	92	1	ROS	090899	0354	BO	47 00.05	N	145 48.35	W	GPS	4804	-9	602	600		
49MR99K05/1	P1C	92	1	ROS	090899	0410	EN	46 59.99	N	145 48.35	W	GPS	4801					
49MR99K05/1	P1C	92	2	ROS	090899	0420	BE	46 59.96	N	145 48.40	W	GPS	4808				12	1-8,12,13,23,24,26,27,39,43,45-48
49MR99K05/1	P1C	92	2	ROS	090899	0533	BO	46 59.74	N	145 48.33	W	GPS	4779	10	4798	4882		
49MR99K05/1	P1C	92	2	ROS	090899	0641	EN	46 59.54	N	145 48.26	W	GPS	4806					

1=Sal, 2=DO, 3=SiO2, 4=NO2, 5=NO3, 6=PO4, 7=CFC11, 8=CFC12, 12=C14, 13=C13, 23=DIC, 24=Alk, 26=pH, 27=CFC113, 34=Chla, 39=Ba, 43=TOC, 45=SF6, 46=Cu, 47=Ni, 48=Ca

P1H

I. Cruise Narrative

Masao Fukasawa (Tokai University)

The cruise of P1H was carried out as an appendix of the second leg of MR99K05 of Mirai. This leg was assigned for the arctic observation under the control of Dr. Takizawa who is the chief scientist of the leg. As is in the documentation of P1C, the first leg of MR9905, designated as SAGE P1 revisit cruise, could not complete stations off Hokkaido. Dr. Takizawa was so kind to try to back up those stations. As the result, nine stations were occupied, however, most of chemical tracers were not analyzed. The second leg of MR99K05 was not designed for WHP, so the number of observation item and their accuracy were decreased compared to other P1 revisit cruises.

The period of observation concerning P1C was from September 30, 1999 to October 1, 1999.

We would like to thank Dr. Takizawa for his kind efforts. Raw data including underway observations e.g. the ship board ADCP and meteorology are kept in DMO of JAMSTEC, however, the multi-narrow beam did not work well.

II. Cruise summary

1. Ship name

    Mirai (Japan Marine Science and Technology Center)

2. Cruise period

    From 11 September 1999 to 6 October 1999

3. Observation

    9 stations along WHP P1 off Hokkaido

4. Chief Scientist

    Takatoshi Takizawa (Japan Marine Science and Technology Center)

    e-mail: takizawat@jamstec.go.jp

5. Observation Item and PI

CTD	Masao Fukasawa (Tokai University): fksw@jamstec.go.jp
Bottle Salinity	Hiroyuki Yoritaka (Hydrographic Department Japan Maritime Safety Agency): yoritaka@jodc.go.jp
Bottle Oxygen	Masao Fukasawa (Tokai University): fksw@jamstec.go.jp
Nutrients	Chizuru Saitoh (Japan Marine Science and Technology Center): saitoc@jamstec.go.jp
DIC*	Tsuneo Ono (National Research Institute of Fishery Laboratory): onot@jamstec.go.jp

* Collected samples were freezed. Analyses were carried out a week after the collection.

III. Sample water salinity measurements

(1) Personal

Hiroyuki Yoritaka (Hydrographic Department, Maritime Safety Agency)
Satoshi Ozawa (Marine Works Japan)
Toru Idai (Marine Works Japan)
Hitoshi Yamanobe (Marine Works Japan)
Hiroyuki Nakajima (Tokai University)
Satoko Katsuyama (Tokai University)
Fujio Kobayashi (Marine Works Japan)

(2) Objective

Calibration of salinity measured by CTD.

(3) Measured Parameter

Sample water salinity

(4) Instruments and Method

The salinity analysis was carried out by a Guildline Autosal salinometer model 8400B, which was modified by addition of an Ocean Science International peristaltic-type sample intake pump. Data of salinometer was collected simultaneously by a personal computer. A double conductivity ratio was defined as a median of 15 readings of the salinometer. Data collection was started after 5 seconds and it took about 5 seconds to collect 15 readings by a personal computer.

The salinometer was operated in the air-conditioned ship's laboratory at a bath temperature of 24 degree C. An ambient temperature varied from approximately 23 to 24 degree C.

i) Standard Sea Water

Autosal model 8400B was standardized only before sequence of measurements by use of IAPSO Standard Seawater batch P135 whose conductivity ratio was 0.99992. After the standardization, 8400B was monitored by SSW ampoule before and after the measurements for samples of one station. Total 23 ampoules of SSW were measured for monitoring, whose standard deviation was 0.0004 psu.

ii) Salinity Sample Collection

The bottles in which the salinity samples are collected and stored are 250ml clear glass bottles with inner caps and outer screw caps. Each bottle were rinsed twice and filled with sample water. Salinity samples were stored by the end of leg 1 in the same laboratory as the salinity measurement was made.

iii) Replicate Samples

Replicate samples were drawn from several Niskin bottles for each station. Standard deviation in the measurements of replicate samples was 0.0013 psu for 54 pairs.

iv) Quality Flag

Quality flag was made according to difference from corrected salinity measured with CTD. CTD salinity was corrected by linear fitting with bottle salinity for pressure in the upper layer (<1000db) and the deep layer (>1000db) at each station (see CTD). For the bottle salinity exceeded double standard deviation, bad (4) or doubt (3) flag was made. RMS of residual difference was 0.001 between CTD salinity and good bottle salinity for deeper layer.

IV. Sample water oxygen measurements

(1) Personal

Masao Fukasawa (Tokai University)
Katsunori Sagishima (Marine Works Japan)
Hiroaki Muraki (Marine Works Japan)

(2) Objective

To detect changes in the transect between 1985 and 1999.

(3) Measured Parameter

Sample water dissolved oxygen

(4) Instruments and Method

(a) Instruments and Apparatus

Dispenser: Eppendorf Comforpette 480/ 1000µl.
OPTIFIX/ 2ml
Metrohm Model 725 Multi Dosimat/ 20ml

Titrator: Metrohm Model 716 DMS Titrino / 10ml of titration vesswl
Pt electrode/ 6.0403.100(NC)

Software: Data acquisition / Metrohm, METRODATA / 606013/000
Endpoint evaluation

(b) Methods

Samples were colleted from 12L Niskin bottles and a bucked for the surface into the volumetrically calibrated dry grass bottles. At least two times of bottle volumes of sample water were overflowed before each sampling. Sampling water temperatures for 4 or 5 bottles were measured by a thermister-thermometer to calculate the change in the volume of sampled water at the time of the titration. For other samples of which temperature were not measured, potential temperatures derived from CTD data were used. The sampling bottles consist of ordinary BOD flask (ca. 200ml) and glass stopper with long nipple inside which is modified from the nipple in Green and Carritt (1966). Oxygen in the sample was fixed immediately after the collection. Bottles were kept in a wooden box in the temperature-controlled laboratory until the titration.

The analytical method and the preparation of regents were carried out in the same way as described in WHP Operations and Methods (Culberson, 1991). A 0.05N thiosulfateof titrant was adopted during the cruise. Volumetric apparatus except titrator were calibrated before the cruise. A titration was started about one hour after the fixation of dissolved oxygen. Two sets of Metrohm titrators with the automatic piston burette of 10ml and Pt electrode were used for the titration in the temperature-controlled laboratory. The temperature of samples which had been stored was 21 deg. C +/- 2 deg. C during the cruise. The end point was determined by the potentiometric method and evaluated by the second-derivative curve method. Concentration of dissolved oxygen was computed using the equation in WHP Operation and Methods (Culberson, 1991).

(5) Results

We carried out 366 analyses of DO. Results are shown in .sea file.

(a) Thiosulfate Standardization

Thiosulfate regent was standardized when thiosulfate bottles of titrator were empty. A 0.0100N KIO3 standard solution was used for the standardization e.g. Lot 990715(0.01002N). The averaged volumes of thiosulfate for the standardization were 1.973ml (titrator #1) and 1.974ml (titrator #2), with standard deviation of 0.001ml and 0.002ml, respectively.

(b) Pure water blank

The blank value comes from the presence of redox species aparted from oxygen in the regents, which behaves equivalently to oxygen to be analysed. The pure water blank or the titration blank was determined using deionized water (Milli-Q SP, Millipore) at each thiosulfate standardization. The average of pure water blanks was -0.019ml (#1) and -0.018ml (#2) with standard deviation of 0.008ml and 0.005ml, respectively.

(c) Reproducibility

In the cruise, replicate samples were drawn from some Niskin bottles at each station to estimate the precision of the analysis. 30 pair of replicate samples are analyzed to show the standard deviation (2 sigma) of 0.018ml/l or 0.2% of maximum value of DO concentration of 7.314ml/l in the cruise.

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

(1) Personnel

Masao Fukasawa (Tokai University): sample collection

Robert Key (Princeton University): sample analysis

(2) Sample collection

Sampling stations of 14C are planned to be every five degrees except the western boundary area. Samples were collected from depth using 12 liter Niskin bottles. Sampling glass bottles of c.a. 500ml were baked at 450 degree C for tow hours after dipped into 1 N of HCl solution. After baking, each bottle was capped with an aluminum foil until the sampling on the shipboard. The seawater sample was siphoned into the glass bottle with enough seawater to fill the glass. Immediately after the collection, about 10 ml of seawater was removed from the bottle and poisoned by 1 ml of saturated $HgCl_2$ solution. The bottle was put a screwed plastic cap on and sealed with butyl tape. Then the bottle was put in a wooden container.

51 samples were collected from 3 stations.

(3) Sample measurements

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

VI. CTD measurement

(1) Personnel

Masao Fukasawa (Tokai University)

Satoshi Ozawa (Marine Works Japan)

(2) Apparatus

Body and Circuit: Sea-Bird CTD9 plus

Sensors

Temperature sensor (Primary): 1464

Temperature sensor (Secondary): 1525

Conductivity sensor: 041723,042271

Pressure sensor: Digiquartz 410k-105 s/n 59960

(3) Sensor calibration

(3)-1 Temperature sensor

(3)-1-1 Primary sensor

Temperature sensor was calibrated before and after the cruise on 29 Apr. 99 and 5 May 00 at Marine Works Japan and Sea-Bird Electronics, respectively. Post-cruise residuals defined as differences between the bath temperature and the instrument temperature were checked at eleven temperature points of -1.5122, 1.0477, 4.6234, 8.1302, 11.6341, 15.1945, 18.6585, 22.1588, 25.6863. 29.1576 and 32.6326 ITS-90 degree C.

The largest sensor drift during the period from the pre-cruise calibration to the post-cruise calibration was found to be +0.0011 deg C over the wide temperature band from 4.6243 to 29.1576 deg C. On the other hand, the absolute temperature difference between the bath and the instrument temperature was found to be largest as 0.0013 deg C at 32.6329 deg C using coefficients decided at the time of pre-cruise. As the result the drift of the temperature sensor was found to be +0.0011 of average with 0.00013 of standard deviation.

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

bath temp (degC)	ambiguity (degC)
-1.41	0.0008
1.01	0.0009
4.59	0.0011
8.19	0.0011
11.62	0.0011
15.18	0.0011
18.68	0.0011
22.18	0.0011
25.74	0.0011
29.16	0.0011
32.69	0.0013

The resulted ambiguity is considerably larger than that for other P1 revisit cruises.

(3)-2-2 Conductivity sensors

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

(3)-2-3 Pressure sensor

Pressure sensor was calibrated at the time of the perches in Aug. 97 and after the cruise on 15 Nov. 99. Calibration was carried out on six pressure values from 14 psia to 10000 psia. Any apparent hysteresis was found. Coefficients were decided so as to make the real pressure value and the CTD out put value are linear with the slope of 1 and the intersect of 0 at the time of newly equipped. Using the same coefficients, the slope value and intersect value were found to be shifted to 1.00010 and +1.54 psi or +1.0646 db. The linearity of calibration line was so good that the largest offset of -0.12 db was found at around 2000 psi.

(3)-2-4 DO sensor

DO sensor was not used.

(4) Data calibration

(4)-3-1 Temperature

The residual which was detected at post-cruise sensor calibration at 14 temperature points were so large and it is impossible to know the history of the time drift. So, we gave up to add any artificial values to out put from CTD.

(4)-3-2 Salinity

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

stn	cast	SD(0-1000) PSS-78	SD(1000-bottom) PSS-78
4	1	6.6727837e-003	N/A
5	1	8.6979969e-003	3.4647951e-004
6	1	1.5797235e-003	6.0450398e-004
7	1	1.2629831e-003	8.2629089e-004
10	1	6.7736760e-003	7.0933285e-004
13	1	1.2327109e-003	6.3209221e-004

As for the traceability of SSW P-135 was -15/10000 psu to Mantyla's value. Aoyama et al. (2002) also reported -16/10000, -14/10000, -14/10000 for P135. It must be noted that data calibration did not include the traceability.

(4)-3-3 Pressure

CTD outputs were re-produced using coefficients noted above.

P1H .sum file

P1H R/V MIRAI CRUISE MR99K05 LEG 2

SHIP/CRS EXPOCODE	WOCE SECT	STNNBR	CASTNO	CAST TYPE	DATE	UTC TIME	EVENT CODE	POSITION LATITUDE	LONGITUDE	NAV	UNC DEPTH	HT ABOVE BOTTOM	WIRE OUT	MAX PRESS	NO. OF BOTTLES	PARAMETERS	COMMENTS
49MR99K05/2	P1H	13	1	ROS	093099	1859	BE	41 21.54 N	146 41.47 E	GPS	5482				4	1-6,12,23,24	
49MR99K05/2	P1H	13	1	ROS	093099	1906	BO	41 21.98 N	146 41.29 E	GPS	5486	10	-9	201			
49MR99K05/2	P1H	13	1	ROS	093099	1913	EN	41 21.98 N	146 41.22 E	GPS	5484						
49MR99K05/2	P1H	13	2	ROS	093099	1919	BE	41 22.00 N	146 41.17 E	GPS	5486				12	1-6,12,23,24	
49MR99K05/2	P1H	13	2	ROS	093099	2042	BO	41 22.24 N	146 40.58 E	GPS	5496	10	5514	5581			
49MR99K05/2	P1H	13	2	ROS	093099	2218	EN	41 22.61 N	146 40.20 E	GPS	5492						
49MR99K05/2	P1H	12	1	ROS	093099	2348	BE	41 40.42 N	146 32.00 E	GPS	6263				0		No sample
49MR99K05/2	P1H	12	1	ROS	100199	0115	BO	41 40.87 N	146 31.30 E	GPS	6294	294	5950	6001			
49MR99K05/2	P1H	12	1	ROS	100199	0233	EN	41 41.28 N	146 31.19 E	GPS	6327						
49MR99K05/2	P1H	10	1	ROS	100199	0345	BE	41 52.60 N	146 18.20 E	GPS	6851				4	1-6,12,23,24	
49MR99K05/2	P1H	10	1	ROS	100199	0351	BO	41 52.57 N	146 18.23 E	GPS	6672	-9	197	200			
49MR99K05/2	P1H	10	1	ROS	100199	0334	EN	41 52.55 N	146 18.25 E	GPS	6719						
49MR99K05/2	P1H	10	2	ROS	100199	0404	BE	41 52.54 N	146 18.24 E	GPS	6703				12	1-6,12,23,24	
49MR99K05/2	P1H	10	2	ROS	100199	0531	BO	41 52.33 N	146 18.02 E	GPS	6655	655	5888	6000			
49MR99K05/2	P1H	10	2	ROS	100199	0658	EN	41 52.07 N	146 17.80 E	GPS	6630						
49MR99K05/2	P1H	9	1	ROS	100199	0747	BE	41 59.02 N	146 13.58 E	GPS	6170				0		No sample
49MR99K05/2	P1H	9	1	ROS	100199	0914	BO	41 59.02 N	146 12.97 E	GPS	6054	-9	5892	6000			
49MR99K05/2	P1H	9	1	ROS	100199	1029	EN	41 59.03 N	146 12.01 E	GPS	6000						
49MR99K05/2	P1H	8	1	ROS	100199	1136	BE	42 10.79 N	146 05.00 E	GPS	5058				0		No sample
49MR99K05/2	P1H	8	1	ROS	100199	1251	BO	42 11.28 N	146 04.90 E	GPS	5010	10	4949	5000			
49MR99K05/2	P1H	8	1	ROS	100199	1350	EN	42 11.59 N	146 04.69 E	GPS	4959						
49MR99K05/2	P1H	7	1	ROS	100199	1427	BE	42 17.18 N	146 03.29 E	GPS	4165				4	1-6,12,23,24	
49MR99K05/2	P1H	7	1	ROS	100199	1434	BO	42 17.24 N	146 03.28 E	GPS	4157	-9	198	200			
49MR99K05/2	P1H	7	1	ROS	100199	1441	EN	42 17.29 N	146 03.25 E	GPS	4148						
49MR99K05/2	P1H	7	2	ROS	100199	1447	BE	42 17.34 N	146 03.22 E	GPS	4154				12	1-6,12,23,24	
49MR99K05/2	P1H	7	2	ROS	100199	1549	BO	42 17.65 N	146 03.33 E	GPS	4144	-9	3956	4000			
49MR99K05/2	P1H	7	2	ROS	100199	1654	EN	42 17.91 N	146 03.56 E	GPS	4107						
49MR99K05/2	P1H	6	1	ROS	100199	1810	BE	42 29.06 N	145 50.36 E	GPS	3168				12	1-6	#5 miss fire
49MR99K05/2	P1H	6	1	ROS	100199	1859	BO	42 29.18 N	145 50.42 E	GPS	3165	10	3151	3192			
49MR99K05/2	P1H	6	1	ROS	100199	1956	EN	42 29.14 N	145 50.60 E	GPS	3169						
49MR99K05/2	P1H	5	1	ROS	100199	2056	BE	42 38.96 N	145 41.99 E	GPS	2388				12	1-6	
49MR99K05/2	P1H	5	1	ROS	100199	2134	BO	42 38.92 N	145 41.92 E	GPS	2396	-9	2375	2404			
49MR99K05/2	P1H	5	1	ROS	100199	2221	EN	42 38.95 N	145 41.98 E	GPS	2392						
49MR99K05/2	P1H	4	1	ROS	100199	2318	BE	42 48.43 N	145 35.17 E	GPS	1580				12	1-6	
49MR99K05/2	P1H	4	1	ROS	100199	2345	BO	42 48.39 N	145 35.02 E	GPS	1538	10	1506	1522			
49MR99K05/2	P1H	4	1	ROS	100299	0013	EN	42 48.40 N	145 34.81 E	GPS	1501						

