R.S.V. AURORA AUSTRALIS CRUISE AU9705 (Voyage 5, Jan.-Mar. 1997) - CTD DATA PROCESSING NOTES

Mark Rosenberg, Antarctic CRC, July 1997.

Data collection, calibration and processing methods

CTD 1103 (unit no. 7) used for the entire cruise
CTD parameters processed - pressure, temperature, salinity
bottle samples processed - salinity only

CTD laboratory calibrations - the pre cruise pressure, platinum temperature and pressure temperature calibrations for CTD 1103 performed at CSIRO in June-July 1996 were applied to the cruise data set.

Salinity bottle samples - analysed by Neale Johnston in April 1997 on a Guildline Autosal (serial 62549), and using International Seawater Standard batch number P130. The salinometer temperature bath setting was set to 21^{o}C. No significant salinometer drift was observed throughout the analyses (i.e. the salinometer performed well).

This report outlines details relevant to the calibration of cruise au9705. For a complete description of data calibration and processing methodology, see Appendix 2 in Rosenberg et al. (1995).

Results

CTD station positions are shown in Figure 1. The final calibration results for conductivity/salinity, along with the performance check for temperature, are shown in Figures 2 to 4. Note that in Figure 2, Temp(DSRT) is the reversing thermometer temperature. Table 1 lists important data quality information relevant to the CTD 2dbar averaged data. Vertical profile plots are also provided.

Temperature

The comparison of CTD temperature to reversing thermometer measurements is poor (Figure 2) (an offset of 0 and a standard deviation <0.02 are usually hoped for). The problem is most likely due to reversing thermometer measurements - they display large scatter, and should not be trusted. Thus no reliable performance check of the CTD temperature is available.

Conductivity/salinity

The conductivity calibration for CTD 1103 was of good quality (Figures 3 and 4), with salinity accurate to well within the WOCE specification of 0.002 (PSS78) for the bottle samples available. Obviously more bottle samples would have increased the reliability of the calibration, particularly for stations 1 and 2. However given the limited time and resources available for CTD data collection, salinity bottle sampling was adequate, and sample depths were chosen well.

The following salinity bottles were manually flagged out for conductivity calibration:

stn 1, rosette position 11
stn 5, rosette position 12

On Aurora Australis cruise au9601 along the SR3 transect (August to September 1996), a discrepancy was found between International Seawater Standard (ISS) batch numbers P128 and P130. The standards were compared by standardising a Guildline Autosal with one standard, measuring the other standard, and comparing the measurement with the second standard's nominal value. It was found that P128 read 0.0018 ± 0.0003 (PSS78) higher than P130. As a result, salinity samples standardised against P128 were lower by 0.0018 (PSS78) than samples standardised against P130. At the time of writing, it is not known which ISS batch is at fault (the supplier Ocean Scientific have been alerted to the problem). For cruise au9705, ISS batch P130 was used for the entire cruise. If it turns out that P130 is a faulty batch, then all salinities for this cruise will need to be corrected by -0.0018 (PSS78).

Pressure

Pressure signal noise was minimal.

For stations 1, 3 and 10, logging of CTD data appears to have commenced when the CTD was already in the water. Thus some surface data is missing for these stations, and surface pressure offsets were chosen manually, taking into account values from surrounding stations. Any resulting additional error in pressure for these stations is small (<0.5 dbar).

Several bottle firing depths as recorded on the CTD sheets were found to be incorrect (or were not recorded). This applies to the following bottles:

station	rosette position
1	2
2	1, 2
5	11

Note that calibrated CTD upcast burst data at the time of bottle firings (i.e. pressure, temperature and salinity) are available in the bottle data file (a9705.bot). These values, not values from the CTD sheets, should be used when supplying data for other samples drawn (helium).

<u>Table 1:</u> Data quality information relevant to CTD 2dbar averaged files.

suspect 2dbar bins (refers to all parameters except pressure):

station	pressure (dbar)	flag	comment
6	2	suspect	transient error when entering water
9	2	suspect	transient error when entering water

missing 2 dbar bins:

station	pressure (dbar)
1	2, 4, 86
3	2 - 10
10	2 - 58

raw CTD data points deleted

station	point number range
1	1, 681
1	9050, 9055
3	1, 4
10	1, 5

Table 2: **Altimeter elevations above the ocean bed at the bottom of each CTD cast.**

station	elevation above bottom (m)	station	elevation above bottom (m)
1	-	6	-
2	15	7	-
3	-	8	10.0
4	10.5	9	18.0
5	13	10	-

Density inversions

Numerous small vertical density inversions appear throughout the CTD data. These typically occur in regions of high local vertical gradients where mixing is occuring, and are assumed to be real. Note in particular station 1, near the bottom of the cast, where larger density inversions occur - bottle data is unavailable for confirmation (see profile plot), however there is no indication of CTD sensor problems, so the data are real. For this particular example however, salinity spiking may be exaggerated due to sensor mismatch in the extremely high vertical gradients.

Station data

All station positions and sounder depths are as recorded on the CTD sheets. Start and end times of CTD casts are recorded automatically by the CTD logging PC. Altimeter elevations at the bottom of CTD casts are listed in Table 2.

4. Data formats

2 dbar averaged CTD data file

The final format in which CTD data is distributed is as 2 dbar averaged data, contained in column formatted ascii files, named a9705ixxx.all (Table 3), for i=CTD unit number, and xxx=station number. Averaging bins are centered on even pressure values, starting at 2 dbar. A 15 line header is followed by the data, as follows:

column	parameter
1	pressure (dbar)
2	temperature (^{o}C) (ITS-90)
3	salinity (PSS78)
4	σ_T = density-1000 (kg.m^{-3})
5	specific volume anomaly x 10^8(m^3.kg^{-1})
6	geopotential anomaly (J.kg^{-1})
7	dissolved oxygen (μmol.l^{-1}) (blank for this cruise)
8	number of data points used in the 2 dbar averaging bin
9	standard deviation of temperature values in the 2 dbar bin
10	standard deviation of conductivity values in the 2 dbar bin

All files start at the 2 dbar pressure level, incrementing by 2 dbar for each new data line. Missing data are filled by blank characters (this most often applies to dissolved oxygen data).

Table 3: **Example 2 dbar averaged CTD data file (*.all file).**

SHIP : R.V. Aurora Australis
STATION NUMBER : 4
DATE : 02-JAN-1994 (DAY NUMBER 2)
START TIME : 1020 UTC = Z
BOTTOM TIME : 1100 UTC = Z
FINISH TIME : 1222 UTC = Z
CRUISE : Au94/07
START POSITION : 44:07.03S 146:13.35E
BOTTOM POSITION : 44:07.14S 146:13.71E
FINISH POSITION : 44:06.61S 146:13.95E
MAXIMUM PRESSURE: 1038 DECIBARS
BOTTOM DEPTH : 1015 METRES

PRESS	TEMP	SAL	SIGMA-T	S.V.A.	G.A.	D.O.			
	(T-90)								
2.0	11.899	34.773	26.432	158.69	0.032		30	0.001	0.007
4.0	11.899	34.778	26.436	158.41	0.063		30	0.001	0.001
6.0	11.903	34.779	26.436	158.46	0.095		45	0.001	0.002
8.0	11.903	34.778	26.435	158.55	0.127		41	0.000	0.000
10.0	11.903	34.778	26.435	158.60	0.159		32	0.001	0.001
12.0	11.904	34.778	26.435	158.66	0.190		32	0.001	0.001
14.0	11.905	34.778	26.435	158.72	0.222		40	0.000	0.000
16.0	11.907	34.779	26.435	158.76	0.254		34	0.002	0.002
18.0	11.908	34.780	26.435	158.77	0.286		25	0.002	0.002

