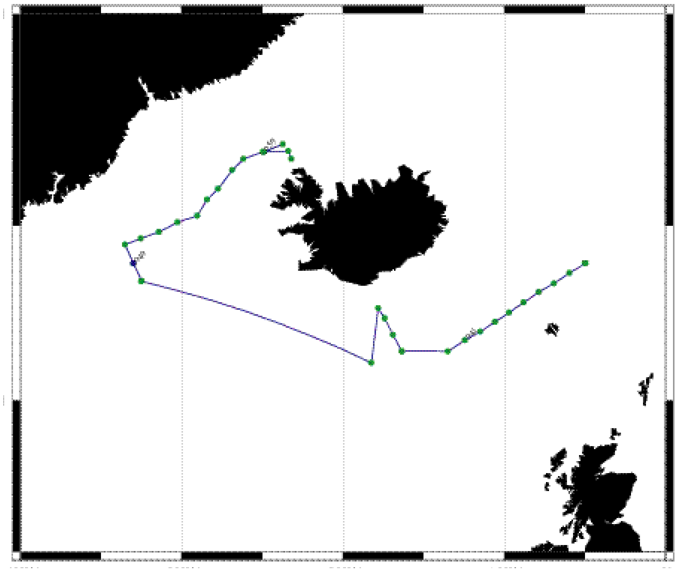

NORDIC WOCE PILOT CRUISE
preliminary data report
may 5, 1995

A. Cruise Narrative

A.1. Highlights

A.1.a WOCE Line **AR18**

A.1.b EXPOCODE **58JH1092_1**

A.1.c Chief Scientists

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A.1.d Ship R/V Johan Hjort

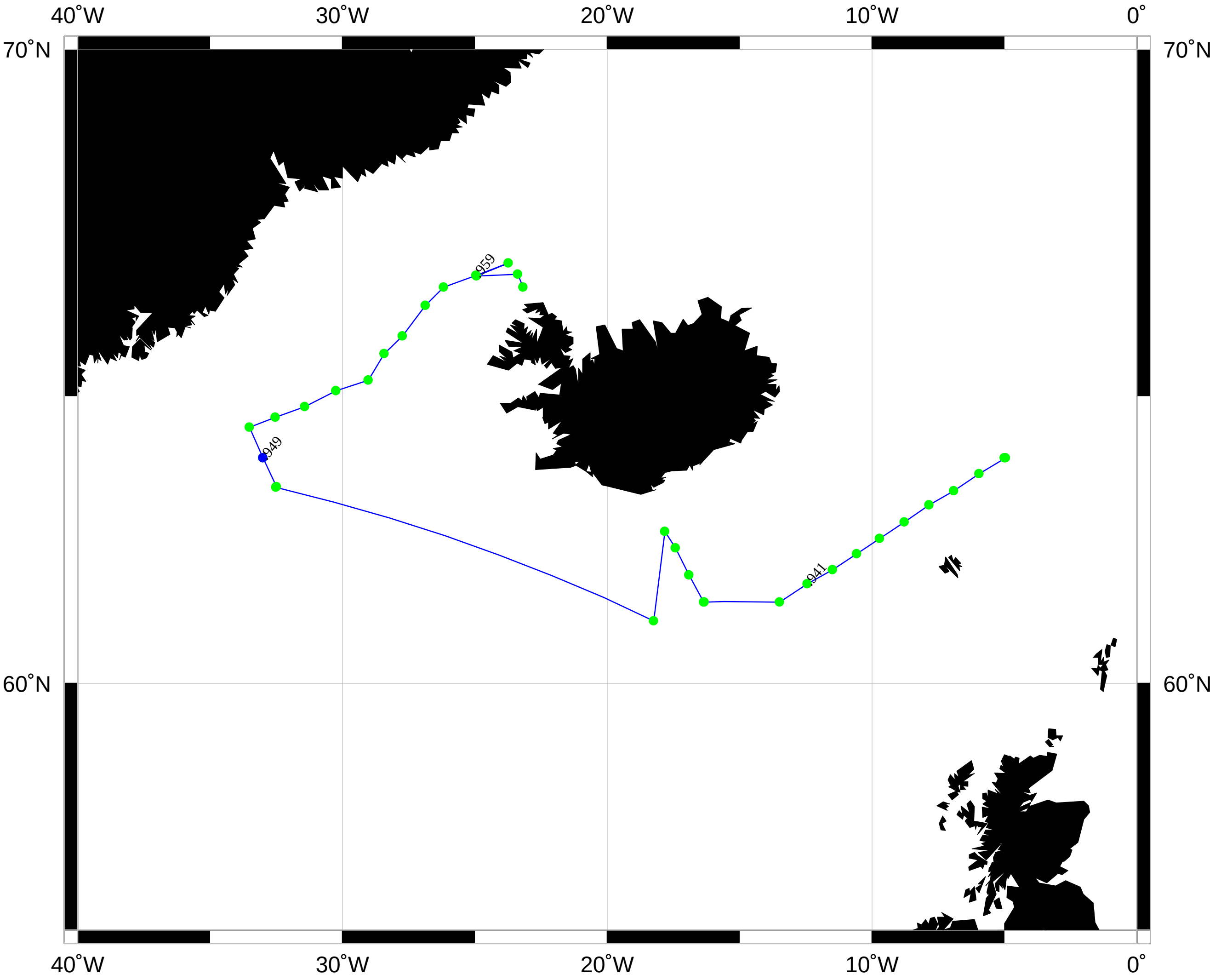
A.1.e Ports of Call Departure from Bergen, Norway, with call in Reykjavik, Iceland, and return to Bergen.

