P-05-191

Oskarshamn site investigation

Oceanographic measurements

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June 2005

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ISSN 1651-4416
SKB P-05-191

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Keywords: Oceanography, Current velocity, Current direction, Water temperature, Salinity.

Abstract

This report describes oceanographic measurements of temperature, conductivity (salinity), current velocity and direction conducted at distinct points within an area approximately 16 × 13 km along the coast in the Simpevarp area. Data were continuously measured at different depths over a period of one year. This report describes which instruments were used, their calibration and regular function control and the surveys history. Positioning of the rigs within the survey area as well as details about the instruments are given in tabulated form. The data are presented as graphs, for access to the original data the reader is referred to the SICADA database. Concerning the outcome of the measurement campaign there was some data loss mainly due to battery problems. Yet nearly all of the data obtained where considered reliable after quality control.

Sammanfattning

Denna rapport beskriver oceanografiska mätningar av temperatur, konduktivitet (salthalt) och strömhastighet och -riktning som genomfördes på olika platser inom ett kustområde omkring 16 × 13 km nära Simpevarp. Mätningarna genomfördes kontinuerlig med kortare avbrott under ett år. Rapporten beskriver mätinstrumenten, deras kalibrering och funktionskontroller liksom undersökningens historik. Riggarnas positionering inom undersökningsområde och detaljer om instrumenten presenteras i tabellform. Data presenteras som bilder och för tillgång till originaldata hänvisas till SKB:s databas SICADA. Angående mätkampanjens utfall saknas en del data, främst pga. batterifel. Dock har nästan alla data som erhållits bedömts som tillförlitlig efter kvalitetsgranskning.

Contents

1 Introduction

This document reports the oceanographic measurements, which were one of the activities performed within the site investigation at Simpevarp. The work was carried out in accordance with activity plan AP PS 400-04-10. In Table 1-1 controlling documents for performing this activity are listed. Both activity plan and method description are SKB's internal controlling documents.

The survey is part of the site investigations for deep repository in the Simpevarp area.

The survey was conducted between the end of March 2004 and the middle of April 2005. This period was interrupted for short times when data were read out, batteries were changed and instruments were checked for functionality. Interruptions occurred around July 6, September 30 and January 11. The position of the different rigs is shown in Figure 1-1.

The data from this activity are stored in the SICADA database and are traceable by the activity plan number.