1=Sal, 2=DO, 3=SiO2, 4=NO2, 5=NO3, 6=PO4, 12=C14, 23=DIC, 24=Alk

P1E

I. P1E Project Report

1. **Cruise/Project No.:** 9910
2. **Dates:** May 31 to June 24, 1999
3. **Project Name:** Line P
4. **Area(s) of Operation:** Along 47N from the Washington State coast to 145 W
Line P(50N, 145W to 48 34N, 125 30W)
Juan de Fuca Strait to Victoria, B.C.
5. **Platform:** John P. Tully
6. **Master:** Bill Noon
7. **Days Allocated:** 25
8. **Days at** Sea: 24
9. **Days lost to weather: none**
10. **Days lost to other causes:** 1 day for loading, 4 days for medical evacuation.
11. **Appropriateness of platform:** very appropriate
12. **Safety issues: (attach narrative if required):**

The ship's drainage system was temporarily blocked resulting in drainage water welling up on the aft deck. The planned dilution of radioactive wastes into the ships drainage system was therefore disallowed due to safety concerns. To avoid problems, all radioactive waste was saved in carboys and disposed over the side in accordance with the permit. If, in future, the sink is to be used for dilution of radioactive wastes, it should have a separate drainage pipe not connected with the ships main drainage system.

13. **Cruise/Project Results (see appendix for details):**

Nutrient results were mixed between average and low values at the various depths sampled and require detailed analysis. At some stations, low nutrients and iron combined with high chlorophyll or zooplankton levels suggesting that the spring bloom had recently come to an end.

Data Collected:

Rosette/CTD casts for chemical sampling were completed at P4, P12, P16, P20 and P26 and at 24 stations along 47 N latitude(Line P1E). Onboard chemical analyses included salinity, oxygen, nutrients, freons, alkalinity, total CO2, chlorophyll, dimethyl sulfide, dissolved organic nitrogen. The P1E data will be combined with concurrent Japanese data along 47N spanning the entire Pacific Ocean.

CTD/transmissometry survey was completed at 21 stations along Line P.

Primary productivity experiments were carried out at P26, P20, P16, P12 and P4.

Iron sampling and analysis were completed at P4, P12, P16, P20 and P26.

Primary productivity, Rosette and CTD work was done inside and outside the so-called Haida Eddy, 47 30N, 137 30W.

The P4 and P26 sediment trap moorings were recovered and the P4 mooring was re-deployed.

A mooring to study the re-mineralization of nutrients was recovered at P26.

Free drifting sediment traps were deployed for 2 days at P26.

Underway measurements include PCO2, temperature, salinity and ADCP profiles.

Net tows for zoo plankton and phytoplankton along Line P were completed.

Sixteen casts of CTD/transmissometry/fluometry/PAR casts were done the Straits of Juan de Fuca to aid another DFO science program.

A freon profile in Saanich Inlet was taken as part of an on-going monitoring program.

Halo-acetic acid was profiled at P20 and at the surface at major line P stations.

A barrel of particulate blank water was obtained at P19.

Net tows were done at the ecological monitoring buoy in Saanich Inlet, off Sombrio Point and off Sooke.

14. **Primary Institute:** Institute of Ocean Sciences, DFO
15. **Associated Institutes:** UBC
16. **Chief Scientist/Affiliation:** Ron Perkin, IOS (Ocean Sciences and Productivity)
17. **Science Staff/Affiliations:**

Ron Perkin	IOS	Janet Barwell-Clarke	IOS
Elaine Baird	IOS	Angelica Pena	IOS
Vince Coronini	IOS	Nes Sutherland	IOS contract
Marty Davelaar	IOS	Melanie Quenneville	IOS contract
Wendy Richardson	IOS		
Tim Soutar	IOS	Hugh Maclean	UBC
Darren Tuele	IOS	Michael Lipsen	UBC
Marie Robert	IOS	Cathleen Vestfalls	UBC
Michael Arychuk	IOS	Michael Bentley	Bird survey

18. **Equipment:**

Sail: no **ADCP:** yes **Other:** sounder

Winches: .

type	ID No	Wire type	Wire Condition/Spooling	No Casts/ Depth max
329 CTD	**1579**	5350 m CTD	good	70/4790
329 CTD	**1307**	3000 m CTD	Not used	0
310 hydro	**1082**	5400.m 5/32"	good	70/1000 m
331 work	**1231**	2500 m ½"	not used	0
329 work	**1579**	Bare drum	good	5/mooring
455 Spooling	**1451**	mooring	good	5/mooring

Equipment Deployed/recovered

Description	Deployment	Recovery
Free drifting traps, 1000 m	June 11	June 13
Re-mineralization Mooring		June 11
Sediment Trap mooring at P26		June 12
Sediment Trap Mooring at P4	June 22	June 22
AR Mooring (UBC)		not recovered

19. **Comments and recommendations:**

See "Safety Issues" regarding the lab sink drains.

The salinometer should be installed in a room with good temperature control in order to achieve the necessary precision for this instrument. The WOCE manual(Report 68/91) shows that for the Guildline Autosal models, each 1ºC change in room temperature results in an error of .001 in salinity determinations. With so much traffic from the lab to the aft deck, cold outside air frequently sends the lab temperature into wild fluctuations and, although the Portasal may be somewhat less sensitive than the Autosal, it cannot produce WOCE quality data in conditions like that. This was demonstrated with the frequent re-standardizations necessary on this Mission where the outside temperature was often more than 10C colder than normal room temperature.

It should be cleared up as to who is now responsible for the maintenance of the sounder equipment. The control panel for the depth sounder in the lab has developed an intermittent fault in the menu selection joystick and it should be fixed before it becomes a major problem. At present, the depth sounder is needed to detect the proximity of the Rosette to the bottom.

On occasion, the heave compensator was reported to have lost pressure between stations. However, the following cruise(Mission 99-16) reported that there was no pressure loss. This is something that should be monitored on subsequent missions.

The science radios are gradually being replaced as money becomes available. This process should be accelerated as a number of radio failures were reported.

Appendix: Reports from Participants

I. Cruise Narrative
Ron Perkin (IOS)

Departure day, June 1, was taken up largely by work in Saanich Inlet including two anchor installations, a net tow and a freon profile aided by Dave Wisegarver from PMEL in Seattle. After passing through the underway stations in the Straits of Juan de Fuca, the ship sailed directly to the Washington State end of the P1E line along 47N latitude. Intensive sampling to the bottom and on-board analysis proceeded to station P1E100 where the cruise took a brief detour to the center of the large eddy which IOS has been tracking for the last year. Primary productivity and chemical sampling of the eddy was done at the eddy core and, subsequently, outside the eddy at station P1E98. The P1E line was completed to station P1E92(longitude 145 48.5W) and the ship proceeded to Station Papa.

At Station P, some of the mooring deployment and recovery was done on arrival, June 11, but worsening weather limited work to the hydro winch which is mounted amidships. This allowed the primary productivity and iron trace-metal work to be done. A medical emergency limited time at station P to two days, however, a deep rosette cast was completed and the FDSTAR was recovered before returning to Cape Scott. Bad weather made dragging for the UBC mooring impossible and the re-deployment of the sediment trap mooring was put off until September.

The ship returned to the next major Line P station, P20, and, with good weather for the balance of the voyage, finished the remainder of the Line P work in good time.

The last day, June 24th, was spent as planned doing stations in the Strait of Juan de Fuca for the following mission (99-16:Strait of Georgia Survey) and the ship docked in Victoria at about 13:30.

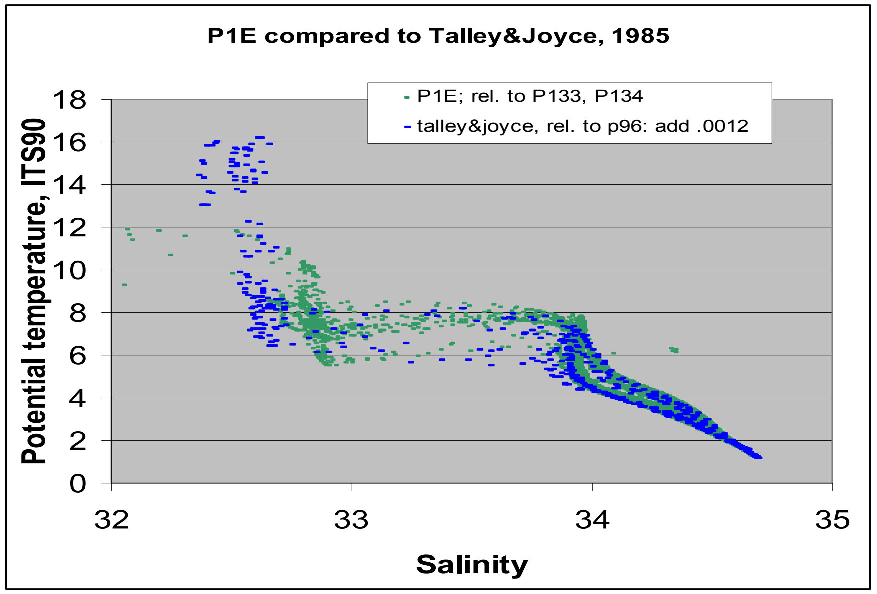
Summary

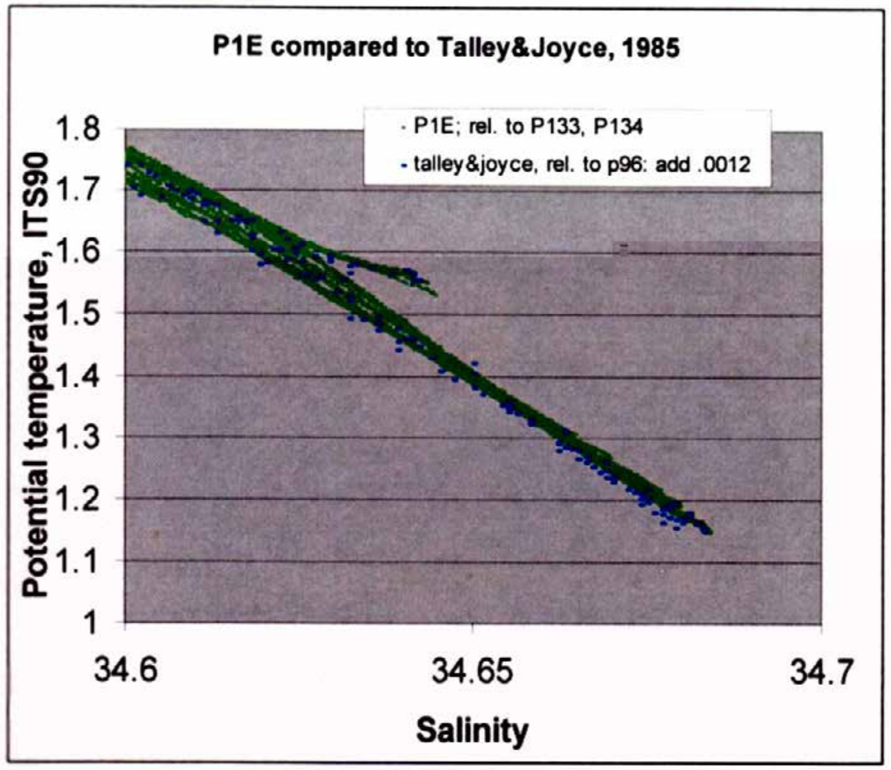
This was a rather busy cruise with a wide assortment of tasks and chores and the challenge of doing WOCE quality chemistry and physics with a minimum of preparation. Thanks are due to the UBC and bird-watching crew for assisting with watch keeping through the period of intensive sampling and analysis. Although some major objectives such as the dragging for the UBC mooring were regrettably not met, the amount of work accomplished was nevertheless quite satisfying.

Captain Noon and all the officers and crew have our heartfelt thanks for their competent and efficient seamanship and untiring efforts to make this cruise not only a success but an enjoyable experience. Their medical competence and concern shown for our ailing science crewmember was amply demonstrated and much appreciated.

II. CTD/Transmissivity
Ron Parkin (IOS)

A total of 56 CTD/Transmissivity profiles were taken at the following stations, many combined with chemical sampling. Eleven additional stations were occupied in the Strait of Juan de Fuca with fluorometer and PAR sensors, every third one with chemical sampling.
Comparison with the previous P1 cruise, Talley&Joyce(1985)(P96(1.2), showed good agreement(see below). Salinities are relative to P133(-1.4) and after cast 20, P134(-.9).





