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James Rennell Centre
for Ocean Circulation

INTERNAL DOCUMENT No. 9

Underway temperatures and salinity during RRS *Discovery* Cruise 198

A I Morrison*

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CONTENTS

1. Introduction

Several near-surface temperature measurements were available on this cruise:

- SeaSoar;

- RVS meteorological package;

- ADCP;

- thermosalinograph.

The temperature sensor aboard SeaSoar is believed to be the most accurately calibrated and most stable of these; its resolution is 0.0005°C and is accurate to 0.001°C. In the following sections, the results from the other sensors are compared with those from SeaSoar to assess their stability and accuracy. The SeaSoar was deployed in three regions: the Drake Passage (DP) and two ice edge surveys (IE1 and IE2). Data from all of these surveys are used in this assessment of the quality and calibration of temperature measurements from each instrument.

Underway measurements of salinity were taken using the thermosalinograph. The stability and accuracy of these measurements is discussed.

2. Near-surface temperature measurements on Discovery 198.

2.1 RVS meteorological package.

The RVS meteorological package includes a hull-mounted sea temperature module. It consists of an RS components platinum resistance thermometer (PRT) mounted on the port side (around 4 metres from the centreline) of the hull in the forward hold at approximately 3 metres below the sea surface. The measurements are logged through a personal computer which emulates a level A interface unit. One sample is taken every second; 29 of these samples are averaged together every 30 seconds (it resynchronises with the clock after each average, hence the one second gap). The 30- second average is then transferred to the level B system. After extraction to the level C computer, the sensor témperature measurement needs calibrating according to RVS laboratory-measured coefficients, to give a more accurate value; it should be noted that the laboratory testing was only within the range of temperatures from 4.7 to 29.5°C, while the temperatures in our survey regions were within the range -2 to 8°C.

The temperature resolution of the PRT is 0.1°C within the range -50 to 450°C. However, the averaging process produces values for temperature to two decimal places, which have a tendency towards values of round tenths of a degree.

SeaSoar temperatures at 3 metres depth were extracted and combined with the meteorological measurement of sea temperature.As is seen in Figure 1, the correlation between the two temperatures isquite good at low temperatures, but poorer at the higher temperatures in our range of measurements. The met-measured sea temperature is steadily higher than the SeaSoar temperatures by about 0.15°C (see Figure 2), with standard deviation of 0.175°C, which can be applied as a shift to correct the met measurement. The poor resolution of the instrument means that it is of little use to us, as accuracy of temperature to better than 0.1°C is required. However, it is worth noting that this instrument gives stable results.

2.2 ADCP

The ADCP system includes a temperature sensor, a PRT, which is mounted in the transducer unit in the winch room. This is located in the forward end of the winch room, about 1.2 metres to port of the ship's centreline, at approximately 5 metres below the sea surface. Temperature is sampled every ping, approximately once per second, then averaged over each two minute ensemble and logged through a personal computer which emulates a level A interface unit. The 2 minute measurement is then transferred to the level B system. No laboratory calculated calibration coefficients are available for this device.

The temperature resolution of the PRT is 0.012°C, and the manufacturer's specification accuracy is 0.2°C within the range -5 to 45°C.

SeaSoar data between 4.5 and 5.5 metres below the sea-surface were extracted from the survey datasets, and merged with the ADCP temperature. The difference between the two temperatures is illustrated in figure 3 Over the Burdwood Bank region, massive spikes occur, as great as 0.7°C in magnitude; these are believed to occur because there is much structure in the near-surface temperature, and if the SeaSoar depth and ADCP measurement depth are different by even a small amount, large temperature difference will be recorded. During the first of the two ice edge surveys, a shift in differences from jday 330 to jday 332 (25 to 27 November) cannot be explained. Excluding the large differences at the higher temperatures, a temperature dependent relationship is evident between the SeaSoar/ADCP temperature difference and ADCP temperature (figure 4). Best fit line to this is:

temperature correction = (-0.014 x ADCP temperature) + 0.011.

After applying this as a correction to ADCP temperature, the ADCP temperature to SeaSoar temperature difference has a standard deviation of 0.031°C.