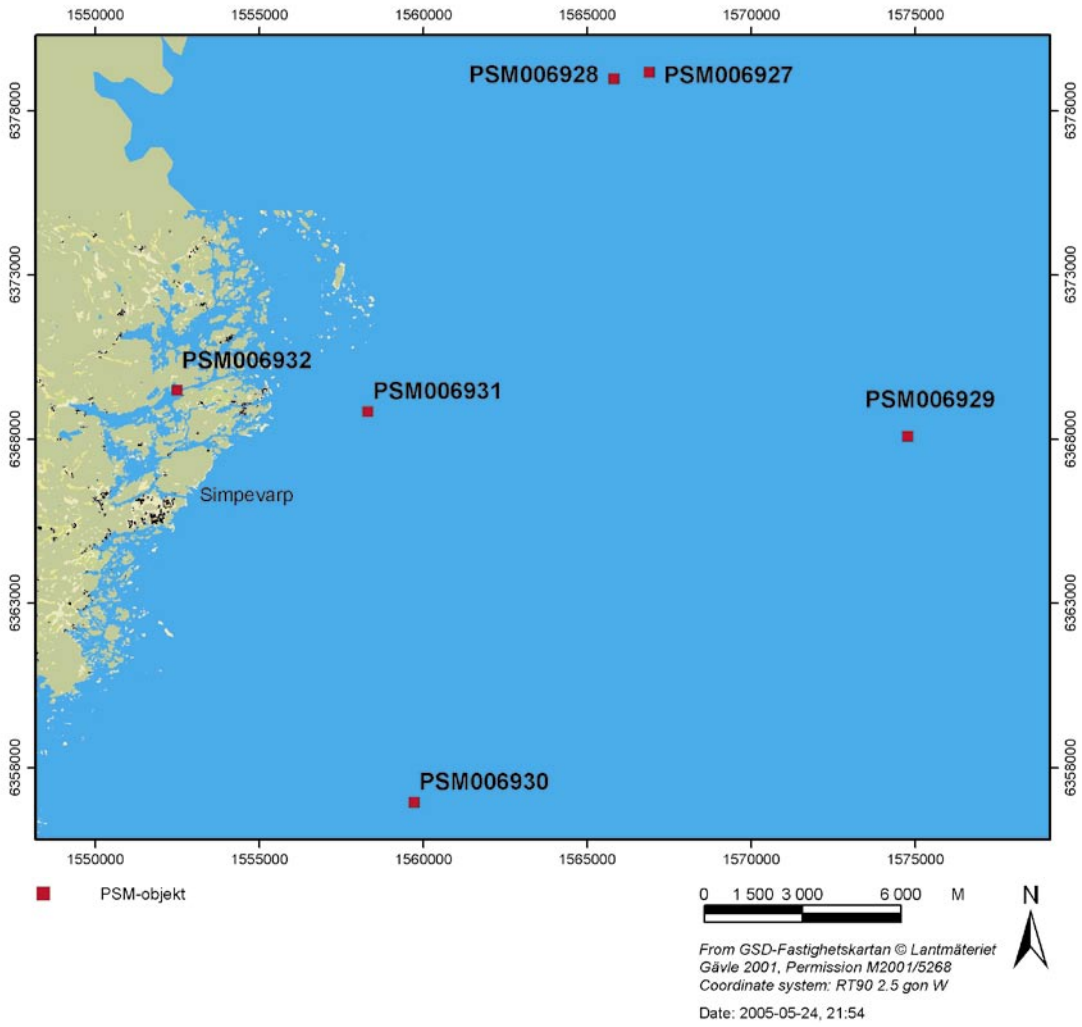

Figure 1-1. *General overview over Simpevarp site investigation area with positions of the oceanographic measurement rigs.*

Table 1-1. Controlling documents for performance of the activity.

Activity plan	Number	Version
Insamling av oceanografiska parametrar	AP PS 400-04-10	1.0
Method descriptions	**Number**	**Version**
Oceanographic measurements	SKB MD 364.009e	1.0

2 Objective and scope

The oceanographic investigation program includes measurements of temperature, salinity and currents. Measurements are conducted at five positions located along the coast at Simpevarp. The measurements are intended to describe the oceanographic conditions in the area and will even be used to validate oceanographic models over the Simpevarp area. Activities conducted by the SMHI as a subcontractor include deployment of equipment intended to collect oceanographic data, function control and operation of the equipment, registration of data and an initial quality control of the data delivered. Positions and parameters measured are given in Table 2-1 below and marked in Figure 1-1.

Table 2-1. Positions and depths as well as measured parameters for stations in the Simpevarp area.

station	position (RT90 2.5 gon V)	vertical extension	parameter	instrument
PSM006928, Northern boundary	6379016 N 1565837 E	upward, cell size 2 m	velocity components east, north, up	Nortek AQD1358
PSM006927, Northern boundary	6379201 N 1566900 E	2 m (5 m while ice covered); 10 m; 17.5 m; 30 m	temperature, conductivity, depth	Seabird microcat SBE37
PSM006929, Eastern boundary	6368104 N 157496 E	49 m	velocity	Aanderaa RCM9, Interocean Systems S4
PSM006930, Southern boundary	6356926 N 1559731 E	upward, cell size 2 m	velocity components east, north, up	Nortek AWAC
PSM006930, Southern boundary	6356926 N 1559731 E	26 m	temperature, conductivity, pressure	Valeport Typ620
PSM006931, Inner point	6368855 N 1558314 E	from 22 m up in 2 m intervals	temperature	Aanderaa TR7
PSM006931, Inner point	6368855 N 1558314 E	2 m (5 m while ice covered); 10 m; 17.5 m	temperature, conductivity	Seabird microcat SBE37
PSM006932, Djupesund	6369500 N 1552493 E	3 m	speed, direction, temperature, conductivity, density	Interocean Systems S4

3 Equipment

3.1 Description of equipment/interpretation tools

The survey was conducted from moored rigs equipped with instruments measuring temperature, conductivity and flow velocity and direction. Data were averaged over 3–5 minutes every half or full hour. Instruments used are described in Table 3-1 below. Current meters were standing on the bottom at most stations while temperature and conductivity were measured at 3–4 depth in the water column. For details on deployment depths see Table 2-1 and for sketches on the rigs see Appendix 3. On calibration and handling of the instruments see Section 4.2.

Accuracies given in Table 2-1 are those given by the manufacturer and can be obtained only under ideal circumstances during calibration in the laboratory. Under working conditions the ranges given in the method description are reasonable. Under certain circumstances it may be possible to achieve accuracies that are better than stated in the method description as was the case for current measurements in the surveillance area.