Station	Cast #	Date	Time (PDT)	Latitude	Longitude	Water Depth
SI03	2	01/06/99	18:54	48.594	-123.5	227
P1E115	4	02/06/99	18:42	46.901	-124.994	777
P1E114	5	02/06/99	21:30	47.003	-125.058	822
PIE113	6	03/06/99	00:31	47.001	-125.509	1762
PIE112	7	03/06/99	04:36	46.999	-126.001	2565
PIE111	8	03/06/99	09:18	47.002	-126.469	2565
P1E110	9	03/06/99	14:28	47	-127.201	2649
P1E109	10	03/06/99	19:38	47.001	-127.923	2712
P1E109	11	03/06/99	23:20	47.001	-127.922	2712
P1E108	12	04/06/99	06:11	47	-128.646	2741
P1E107	13	04/06/99	12:24	46.997	-129.385	2573
P1E106	14	04/06/99	21:42	47.001	-130.018	2650
P1E105	15	05/06/99	08:34	47	-131.231	2750
P1E104	16	05/06/99	21:01	46.998	-132.366	3320
P1E103	17	06/06/99	07:20	47	-133.463	3649
P1E102	18	06/06/99	16:24	46.998	-134.612	3982
P1E101	19	07/06/99	01:16	47.001	-135.735	4137
P1E100	20	07/06/99	09:10	46.997	-136.849	4137
ED1	21	07/06/99	13:53	47.249	-137.164	4121
ED2	22	07/06/99	17:27	47.528	-137.46	4090
ED2	23	07/06/99	18:25	47.532	-137.46	4090
P1E99	24	31/12/79	17:00	46.997	-137.964	4166
P1E98	25	08/06/99	08:52	47.001	-139.067	3527
P1E98	26	08/06/99	09:27	47	-139.069	3917
P1E97	27	08/06/99	17:19	46.999	-140.224	4325
P1E96	28	09/06/99	00:54	47.001	-141.352	4403
P1E95	29	09/06/99	08:21	47.001	-142.439	4494
P1E94	30	09/06/99	15:48	46.997	-143.494	4597
P1E94	31	09/06/99	23:59	46.999	-144.669	4683
P1E92	32	10/06/99	07:55	46.996	-145.809	4783
P26	33	11/06/99	19:47	50	-145	4200
P26	34	13/06/99	08:35	49.999	-145.005	4200
P20	35	17/06/99	12:59	49.566	-138.66	3968
P20	36	17/06/99	14:31	49.568	-138.663	3968
P19	38	18/06/99	13:02	49.498	-137.665	3968
P18	39	18/06/99	18:12	49.431	-136.669	3841
P17	40	18/06/99	23:22	49.349	-135.666	3661
P16	42	19/06/99	07:09	49.271	-134.654	3661
P16	43	19/06/99	09:16	49.273	-134.692	3661
P15	44	19/06/99	23:57	49.199	-133.669	3422
P14	45	20/06/99	05:09	49.123	-132.665	3332
P13	46	20/06/99	10:27	49.042	-131.667	3035
P12	47	20/06/99	16:56	48.971	-130.669	3027
P12	49	21/06/99	06:35	48.972	-130.669	3251
P11	50	21/06/99	11:16	48.931	-130.169	2770
P10	51	21/06/99	14:23	48.892	-129.666	2659
P9	52	21/06/99	17:32	48.857	-129.167	2357
P8	53	21/06/99	20:42	48.816	-128.668	2537
P7	54	21/06/99	23:44	48.776	-128.17	2524
P6	55	22/06/99	02:55	48.743	-127.665	2562
P5	56	22/06/99	05:53	48.691	-127.165	2105
P4	57	22/06/99	12:55	48.65	-126.67	1342
P4	58	22/06/99	14:36	48.65	-126.668	1342
P2	0	23/06/99	09:11	48.599	-125.997	118
P1	62	23/06/99	11:29	48.572	-125.499	135
103	63	23/06/99	17:29	48.55	-124.717	124

Additional stations occupied for Mission 99-16 are shown in the following map.

III. Cruise Report 9910
Janet Barwell-Clarke and Elaine Baird

Nutrient and chlorophyll samples were analyzed along Line P1E, Line P and the first two stations of Cruise 9916. Silicate, nitrate and phosphate were analyzed for all samples. No ammonia samples were analyzed due to a colourimeter failure. Loop Samples were analyzed for nutrients, chlorophyll, and salinity along Line P1E, underway to Stn.P 26, underway to Port Hardy and back to Stn. P20, and along Line P.

A free drifting sediment trap array was deployed for two days to 1000 m at Stn. Papa. The samples were split, filtered and frozen for future C/N, Opal and Trace Metal analysis.

An in situ productivity experiment was conducted at Stn. Papa to 100 m using GOFLO samplers. The samples were filtered, frozen and will be analyzed at IOS. POC/N samples were collected at the same depths and frozen for analysis at IOS. Poor weather prevented collection of deep POC samples.

Sequential sediment traps were recovered at P26 and P04. Many of the P26- 200 m trap samples were filled with copepods and pteropods and smelled extremely foul. The amount of preservative should be increased for the next deployment. The P26-1000 m trap contained a complete set of samples, however the P26-3800 m trap was plugged after only two samples. It was suspected that this would be the case because the remineralization trap (deployed at the same time) was also plugged by September. The P04 trap was recovered with a full set of samples with the trap and bottles themselves covered with a fine hair-like growth of algae.

A remineralization experiment buoy was recovered at Stn. P26 and will be analyzed for POC/N, CaCO3, and Opal.

TCO2 and alkalinity samples were collected and analyzed along Line P1E and Line P. 13C samples were collected for analysis at IOS.

Hydro and Loop data files were generated as well as WOCE –SEA and –SUM files.

IV. Productivity Experiments
Lipsen, Vestfals and Quenneville (IOS and UBC):

Line P Monitoring

As a continuation of our work in 1998, the principal focus along line P was to measure ^{14}C incorporation into organic and inorganic particulate carbon. Size fractionated chlorophyll *a* concentrations were also measured at the 6 depths of the productivity samples as well as biogenic silica. P v I curves were also generated from each major station at 55% light depth. Samples were collected at all major stations.

Again as a continuation of last years cruise work, we took samples from all major P stations for epifluorescence microscopy, inverted microscopy and scanning electron microscopy in order to enumerate the principal producers of organic and inorganic particulate carbon.

Phytoplankton net (30 µm mesh) samples were taken from line P stations at the 1% light level as well as 150 m. Samples were preserved immediately for qualitative analysis. Initial examination will focus on the larger phytoplankton species with an emphasis on diatoms.

An experiment was conducted to examine the influence of iron and light limitation of phytoplankton at station P26. Water from station P26 was collected using a teflon pump, supplemented with iron and incubated at various light intensities in the deck mounted incubators, together with appropriate non-supplemented controls. These were incubated for over 1 week and samples taken for chlorophyll, species composition, primary productivity, nutrients and dissolved iron.

Isotope Inventory

5 µCi of ^{14}C bicarbonate were taken on board. The whole quantity was used in experiments. Low level liquid waste was diluted and disposed over the side following set protocols. No ^{14}C will be returned to shore with the exception of low level solid waste and filter material.

One µCi of ^{32}Si was brought on board. 0.91 µCi was used in experiments. Liquid and low level solid waste will be dealt with as above. The remaining 0.09 µCi will be transported back to UBC packed in an appropriate container.

V. Line P
A. Peña (IOS)

Field experiments were initiated as part of a study of processes regulating the variability of primary production and of carbon fluxes along Line P transect. The main focus was at Station P26 and P4; the two-end members of Line P transect, where experiments were conducted to examine the influence of light intensity on changes in phytoplankton carbon to chlorophyll ratios. Water was collected using 10L GOFLO bottles at two depths (55% and 3.5% light depth) and diluted with filtered sea water from same depth. One set of samples was inoculated with ^{14}C. All samples were incubated at 6 light intensities in on-deck incubators. Also, chlorophyll and phytoplankton samples for microscopic analyses (epifluorescence and inverted microscope) were obtained from 6 depths for determination of species composition and carbon content.

In all major P stations, samples were collected at 2 depths (55 and 3.5% light depth) for photosynthesis vs. irradiance measurements and chlorophyll concentration.

VI. Eddy site
A. Peña (IOS)

With M. Quenneville (IOS), primary production was measured at 6 depths at two stations, one outside and one at the center of an eddy in an attempt to document potential enhancement of primary production by eddies.

VII. Isotope Inventory
A. Peña (IOS)

10 µCi of ^{14}C bicarbonate was brought on board. 6 µCi were used in the above experiments and 3 mCi in size fractionated primary production work of UBC/ IOS. The remaining 1 µCi was transported back to IOS. Low level liquid waste was diluted and disposed over the side following set protocols. Only ^{14}C in low level solid waste and filter material was returned to shore.

P1E .sum file

P1E JOHN P. TULLY CRUISE 9910 LEG 1

SHIP/CRS EXPOCODE	WOCE SECT	STNNBR	CASTNO	CAST TYPE	DATE	UTC TIME	EVENT CODE	POSITION LATITUDE	LONGITUDE	NAV	UNC DEPTH	HT ABOVE BOTTOM	WIRE OUT	MAX PRESS	NO. OF BOTTLES	PARAMETERS	COMMENTS
18DD9910/1	P1E	JF01	1	USW	060299	0922	BE	48 13.20 N	123 32.15 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	wrong lat & long
18DD9910/1	P1E	JF02	1	USW	060299	1119	BE	48 18.65 N	123 59.79 W	GPS	181			5	1	1,3,6,34,NO2+NO3	not at position b.o. cargo ship
18DD9910/1	P1E	JF03	1	USW	060299	1327	BE	48 26.87 N	124 30.16 W	GPS	237			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	JF04	1	USW	060299	1525	BE	48 31.91 N	125 00.50 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E115	1	ROS	060399	0142	BE	46 54.08 N	124 59.62 W	GPS	777						Problems with winch. No sec. Salinity
18DD9910/1	P1E	P1E115	2	USW	060399		BE	46 54.08 N	124 59.62 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	Folded chain in half to reduce length
18DD9910/1	P1E	P1E115	1	ROS	060399	0157	BO	46 53.99 N	124 59.81 W	GPS	-9	-9	-9	799			
18DD9910/1	P1E	P1E115	1	ROS	060399	0223	EN	46 54.05 N	124 59.99 W	GPS	-9				12	1-3,6-8,13,23,24,NO2+NO3	
18DD9910/1	P1E	P1E114	1	ROS	060399	0430	BE	47 00.18 N	125 03.49 W	GPS	822						New CTD
18DD9910/1	P1E	P1E114	2	USW	060399		BE	47 00.18 N	125 03.49 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E114	1	ROS	060399		BO	47 00.36 N	125 03.50 W	GPS	-9	-9	-9	800			
18DD9910/1	P1E	P1E114	1	ROS	060399		EN	47 00.70 N	125 03.58 W	GPS	-9				13	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E113	1	ROS	060399	0727	BE	47 00.03 N	125 30.61 W	GPS	1760						
18DD9910/1	P1E	P1E113	2	USW	060399		BE	47 00.03 N	125 30.61 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E113	1	ROS	060399	0808	BO	47 00.10 N	125 30.19 W	GPS	-9	-9	-9	1760			
18DD9910/1	P1E	P1E113	1	ROS	060399	0900	EN	46 59.98 N	125 29.87 W	GPS	-9				16	1-3,6-8,23,24,NO2+NO3	
18DD9910/1	P1E	P1E112	1	ROS	060399	1136	BE	46 59.93 N	126 00.07 W	GPS	2565						
18DD9910/1	P1E	P1E112	2	USW	060399		BE	46 59.93 N	126 00.07 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E112	1	ROS	060399	1241	BO	46 59.99 N	126 00.13 W	GPS	-9	-9	-9	2566			Conds off by 0.002
18DD9910/1	P1E	P1E112	1	ROS	060399	1350	EN	46 59.99 N	126 00.79 W	GPS	-9				20	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E111	1	ROS	060399	1618	BE	47 00.12 N	126 28.18 W	GPS	2563						Soak CTD cell triton
18DD9910/1	P1E	P1E111	2	USW	060399		BE	47 00.12 N	126 28.18 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E111	1	ROS	060399	1711	BO	47 00.46 N	126 28.45 W	GPS	-9	-9	-9	2570			
18DD9910/1	P1E	P1E111	1	ROS	060399	1817	EN	47 00.62 N	126 29.40 W	GPS	-9				20	1-3,6-8,13,23,24,NO2+NO3	
18DD9910/1	P1E	P1E110	1	ROS	060399	2130	BE	47 00.00 N	127 12.06 W	GPS	2649						Have to wait 2 hrs before sampling. Not enuf
18DD9910/1	P1E	P1E110	2	USW	060399		BE	47 00.00 N	127 12.06 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	freon syringes.
18DD9910/1	P1E	P1E110	1	ROS	060399	2219	BO	46 59.98 N	127 12.27 W	GPS	-9	-9	-9	2655			
18DD9910/1	P1E	P1E110	1	ROS	060399	2317	EN	47 00.07 N	127 12.59 W	GPS	-9				20	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E109	1	ROS	060499	0237	BE	47 00.05 N	127 55.40 W	GPS	2712						
18DD9910/1	P1E	P1E109	2	USW	060499		BE	47 00.05 N	127 55.40 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E109	1	ROS	060499	0320	BO	46 59.92 N	127 55.62 W	GPS	-9	-9	-9	2705			
18DD9910/1	P1E	P1E109	1	ROS	060499	0427	EN	46 59.71 N	127 55.92 W	GPS	-9				20	1-3,6,23,24,NO2+NO3	
18DD9910/1	P1E	P1E109	3	ROS	060499	0620	BE	47 00.07 N	127 55.33 W	GPS	2712						Freon cast
18DD9910/1	P1E	P1E109	3	ROS	060499	0712	BO	47 00.39 N	127 55.11 W	GPS	-9	-9	-9	2711			
18DD9910/1	P1E	P1E109	3	ROS	060499		EN	47 00.62 N	127 55.33 W	GPS	-9				20	1,7,8	
18DD9910/1	P1E	P1E108	1	ROS	060499	1311	BE	46 59.99 N	128 38.76 W	GPS	2741						
18DD9910/1	P1E	P1E108	2	USW	060499		BE	46 59.99 N	128 38.76 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E108	1	ROS	060499	1402	BO	46 59.69 N	128 38.96 W	GPS	-9	-9	-9	2747			
18DD9910/1	P1E	P1E108	1	ROS	060499		EN	N	W	GPS	-9				20	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E107	1	ROS	060499	1926	BE	46 59.96 N	129 22.95 W	GPS	2573						
18DD9910/1	P1E	P1E107	2	USW	060499		BE	46 59.96 N	129 22.95 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E107	1	ROS	060499	2011	BO	46 59.56 N	129 23.43 W	GPS	-9	-9	-9	2573			
18DD9910/1	P1E	P1E107	1	ROS	060499	2114	EN	46 59.46 N	129 24.09 W	GPS	-9				20	1-3,6-8,13,23,24,NO2+NO3	
18DD9910/1	P1E	P1E106	1	ROS	060599	0443	BE	47 00.04 N	130 01.13 W	GPS	2728						
18DD9910/1	P1E	P1E106	2	USW	060599		BE	47 00.04 N	130 01.13 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	