2.3 Thermosalinograph

The thermosalinograph (TSG) system consists of a Falmouth Scientific (FSI) Ocean Temperature Module (OTM) mounted in the hull, at the non-toxic water supply intake, and an Ocean Conductivity Module (OCM) mounted, along with a second OTM, within a polythene tube, through which the non-toxic supply passes. The OTM contains an FSI reference grade PRT. The hull-mounted OTM is located in the forward hold at a depth of approximately 4 to 4.5 metres below the water surface, 2.2 metres to the starboard of the centreline: the datastream from this module is known as the "remote temperature". The OCM and second OTM are located on the starboard side of the hangar; they are mounted in a polythene tube through which the non-toxic water supply is pumped: this OTM measures the "housing temperature". A header tank is located approximately 2.5 metres above (by the winch control room) to supply enough water pressure for adequate rate of flow, free of bubbles; the volume flow rate through the tube is approximately 20 litres per minute, well within the manufacturer's recommendations. The flow through the tube is upwards, passing the OTM before the OCM. The measurements of temperature and conductivity from all the modules are logged through a personal computer, emulating a level A interface, and on to the level B at 15 second intervals. The sampling frequency is adjustable, through the computer.

The temperature resolution of the FSI OTM is 0.0001°C with manufacturer's quoted accuracy of 0.003°C in the range -2 to 32°C Its specifications state that is should be stable to 0.0005°C /month.

On jday 321, 16 November, after the section through the Drake Passage, there were some concerns about the data from the remote temperature module. Spikes were occurring and it seemed that negative values were flipping to positive when the temperature was negative. Both modules were removed for testing. During this procedure the housing OTM became damaged and could no longer be used. The remote OTM was relocated to the hangar and became the new housing OTM, so that the salinity could still be calculated using the OCM output. Hence, from the time that the non-toxic supply was re-started, early on jday 322, 17 November, there was no remote temperature.

During the transect of the Drake Passage, both temperature sensors were available on the TSG. Comparisons of its temperature measurements with those of SeaSoar were made with extracts from SeaSoar data at pressures between 3.5 and 4.5db, because the TSG is taking the temperature of water at around 4 metres deep (figure 5). In regions where the SeaSoar was towed at shallow (less than 200 metres of cable) depths, for example, over Burdwood Bank, the agreement is poor because there was a great deal of structure in the near-surface temperature, which means that even a small error in matching SeaSoar depth, to thermosalinograph intake depth, leads to large differences in temperature. In the region from 55 to 58 S, the agreement between the remote temperature and SeaSoar temperature is excellent. Within this region, the offset has a mean value of -0.008°C and standard deviation of 0.008°C, which can be applied as a correction to the remote temperature. At 58 S the SeaSoar was again towed at shallow depth (fog and the risk of icebergs slowed the ship down) causing massive differences between the remote and SeaSoar temperatures. On returning to deeper towing (59 S), the same offset as before is seen in remote temperature, but the data is much spikier, having a standard deviation of 0.035°C, which was why the remote module was removed for investigation. During the two ice edge surveys, only housing temperature was available. This does not show a steady difference from SeaSoar temperatures, not surprisingly, because heating of the non-toxic supply on its way to the hangar unit may vary. Variations in the mean of the difference between the housing temperature and SeaSoar temperature are of the order of 0.1°C.

3. Salinity from thermosalinograph

The thermosalinograph system is described in the "near-surface temperature" section. Output from the Ocean Conductivity Module (OCM) and housing Ocean Temperature Module (OTM) were processed using PSTAR program sal83 to give salinity measurements, taking the pressure to be 0 db at all times. Water bottle samples were taken from the system at hourly intervals throughout the duration of the cruise, and their salinities determined using a salinometer These were combined and compared with the TSG salinity data. (see figure 6) This showed that the TSG salinities differed from the bottle salinities by a varying amount up to 0.1psu So it was decided that the best way to calibrate the TSG was to first of all throw out any bottle salinities which differed greatly from the TSG (probably due to errors in recording the time of drawing the sample). Then, the bottle samples being sparser in time than the TSG data, the differences were interpolated in time to assign a correction factor to each TSG value. This correction was then added to the TSG data. The mean difference was -0.091psu, with standard deviation of 0.019. Therefore, corrected salinities should be correct to within about 0.02psu.

