

Preliminary report
may 15, 1995
A. Cruise Narrative
A.1 Highlights

A.1.a WOCE Designation Leg1=PR20/Leg2=PR21
A.1.b EXPOCODE designation Leg1=21OR287/1, Leg2=21OR287/2
A.1.c Chief Scientist Cho-Teng Liu
Institute of Oceanography
National Taiwan University
Taipei POB 23-13, Taiwan, ROC 10764

A.1.d Ship R/V Ocean Researcher I

A.1.e Ports of Call Leg 1: Kaohsiung to San Fernando
Leg 2: San Fernando to Kaohsiung

A.1.f Cruise Dates Leg 1: June 26-July 4, 1991, southbound
Leg 2: July 8-July 12, 1991, northbound

A.2 Cruise Summary

A.2.a Geographic boundaries
A.2.b Total number of stations Occupied

PR20: 29 CTD stations, including 21 water sample stations
PR21: 13 CTD stations, including 12 water sample stations

A.2.c Floats and drifters deployed
A.2.d Moorings deployed or recovered

A.3 List of Principal Investigators

Table 1: List of Principal Investigators

Name	Responsibility	Institution*
LIU, Cho-Teng	calibration, processing and interpretation of CTD data	NTU
PAI, Su-Cheng	collection, analysis and interpretation of water sample data	NTU
Israel Bentillo	interpretation of CTD data along with C-T Liu	UP
CHEN, Cheng-Tung	Arthur developing method for collecting C-14 samples	NSYSU

*See Table 2 for list of Institution

Table 2: List of Institutions

Abbreviation	Institution
NTU	National Taiwan University Taipei, Taiwan, ROC 10764
UP	University of the Philippines Quezon City, RP

A.4. Scientific Programme and Methods

This cruise was carried out jointly by oceanographers from the Republic of China in Taiwan and from the Republic of the Philippines. R/V Ocean Researcher 1 left Kaohsiung Harbor at 12:00 of June 23, 1991. Because of the severe swell produced by approaching gale system, the ship was not able to reach the first CTD station near the southern tip of Taiwan, and she had to return Kaohsiung harbor and departed again on June 26.

A.5. Major Problems

Because the CTD cable has a bend at about 2100 m, many of the casts was not able to reach 2000 m depth as planned.

A.6 Other incidents of note

None

A.7 List of Cruise Participants

Table 3: List of Cruise Participants

Name	Responsibility	Institution*
LIU, Cho-Teng	chief scientist	NTU
PAI, Su-Cheng	chief chemist	NTU
CHIU, Tai-Sheng	chief zoologist	NTU
CHENG, Shih-Pei	CTD data processing	NTU
YANG, Chung-Cheng	nitrate analysis	NTU
JENG, Kwung-Lung	phosphate, silicate and nitrite analysis, & chemical hydrography data	NTU
KUO, Ting-Yu	salinity and dissolved oxygen analysis	NTU
CHEN, Hung-Yu	heavy metal analysis processing	NTU
BENTILLO, Israel G.	physical oceanographer	UP
WANG, Shu-lun	pH analysis	NSYSU
HUANG, Ming-Shung	Alkalinity	NSYSU
WANG, Chi-Hua	pH analysis	NSYSU

*See Table 2 for list of Institutions

B. Underway Measurements

- B.1 Navigation and bathymetry
- B.2 Acoustic Doppler Current Profiler (ADCP)
- B.3 Thermosalinograph and underway dissolved oxygen, fluorometer
- B.4 XBT and XCTD
- B.5 Meteorological observations
- B.6 Atmospheric chemistry

C. Hydrographic Measurements

The pressure, temperature (T) and salinity (S) were derived from the CTD data according to the methods described in the SBE-9 CTD manual. The CTD Digiquartz pressure transducer was calibrated in 1987. The CTD temperature sensor was calibrated on 1990/12/05 and 1991/06/14 through Sea Bird Electronics Inc.. Assuming that the rate of drift of

temperature sensor is constant in time (0.002 C in 6 months), then the bias of temperature data was about 0.0002 C, which is within the requirement for WOCE hydrography. So, no correction is applied on the temperature data. The CTD conductivity sensor were calibrated on 23 Feb 1990 and 14 June 1991. The conductivity and salinity data were correctly by the following procedure:

- 1) Use the Guildline Salinometer to measure the salinity of collected water samples.
- 2) Use the CTD temperature data (IPTS68) and the measured salinity from step (1) to derive the in situ conductivity of each sample.
- 3) Use polynomial fit to derive the bias of CTD's conductivity; the bias was found to be negligible.
- 4) No correction is applied on either CTD conductivity or salinity data.

Comparing the T-S data of St 112 (20 04 N, 120 42.9 E) along WHP PR21 to those of St. 36 (19 59.7 N, 123 13.2 E) and St. 37 (22 22.0 N, 121 36.9 E) of INDOPAC Expedition, we found that the T-S curve of St. 112 is smoother than those of St. 36 and 37 of INDOPAC Expedition. This observation agrees with the general case that both the salinity maximum of NPTW (North Pacific Tropical Water) and the salinity minimum of NPIW (North Pacific Intermediate Water) are less apparent for water on the shelf side of Kuroshio (e.g. at St. 112) than on the deep Ocean side (e.g. at St. 36 and 37).