A.1.f Cruise dates 12 - 28 July 1992.

A.2 Cruise summary

A.2.a geographic boundaries

Station locations for AR18 JUL 1992: BLINDHEIM



Produced from .sum file by WHPO-SIO

A.2.b Total number of stations occupied

Sampling Accomplished

In total 32 CTD/rosette stations were occupied using a 12 bottle GO rosette sampler with 10 l Niskin bottles. Samples for determination of oxygen and nutrients (silicate, nitrate, nitrite and phosphate) were drawn from all bottles. Samples for tracer analyses (CFC11, CFC12, CFC113, CCl4, tritium/helium, C14, C13) as well as dissolved inorganic CO_2 and pCO_2 were drawn from selected stations (See AR18.SEA).

A.2.c Total number of stations occcupied

A.2.d Moorings deployed or recovered

A.3 Principal Investigators

Names of principal investigators for all variables measured are given in the following table:

Table 1: List of Principal Investigators

Name	**Responsibility**	**Affiliation***
S. Osterhus	CTD/Rosette/Salinity	GI, Univ. Bergen
F. Rey	Oxygen, nutrients	IMR, Bergen
E. Fogelqvist	CFCs	Univ. Gothenburg
R. Bayer	Helium/tritium	Univ. Heidelberg
J. Olafsson	Carbon dioxide	MRI, Reykjavik
R. Nydal	Carb. isotopes/CO2	Univ. Trondheim
R. Hietala	ADCP	FIMR, Helsinki

* See table 3 for list of institutions

A.4 Scientific Programme and Methods

R/V Johan Hjort departed Bergen July 12, 1992 heading for the northernmost station on section I. At each station a profile with a Neil Brown Mark III CTD was performed, taking water samples using a 12 position GO rosette sampler with 10 l Niskin bottles. Sample analysis included salinity, dissolved oxygen, nitrate, nitrite, phosphate, silicic acid, CFC-tracers, carbon tetracloride, partial pressure of carbon dioxide and dissolved inorganic carbon. Additional samples were drawn and returned to shore laboratories for analysis of tritium, helium, C14 and C13. Along-track measurements of upper layer currents were performed using an Acoustic Doppler Current Profiler.

A.5 Major Problems and Goals not Achieved

The northern part of the Denmark Strait was covered with great amounts of Arctic Ocean drift ice preventing us from reaching the deeper parts just north of the Denmark Strait sill. For this reason no sampling on the deep water masses could be carried out.

Some problems occurred due to unclear distribution of responsibility, misunderstandings among cruise participants belonging to different research groups with little experience from earlier cooperation, and simply, incomplete knowledge of WOCE operational procedures. This resulted in some deficiencies in the data logging. Hense, meter wheel readings were not logged although this variable was routinely used on all stations. Similarly, salinity samples were not drawn from all Niskin bottles.