4. Summary

Three underway near-surface temperatures were available during this cruise. The RVS meteorological package temperature sensor was stable, but gave temperatures accurate to only 0.3°C. While it was operational, the thermosalinograph was stable and gave results to within about 0.01°C of the SeaSoar values, after applying a shift of 0.008°C. Of the three temperature sensors, the ADCP proved most useful during this cruise because it was in operation throughout, and gave temperature measurements accurate to within about 0.03°C. A temperature dependent correction was applied to the raw temperatures to achieve this accuracy.

The underway salinities measured by the thermosalinograph were tested against hourly samples of water from the non-toxic supply. They proved to differ from these samples by varying amounts, and so were calibrated by merging with salinities interpolated between hourly samples. This meant then that the thermosalinograph salinities were correct to within about 0.02psu.

Figure 1. Correlation between meteorological package sea temperature and SeaSoar temperature at 3 metres depth.

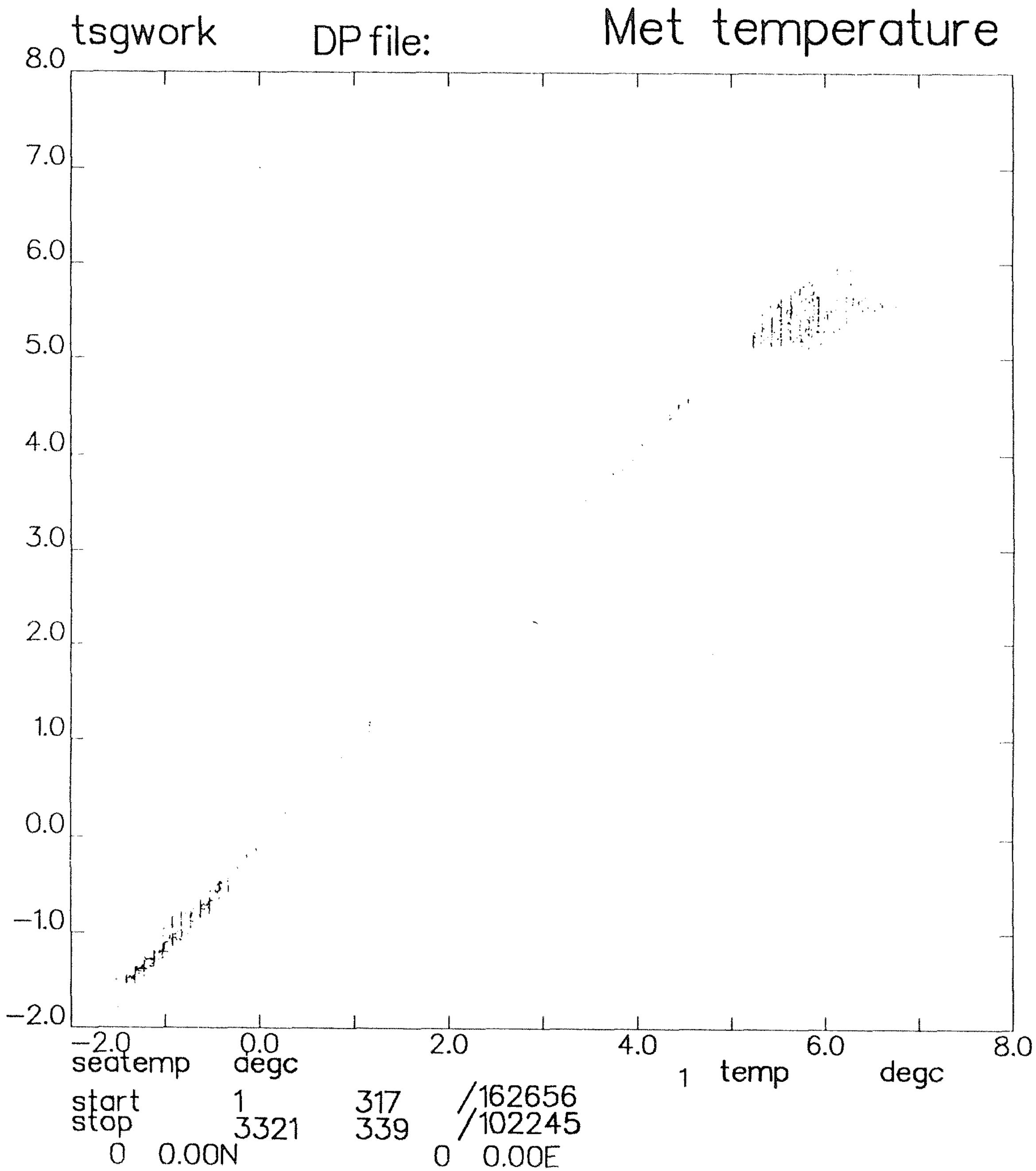


Figure 2. Comparison between meteorological package sea temperature and SeaSoar temperature at 3 metres depth. Section shown is from the second ice edge survey.