Table 3-1. Description of instruments used during the survey.

station	manufac-turer	instrument	parameter	range	resolution	accuracy
PSM006928	Nortek	AQD1358	Current-speed			1% of measured value, ±0.5 cm/s
	Nortek	AQD1358	Current-direction	360°	0.1°	2°
PSM006930	Nortek	AWAC	Current-speed			1% of measured value, ±0.5 cm/s
	Nortek	AWAC	Current-direction	360°	0.1°	2°
PSM006927, PSM006931	Seabird	microcat SBE37	pressure	0 to full scale range	0.002% of full scale range	0.15% of full scale range
	Seabird	microcat SBE37	temperature	–5°C to +35°C	0.0001°C	0.002°C
	Seabird	microcat SBE37	conductivity	0 to 7 S/m	0.0001 S/m	0.0003 S/m
PSM006929	Aanderaa	RCM9	Current-speed	0 to 300 cm/s	0.3 cm/s	±1% of reading ±0.15 cm/s
	Aanderaa	RCM9	Current-direction	360°	0.35°	±5° within tilt angles 0° to 15°; ±7.5° within tilt angles 15° to 35°
	Aanderaa	RCM9	temperature	–2.7°C +21.77°C	0.1% of range	±0.05°C
	Aanderaa	RCM9	conductivity	0 to 74 mS/cm	0.1% of range	±0.2% of range
	Aanderaa	RCM9	pressure	0 to 700 kPa	0.1% of range	±0.25%
PSM006931	Aanderaa	TR7	temperature	–0.34°C +32.17°C	0.1% of range	±0.05°C
PSM006930	Valeport	Typ620	temperature	–5°C +35°C	0.001°C	±0.0005°C
	Valeport	Typ620	conductivity	0 to 80 mS/cm	0.002 mS/cm	±0.01 mS/cm

station	manufac-turer	instrument	parameter	range	resolution	accuracy
PSM006929, PSM006932	Interocean Systems	S4	Current-speed	0 to 350 cm/s (max. depth 70 m)	0.2 cm/s	2% of reading ±1 cm/s
	Interocean Systems	S4	Current-direction	0° to 360°	0.5°	±2° within tilt angles 0° to 5°; ±4° within tilt angles 15° to 35°
	Interocean Systems	S4	temperature		0.05°C	±0.2°C
	Interocean Systems	S4	conductivity		0.1 mS/cm	±0.2 mS/cm
transects	RDI	Workhorse ADCP, vessel-mounted, 600 mHz	current	Max. depth 60 m	Depends on depth and current velocity.[1]	
comparisons	SAIV A/S	STD/CTD-model SD204	temperature	–2°C to 40°C	0.001°C	±0.01°C
	SAIV A/S	STD/CTD-model SD204	conductivity	0 to 70 mS	0.01 mS/cm	±0.02 mS/cm
	SAIV A/S	STD/CTD-model SD204	density	500 m	0.01% of range	±0.2% of range

[1] Concerning accuracy for the Acoustic Doppler Profilers from RDI the following can be stated: According to the manufacturers manual a single ping typically has an accuracy of about 0.8 cm/s. Averaging the results of multiple pings reduces the short term random error, the long-term bias is about 0.2 cm/s, setting a lower limit for error reduction.

4 Execution

4.1 General

During one calendar year continuous measurements of temperature, conductivity, current speed and current direction were conducted at five positions throughout the survey area. Conductivity was recalculated to salinity (see Section 4.4) expressed as psu (practical salinity unit).

The following method description has been used: Method description for Oceanographic Measurements (SKB MD 364.009e, SKB internal document).

4.2 Preparations

Oceanographic instruments deployed by the SMHI during surveys are sent to the manufacturer at certain intervals for calibration. In between a function and performance control is conducted before every new assignment. Below a short description of tests conducted for different instruments used during this survey.

4.2.1 Temperature and conductivity sensors

Sensors are tested in a plastic bucket containing water with a given conductivity. Conductivity in the bucket is analysed at regular intervals at an accredited laboratory. Temperature is measured by a temperature sensor calibrated at regular intervals. When instruments are deployed or recovered, a control measurement with a CTD probe calibrated at regular intervals is conducted.

4.2.2 Currentmeter, electromagnetic (Interocean Systems, type S4)

The instrument is checked by conduction a simple zero test as described in the manufacturers manual. The test is conducted in a plastic container at least 50 cm in diameter, holding approximately 150 l water.