The echo depth was recorded with the actual sound speed entered in the echo sounder instead of 1500 m. On CTD stations real time print out of sound speed was made every 5 decibar when the CTD was lowered along with sound speed averaged between the sea surface and the current pressure.

A.7 List of Cruise Participants

Table 2: List of Cruise Participants

Participant	Responsibility	Affiliation*
Johan Blindheim	Chief Scientist	IMR, Bergen
Erik Buch	Co-chief scientist	RDANH, Copenhagen
Elisabeth Fogelqvist	CFCs	Univ. Gothenburg
Markus Frank	Helium/Tritium	Univ. Heidelberg
Jorunn Gislefoss	Carbon isotopes, CO_2	Univ. Trondheim
John Goddard	CO_2	LDGO, Palisades
Rachel Goddard	CO_2	LDGO, Palisades
Oystein Godoy	CTD/ADCP	GI, Univ. Bergen
Bogi Hansen	CTD/S	FLF, Torshavn
Stefan Kristmannsson	CTD/S	MRI, Reykjavik
Mikael Krysell	CFCs	Univ. Gothenburg
Reidar Nydal	Carbon isotopes, CO_2	Univ. Trondheim
Jon Olafsson	CO_2	MRI, Reykjavik
Svein Osterhus	CTD, S	GI, Univ. Bergen
Ronald Pedersen	Instrument techn.	IMR, Bergen
Francisco Rey	Nutrients, oxygen	IMR, Bergen
Paul Samuel	Remote sens. gr. truth	NERSC, Bergen
Jane Stromstad	Nutrients, oxygen	IMR, Bergen
Hannu Vouri	ADCP	FIMR, Helsinki

*See Table 3 for list of Institutions

Table 3: List of Institutions

Abbreviation	Institution
MRI	Marine Research Institute
	Reykjavik, Iceland
IMR	Institute of Marine Research
	Bergen, Norway
RLD	Radiological Dating Laboratory
	Trondheim, Norway
FIMR	Finnish Institute of Marine Research
	Helsinki
LDGO(LDEO)	Lamont-Doherty Earth Observatory
	Palisades, New York, U.S.A
NERSC	Nansen Environmental Remote Sensing Center
	Bergen, Norway
FLF	Fisheries laboratory of the Faroes
	Thorshaven, Denmark

Underway Measurements

B.1 Navigation and bathymetry
B.2 Acoustic Doppler Current Profiler (ADCP)
B.3 Thermosalinograph and underway dissolved oxygen, fluorometer, etc
B.4 XBT and XCTD
B.5 Meteorological observations

C. Hydrographic Measurements

C.1 CTD Measurements

(Svein Osterhus)

Calibrations

The CTD measurements were carried out by means of an NBIS Mark III CTD equipped with a General Oceanics Rosette sampler. This was a system which was not upgraded to WOCE standards. Temperature and conductivity were therefore read only to the third decimal place. Calibrations in the laboratory was done in accordance with the calibration instructions given by the manufacturer.

The CTD temparature sensor is manufactured by Rosemount who claim a resolution of 0.0005 degrees C and an accuracy of 0.005 degrees C. Prior to the cruise the CTD was checked at atmospheric pressure in laboratory and the temperature was found to be correct within 0.001 degrees C both at 0 and +15 degrees C. The CTD was not checked in the laboratory just after the cruise because the vessel went directly over to an other project. When the next check in the laboratory was made on 25 September, the CTD temperature was 0.001 degrees C too high at 0 degrees C and 0.004 too high at 15 degrees C. No fast response thermistor was used.

The CTD pressure sensor is manufactured by Paine instruments and according to the supplier it has a resolution of 0.1 dbar and an accuracy of 6 dbar. Prior to the cruise it was found correct within ist resolution at 0 dbar and at 3070 dbar.

The conductivity sensor is manufactured by NBIS who claim a resolution of 0.001 mS and an accuracy of 0.005 mS. Calibrations were made in laboratory prior to the cruise, but unfortunately, the conductivity sensor was broken before it could be checked again after the cruise.