Bottle data file

The bottle data file, named a9705.bot, is a column formatted ascii files containing the hydrology data, together with CTD upcast burst data (Table 4). The columns contain the following values:

column	parameter
1	station number
2	CTD pressure (dbar)
3	CTD temperature (^{o}C) (ITS-90)
4	reversing thermometer temperature (^{o}C)
5	CTD conductivity (mS.cm^{-1})
6	CTD salinity (PSS78)
7	bottle salinity (PSS78)
8	ortho phosphate concentration (μmol.l^{-1}) (no data for this cruise)
9	nitrate + nitrite concentration (μmol.l^{-1}) (no data for this cruise)
10	reactive silicate concentration (μmol.l^{-1}) (no data for this cruise)
11	bottle dissolved oxygen concentration (μmol.l^{-1}) (no data for this cruise)
12	bottle quality flag (-1=rejected, 0=suspect, 1=good)
13	niskin bottle number

Missing data values are filled by a decimal point (surrounded by blank characters). Parameters 2,3,5 and 6 are mean values from the upcast CTD burst data at the time of bottle firing, where each burst contains the data 10 sec previous to the time of bottle firing. Parameters 7 to 11 are laboratory values for the hydrology analyses. Parameter 12, the bottle quality flag, is relevant to the calibration of CTD salinities - bottles flagged 1 and 0 are used for calibration, while those flagged -1 are rejected. Parameter 13, the niskin bottle number, is a unique identifier for each bottle. Note that the Niskin bottle numbers were not recorded on the CTD sheets, so I have arbitrarily equated Niskin bottle number with rosette position (not a good practice).

Table 4: Example hydrology data file (*.bot file).

2	148.516	11.904	.	40.025	35.052	35.067	.	.	.	.	-1	4
2	200.278	11.085	.	39.174	34.963	34.965	.	.	.	.	-1	3
2	247.807	10.678	10.691	38.758	34.914	34.914	.	.	.	.	0	2
2	289.188	9.625	.	37.640	34.769	34.794	.	.	.	.	-1	1
3	8.609	15.984	.	44.199	35.274	35.275	.	.	.	.	1	16
3	21.504	15.975	.	44.198	35.276	35.275	.	.	.	.	1	15
3	48.210	15.935	.	44.171	35.277	35.276	.	.	.	.	1	14

Station information file

The station information file, named a9705.sta (Table 5), contains position, time, bottom depth and maximum pressure of cast for CTD stations. The CTD instrument number is specified in the file header. Position and time (UTC) are specified at the start and end of the cast, while the bottom depth is for the start of the cast. Positions at the bottom of each cast are unavailable (obtain underway logging data for this information). Note that small inconsistencies may exist between bottom depth and maximum pressure, due to drift of the vessel between the start and bottom of the cast.

Table 5: Example CTD station information file (*.sta file).

RSV Aurora Australis   Cruise : Au93/09   CTD station list   (CTD unit 4)

stat	start				bottom	max P	bottom			end		
no.	time	date	latitude	longitude	depth(m)	(dbar)	time	latitude	longitude	time	latitude	longitude
1	2032	11-MAR-93	44:06.73S	146:14.35E	1000	956	2118	44:06.37S	146:14.35E	2154	44:06.19S	146:14.60E
2	0027	12-MAR-93	44:00.06S	146:18.61E	300	289	0042	44:00.03S	146:18.77E	0115	43:59.97S	146:18.64E
3	0513	12-MAR-93	44:07.51S	146:14.89E	1100	1115	0549	44:07.48S	146:15.06E	0632	44:07.39S	146:15.23E

Matlab files

The CTD and bottle files are available in matlab format, as follows:

(i) a9705.mat This file contains the CTD 2 dbar averaged data from the *.all files, along with header information. Matrix column numbers correspond to CTD station number. All blanks are filled by NaN. Matrices are as follows:

ctd_press = ctd pressure
ctd_temp = ctd temperature
ctd_sal = ctd salinity
ctd_sigma_t = σ_T
ctd_sva = specific volume anomaly

ctd_ga = geopotential anomaly
ctd_npts = no. of data points used in the 2 dbar averaging bin

botd = bottom depth (i.e. ocean depth)
maxp = maximum pressure of cast
day
month
year

and the following header information at the start and end of each cast:

decimaltime = decimat time from start of year e.g. midday on January 2nd is 1.500
lat = latitude
lon = longitude
time

(ii) a9705bot.mat This file contains the bottle data information from the *.bot file. Matrix column numbers correspond to CTD station number. All blanks are filled by NaN. Matrices are as follows:

ctd_press, ctd_temp, ctd_sal, ctd_cond = CTD pressure, temperature, salinity and conductivity from upcast CTD burst data (see above)
hyd_sal = bottle salinity
therm = protected reversing thermometer temperature
flag = bottle quality flag
niskin = Niskin bottle number
station

References

Rosenberg, M., Eriksen, R., Bell, S., Bindoff, N. and Rintoul, S., 1995. *Aurora Australis marine science cruise AU9407 - oceanographic field measurements and analysis*. Antarctic Cooperative Research Centre, Research Report No. 6, July 1995. 97 pp.

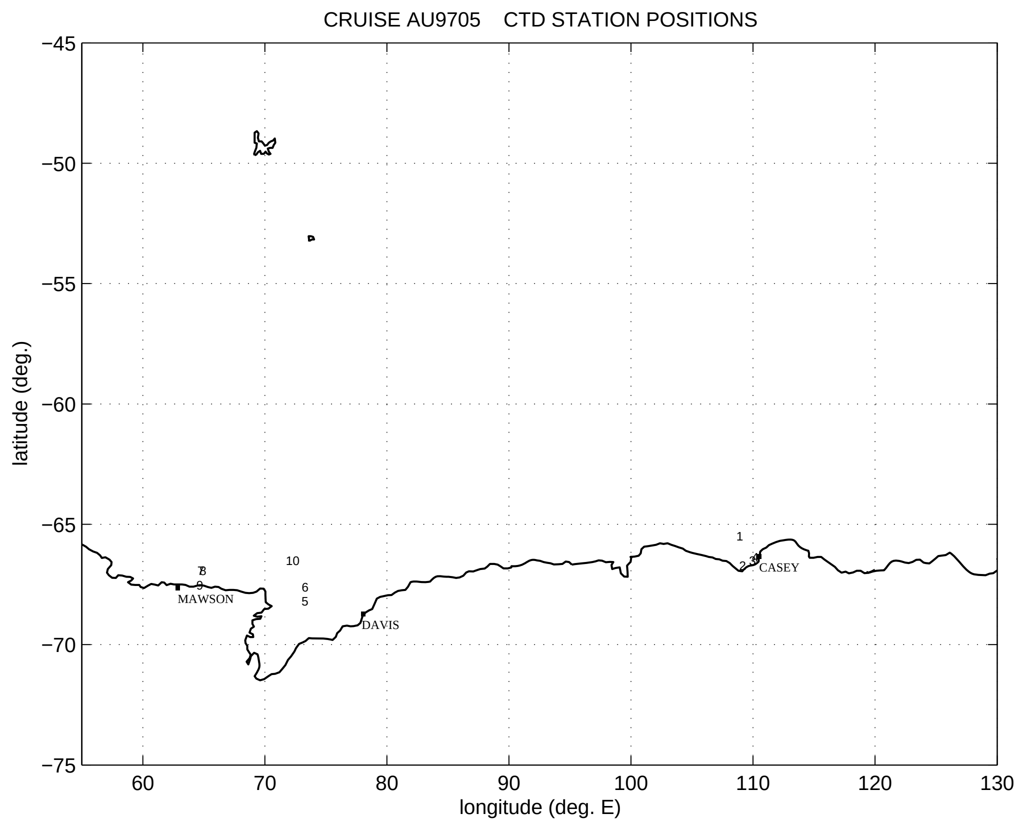
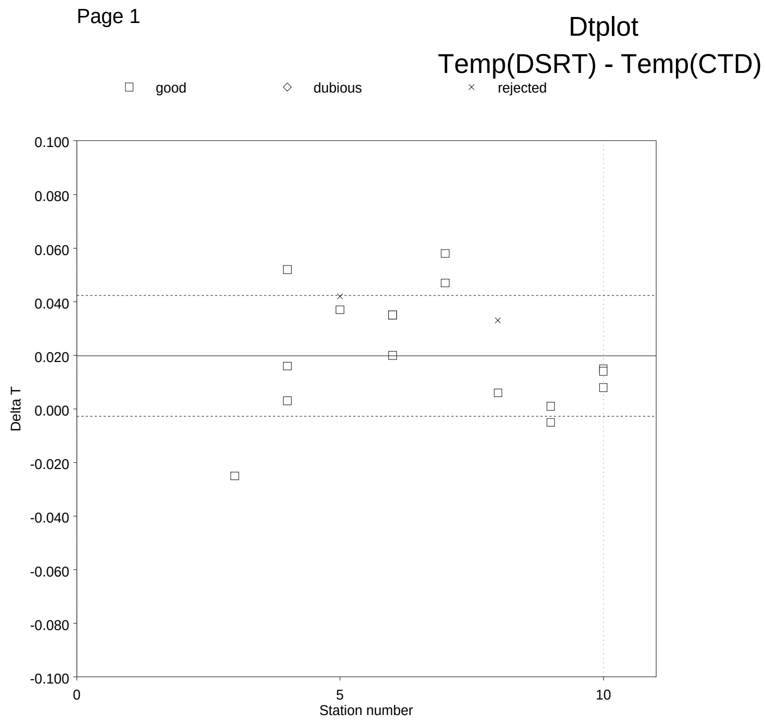