4.2.3 Currentmeter, acoustic (ADCP, manufactured by Aanderaa (type RCM 9), RDI or Nortek (type AWAC))

The technical performance of the instruments is controlled according to the manufacturer's manual, and during deployment and recovery additional current measurements for the purpose of comparison are conducted.

4.2.4 Currentmeter, shipbound

The shipbound currentmeter is acoustic, manufactured by RDI and is controlled according to the description in Section 4.2.3 above. In addition a signal test program is performed before each use.

4.3 Execution of field work

Various types of rigs (see Appendix 1 for sketches) were deployed at five different positions throughout the survey area (see Figure 1-1 and Table 2-1). Measurements of temperature, conductivity and current with a time interval of 30 minutes or 1 hour were conducted during one calendar year between April 2004 and April 2005. Battery changes and data recovery took place 4 times during this period: Between July 5 and July 12, September 28 and October 1, 2004, January 11 and 14 and between March 29 and April 13, 2005. For details see Table 4-1.

4.4 Data handling/post processing

At SMHI the raw data were converted to ASCII and tabulated in Excel®-files. Data collected during deployment and recovery were removed. Data obviously out of the expected range were excluded as well. No spikes were left out in temperature and salinity data records. Concerning flow measurements data from the uppermost cells were eliminated. These are in the vicinity of sea level changes caused by atmospheric pressure, wind or seiches and may even be affected by waves. Over all, removal of data was only conducted for the most obvious cases. Otherwise comments were added in the Excel®-files. Further analysis and interpretation will take place during a later stage of the project when data are used to build and calibrate a model of the survey area. Salinity was calculated from conductivity by a MATLAB® seawater toolbox routine (release 1.1) using the UNESCO recommendations as outlined in /1/.

4.5 Nonconformities

In this chapter a detailed description of unforeseen obstacles during the survey is given. The numbers in the last column in Table 4-1 (pages 41–43) refer to the incidents listed here.

4.5.1 PSM006927, northern boundary

1) During the period March 31 to July 6, 2004 the temperature and conductivity sensors at 17,5 m depth didn't record data due to a printed circuit board detached from the motherboard. This was taken care of during the first service.
2) During the period July 7 to September 30, 2004 the temperature and conductivity sensors at 30 m depth did only record 15 days worth of data. The battery pack went out of function although the manufacturer guarantied a lifetime of at least one year. New batteries were installed and an operating test was conducted before redeployment.
3) It's assumed that some boat sailed into the rig on November 7, 2004, causing a leak in the upper float. According to the pressure gauge the upper instrument sank to 25 m depth. While the depth of the middle instrument is uncertain after November 7 it's assumed that the instrument at 30 m depths didn't change position. The rig was redeployed with a new float attached.

4.5.2 PSM006929, eastern boundary

4) The current meter (Aanderaa typ RCM9) was filled with water due to a broken gasket resulting in a total data loss for the first period (March 31 to July 5, 2004). A new current meter from a different manufacturer (Interocean Systems typ S4) was deployed on July 12, 2004.

5) The current meter in place during the period July 12 to September 29, 2004 ceased working after only some hours as a by the manufacturer newly installed battery for the timer stopped working. The instrument was send back to the manufacturer for additional control. A new current meter of the same type and manufacturer as the first one was deployed on October 20, 2004.

6) The current meter in place after October 20, 2004 was missing when it should be recovered. Presumably some boat sailed into the rig although it was marked with a buoy and its position was announced in the Notices for Mariners published by the Swedish Maritime Administration. Extensive dragging didn't give any hints that the instrument remained in the area. On March 4 a new instrument was deployed. The SMHI assigned Geological Survey of Sweden (SGU) to search the area with a side scan sonar. During this search the instrument rig was found lying on the ground entangled in a buoy deployed close to the rigs initial position by the Swedish Maritime Administration. SGU picked up both buoys and took them to the harbour where SMHI personnel picked up the rig. Data for the period was recovered.

4.5.3 PSM006930, southern boundary

7) The temperature and salinity sensors mounted onto Norteks ADCP didn't work properly during the period March 31 to July 6, 2004. The reason for this was faulty calibration of the sensors by the manufacturer. As the instrument was delivered late there was no time to check its functionality at SMHI before it first was deployed. In the future it should be ensured that time is designated for testing new bought instruments.

4.5.4 PSM006931, inner point

8) During the period September 30 to October 10, 2004 the battery for the sensors at 10 m depth was malfunctioning. The battery pack was replaced with a new one and the battery distributor was contacted to check for more reliable alternatives.