18DD9910/1	P1E	P1E106	1	ROS	060599	0533	BO	47 00.21 N	130 00.80 W	GPS	-9	-9	-9	2658			
18DD9910/1	P1E	P1E106	1	ROS	060599	0654	EN	46 59.96 N	130 01.68 W	GPS	-9				20	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E105	1	ROS	060699	1534	BE	47 00.01 N	131 13.89 W	GPS	2870						
18DD9910/1	P1E	P1E105	2	USW	060699		BE	47 00.01 N	131 13.89 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E105	1	ROS	060699	1642	BO	47 00.03 N	131 15.64 W	GPS	-9	-9	-9	2504			
18DD9910/1	P1E	P1E105	1	ROS	060699	1811	EN	46 59.97 N	131 16.69 W	GPS	-9				20	1-3,6-8,23,24,NO2+NO3	Heave comp. Hook damaged at 600 m. the remainder
18DD9910/1	P1E	P1E104	1	ROS	060699	0403	BE	46 59.91 N	132 22.42 W	GPS	3320						of samples taken on the fly
18DD9910/1	P1E	P1E104	2	USW	060699		BE	46 59.91 N	132 22.42 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E104	1	ROS	060699	0518	BO	47 00.02 N	132 23.26 W	GPS	-9	-9	-9	3300			
18DD9910/1	P1E	P1E104	1	ROS	060699	0700	EN	47 00.22 N	132 24.26 W	GPS	3649				22	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E103	1	ROS	060699	1420	BE	46 59.99 N	133 27.77 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E103	2	USW	060699		BE	46 59.99 N	133 27.77 W	GPS	-9	-9	-9	3590			
18DD9910/1	P1E	P1E103	1	ROS	060699	1526	BO	46 59.91 N	133 28.64 W	GPS	-9				23	1-3,6-8,13,23,24,NO2+NO3	
18DD9910/1	P1E	P1E103	1	ROS	060699		EN	N	W	GPS	-9						
18DD9910/1	P1E	P1E102	1	ROS	060699	2323	BE	46 59.90 N	134 36.71 W	GPS	3982						
18DD9910/1	P1E	P1E102	2	USW	060699		BE	46 59.90 N	134 36.71 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E102	1	ROS	060799	0035	BO	46 59.93 N	134 36.51 W	GPS	-9	-9	-9	4045			
18DD9910/1	P1E	P1E102	1	ROS	060799	0205	EN	47 00.32 N	134 37.80 W	GPS	-9				23	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E101	1	ROS	060799	0816	BE	47 00.06 N	135 44.12 W	GPS	4138						
18DD9910/1	P1E	P1E101	2	USW	060799		BE	47 00.06 N	135 44.12 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E101	1	ROS	060799	0931	BO	47 00.31 N	135 43.91 W	GPS	-9	-9	-9	4190			
18DD9910/1	P1E	P1E101	1	ROS	060799	1051	EN	47 00.63 N	135 43.78 W	GPS	-9				24	1-3,6-8,23,24,NO2+NO3	
18DD9910/1	P1E	P1E100	1	ROS	060799	1610	BE	46 59.83 N	136 50.94 W	GPS	4158						
18DD9910/1	P1E	P1E100	2	USW	060799		BE	46 59.83 N	136 50.94 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E100	1	ROS	060799		BO	46 59.55 N	136 51.05 W	GPS	-9	-9	-9	4150			
18DD9910/1	P1E	P1E100	1	ROS	060799		EN	46 59.72 N	136 51.40 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	ED1	1	CTD	060799	2053	BE	47 14.95 N	137 09.85 W	GPS	4121						
18DD9910/1	P1E	ED1	2	USW	060799		BE	47 14.95 N	137 09.85 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	ED1	1	CTD	060799	2128	BO	47 14.63 N	137 09.72 W	GPS	-9	-9	-9	-9			
18DD9910/1	P1E	ED1	1	CTD	060799		EN	N	W	GPS	-9						
18DD9910/1	P1E	ED2	1	ROS	060899	0034	BE	47 31.56 N	137 27.60 W	GPS	-9						Stop @ 1597 going down bec. no winch for ~ 3 min.
18DD9910/1	P1E	ED2	1	ROS	060899	0039	BO	47 31.47 N	137 27.56 W	GPS	-9	-9	-9	-9			
18DD9910/1	P1E	ED2	1	ROS	060899	0047	EN	47 31.45 N	137 27.55 W	GPS	-9						
18DD9910/1	P1E	ED2	2	ROS	060899	0124	BE	47 31.90 N	137 27.60 W	GPS	4092						
18DD9910/1	P1E	ED2	3	USW	060899		BE	47 31.90 N	137 27.60 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	ED2	2	ROS	060899	0239	BO	47 32.49 N	137 26.76 W	GPS	-9	-9	-9	4144			
18DD9910/1	P1E	ED2	2	ROS	060899		EN	47 32.36 N	137 24.45 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E99	1	ROS	060899	0817	BE	46 59.89 N	137 57.89 W	GPS	4166						
18DD9910/1	P1E	P1E99	2	USW	060899	0820	BE	46 59.89 N	137 57.89 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E99	1	ROS	060899	0935	BO	46 59.18 N	137 58.08 W	GPS	-9	-9	-9	4224			Pressure spikes @ beg.
18DD9910/1	P1E	P1E99	1	ROS	060899	1122	EN	46 58.64 N	137 58.22 W	GPS	-9				24	1-3,6-8,13,23,24,NO2+NO3	Computer slow by 15 min. End time good
18DD9910/1	P1E	P1E98	1	ROS	060899	1552	BE	47 00.06 N	139 04.04 W	GPS	3527						
18DD9910/1	P1E	P1E98	1	ROS	060899	1556	BO	47 00.10 N	139 04.02 W	GPS	-9	-9	-9	75			
18DD9910/1	P1E	P1E98	1	ROS	060899	1604	EN	47 00.14 N	139 04.00 W	GPS	-9						
18DD9910/1	P1E	P1E98	2	ROS	060899	1628	BE	46 59.99 N	139 04.15 W	GPS	3917						
18DD9910/1	P1E	P1E98	3	USW	060899	1631	BE	46 59.99 N	139 04.15 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E98	2	ROS	060899	1750	BO	47 00.15 N	139 04.83 W	GPS	-9	-9	-9	4285			
18DD9910/1	P1E	P1E98	2	ROS	060899	1920	EN	47 00.05 N	139 05.45 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E97	1	ROS	060999	0019	BE	46 59.92 N	140 13.45 W	GPS	4325						Strong current pushing us westward
18DD9910/1	P1E	P1E97	2	USW	060999	0022	BE	46 59.92 N	140 13.45 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E97	1	ROS	060999	0138	BO	46 59.24 N	140 14.17 W	GPS	-9	-9	-9	4392			

18DD9910/1	P1E	P1E97	1	ROS	060999	0320	EN	46 59.19 N	140 16.89 W	GPS	-9				24	1-3,6-8,23,24,NO2+NO3	
18DD9910/1	P1E	P1E96	1	ROS	060999	0754	BE	47 00.07 N	141 21.16 W	GPS	4403						
18DD9910/1	P1E	P1E96	1	ROS	060999	0916	BO	47 00.26 N	141 21.59 W	GPS	-9	-9	-9	4464			
18DD9910/1	P1E	P1E96	2	USW	060999	1000	BE	47 00.06 N	141 22.12 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E96	1	ROS	060999	1041	EN	47 00.05 N	141 22.79 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E95	1	ROS	060999	1520	BE	47 00.07 N	142 26.36 W	GPS	4494						
18DD9910/1	P1E	P1E95	2	USW	060999	1530	BE	47 00.07 N	142 26.36 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E95	1	ROS	060999	1646	BO	47 00.61 N	142 26.46 W	GPS	-9	-9	-9	4577			
18DD9910/1	P1E	P1E95	1	ROS	060999	1814	EN	47 01.38 N	142 26.48 W	GPS	-9				24	1-3,6-8,13,23,24,NO2+NO3	
18DD9910/1	P1E	P1E94	1	ROS	060999	2250	BE	46 59.83 N	143 29.66 W	GPS	4577						
18DD9910/1	P1E	P1E94	2	USW	060999	2255	BE	46 59.83 N	143 29.66 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E94	1	ROS	061099	0011	BO	46 59.75 N	143 28.35 W	GPS	-9	-9	-9	4662			
18DD9910/1	P1E	P1E94	1	ROS	061099	0145	EN	46 59.62 N	143 27.30 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E93	1	ROS	061099	0658	BE	46 59.93 N	144 40.11 W	GPS	4674						
18DD9910/1	P1E	P1E93	2	USW	061099	0706	BE	46 59.93 N	144 40.11 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E93	1	ROS	061099	0820	BO	46 59.62 N	144 39.47 W	GPS	-9	-9	-9	4753			Wrong station name in header
18DD9910/1	P1E	P1E93	1	ROS	061099	0955	EN	46 59.38 N	144 39.83 W	GPS	-9				24	1-3,6-8,NO2+NO3	
18DD9910/1	P1E	P1E92	1	ROS	061099	1455	BE	46 59.77 N	145 48.53 W	GPS	4783						
18DD9910/1	P1E	P1E92	2	USW	061099	1500	BE	46 59.77 N	145 48.53 W	GPS	-9			5	1	1,3,6,34,NO2+NO3	
18DD9910/1	P1E	P1E92	1	ROS	061099	1628	BO	46 58.76 N	145 48.32 W	GPS	-9	-9	-9	4888			
18DD9910/1	P1E	P1E92	1	ROS	061099	1804	EN	46 58.97 N	145 49.46 W	GPS	-9				24	1-3,6-8,13,23,24,NO2+NO3	

1=Sal, 2=DO, 3=SiO2, 6=PO4, 7=CFC11, 8=CFC12, 13=C13, 23=DIC, 24=Alk

Figure caption

Figure 1 Station location with bottom topography based on Smith and Sandwell (1997). Stations of X13, X14, X15 and X16 are crossing-over stations with P13, P14, P15 and P16, respectively.

Figure 2 Cross section of potential temperature (^oC) calculated from CTD temperature and salinity data calibrated by bottle salinity measurements. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 3 CTD salinity cross section (psu) calibrated by bottle salinity measurements. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 4 Same as figure 3 but with SSW batch correction using values reported by Mantyla(1987) and Aoyama et al. (2002).

Figure 5 Sigma_0 (kg/m^3) cross section calculated using CTD temperature and calibrated salinity data with SSW batch correction. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 6 Same as figure 5 but for sigma_4 (kg/m^3).

Figure 7 Cross section of bottle sampled dissolved oxygen (µmol/kg). Data with quality flags of 2 were potted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 8 Silicate (µmol/kg) cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 9 Nitrate (µmol/kg) cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 10 Nitrite (µmol/kg) cross section. Data with quality flags of 2 were plotted.

Figure 11 Cross section of sum of Nitrate (µmol/kg) and Nitrite (µmol/kg). Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 12 Phosphate (µmol/kg) cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 13 (a) upper panel: Freon_11 (pmol/kg) cross section.
(b) lower panel: Freon_12 (pmol/kg) cross section.
Data with quality flags of 2 are plotted for both components.

Figure 14 (a) upper panel: Freon_113 (pmol/kg) cross section.
(b) lower panel: SF_6 (fmol/kg) cross section.
Data with quality flags of 2 are plotted for both components.

Figure 15 pH cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

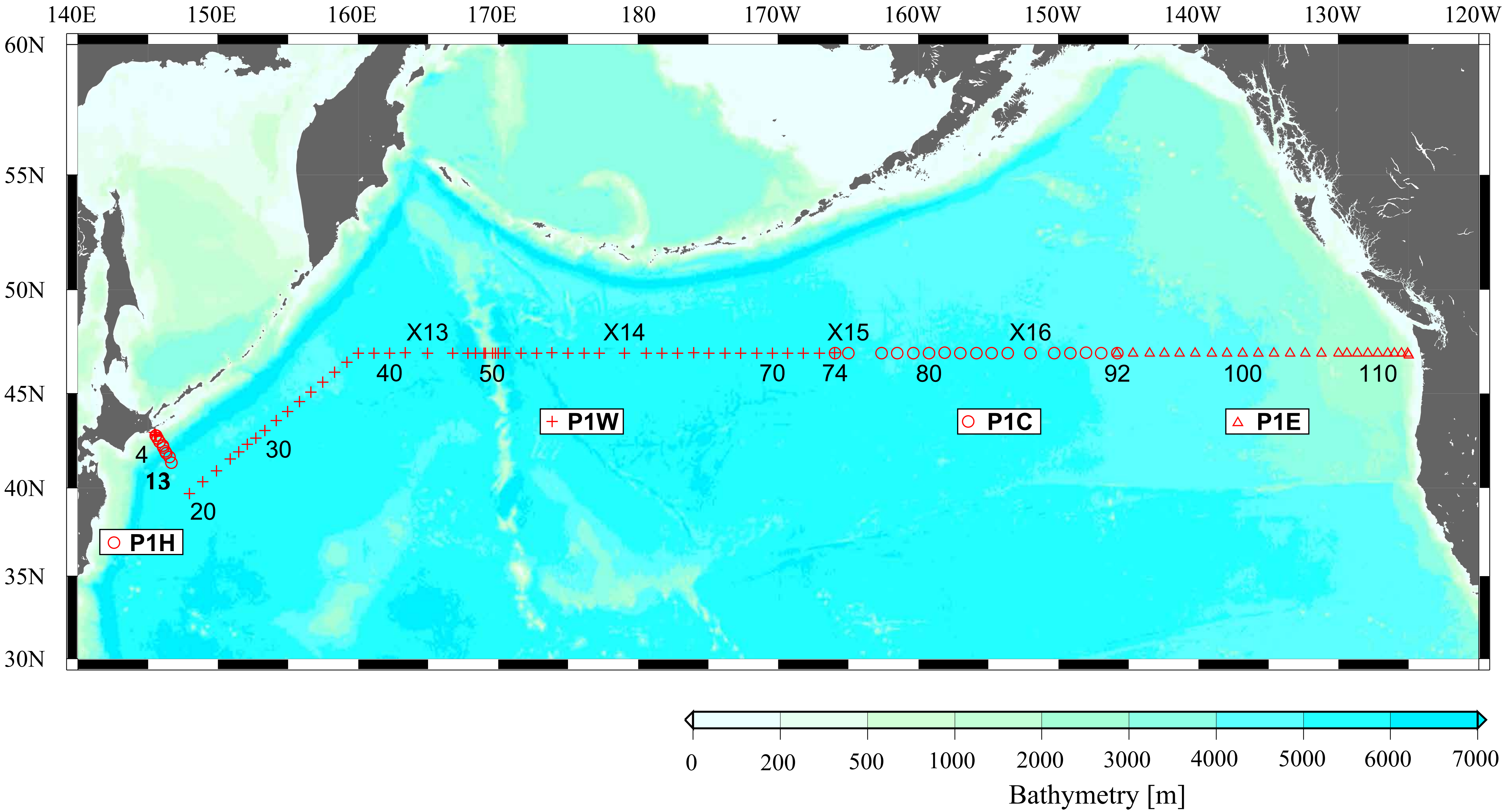
Figure 16 Total Alkalinity (µmol/kg) cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 17 Total Carbon (µmol/kg) cross section. Data with quality flags of 2 were plotted. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 18 Difference in potential temperature between results from 1999 and 1985. Red and blue areas shows areas where potential temperature increased and decreased in 1999, respectively. On white areas differences in temperature do not exceed the detection limit of 0.002 ^oC. Vertical exaggeration is 1:2.5 for upper 1000m.

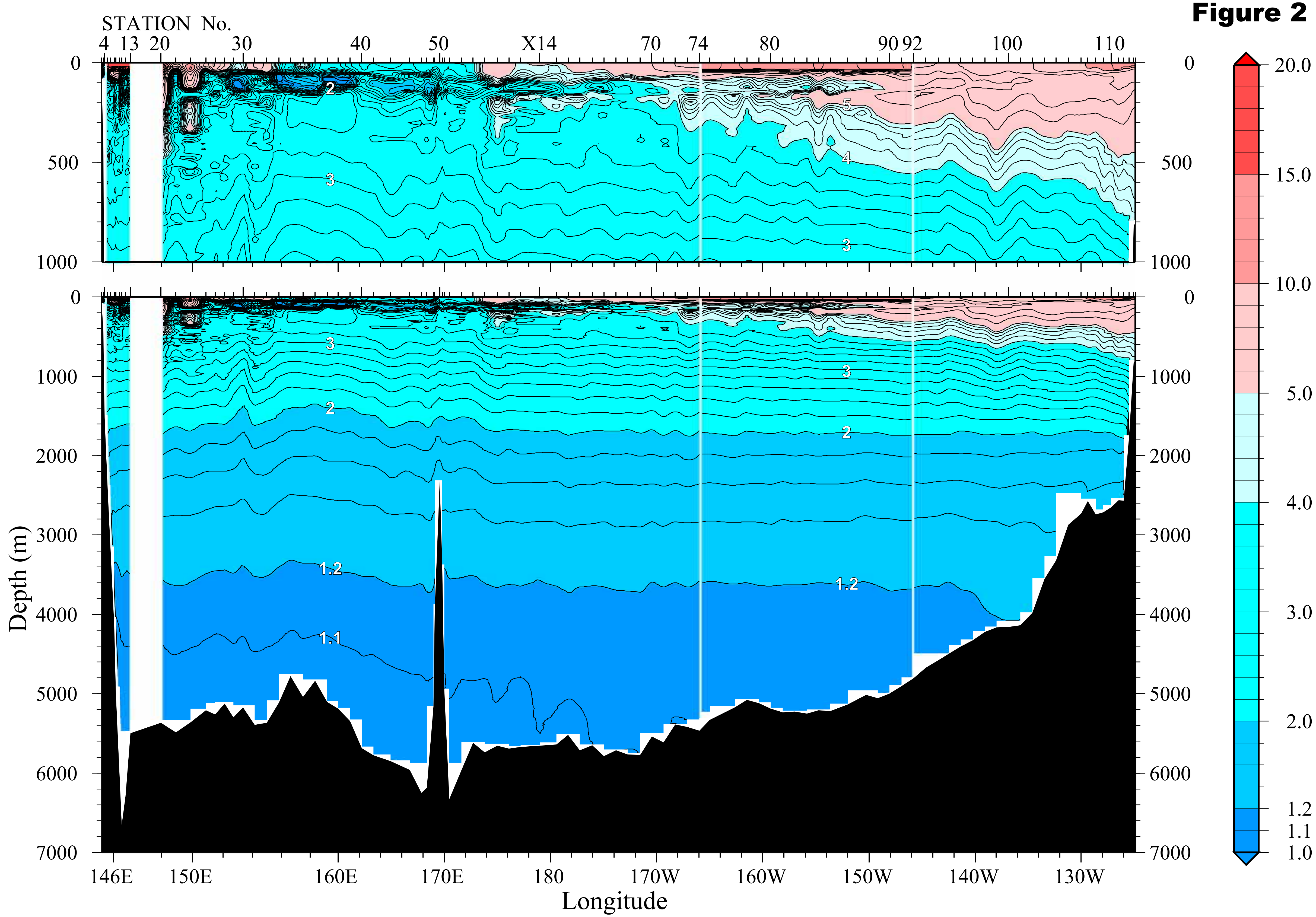
Figure 19 Difference in salinity between results from 1999 and 1985. Red and blue areas shows areas where salinity increased and decreased in 1999, respectively. On white areas differences in salinity do not exceed the detection limit of 0.003 psu. Vertical exaggeration is 1:2.5 for upper 1000m.