Figure 1



Calibration data for cruise : Au97/05

Calibration file : histcal.lis

Mean offset Temperature = 0.01981312c (s.d. = 0.0226 ˚c)

Number of samples used = 16 out of 18

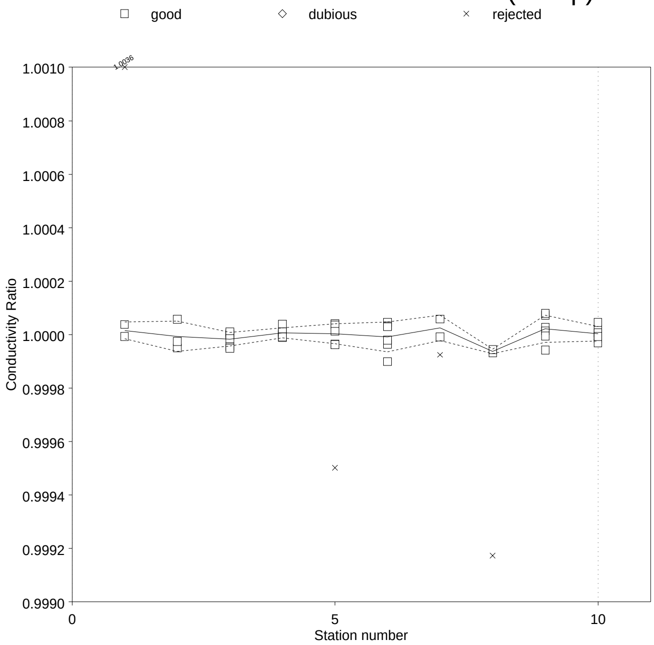
Figure 2

Page 1

Calplot

Cond(Samp) / Cond(CTD)

Wed Jul 16 11:57:29 1997



Calibration data for cruise : Au97/05

Calibration file : histcal.lis

Conductivity s.d. = 0.00003 (0.0016 psu)

Number of bottles used = 44 out of 48 Mean ratio for all bottles = 1.00000

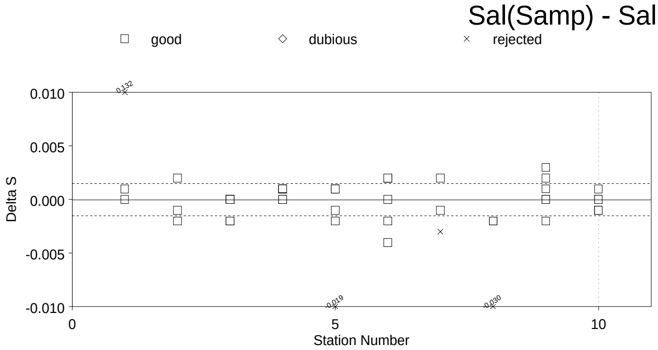
Figure 3

Page 1

Dsalplot

Sal(Samp) - Sal(CTD)

Wed Jul 16 11:57:40 1997



Calibration data for cruise : Au97/05

Calibration file : histcal.lis

Mean offset salinity = 0.0000psu (s.d. = 0.0015 psu)