9) During the period October 10 to December 3 a new instrument deployed at 10 m depth showed slightly for low conductivity measurements (compared with the CTD-cast in the beginning of the period) although it was controlled before deployment. Despite this bias the data was delivered as the variation in time was comparable with the instruments above and below. Handled with care the data still may give hints about the oceanographic conditions at this place.

10) During the period December 3, 2004 to January 10, 2005 the above mentioned instrument was replaced by a new one of type Sensordata. Although the last mentioned was set up for hourly registration it resumed registering every second after the first record, fast filling the memory. Due to this no data at all was recovered for this period.

4.5.5 PSM006932, Djupesund

11) During the period July 5 to September 28 the instrument ceased working after only 10 days for unknown reason. All batteries were in good condition when the instrument was recovered. The same instrument with new batteries was deployed on September 29, 2004 after some tests. On October 10, 2004 the station was revisited to check on the instrument. The check showed the instrument working as desired.

5 Results

All Temperature and salinity data are presented as Excel®-diagrams in Appendix 2. Some examples are described here.

Figure 5-1 shows a typical annual cycle for sea water temperature close to the surface. During late winter and spring the temperature rises due to solar radiation. Later, during early summer the water column gets layered with the temperature rising faster and higher in the upper layers than further down in the water column. This layering can be destroyed in shallower waters (water depth below 20 m) in late summer, especially when stronger winds or long warm periods are present. During the autumn the temperature in the whole water column decreases to below 5°C where it stays during winter. In deeper layers the temperature shows little variation. It usually stays around 5°C at depths below 40 m with summer temperatures in the vicinity of 7 to 8°C and winter temperatures as low as 2°C. Examples for temperature measurements at greater depths can be found in Appendix 2.

In this region salinity values are between roughly 6 to 7.5 psu in the surface layers and up to 10 psu at 60 m depths. The annual cycle for salinity is not as distinctive as for temperature. Nevertheless strong winds during autumn and winter may bring higher amounts of salty water from the bottom layer to the surface (upwelling) or from regions further south (in the Baltic). This typically occurs during the period from late autumn to early spring. Less saline water at the surface can be caused by higher river runoff (for example after strong rains in late summer) or be transported into the area by currents from the north.