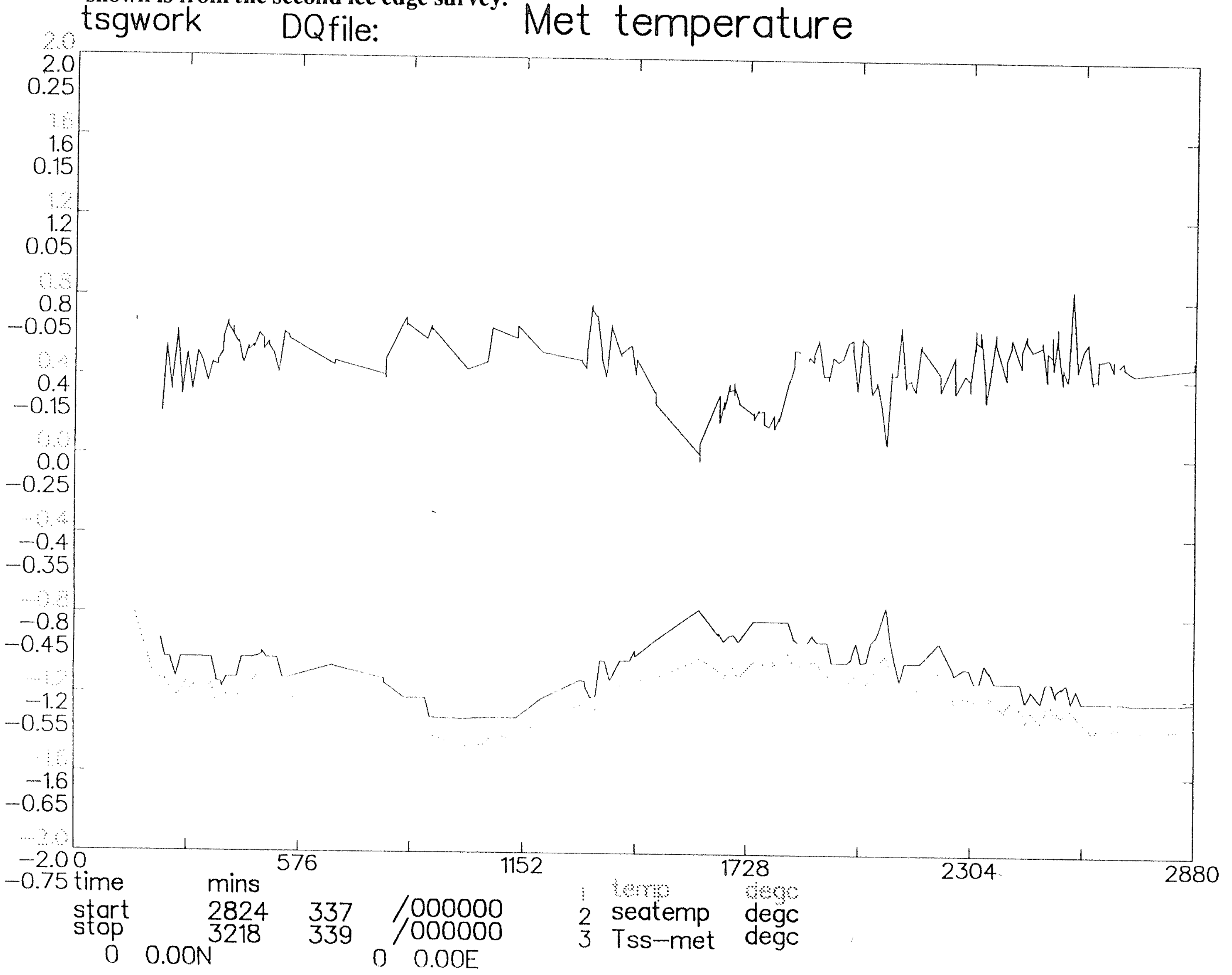


Figure 3. Comparison between ADCP sea temperature and SeaSoar temperature at 5 metres depth. Section shown is across the Drake Passage.