Number of bottles used = 44 out of 48

Figure 4

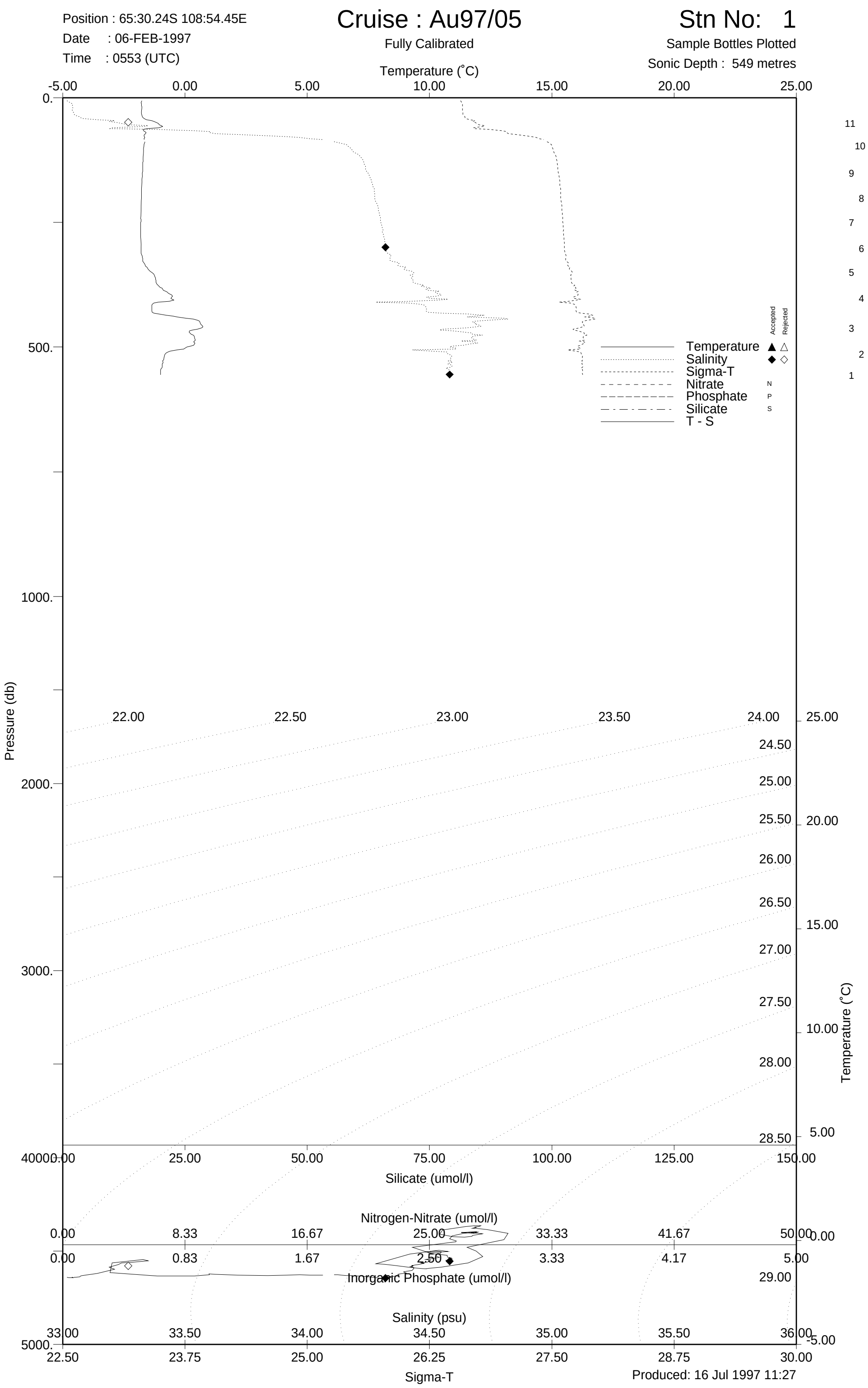
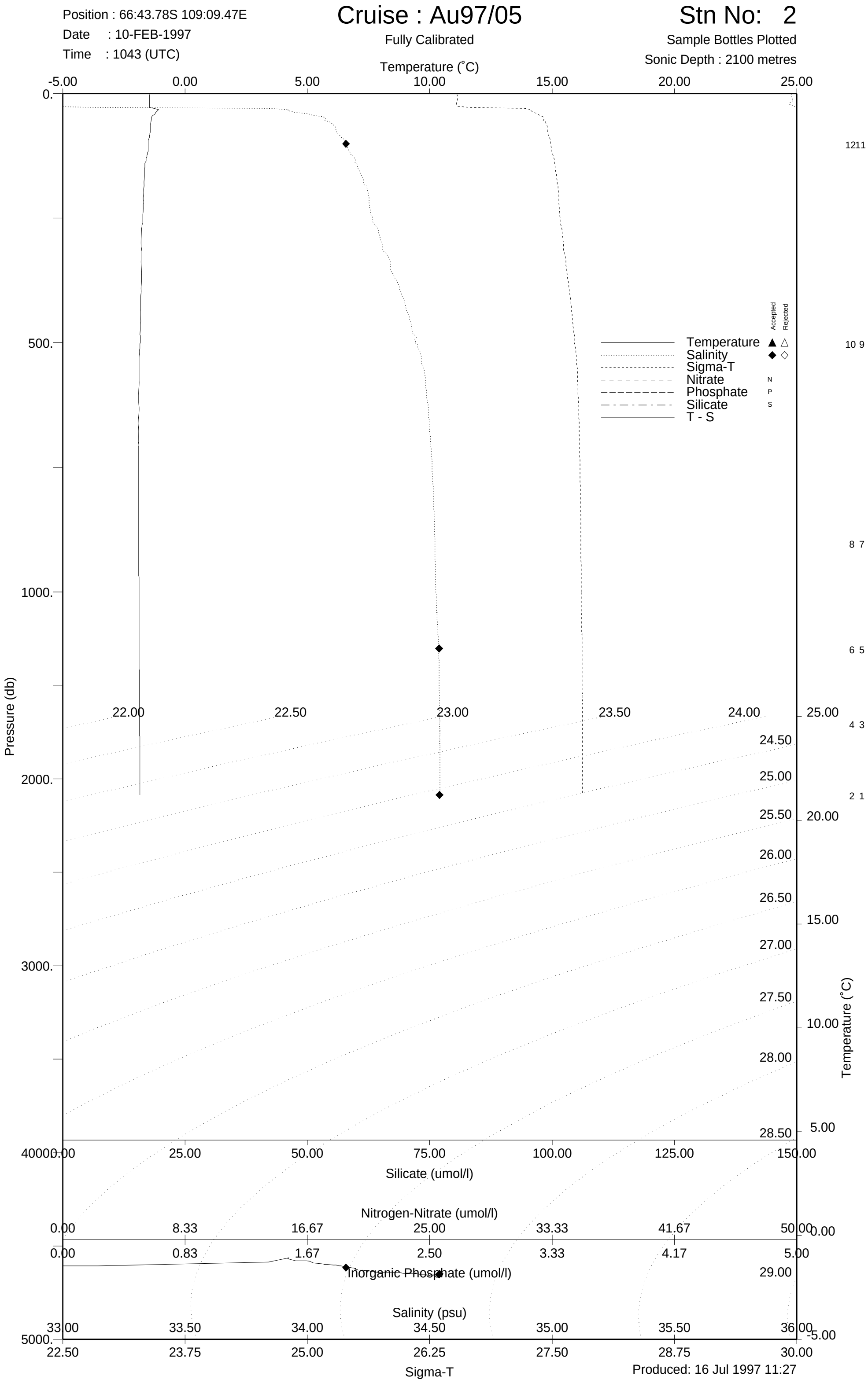
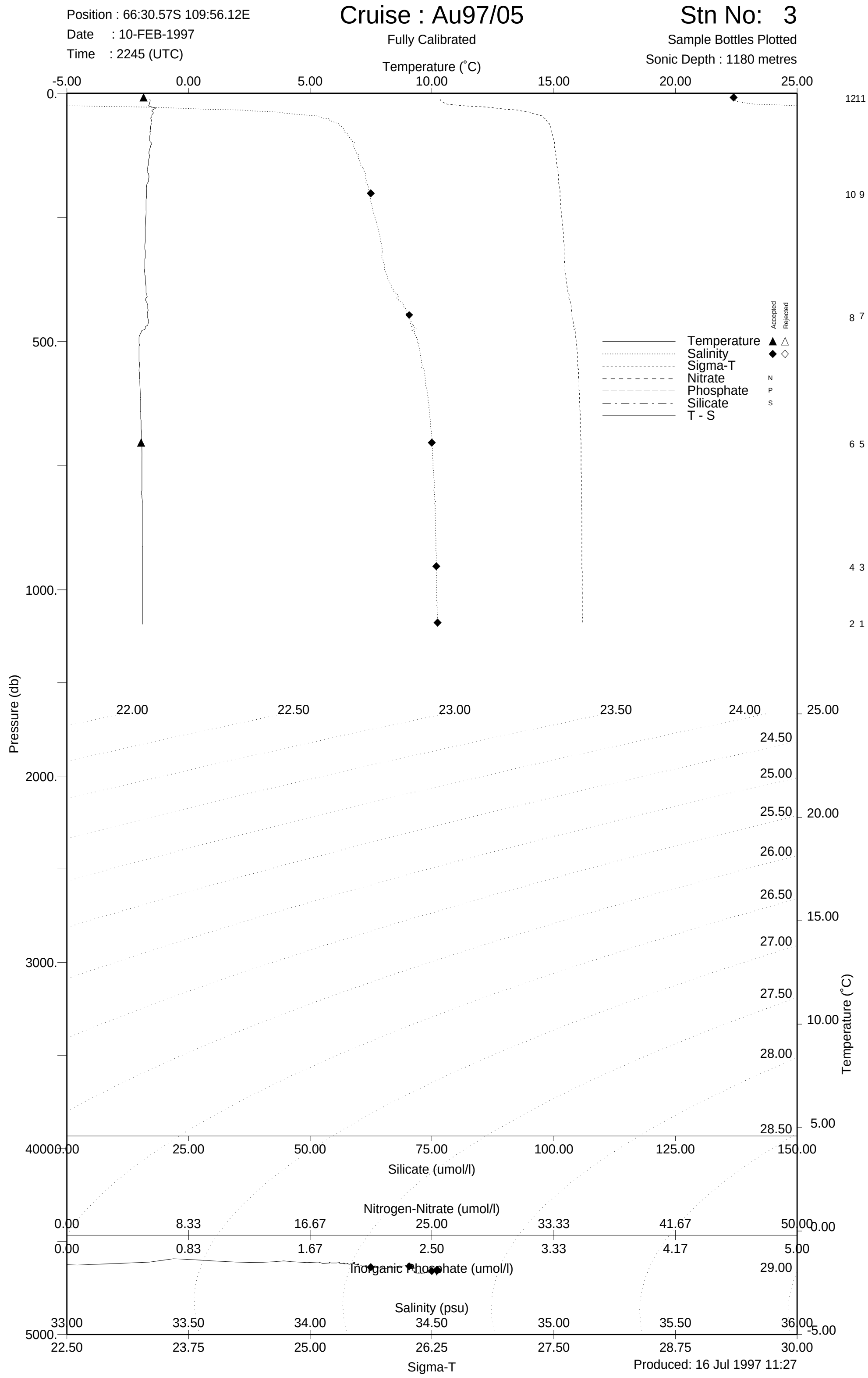