Figure 1



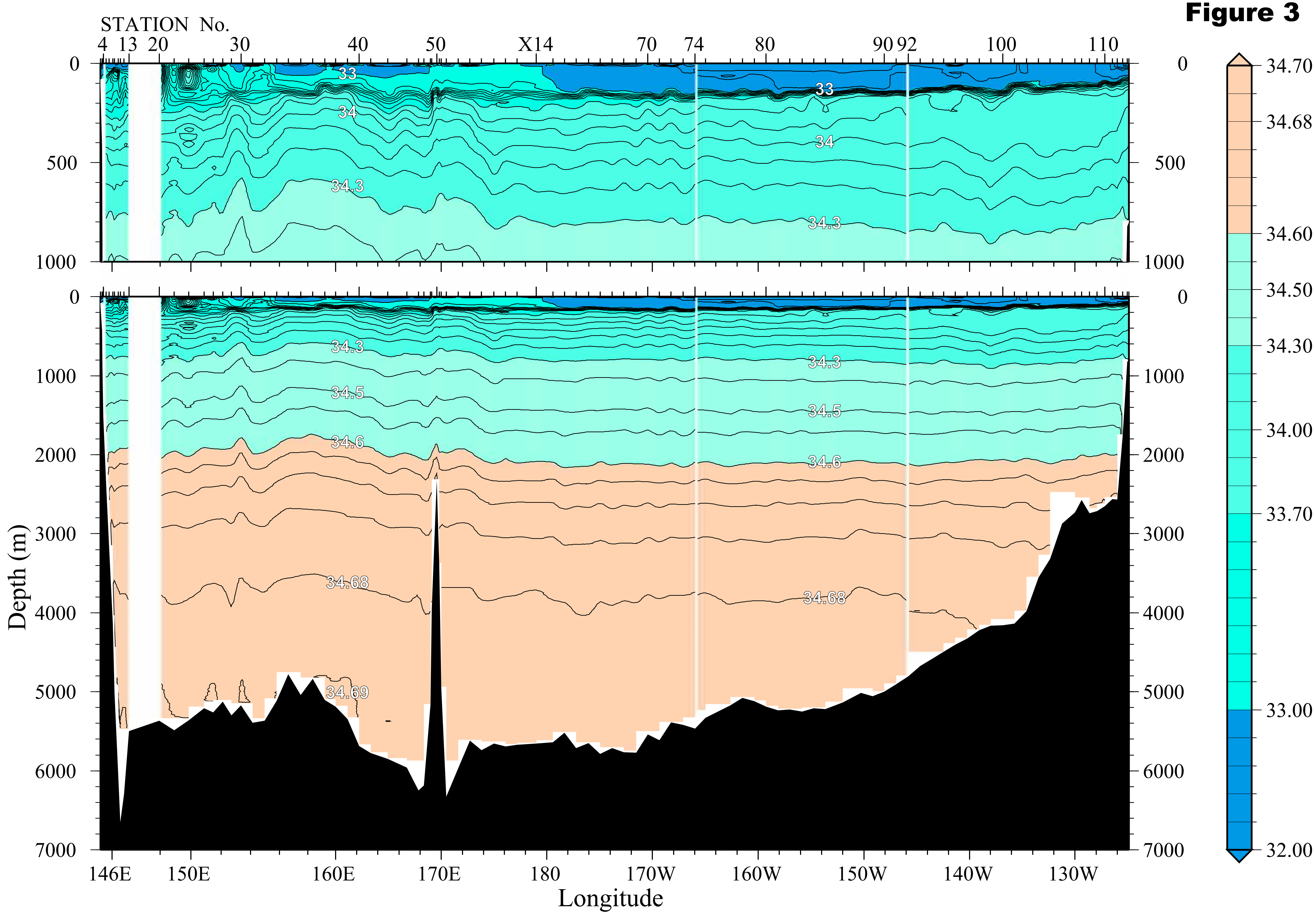
STATION LOCATIONS FOR WHP P01 REVISIT IN 1999

Figure 2



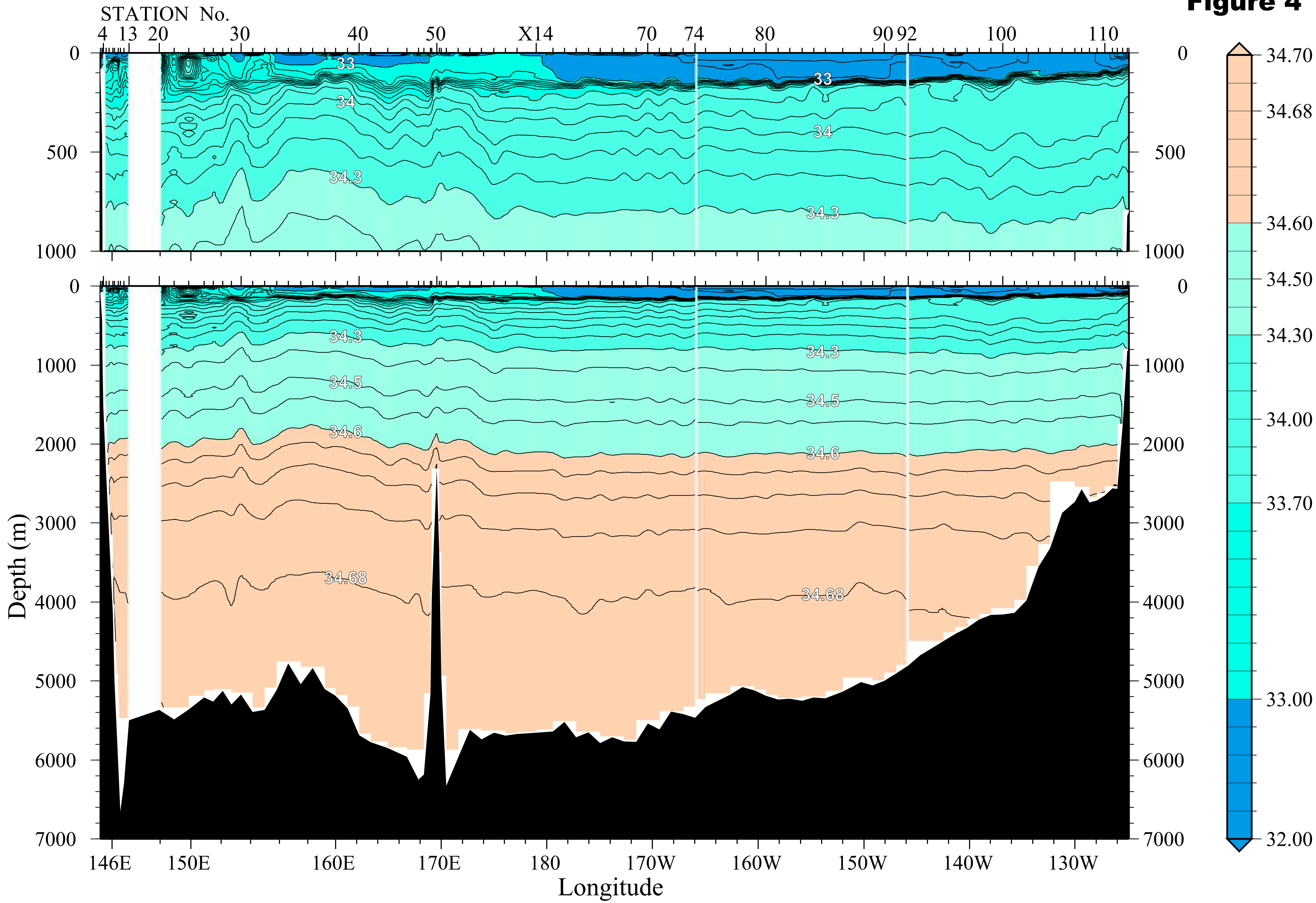
POTENTIAL TEMPERATURE [°C]

Figure 3



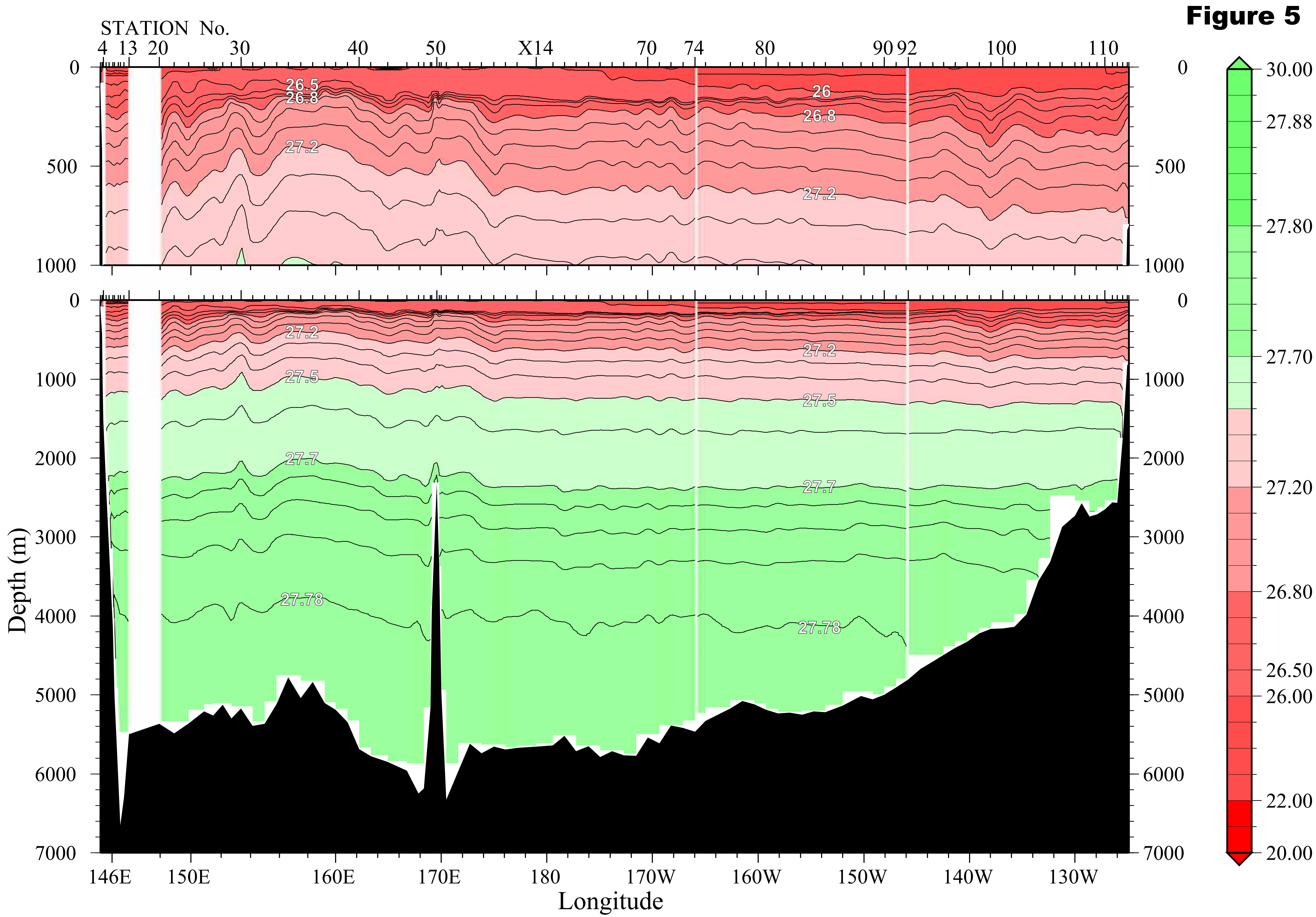
SALINITY [PSU]

Figure 4



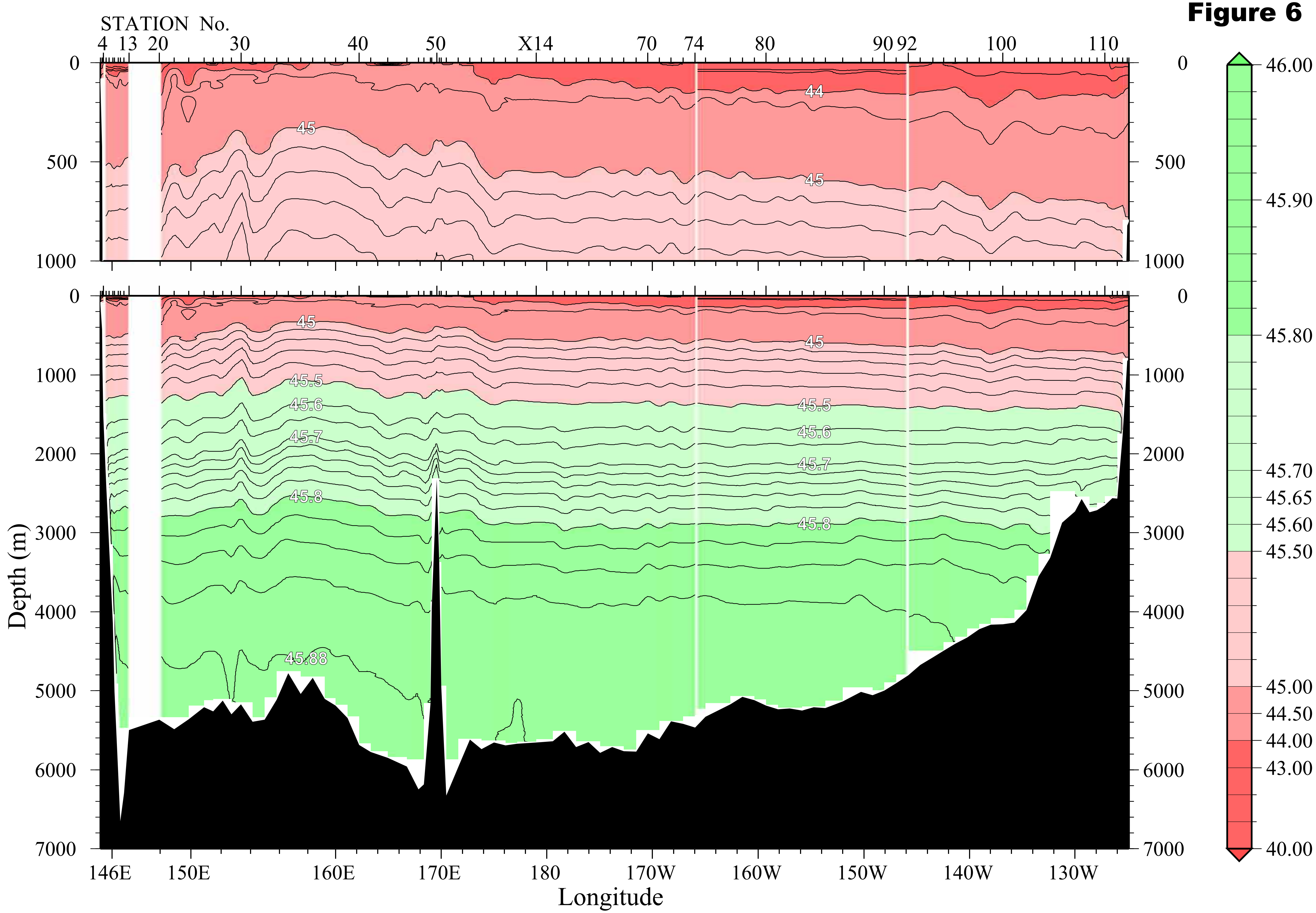
SALINITY AFTER BATCH CORRECTION [PSU]