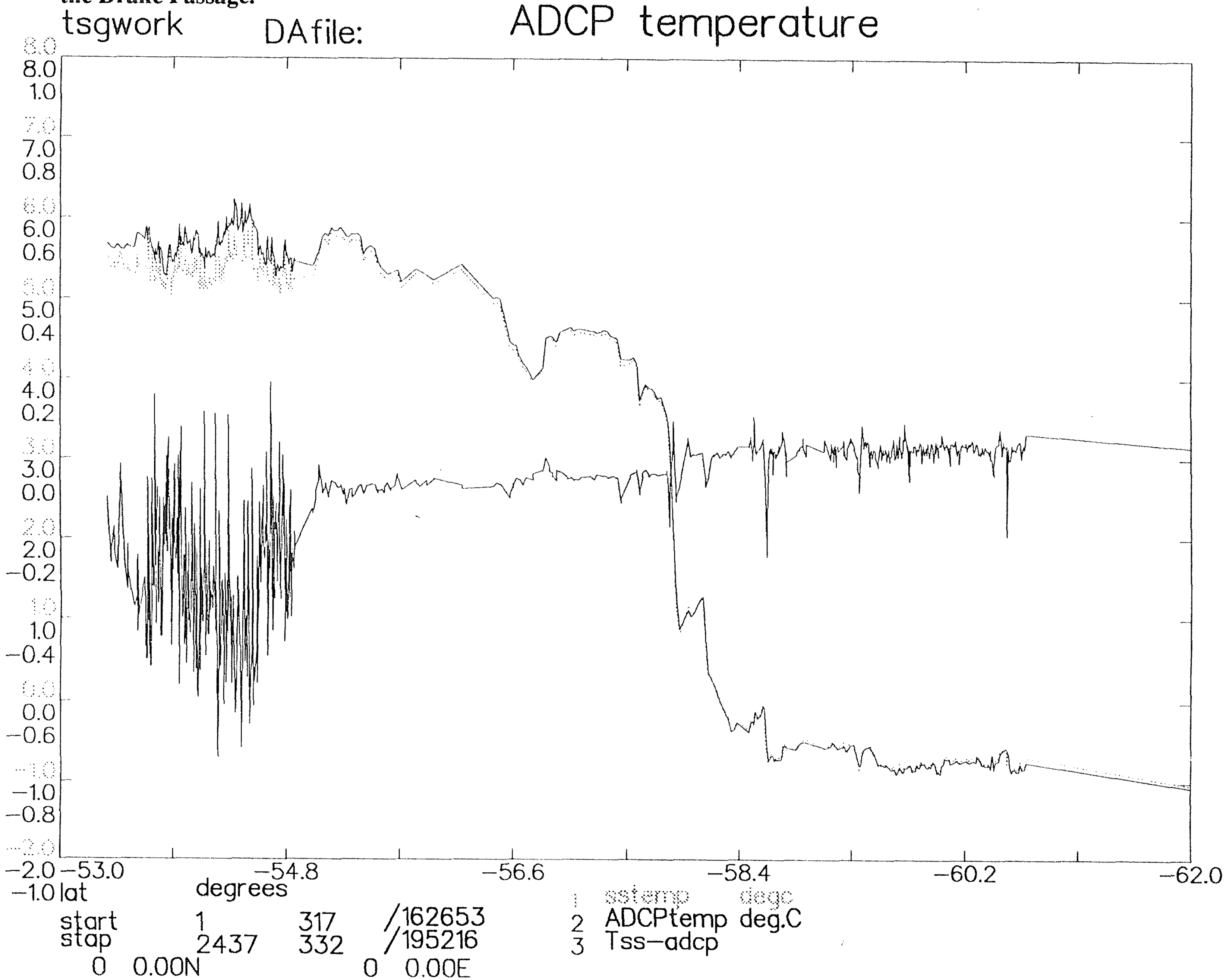


Figure 4. The difference between ADCP and SeaSoar measurements of temperature, plotted against the ADCP temperature. Data from Drake Passage and both ice edge surveys are included. This shows the temperature dependence of the relationship between