Position : 65:30.24S 108:54.45E
Date : 06-FEB-1997
Time : 0553 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 1
Sample Bottles Plotted
Sonic Depth : 549 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5a



Position : 66:43.78S 109:09.47E
Date : 10-FEB-1997
Time : 1043 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 2
Sample Bottles Plotted
Sonic Depth : 2100 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5b



Position : 66:30.57S 109:56.12E
Date : 10-FEB-1997
Time : 2245 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 3
Sample Bottles Plotted
Sonic Depth : 1180 metres
Temperature (°C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5c

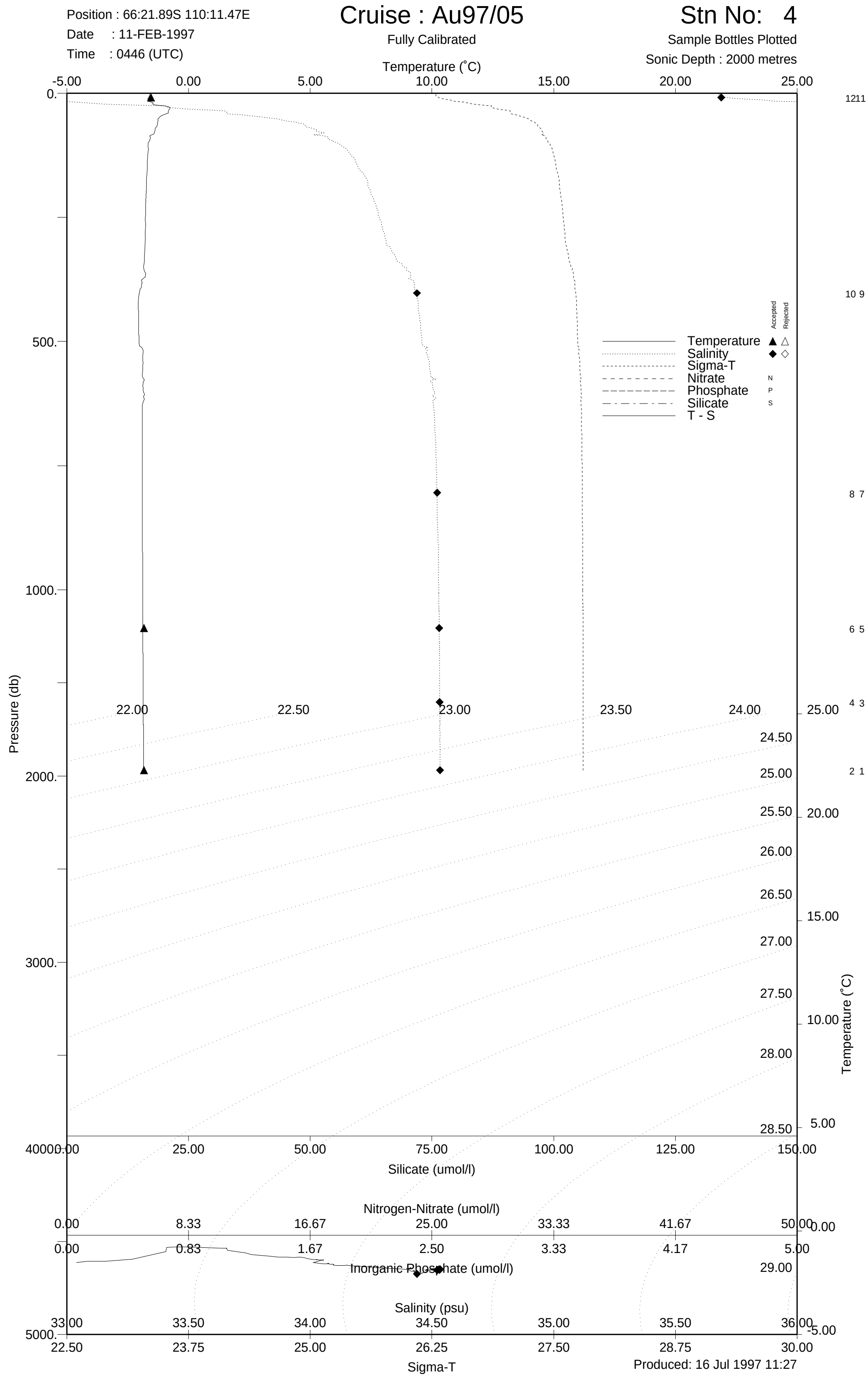
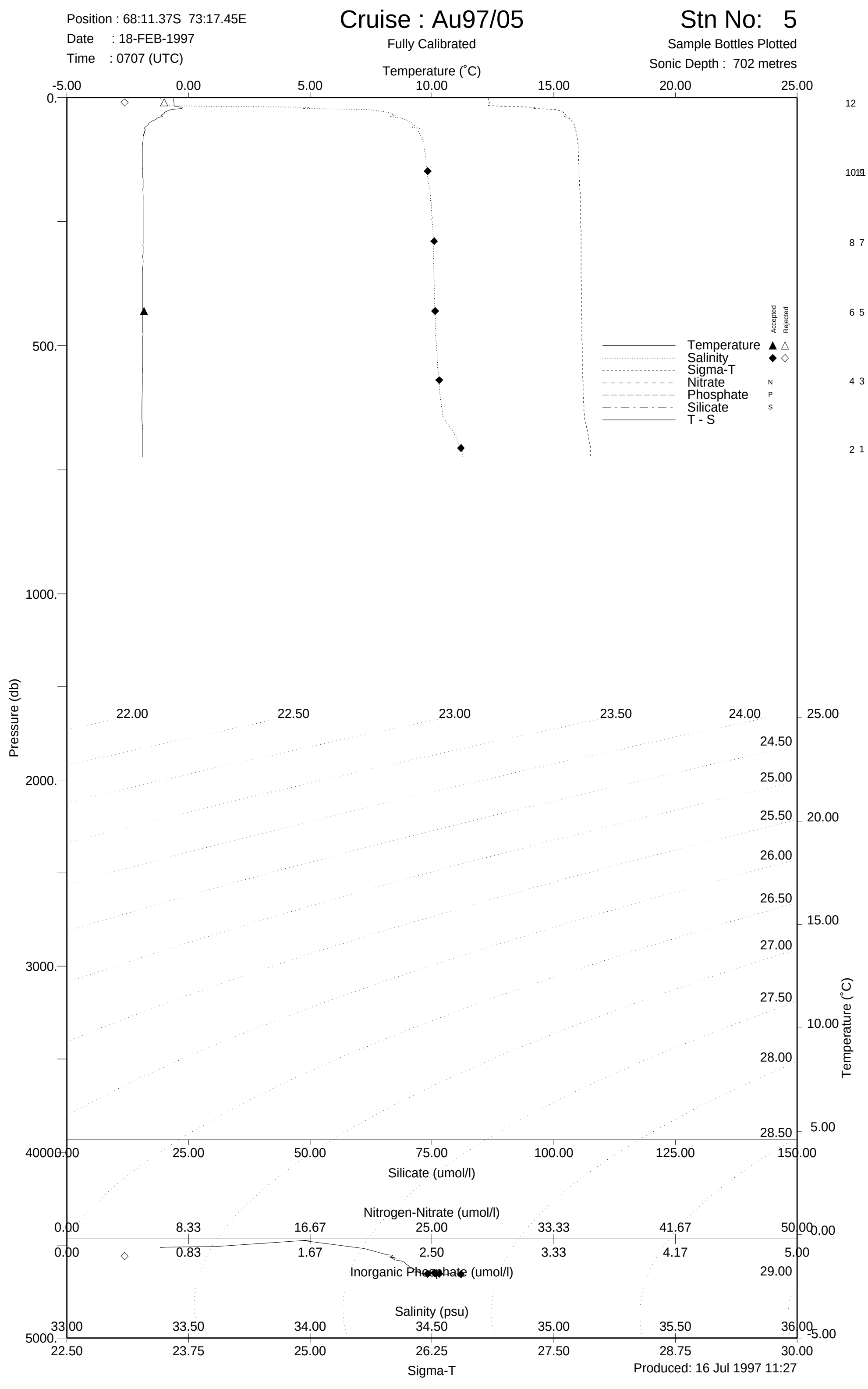
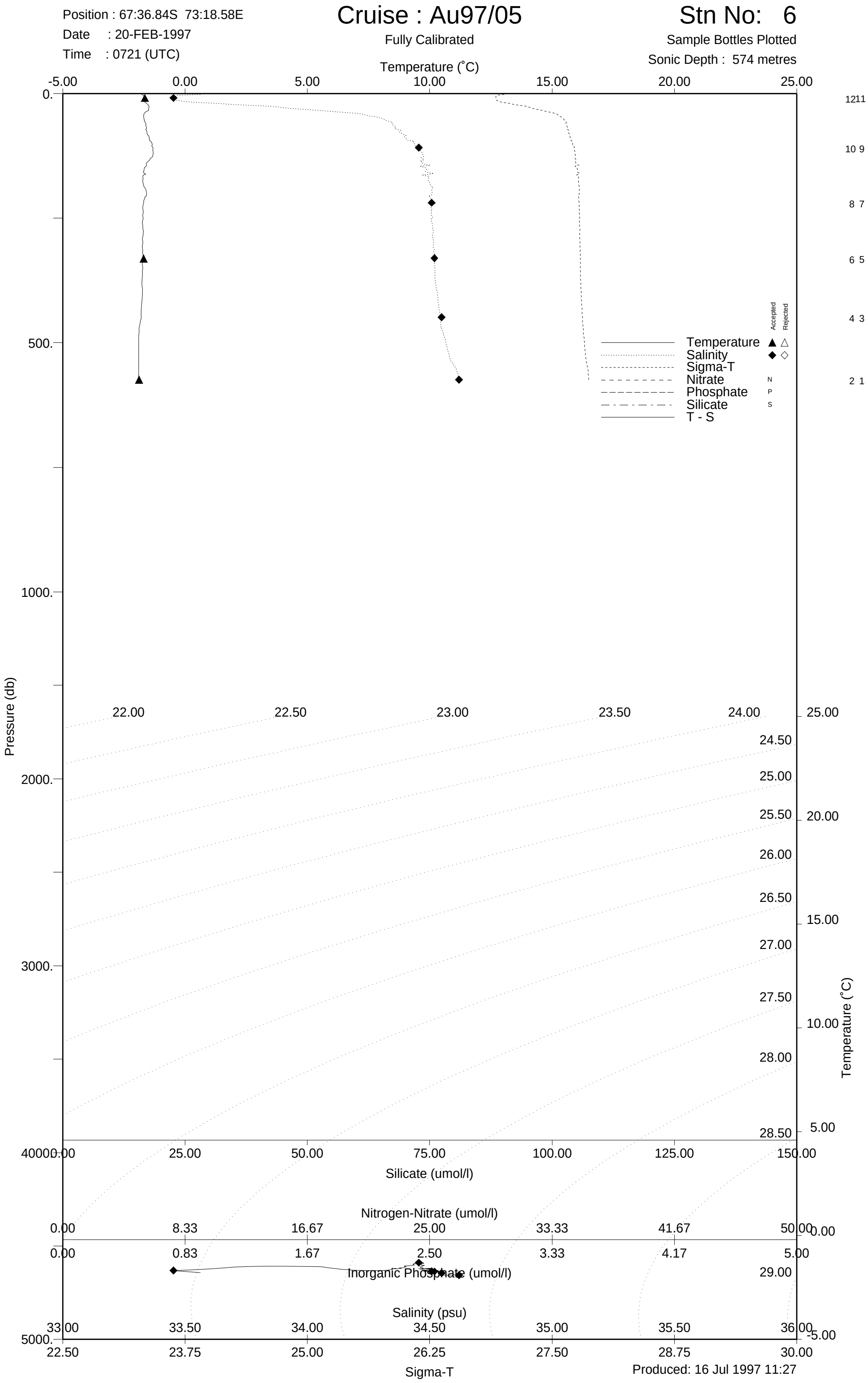