Field calibrations were taken during upcast when Niskin bottles were tripped and temperature, conductivity and pressure were read from the display on the deck unit prior to and after tripping of the bottles.

During the cruise, a malfunctioning occurred on the temperature display on the CTD deck unit which had the effect that the least significant digit was fixed. This was not discovered before toward the end of the cruise. In general this reduced the accuracy of salinity field calibrations to the second decimal place.

CTD Data Collection and Processing.

CTD data aquisition was carried out by means of a HP Vectra PC, 386. All data series were sampled and temporarily stored on hard disk. Post processing was made in accordance with guidelines given SCOR WG 51 (Følling Y. and J. Blindheim, 1991. Post processing of CTD data. Report 4/1991/HSM. Institute of Marine Research, Bergen.) and averages for each decibar were stored. Backup of CTD raw data was transferred to digital casettes.

C.2 Salinity Measurements

Twelve 10 litre Niskin bottles mounted on a General Oceanics Rosette Sampler were used for water sampling. Unfortunately, samples for determination of salinity were not collected from allsampling depths, especially in the beginning of the cruise.

Salinities were analyzed onboard using a Guildline Portasal salinometer which was checked daily against IAPSO standard Sea water , Batch 120. Salinities were read directly from the salinometer to the third decimal place. Salinometer bath temperature was set to 21 degrees C and room temperature was throughout the cruise kept between 19 and 21 degrees C. The salinity was determined at least twice on all samples, and for 65 % of the samples the two readings agreed to the third decimal place in salinity. Less than 1 % had differences larger than 0.001 between the two first readings so that multiple readings were necessary.

Duplicate or triplicate samples were drawn from the same Niskin bottle in 21 cases. Difference between the samples was 0.000 or 0.001 in 19 cases, 0.002 in one case and 0.003 in one case.

C.3 Oxygen measurements

(Francisco Rey)

Oxygen concentration was measured using the Winkler method with visual determination of the titration end-point. Titration was done on whole samples (about 120 ml) using a 20 ml automatic burette (Schotts-Gorens) with a dispensing precision of 0.01 ml. Calibration of the thiosulfate (about 0.04 N) was as a rule done twice a day. The reproducibility of the method estimated as the standard deviation of ten replicates drawn from one 10 l Niskin bottle is 0.015 ml / l at an oxygen concentration of 6 ml / l. Reagents differed from WOCE recommendations as follows: $MnSO_4$ and HCl were used instead of MnCl and H_2SO_4. Otherwise reagents preparation and analyses followed WOCE recommendations as stated in Culberson (1991). Conversion of volumetric to weight concentrations were done as recommended by WOCE using potential temperature.

C.4 Nutrient measurements

(Francisco Rey)

Equipment and Technique

The nutrient analyses were performed by a team from the Institute of Marine Research, Bergen, Norway, using a system built up by the following items: Pump system from ChemLab, England. Reaction units of own fabrication Autosampling , detection and computing units from SANPLUS Segmented Flow Analyzer, Skalar Analytical B.V., The Netherlands.

The methods used were adaptations of standard methods (Strickland and Parsons, 1972) slightly modified to the autoanalyzer system (Føyn et al., 1981). The precision for the different analyses at full scale were less than 0.2% for nitrite, nitrate and silicic acid and less than 2 % for phosphate. The reproducibility were less than 1% for nitrite, nitrate and silicic acid and less than 3% for phosphate.

Sampling procedure

Seawater samples were collected just after the sampling for trace gases and oxygen. After rinsing three times, samples were drawn into 15 ml high-density polyethylene test tubes with pressure caps and kept dark and refrigerated at 4 deg. C without preservative. All samples were analyzed directly in the test tubes within 24 hours after sampling. Tests done for effects of analysis delay showed variations for all nutrients not significantly different to the precision for each analysis.

C.5 Measurements of Dissolved Carbon Dioxide and Carbon Isotopes

(Reidar Nydal and Jorunn S. Gislefoss)

Sampling strategy and procedure

The main goal for the cruise was to get some basic carbon profiles north and south of the Greenland-Scotland Ridge, as a contribution to the study of water overflow. It was especially important to repeat three GEOSECS profiles from 1972. Fairly complete carbon profiles were performed at 8 stations (933, 934, 937, 942, 943, 948, 955 and 961) Stations 933, 948 and 955 coinside with earlier GEOSECS stations (sta. 19,11 and 14). The changes in profiles during a period of 20 years could give valuable information about water exchange with depth.