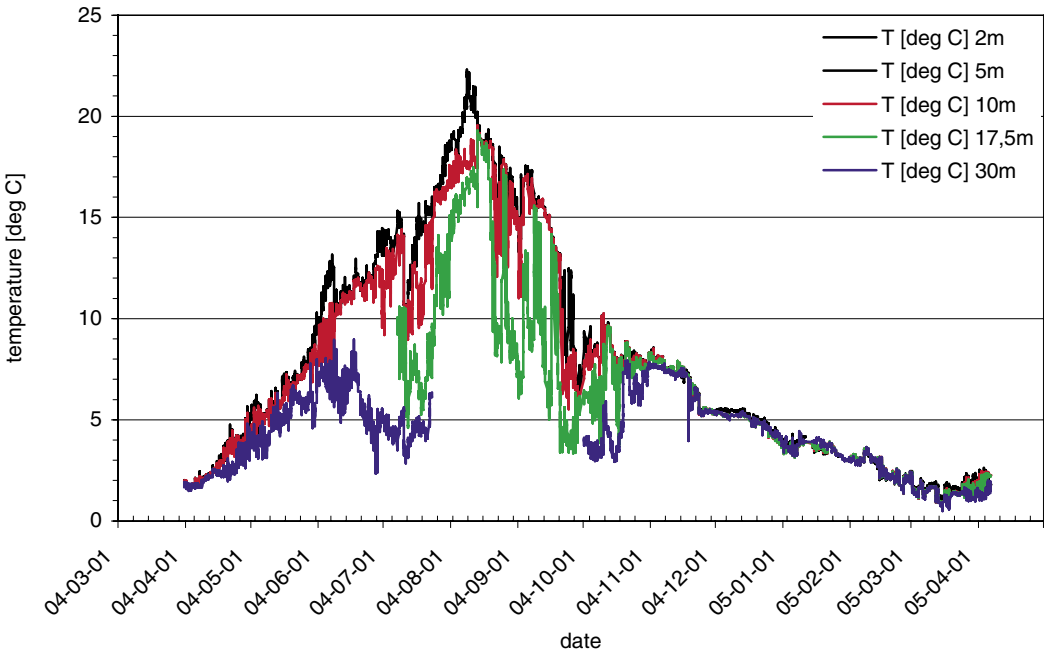

Figure 5-1. *Temperature at station PSM006927.*

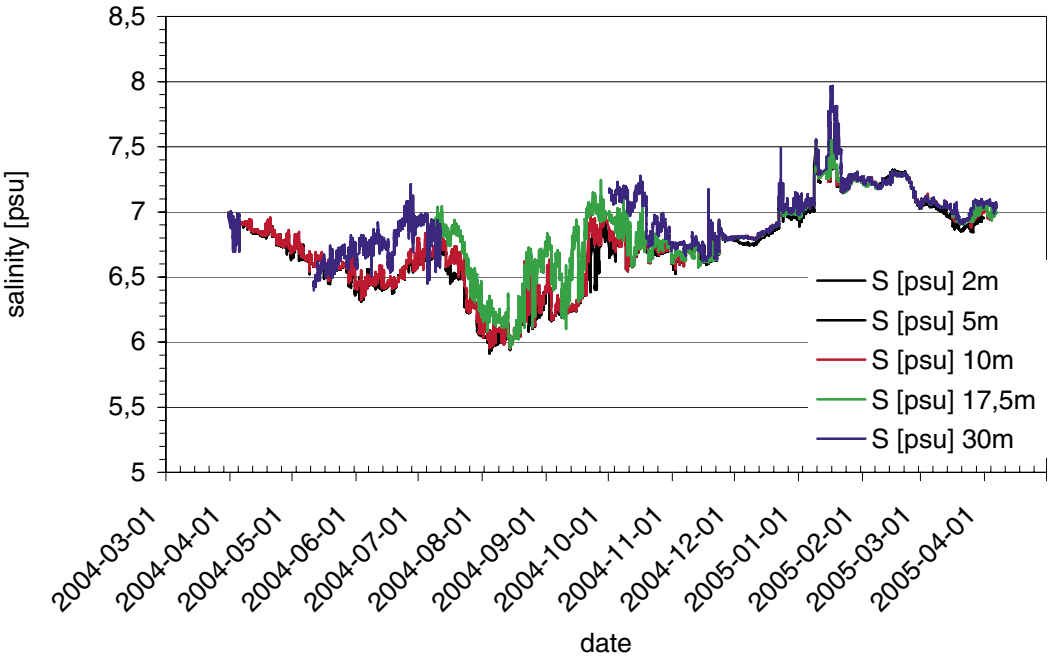

Figure 5-2. *Salinity at station PSM006927.*

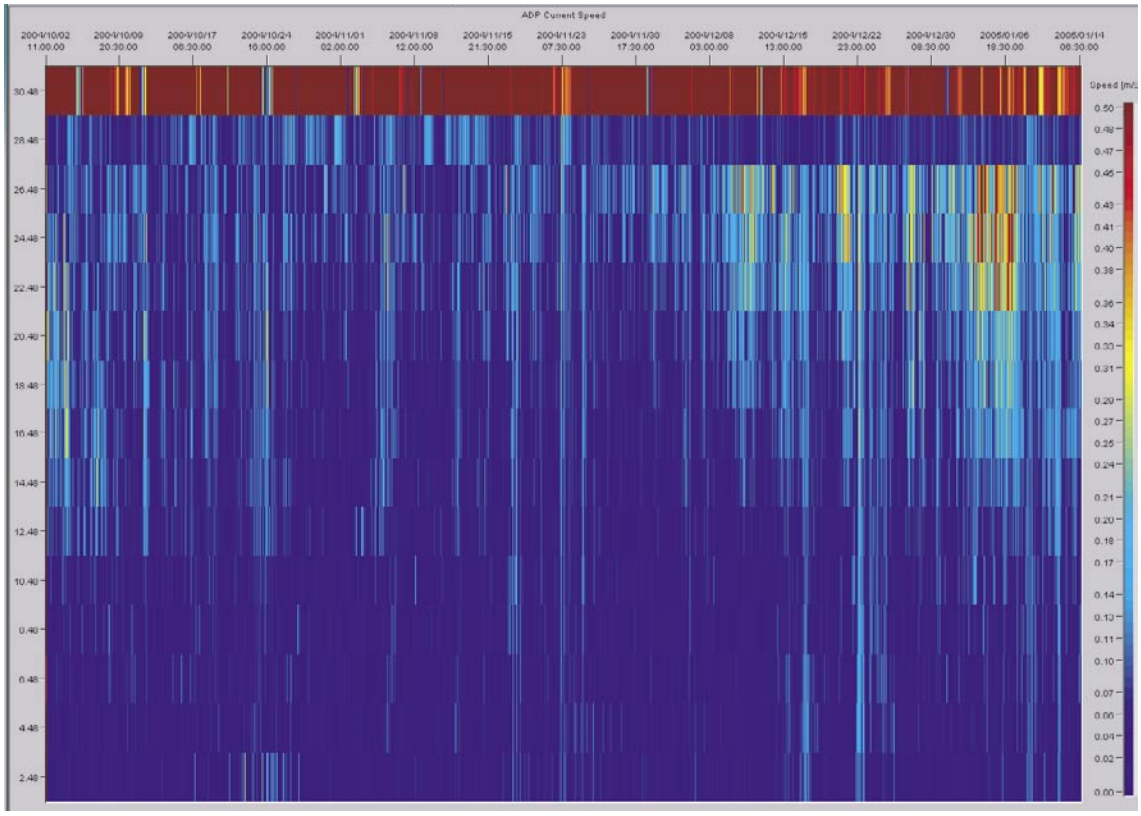

Figure 5-3. *Example of velocity measurements at PSM006928 during the last deployment period. Time (weeks) on the x-axis and depth on the y-axis. Every single line (quadrangle) represents current velocity averaged over a 2 m depth interval over a short period. The instrument measures from the bottom upward (0 m marks the bottom).*

Some examples for measured velocities are given below. Generally velocities are low (for the most part below 10 cm/s) and show high directional variability as can be seen in the lower panel of Figure 5-4. Data are either stored as direction and speed or as the north-south going part (east-west, up-down) of the current. The seemingly high velocities in the uppermost cells measured by an ADCP (as seen in Figure 5-3) are caused by the beam being influenced by the moving sea surface. Variations in sea surface height can be caused by waves or wind induced water level changes.

Original data are stored in the SICADA database. Data are traceable by the Activity Plan number (AP PS 400-04-10). The files listed below in Table 5-1 contain data from the oceanographic measurement campaign.