the two measurements, and the massive spikes which occurred in the Burdwood Bank region.

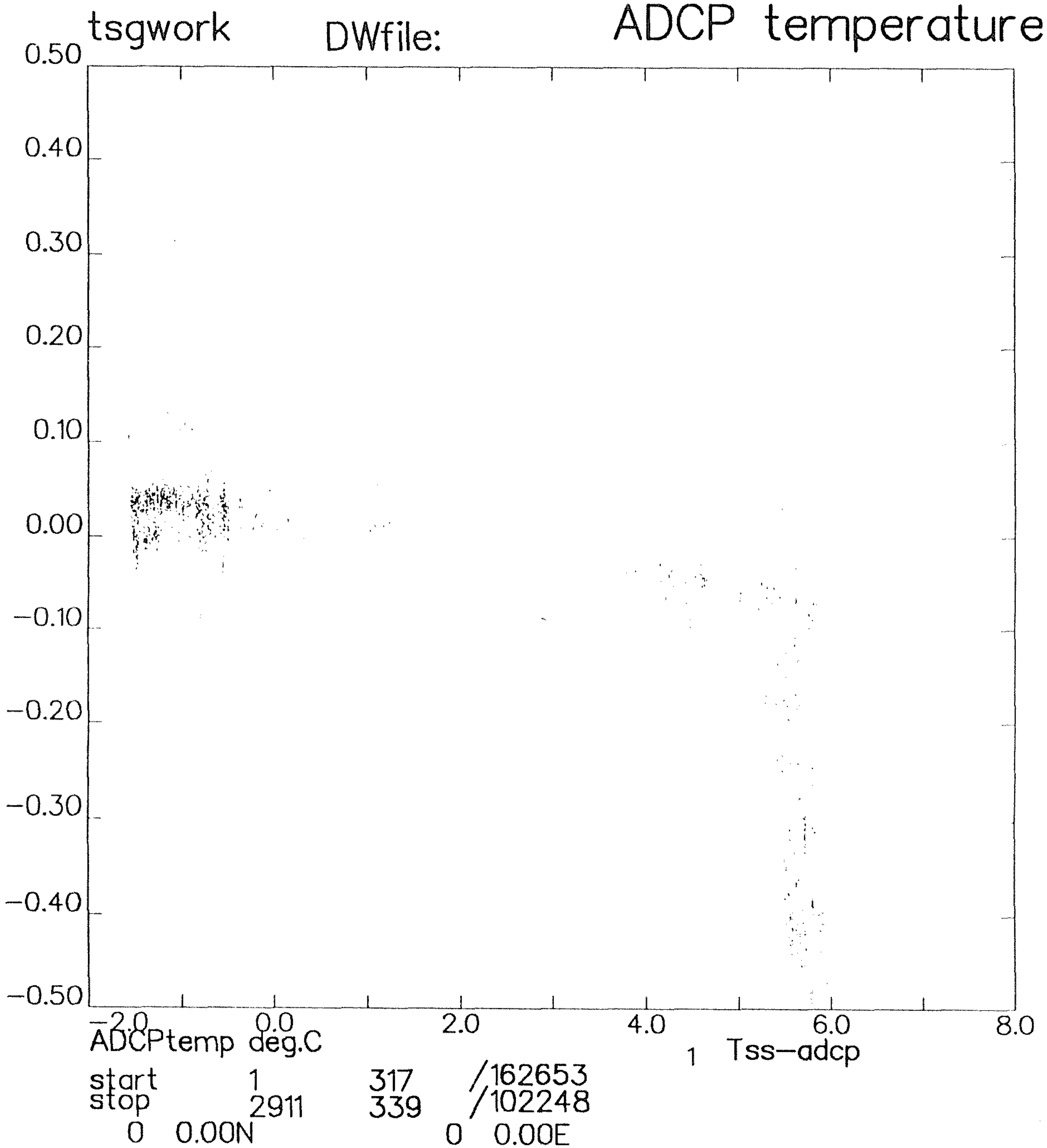


Figure 5. Comparison between thermosalinograph sea temperature and SeaSoar temperature at 4 metres depth. Section shown is across the Drake Passage.