Figure 5



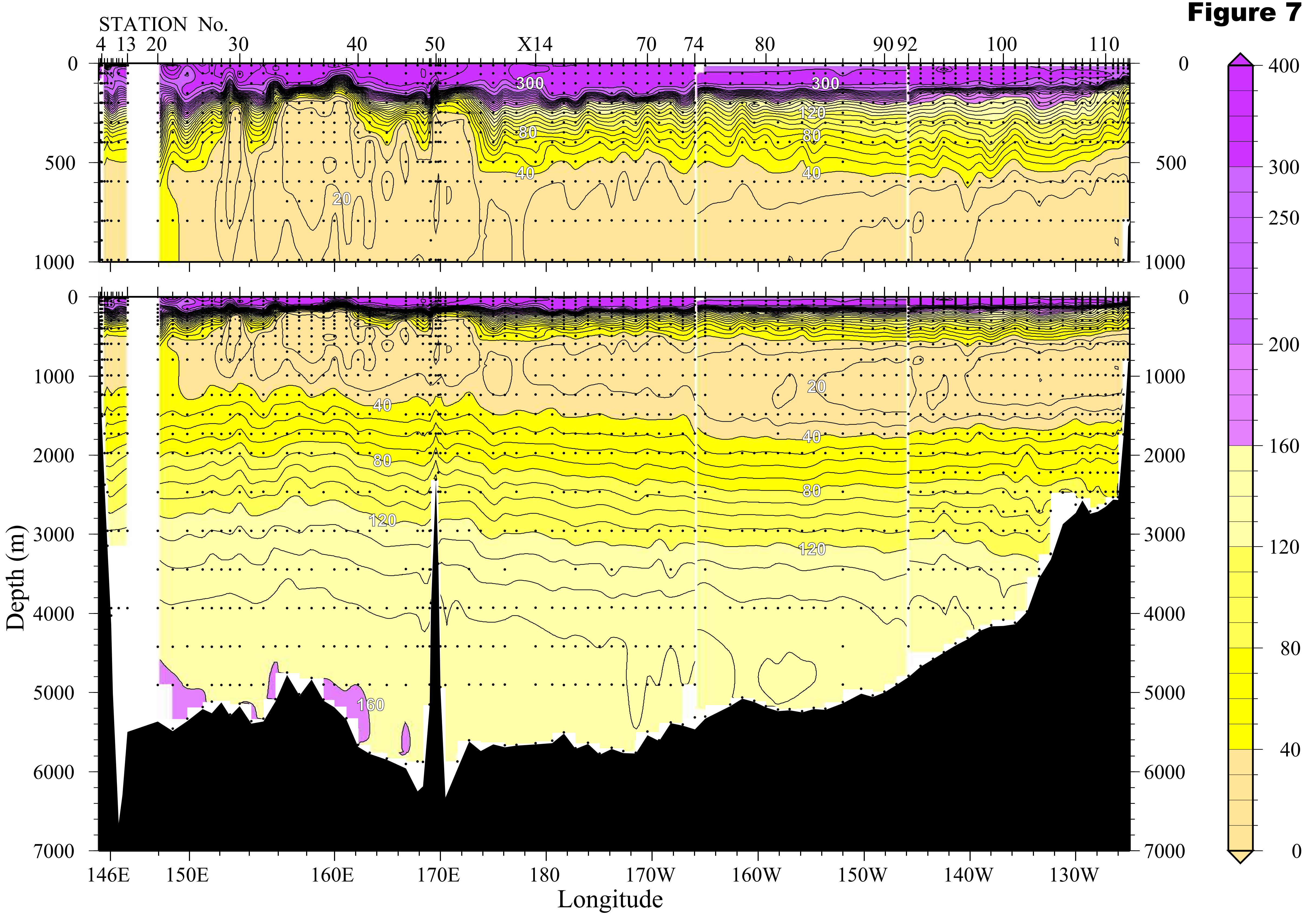
SIGMA THETA

Figure 6



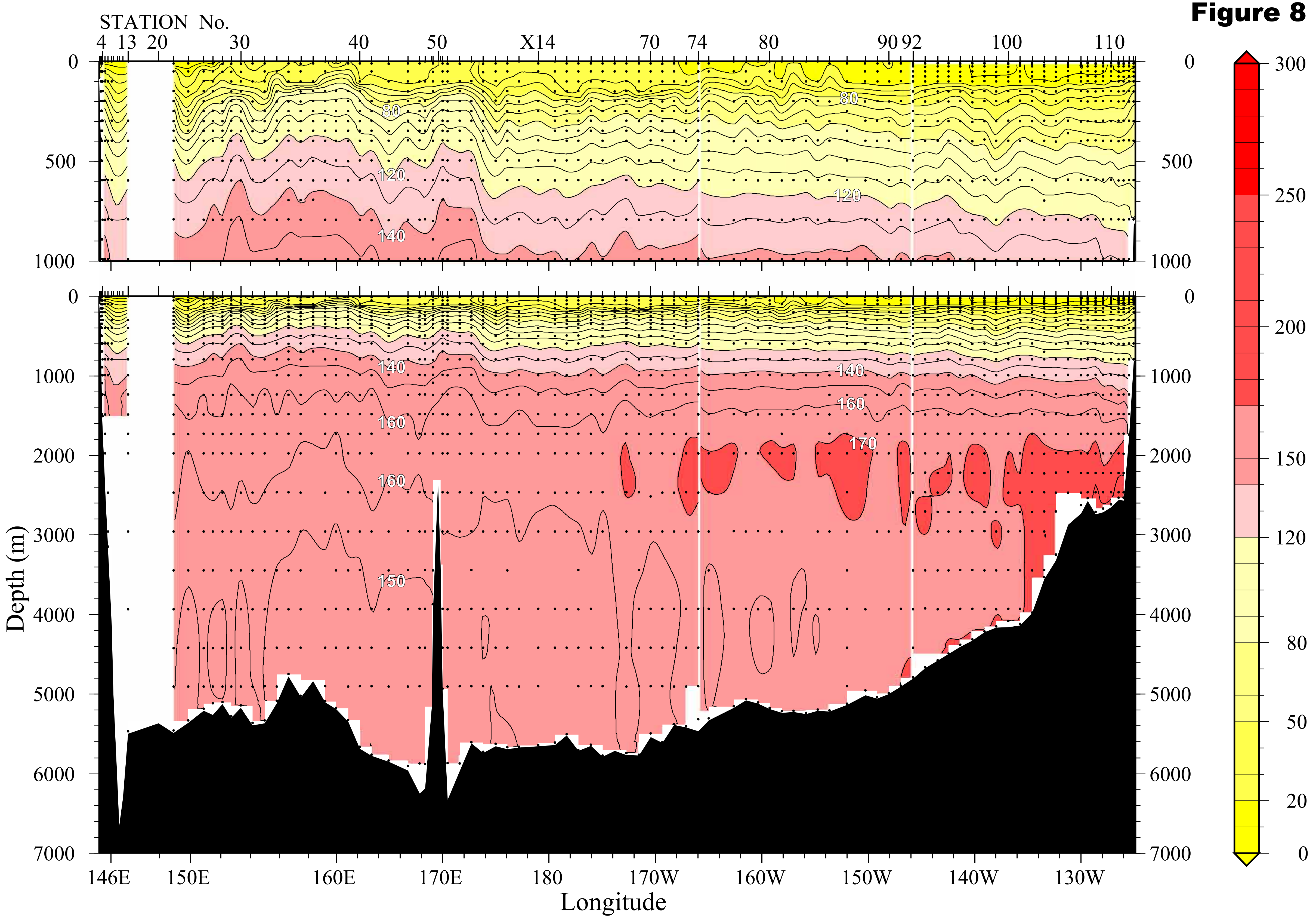
SIGMA 4

Figure 7

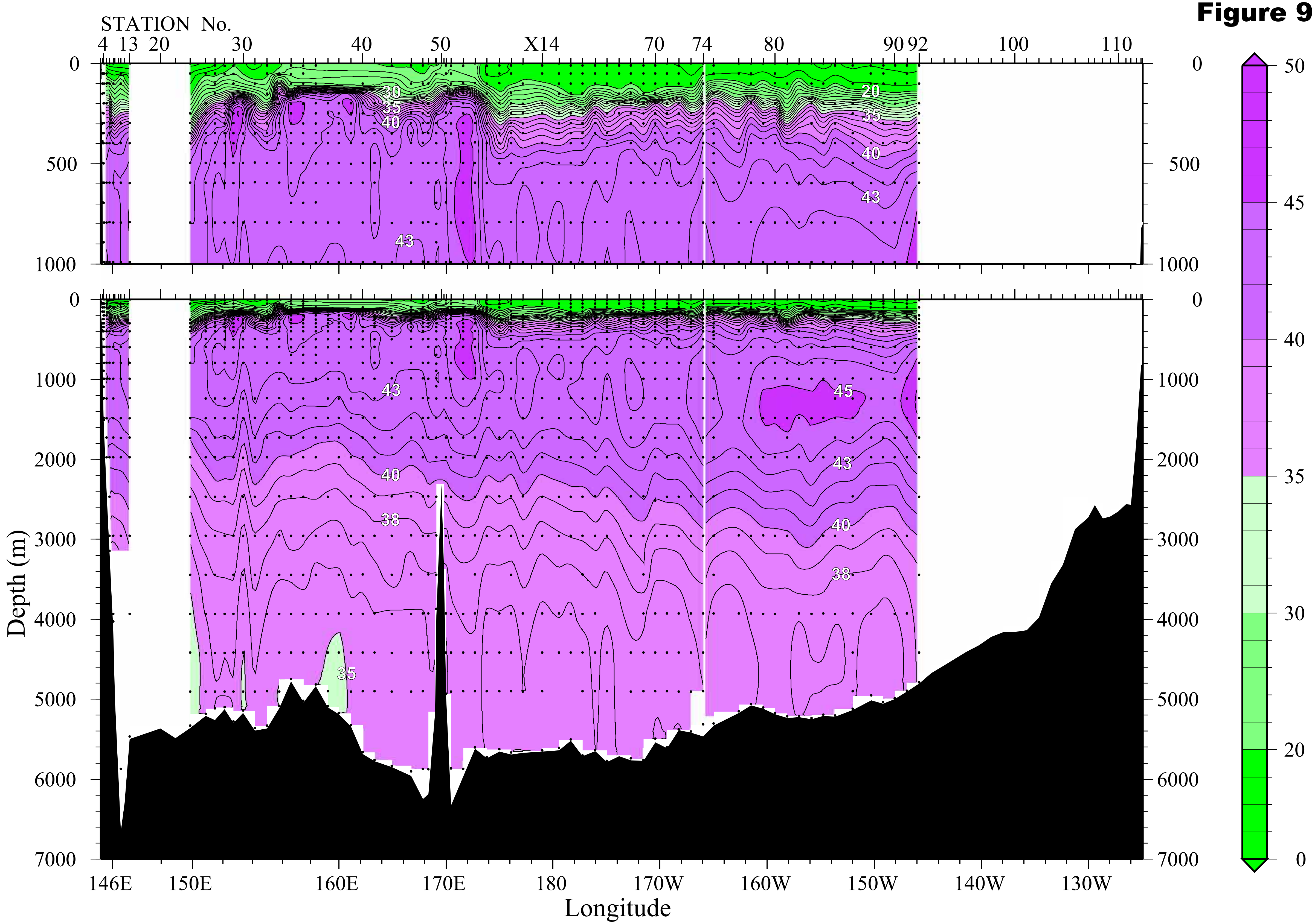


OXYGEN [μmol/kg]

Figure 8

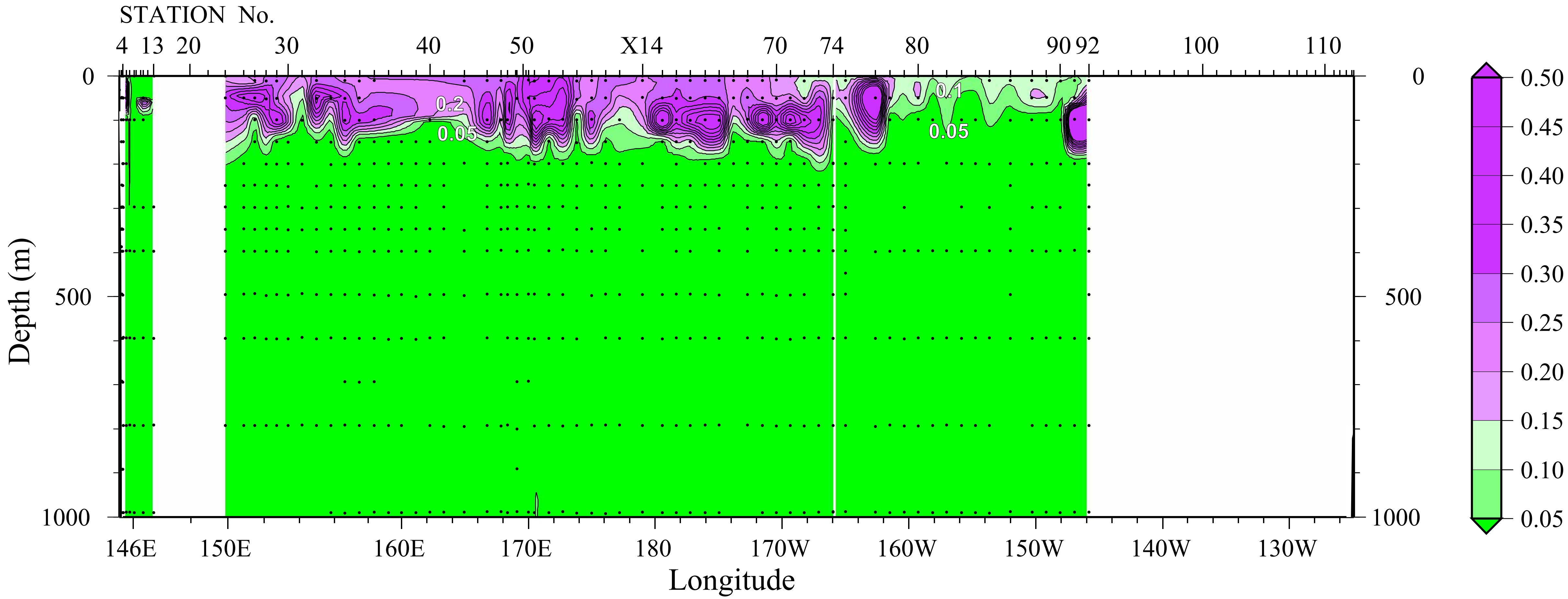


SILICATE [μmol/kg]



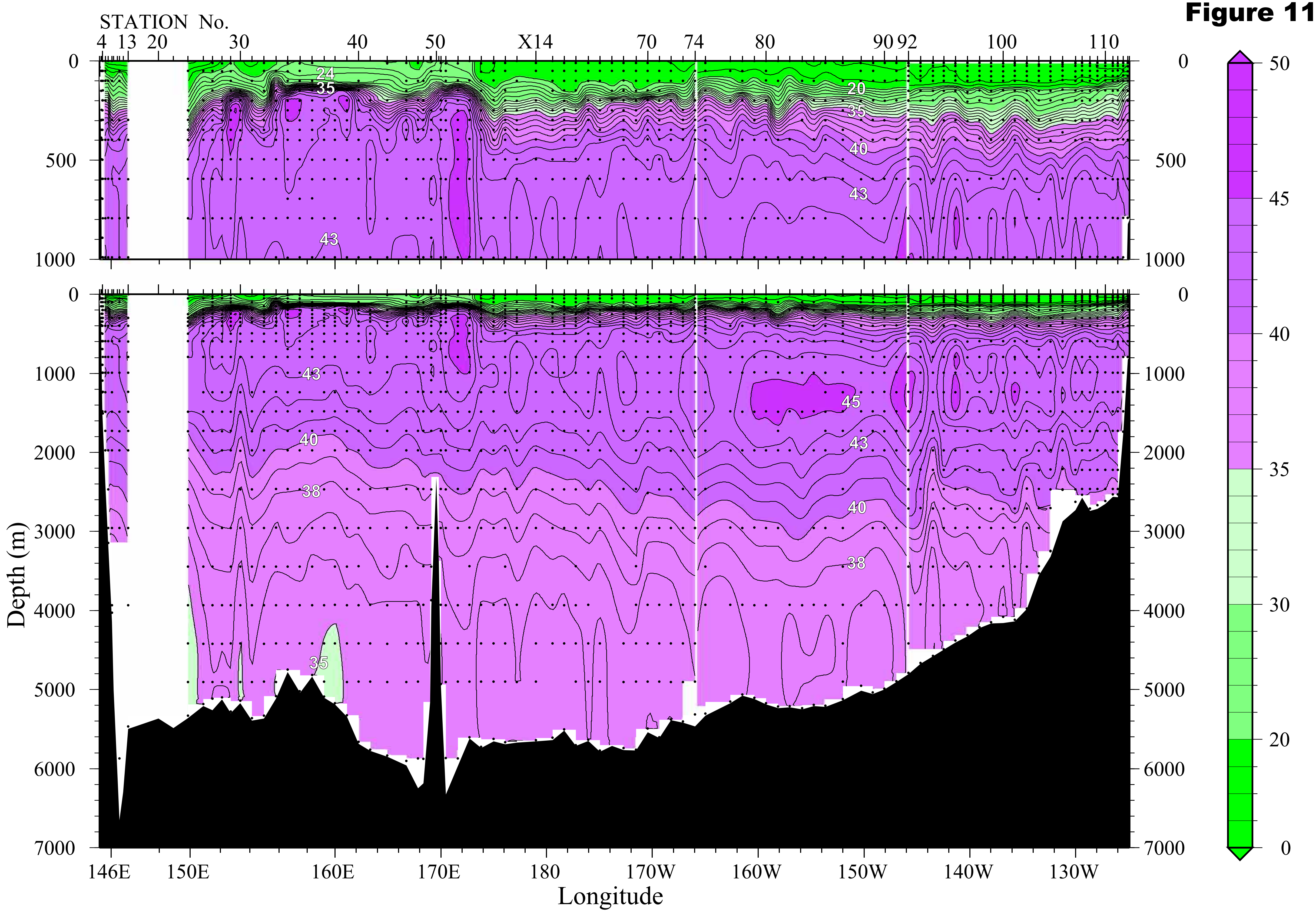
NITRATE [μmol/kg]