The samples were collected in 500 ml glass bottles, which first were rinsed with some of the sampling water, and then filled up. The samples were stored in a refrigerator and analysed within a few days.

Equipment and technique

The extraction of total dissolved carbon dioxide from 500 ml seawater was carried out onboard shortly after collection. A bubbling procedure with nitrogen (99.99%) as a carrier gas, in a closed cycle, was applied for this purpose. The sample was acidified in advance with phosphoric acid to a pH value of 1.5. The bubbling lasted for 15 minutes. The water was removed from the carbon dioxide gas using vapor traps (-80 degrees C) and a drying agent. Carbon dioxide was continuously trapped with liquid nitrogen (-196 degrees C) during the cycle. After the flushing was finished nitrogen was removed and the CO_2-gas was trapped in 25 ml glas ampulles for later measurements in the laboratory after return.

The quantitative measurements of the CO_2-gas are performed with an oil manometer. The obtained precision (standard error) in a single measurement, derived from several measurements on identical samples, has been found to be less than 3 permill. The present procedure for CO_2 extraction is developed at the Radiological Dating Laboratory.

The obtained CO_2-gas (ca 25 ml) is applied for both C14/C12 and C13/C12 Accelerator Mass Spectrometry (AMS) measurements (ca 2 ml).

DELC13

The DELC13 is the relative difference in permill between the C13/C12 ratio in the sample and the international Belemnite standard (PDB):

$$\mathrm{DEL13C} = 1000\ (\mathrm{RSA}-\mathrm{RST})/\mathrm{RST}$$

where RSA = C13/C12 for sample and RST = C13/C12 for standard.

The DELC13 measurements are performed at the Dating Laboratory at the University of Helsinki, using a Finnigan MAT Delta E mass spectrometer. Approximately 5 ml CO_2 gass (from the DIC) was used for the analysis. The instrument usually gives a precision of 0.02 permill, but the total precision for a single measurement is certainly larger (about 0.1

permill). This stable isotope is also important as a tracer in study of carbon exchange, as we here obtain the true C13/C12 ratio of the DIC fraction in the samples.

DELC14 (corrected)

The DELC14corr. is expressed with the equation

$$\text{DELC14corr} = \text{DEL14C} - 2\,(\text{DEL13C} + 25)\,(1 + \text{DELC14}/1000)$$

Profiles of DEL14Ccorr. were obtained in 1972 in the GEOSECS expedition . It is therefore important to obtain profiles to day, to compare the differences that has occurred during these 20 years. These differences can give important information about the ocean circulation. AMS on 5 ml of the CO_2 gas (from DIC), were performed at the University of Arizona (Slota et al., 1987).

Slota, P.J., A.Jt. Jull, T.W. Linick and L.J. Toolin. 1987.
Preparation of small samples for C14 accelerator targets by
catalytic reduction of CO. Radiocarbon, 29 (2): 303 - 306.

C.6 Total dissolved Inorganic Carbon , Partial pressure of Carbon dioxide in Seawater.

(Jon Olafsson and John Goddard)

Total Dissolved Inorganic Carbon

Total CO_2 measurements are made on descrete seawater samples collected at various depths. An approximately 20 ml subsample is injected by positive displacement syringe into a stripping column. Acidification converts all inorganic carbonate species in the sample into a CO_2 gas which is then swept into an electrochemical titration cell. The titration results are measured using a Utopia Instruments Corp. (UIC) model 5011 Coulometer. The performance of the instrument is monitored several times daily using a gas loop calibration system. Overall analytical quality control is evaluated daily with reference material for oceanic CO_2 measurements. This reference material was kindly supplied by Dr. A. Dickson of Scripps Institution of Oceanography, USA. After final processing, results are reported as TCO_2 UMOL/KG.

Partial Pressure of Carbon Dioxide in Seawater (pCO_2).