The raw CTD data still need further corrections by running parallel determination of salinity using an inductive bench-type salinometer (e.g. AUTOSAL). The accuracy of the AUTOSAL was maintained by bathc-wise calibration using a certified I.A.P.S.O. standard seawater. With careful storage of the samples and with extreme precaution in the salinity determination, an accuracy of better than 0.001 psu has been achieved (Fang et al., 1990; Pai et al., 1990).

Dissolved oxygen was determined on board the research vessel using a modified Winkler titration method (Strickland and Parsons, 1972). An ABU80 autotitrator was used to deliver the titrant which provided a resolution of 0.001 ml and a precision of better than 0.5% for samples containing 4 ml/l oxygen. The oxygen sensor installed on the CTD unit also provided real-time oxygen profiles, but its reliability does not justify reporting it.

Nitrite was determined manually on-board the ship within 3 hours after collection of the water samples. A modified pink azo dye method (Pai et al., 1990) was used where in 40-ml aliquot of the sample was treated with 1 ml of 2% s/v sulphanilamide prepared in 15% HCL, followed by 1 ml of 0.3% w/v of N-1- naphthylenediamine solution. The solution was then measured at 543 nm using 5 cm long cuvettes. The accuracy was monitored by running known reference standards to obtain a molar extinction coefficient of 52000 +/- 500/cm/M. A precision of ca. 2% was obtained for samples containing 1 uM nitrite.

Reactive phosphate was also determined immediately after sample collection as significant variations of the concentrations could otherwise occur (Reily, 1975). The reagents for phosphate were prepared according to the method suggested by Murphy and Riley (1962). The molar extinction coefficient for the phospho-antimonyl-molybdenum blue complex formed was found to be 22400 +/- 200/cm/M (Pai et al., 1990) and running standards with each batch of samples analyzed ensured that both the accuracy and precision of the determination were

maintained at ca. 1%.

Nitrate was determined on-board with a home-made flow injection analyzer. The system consisted of a reduction coil threaded with a 1-m long copper-coated cadmium wire. The sample was loaded through a six-way injection valve, and nitrate in the sample was reduced on-line to nitrite. The appropriate reagents were then added and the resulting colored solution measured with a spectrophotometer. Details of the automated system has been presented elsewhere (Pai et al., 1990). A precision of ca. 1% was achieved for samples containing 10 uM nitrate. Calibration curves were constructed by spiking known amounts of the certified Merck standard to a freshly filtered surface seawater.

The determination of silicate was carried out within several hours of sample collection using a home-made flow injection analyzer. The reagents used were similar to that suggested by Strickland and Parsons (1972) except for ascorbic acid which was used as a reductant to replace the metol-sulphite solution. The determination was carried manually and calibration curves were constructed by using appropriate concentrations of Si standard (Titrosol, Merck).

D. Acknowledgments

E. References

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

Unesco, 1991. Processing of Oceanographic Station Data, 1991. By JPOTS editorial panel.

F. WHPO Summary

Several data files are associated with this report. They are the OR28711.sum, OR28711.hyd, OR28711.csl and *.wct files. The OR28711.sum file contains a summary of the location, time, type of parameters sampled, and other pertinent information regarding each hydrographic station. The OR28711.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 OR28711.wct.zip. The OR28711.csl file is a listing of ctd and calculated values at standard levels.

The following is a description of how the standard levels and calculated values were derived for the OR28711.csl file:

Salinity, Temperature and Pressure: These three values were smoothed from the individual CTD files over the N uniformly increasing pressure levels using the following binomial filter-

$$t(j) = 0.25t_i(j-1) + 0.5t_i(j) + 0.25t_i(j+1) \quad j=2 \dots N-1$$

When a pressure level is represented in the *.csl file that is not contained within the ctd values, the value was linearly interpolated to the desired level after applying the binomial filtering.

Sigma-theta(SIG-TH:KG/M3), Sigma-2 (SIG-2: KG/M3), and Sigma-4(SIG-4: KG/M3): These values are calculated using the practical salinity scale (PSS-78) and the international equation of state for seawater (EOS-80) as described in the Unesco publication 44 at reference pressures of the surface for SIG-TH; 2000 dbars for Sigma-2; and 4000 dbars for Sigma-4.

Gradient Potential Temperature (GRD-PT: C/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the interval. The interval being the smallest of the two

differences between the standard level and the two closest values. The slope is first determined using CTD temperature and then the adiabatic lapse rate is subtracted to obtain the gradient potential temperature. Equations and Fortran routines are described in Unesco publication 44.

Gradient Salinity (GRD-S: 1/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the standard level and the two closes values. Equations and Fortran routines are described in Unesco publication 44.

Potential Vorticity (POT-V: 1/ms 10-11) is calculated as the vertical component ignoring contributions due to relative vorticity, i.e. $pv=fN^2/g$, where f is the coriolius parameter, N is the bouyancy frequency (data expressed as radius/sec), and g is the local acceleration of gravity.

Bouyancy Frequency (B-V: cph) is calculated using the adiabatic leveling method, Fofonoff (1985) and Millard, Owens and Fofonoff (1990). Equations and Fortran routines are described in Unesco publication 44.

Potential Energy (PE: J/M2: 10-5) and Dynamic Height (DYN-HT: M) are calculated by integrating from 0 to the level of interest. Equations and Fortran routines are described in Unesco publication, Processing of Oceanographic station data.

Neutral Density (GAMMA-N: KG/M3) is calculated with the program GAMMA-N (Jackett and McDougall) version 1.3 Nov. 94.

G. Data Quality Evaulation