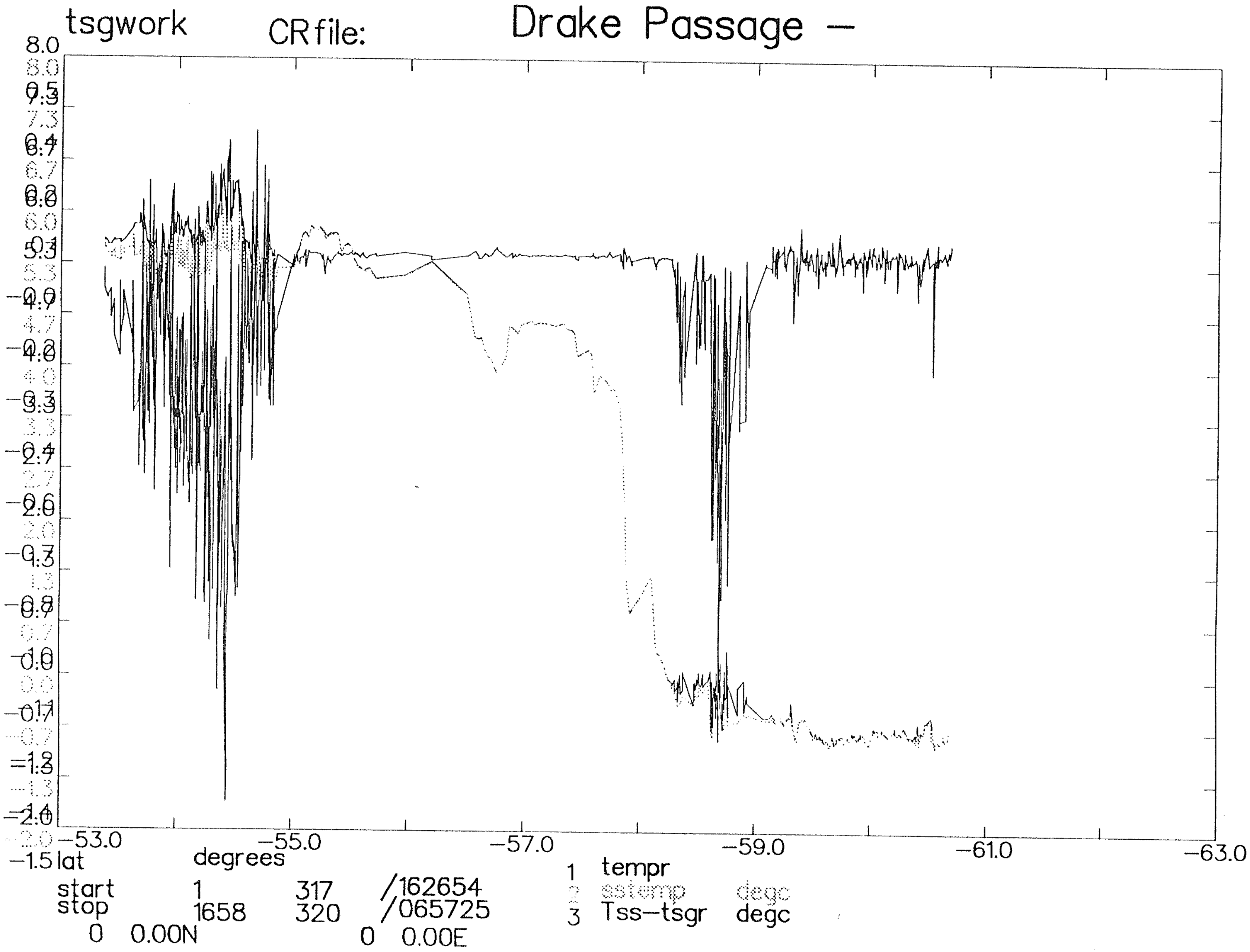
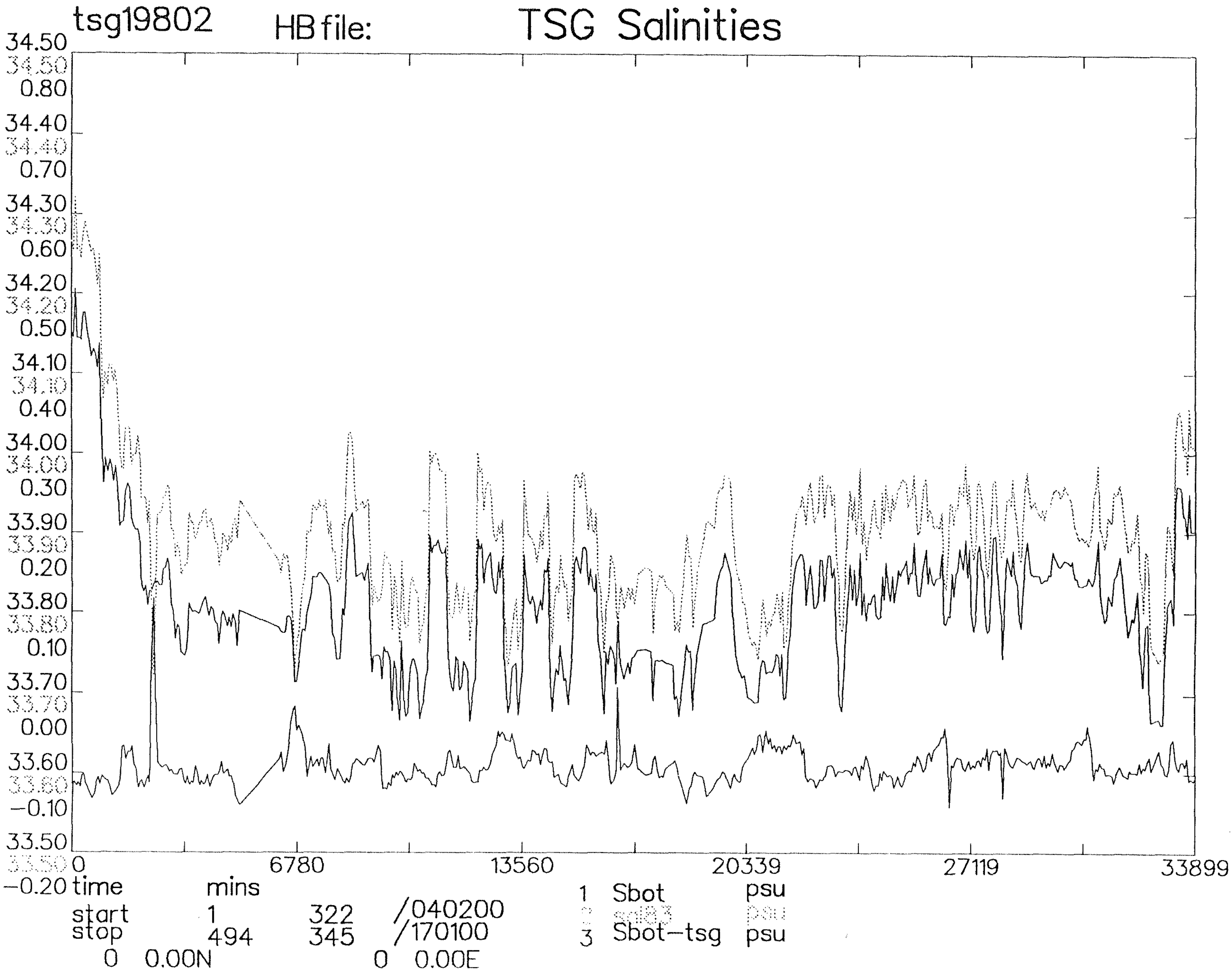


Figure 6. Comparison between salinity as determinedfrom water samples and from the thermosalinograph. Data shown are from the whole cruise.



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