Position : 66:21.89S 110:11.47E
Date : 11-FEB-1997
Time : 0446 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 4
Sample Bottles Plotted
Sonic Depth : 2000 metres
Temperature (°C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5d



Position : 68:11.37S 73:17.45E
Date : 18-FEB-1997
Time : 0707 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 5
Sample Bottles Plotted
Sonic Depth : 702 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5e



Position : 67:36.84S 73:18.58E
Date : 20-FEB-1997
Time : 0721 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 6
Sample Bottles Plotted
Sonic Depth : 574 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Temperature (˚C)
Produced: 16 Jul 1997 11:27

Figure 5f

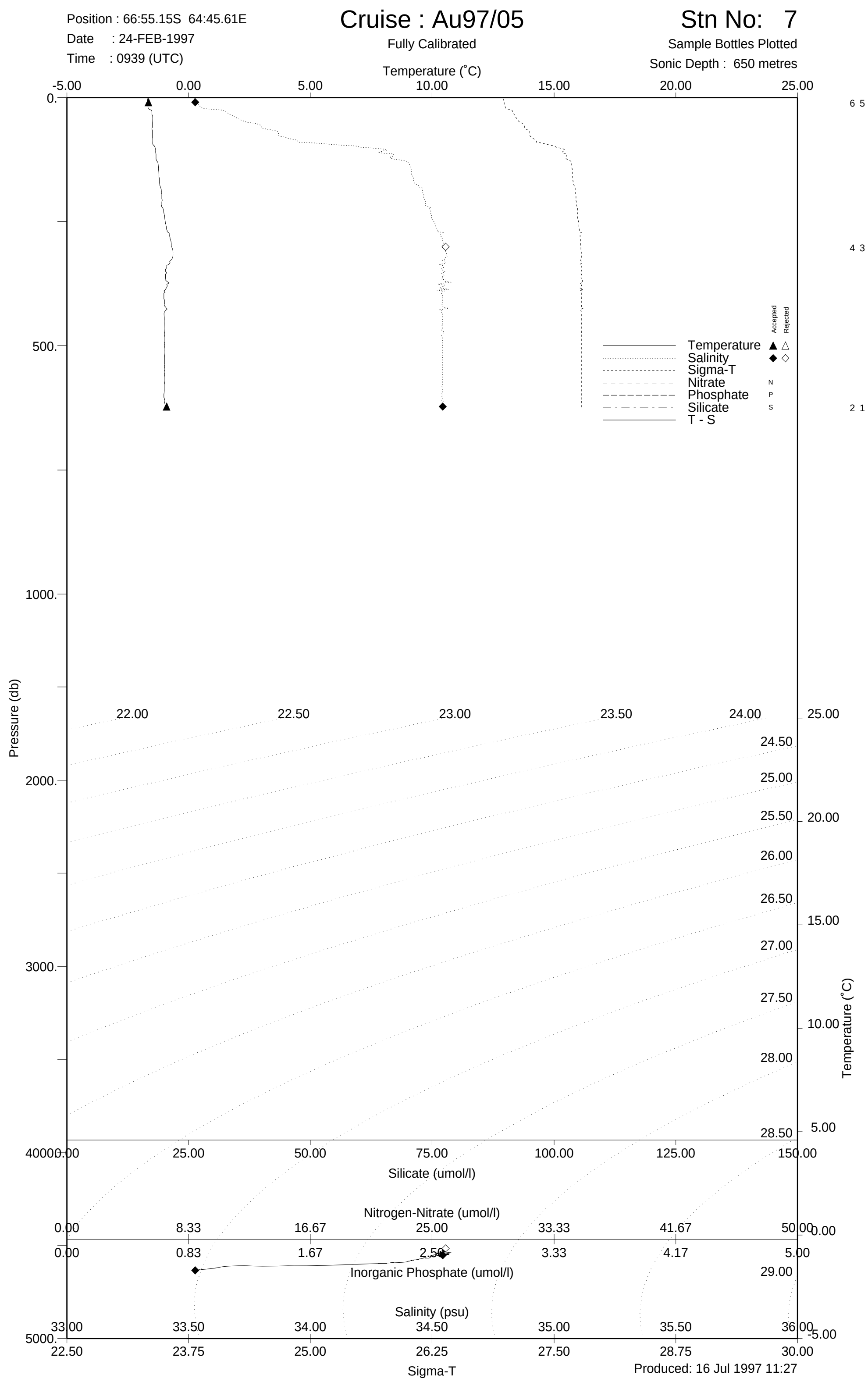
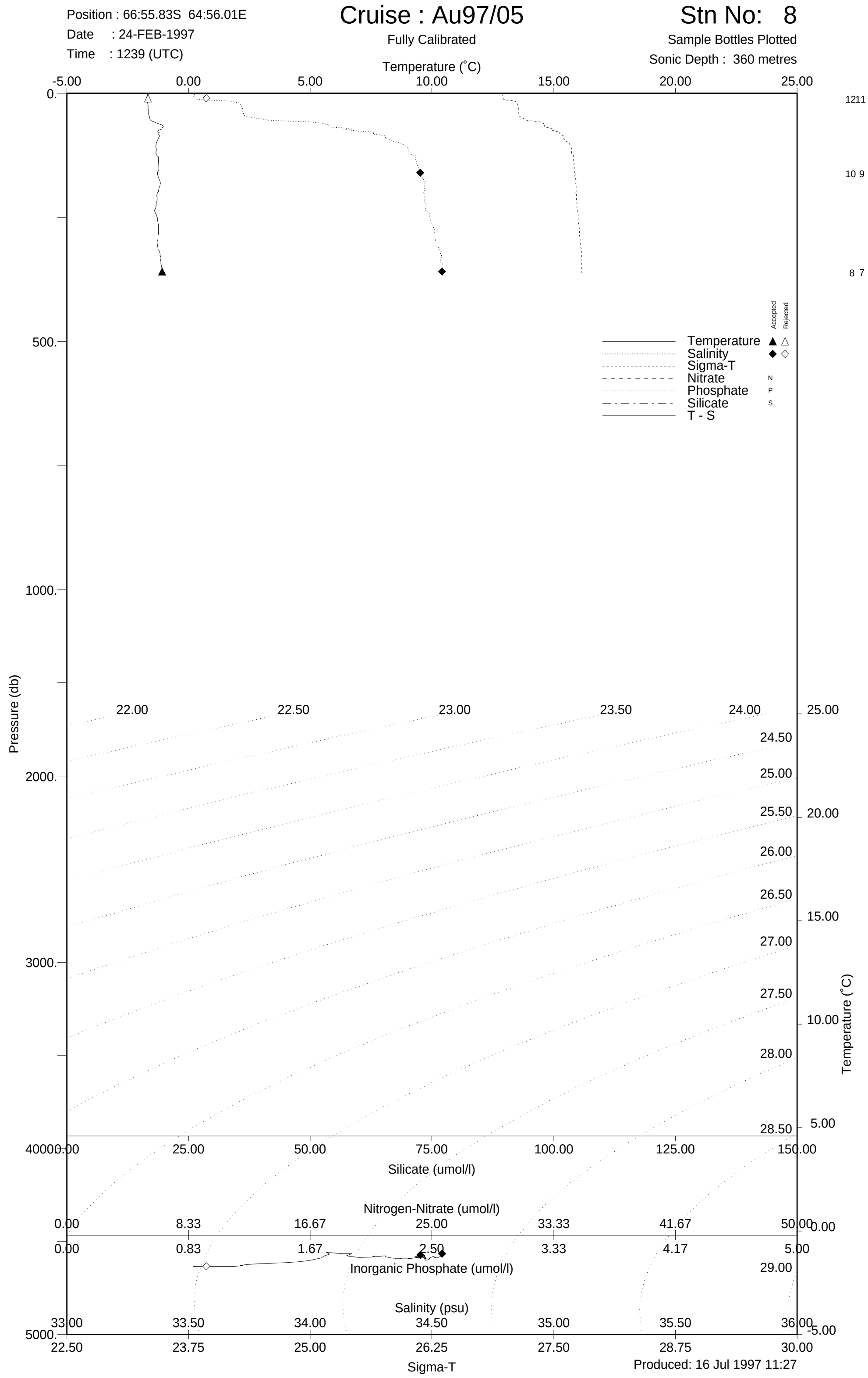
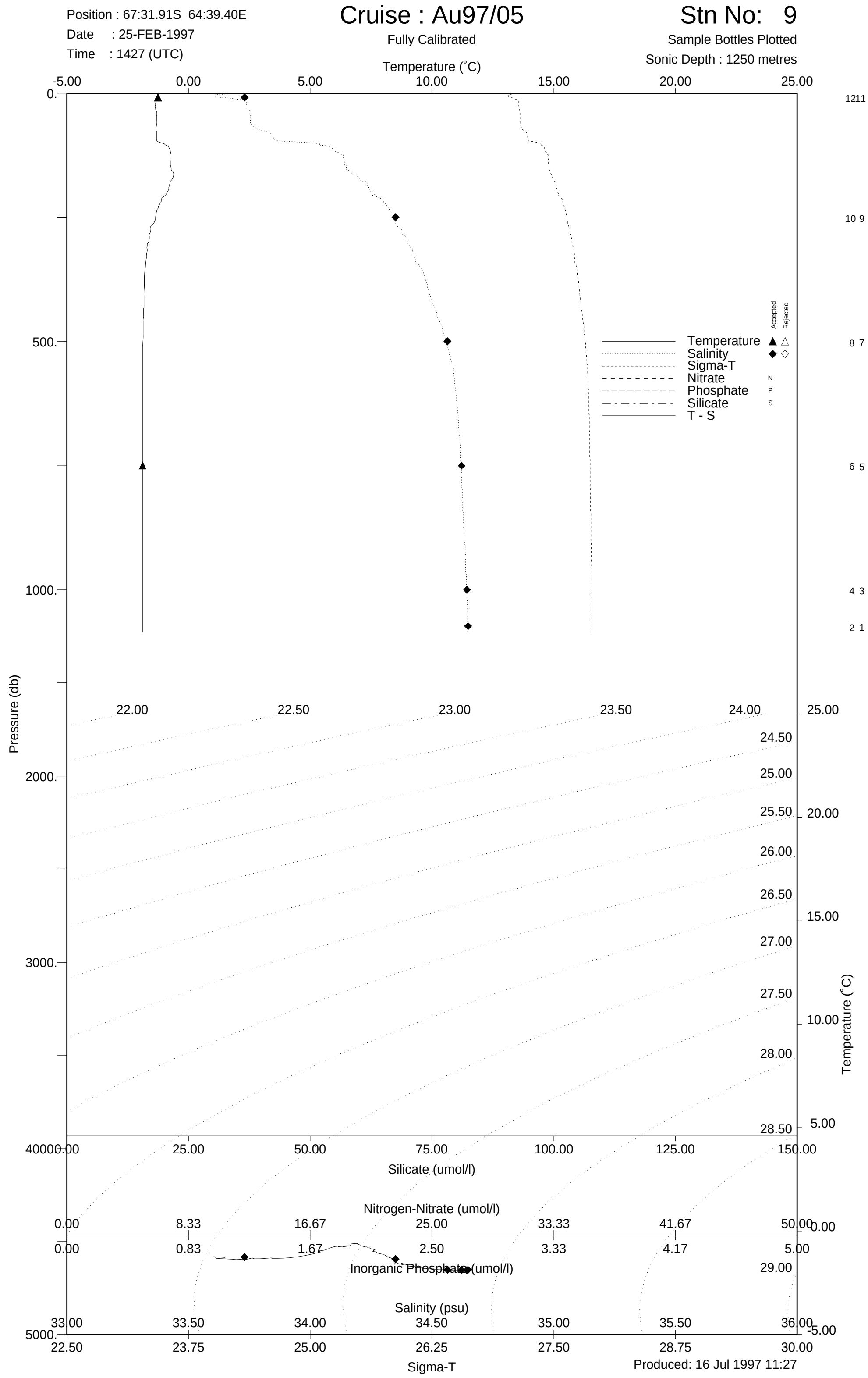