The pCO_2 analysis system uses a closed system seawater equilibrator to bring the partial pressure of CO_2 of discrete seawater samples into equilibrium with a small quantity of air, and a gas chromatograph to analyze the concentration of CO_2 in the equilibrated air. The gas chromatograph uses a flame ionization detector (FID), which is insensitive to CO_2, but which has a highly linear response to hydrocarbons. Using hydrogen as a carrier gas and a ruthenium catalyst, the CO_2 is converted completely to methane prior to reaching the FID. The highly sensitive and linear FID is thus used to quantify the CO_2 content of the equilibrated air. The discrete seawater samples are collected in 500 ml flasks and are equilibrated at a constant temperature bath at 20 degrees C. After corrections and final processing, results are reported as pCO_2 UATM at 20 degrees C.

C.7 Halocarbon Tracer Measurements

(Elisabeth Fogelqvist)

Certain man-made and some naturally produced low molecular weight halogenated hydrocarbons (halocarbons) have been determined in both water and air samples during the cruise. Four man-made tracer compounds (trancient tracers), namely clorofluorocarbons 11, 12 and 113 and carbon tetracloride, provide a most powerful tool for studying timescales and magnitudes of large-scale oceanic subsurface mixing and deep water renewal processes.

Water samples, drawn directly from the Niskin sampling bottles using 100 ml ground glass syringes, were analysed using a purge-and-trap sample work-up technique followed by gas chromatographic separation and detection. The separation of these, and 10 other identified halocarbons, was carried out in a 75 metres long megabore open tubular column. Detection of the compounds was performed using the selective and very sensitive electron capture detector, giving detection limits of the order of 0.01 pmol/kg for CFCs 11 and 12; somewhat higher for CFC 113 and carbon tetrachloride.

C.8 Helium/Tritium Sampling

(Markus Frank)

Tritium is the radioactive isotope of hydrogen. It decays with a halflife of 12.43 years to the helium isotope He-3. The major source of tritium was the nuclear weapon testing in the atmosphere mainly in the 1960s.

At the seasurface He-3 concentrations usually are close to solubility equilibrium with the atmosphere. Water isolated from the surface due to convection will be enriched in tritiogenic He-3 while spreading along the isopycnals. The tritiogenic He-3 is detectable as a deviation of the He-3/He-4 ratio of the water sample from that of an air standard. Measurements of both He-3 excess and tritium concentration allow calculation of formal tritium/he-3 age, whioch is a tool for estimation of mean transfer times, current speeds and renewal times.

During the cruise 122 samples for measurement of both helium and tritium were taken. The helium samples (volume about 40cc) were stored in copper tubes closed tightly at both ends by means of special stainless steel pinch-off clamps.

For tritium analysis one liter of water was stored in a glass bottle sealed by a polyethylene cap.

The analyses will be performed at Univ. of Heidelberg. For measurements of He-3/He-4 ratio a special helium isotope mass spectrometer with an accuracy of about 0.2 % is used.Tritium measurements in Heidelberg are either done by low level counting (with an accuracy of 5%) or by mass spectrometry (He-3 ingrowth method with an accuracy of about 2 % and a detection limit of 0,05 TU).

D. Acknowledgments

E. References

References

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Foyn, L., M. Magnussen and K. Seglem, 1981. Automatic analysis of nutrients with an on-line dataprocessing. A presentation of the building and functioning of the system used at the Institute of Marine Research. Fisken Hav.,Serie B, 1981 (4) : 1-39.(In Norwegian).

Strickland, J.D.H. and T.R. Parsons, 1972. A practical handbook of seawater analysys. Bull. Fish. Res. Bd. Canada. 167: 1-311.

Unesco, 1983. International Oceanographic tables. Unesco Technical Papers in Marine Science, No. 44.

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F. WHPO Summary

Several data files are associated with this report. They are the ar18.sum, jh1092.hyd, jh1092.csl and *.wct files. The jh1092.sum file contains a summary of the location, time, type of parameters sampled, and other pertinent information regarding each hydrographic station. The ar18.hyd file contains the bottle data. The *.wct files are the ctd data for each station. The *.wct files are zipped into one file called jh1092wc.zip. The jh1092.csl file is a listing of ctd and calculated values at standard levels.

The preliminary *.csl files are not availiable at this time due to the ctd data being given in non-uniform levels.