Figure 10



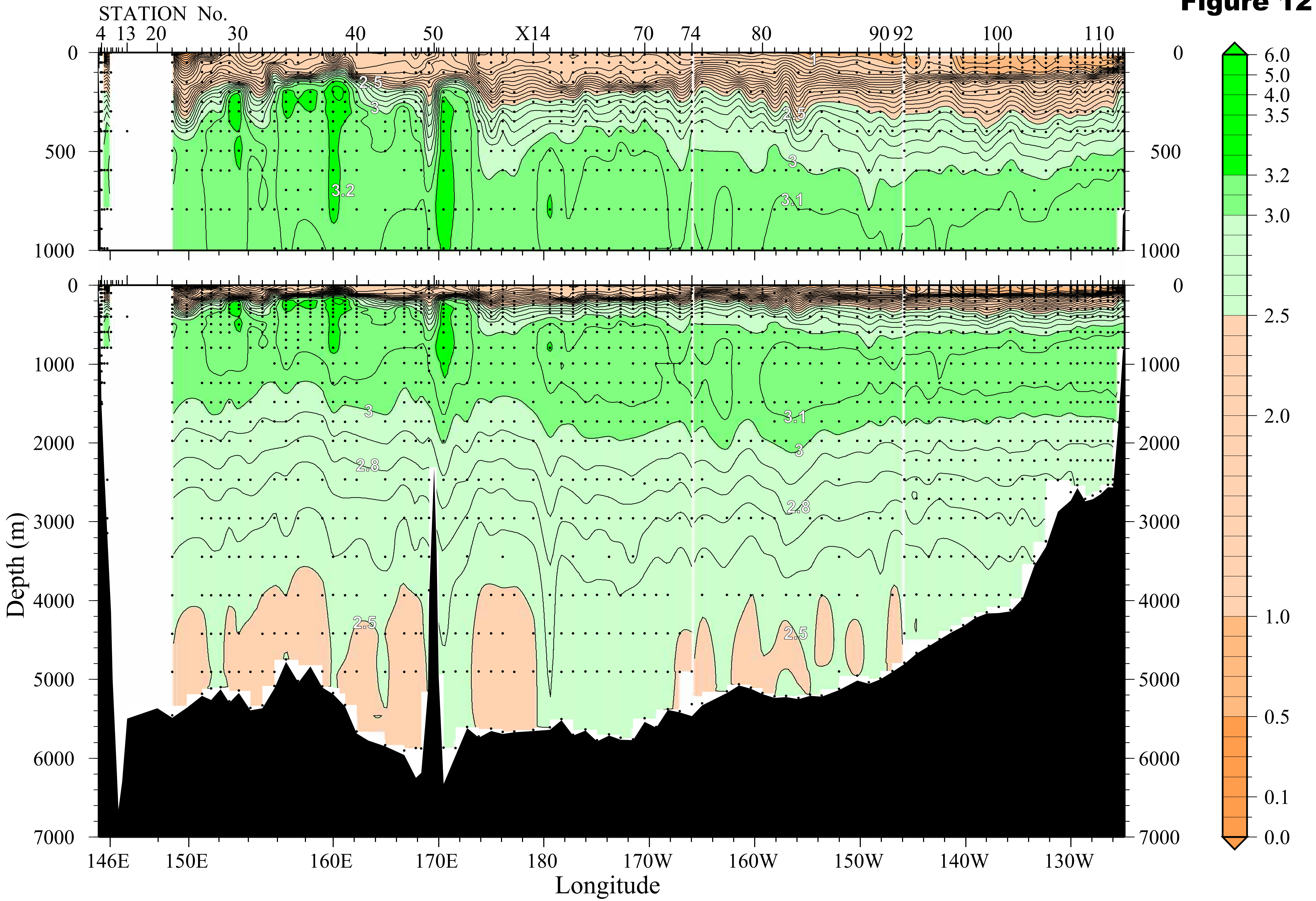
NITRITE [μmol/kg]

Figure 11

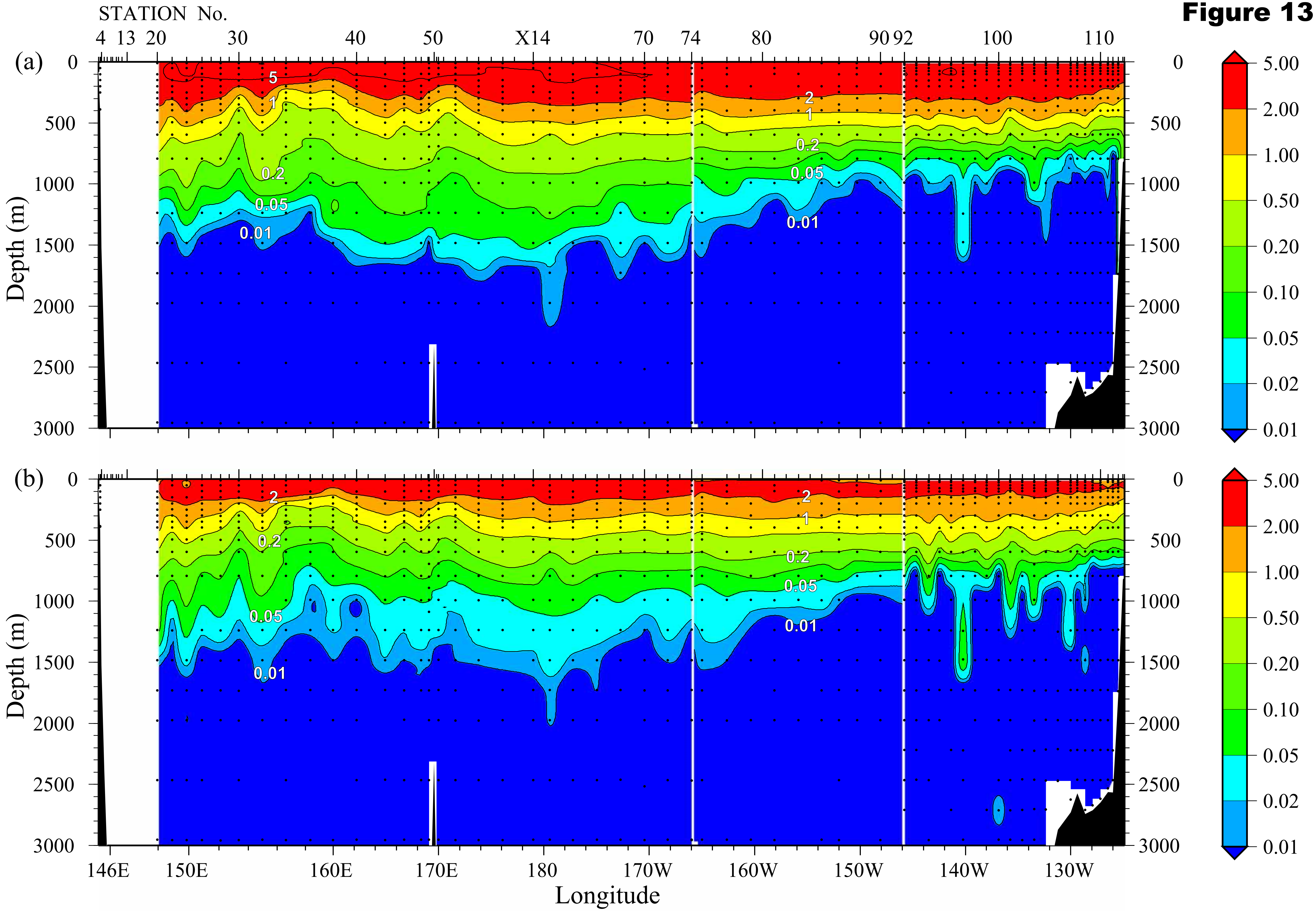


NO2+NO3 [μmol/kg]

Figure 12

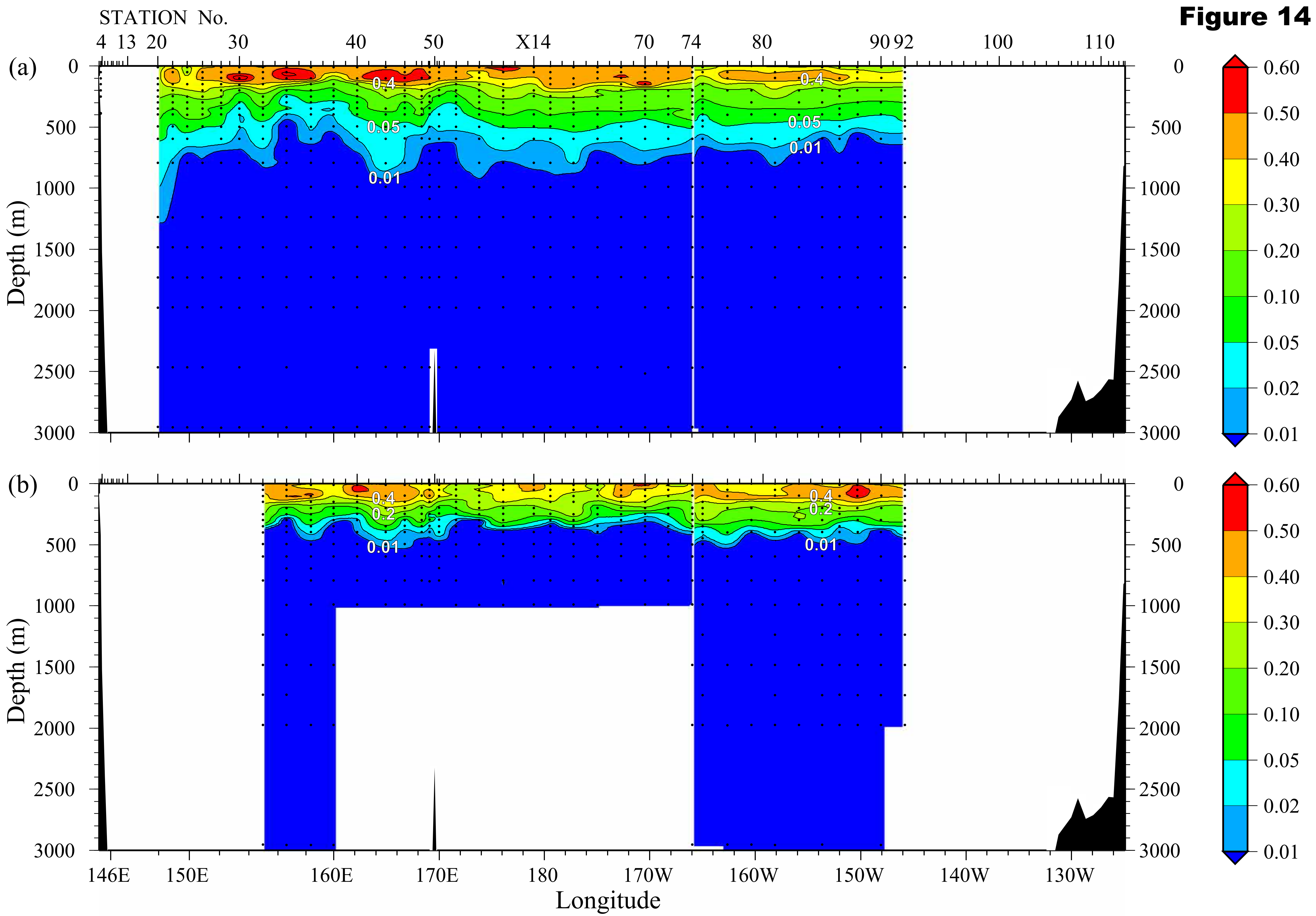


PHOSPHATE [μmol/kg]



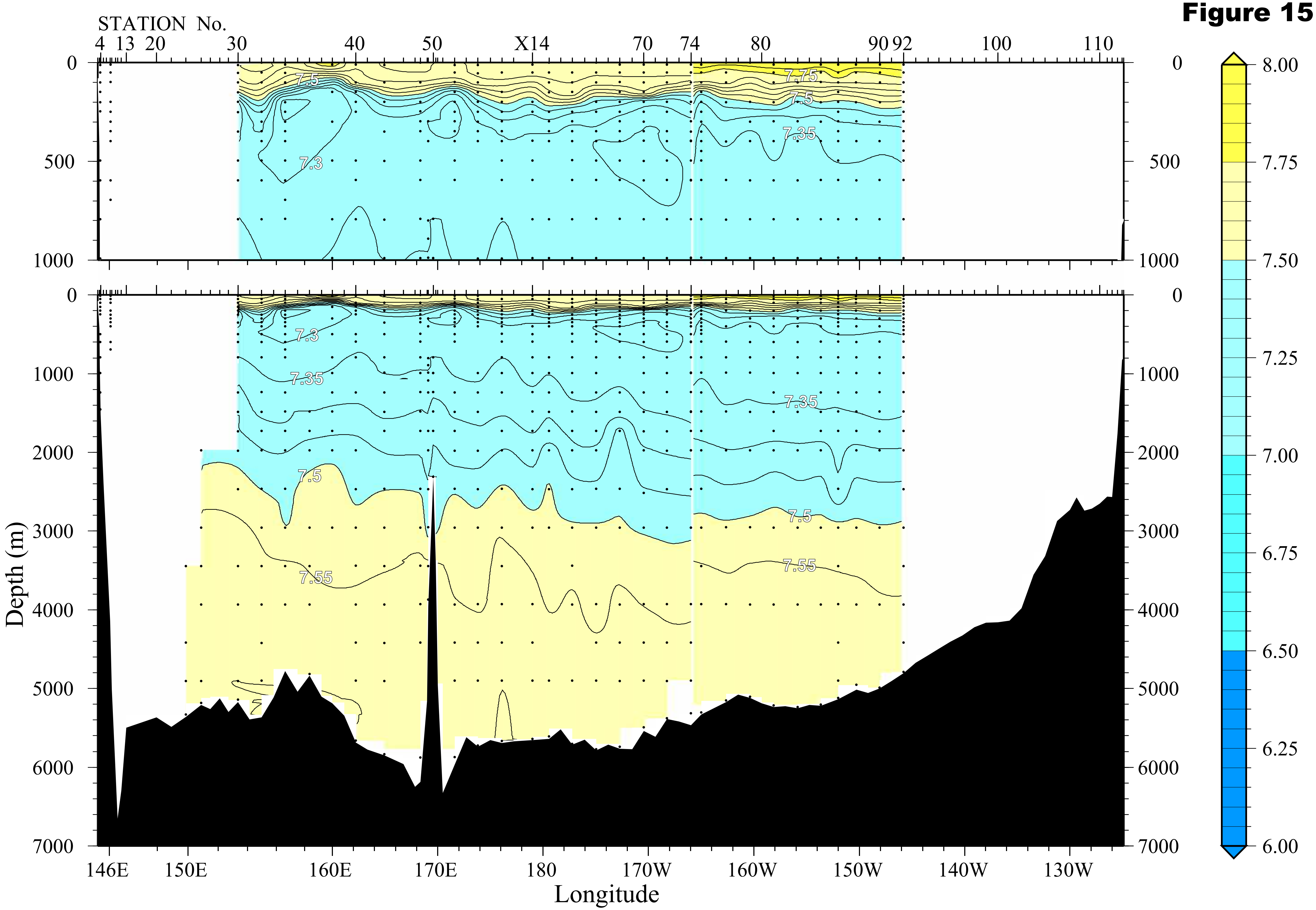
(a) CFC-11 [pmol/kg], (b) CFC-12 [pmol/kg]