Position : 66:55.15S 64:45.61E
Date : 24-FEB-1997
Time : 0939 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 7
Sample Bottles Plotted
Sonic Depth : 650 metres
Temperature (°C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5g



Position : 66:55.83S 64:56.01E
Date : 24-FEB-1997
Time : 1239 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 8
Sample Bottles Plotted
Sonic Depth : 360 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5h



Position : 67:31.91S 64:39.40E
Date : 25-FEB-1997
Time : 1427 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 9
Sample Bottles Plotted
Sonic Depth : 1250 metres
Temperature (°C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Produced: 16 Jul 1997 11:27

Figure 5i

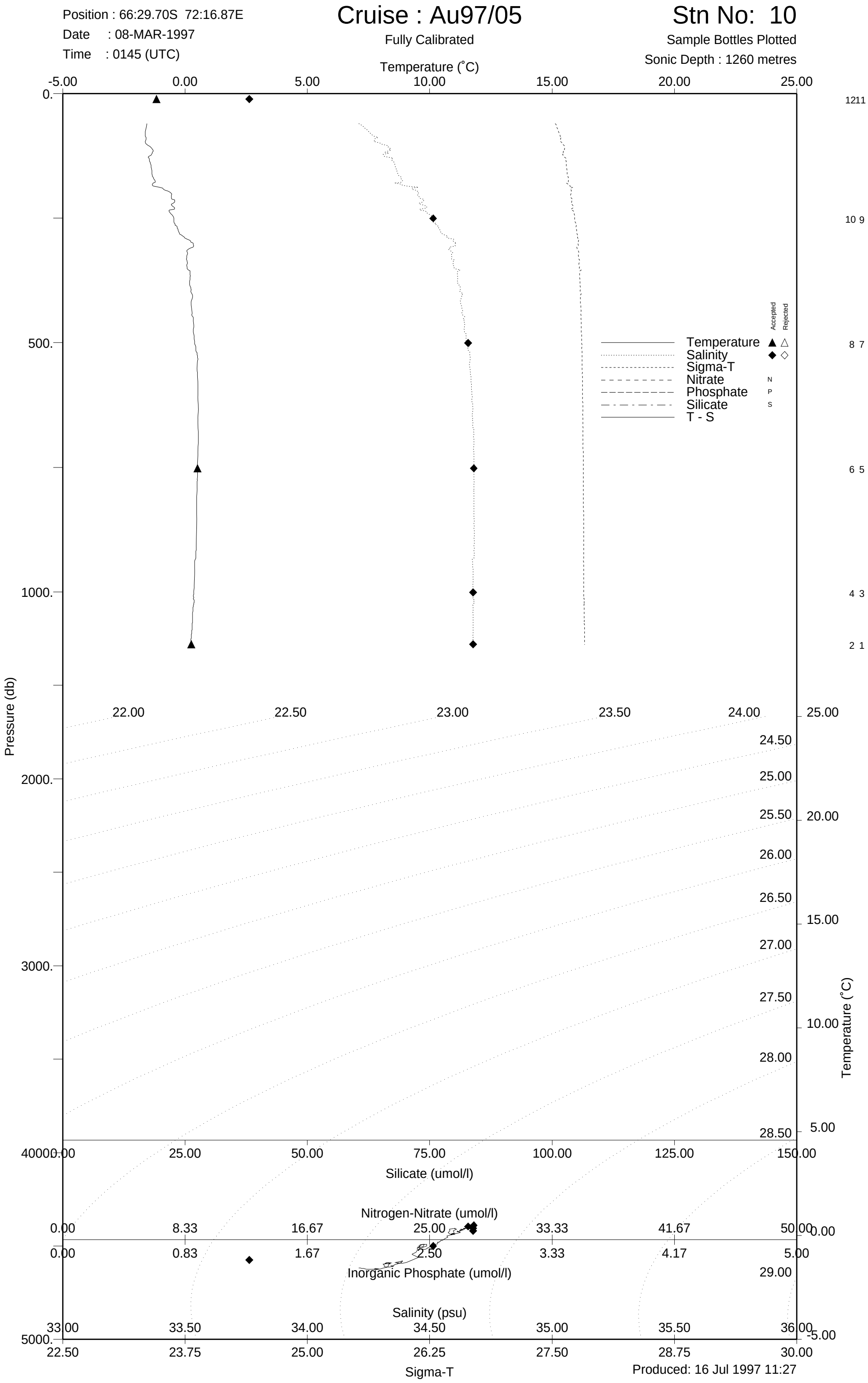

Position : 66:29.70S 72:16.87E
Date : 08-MAR-1997
Time : 0145 (UTC)
Cruise : Au97/05
Fully Calibrated
Stn No: 10
Sample Bottles Plotted
Sonic Depth : 1260 metres
Temperature (˚C)
Pressure (db)
Temperature
Salinity
Sigma-T
Nitrate
Phosphate
Silicate
T - S
Accepted
Rejected
Silicate (umol/l)
Nitrogen-Nitrate (umol/l)
Inorganic Phosphate (umol/l)
Salinity (psu)
Sigma-T
Temperature (˚C)
Produced: 16 Jul 1997 11:27

Figure 5j