Figure 14

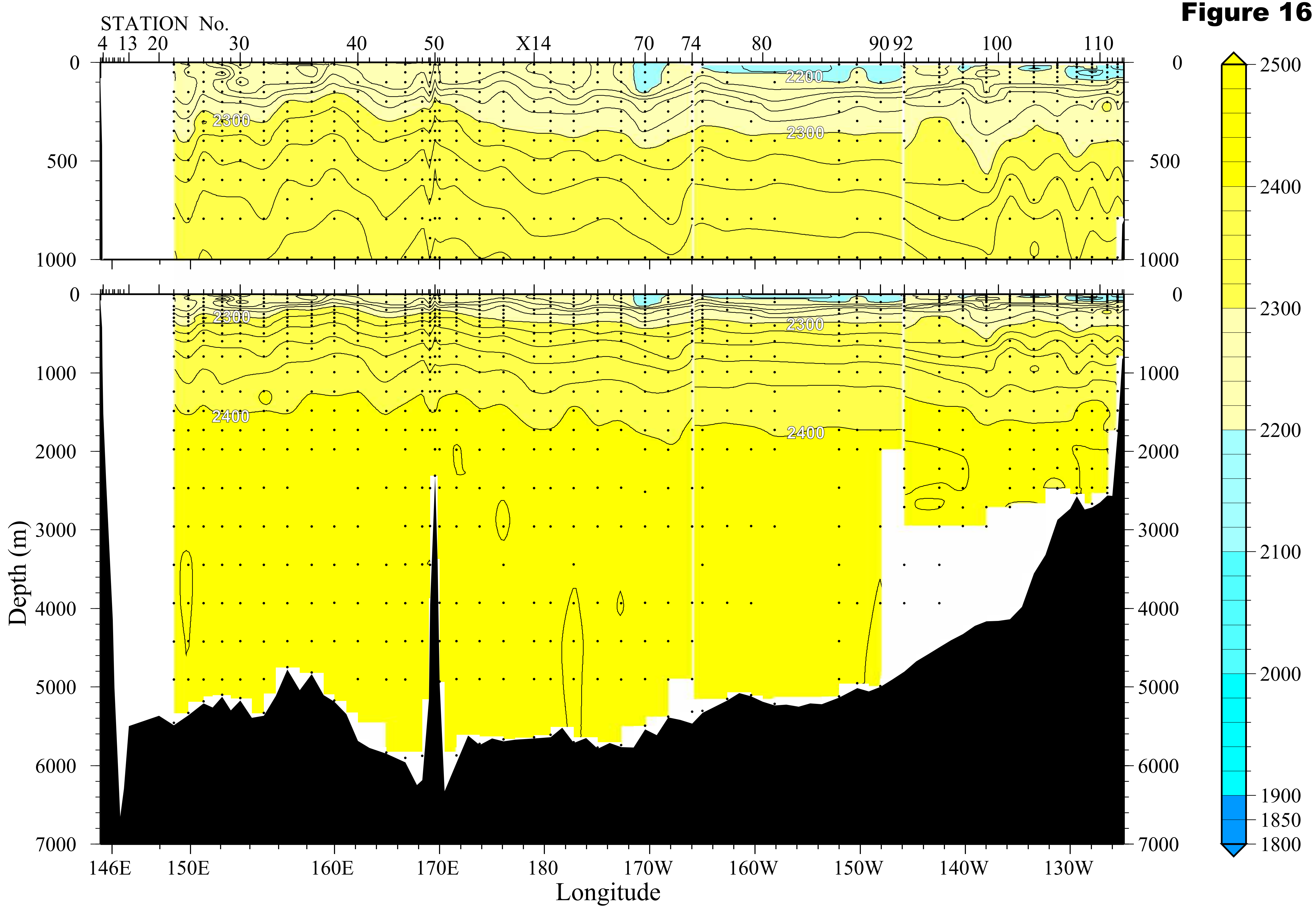


(a) CFC113 [pmol/kg], (b) SF6 [fmol/kg]

Figure 15

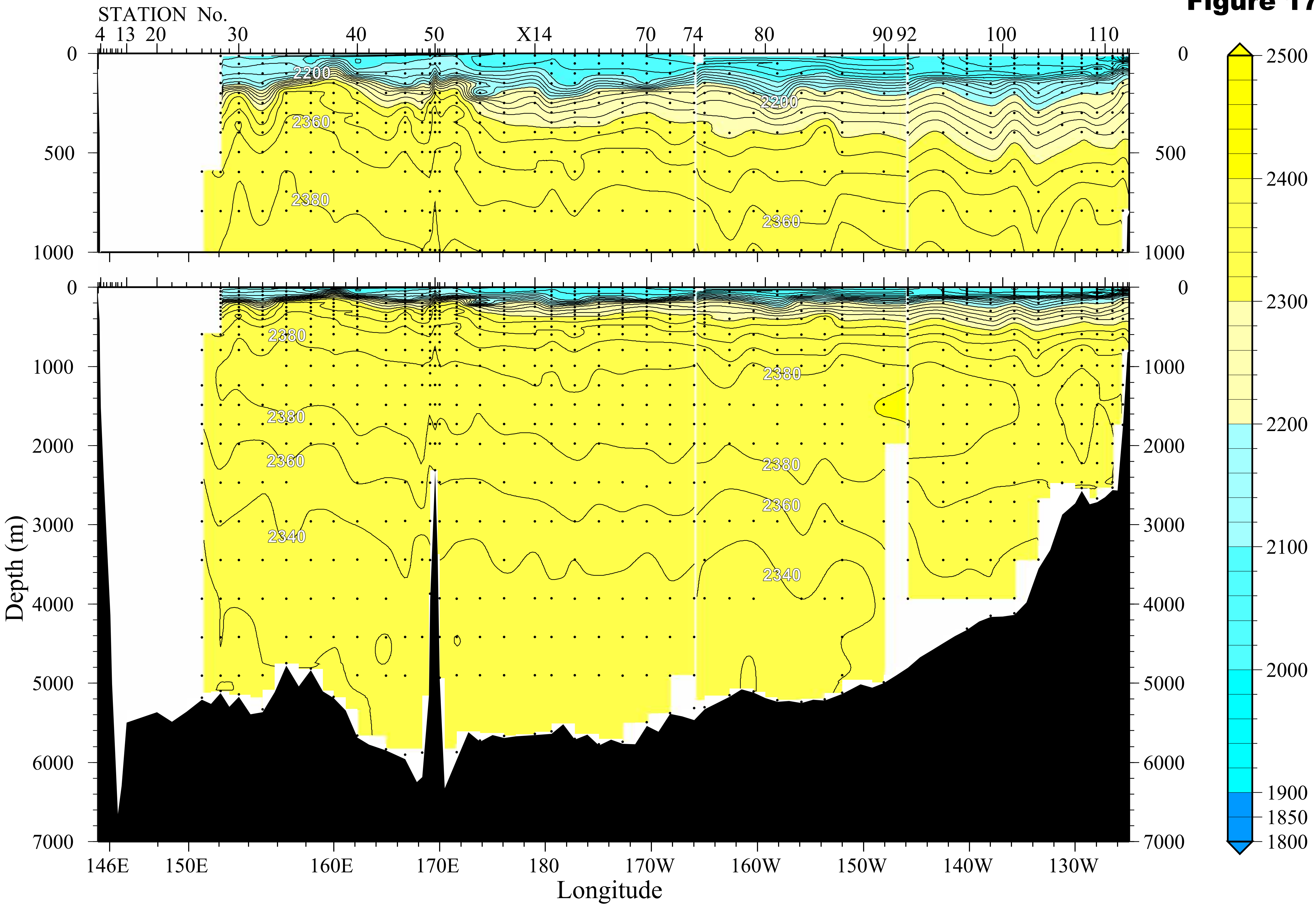

STATION No.
4 13 20 30 40 50 X14 70 74 80 90 92 100 110
0
500
1000
2000
3000
4000
5000
6000
7000
Depth (m)
7.5
7.3
7.35
7.55
7.75
146E 150E 160E 170E 180 170W 160W 150W 140W 130W
Longitude
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00

pH

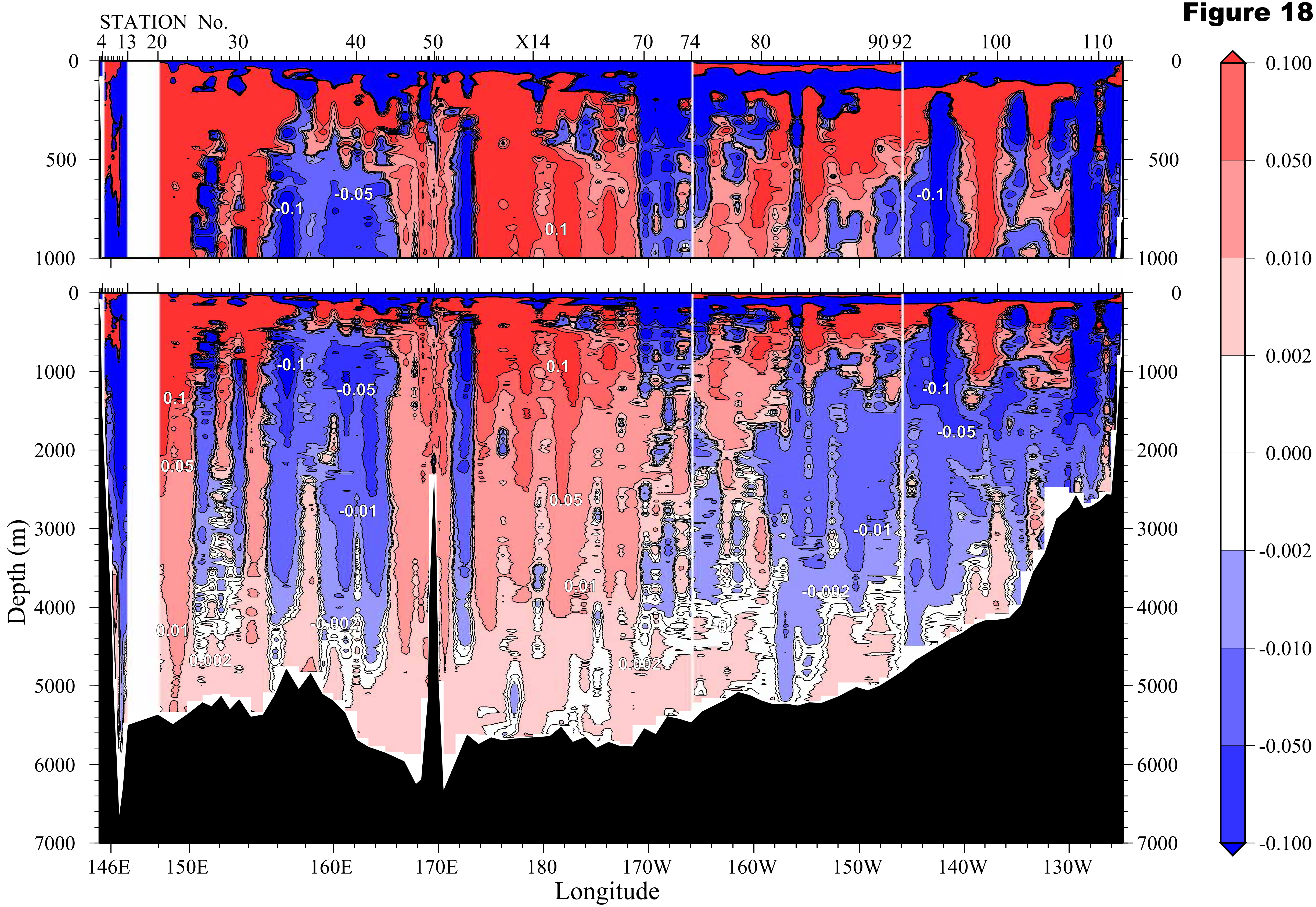


TOTAL ALKALINITY [μmol/kg]

Figure 17

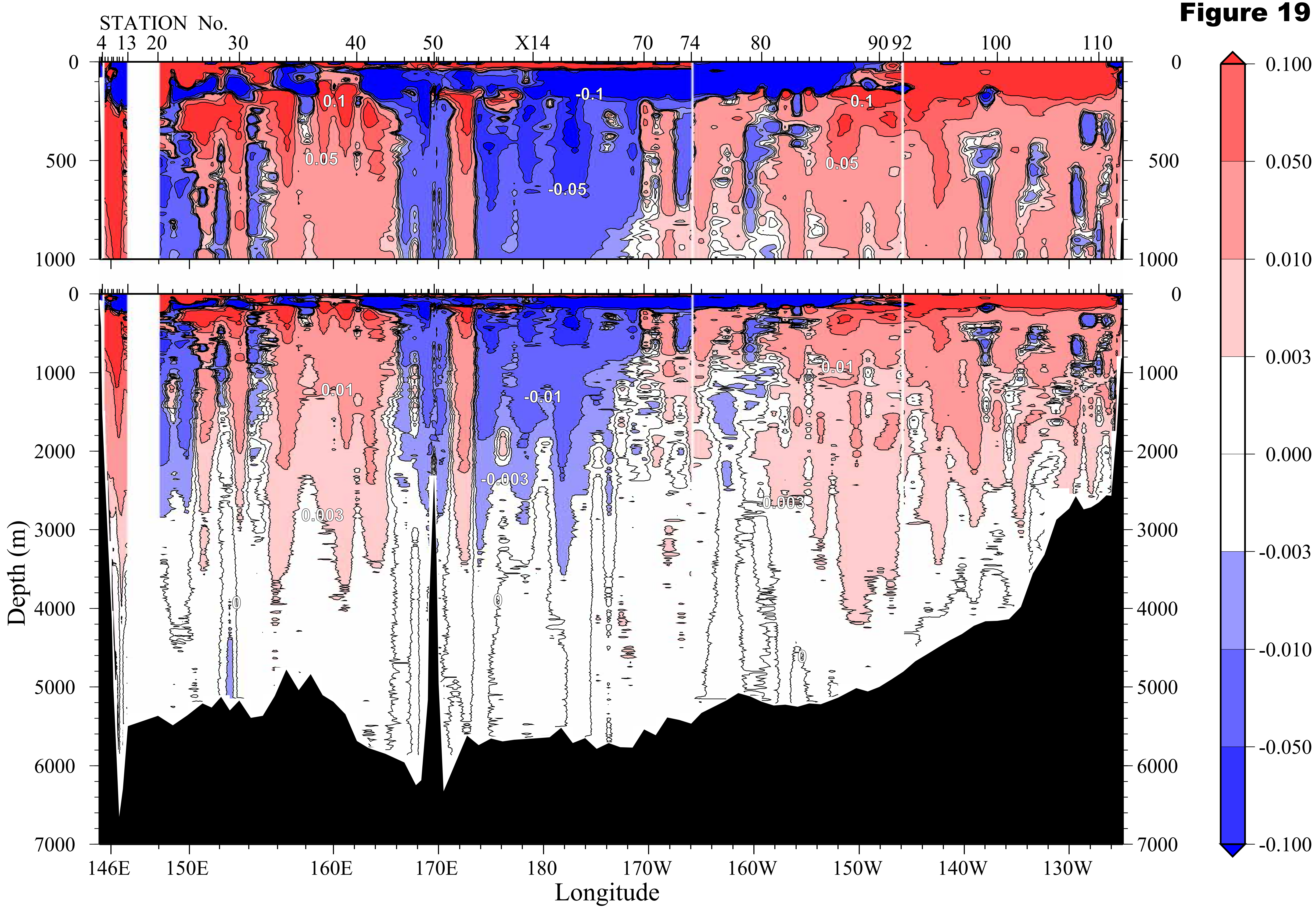


TOTAL CARBON [μmol/kg]



POTENTIAL TEMPERATURE DIFFERENCE BETWEEN 1999 AND 1985 [°C]

Figure 19



SALINITY DIFFERENCE BETWEEN 1999 AND 1985 [PSU]