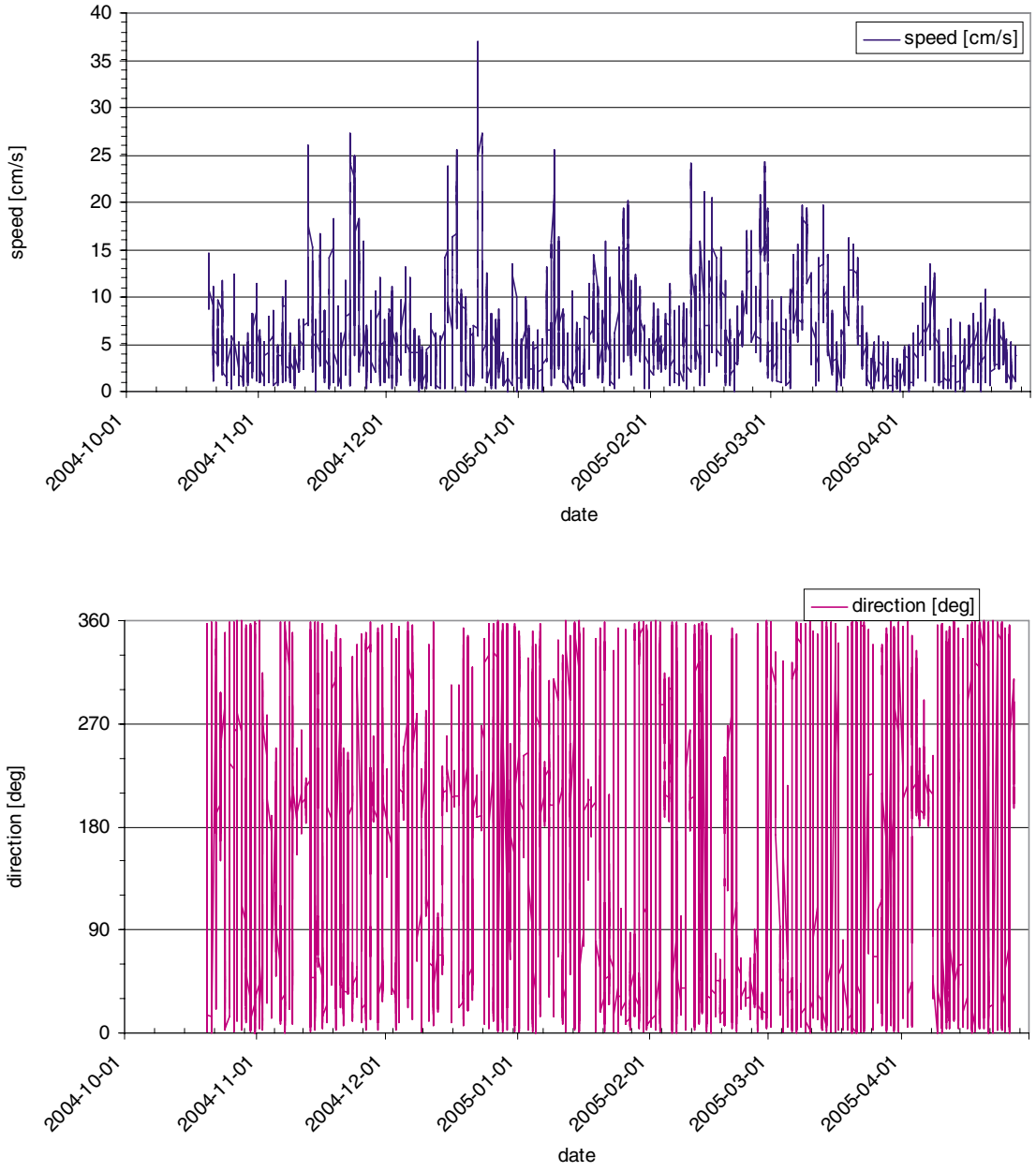

Figure 5-4. *Magnitude (top) and direction (bottom) of currents at PSM006929 between October 2004 and April 2005.*

Table 5-1. Filenames and contents.

period	station	filename	contents
2004-03-31 to 2004-07-06	PSM006928	Si21_101_V1_korr.xls	northward velocity
		Si21_101_V2_korr.xls	eastward velocity
		SI21-101_V3_korr.xls	uppward velocity
	PSM006927	SBE37_Si21_2m.xls	T, cond, S
		SBE37_Si21_10m.xls	T, cond, S
		SBE37_Si21_30m.xls	T, cond, S
2004-03-31 to 2004-07-06	PSM006930	Si23_101_V1.xls	northward velocity
		Si23_101_V2.xls	eastward velocity
		Si23_101_V3.xls	uppward velocity
	PSM006931	SBE37_Si24_2m.xls	T, cond, S
		SBE37_Si24_10m.xls	T, cond, S
		Si24_17m.xls	T, cond, S
		Si24_T_1.xls	T
	PSM006932	s4_djupesund.xls	velocity direction and speed, T, cond, S
2004-07-05 to 2004-09-30	PSM006928	Si21-201_v1.xls	northward velocity
		Si21-201_v2.xls	eastward velocity
		Si21-201_v3.xls	uppward velocity
		Si21-301_v1.xls	northward velocity
		Si21-301_v2.xls	eastward velocity
		Si21-301_v3.xls	uppward velocity
		SI21_201_sen.xls	T and p
		SI21_301_sen.xls	T and p
	PSM006927	Si21_2m.xls	T, cond, S
		Si21_10m.xls	T, cond, S
		SI21_17.5m.xls	T, cond, S
		Si21_30m.xls	T, cond, S
	PSM006930	Si23-201_v1.xls	northward velocity
		Si23-201_v2.xls	eastward velocity
		Si23-201_v3.xls	uppward velocity
		Si23-301_v1.xls	northward velocity
		Si23-301_v2.xls	eastward velocity
		Si23-301_v3.xls	uppward velocity
		Si23-401_v1.xls	northward velocity
		Si23-401_v2.xls	eastward velocity
		Si23-401_v3.xls	uppward velocity
		Si23-201_sen.xls	T and p
		Si23-301_sen.xls	T and p
		Si23-401_sen.xls	T, cond, S and p
	PSM006931	Si24_2m.xls	T, cond, S
		Si24_10m.xls	T, cond, S

period	station	filename	contents
		Si24_17.5m.xls	T, cond, S
		T3035 Si24juli–sept 2004.xls	T
	PSM006932	Si25_040928.xls	velocity direction and speed, depth, T, cond, S
period	station	filename	contents
2004-09-29 to 2005-01-14	PSM006928	Si21-401_v1.xls	northward velocity
		Si21-401_v2.xls	eastward velocity
		Si21-401_v3.xls	uppward velocity
		Si21-401_sen.xls	T and p
	PSM006927	si21_2m.xls	T, cond, S
		si21_10m.xls	T, cond, S
		si21_17.5m.xls	T, cond, S
		si21_30m.xls	T, cond, S
	PSM006930	si23-302_v1.xls	northward velocity
		si23-302_v2.xls	eastward velocity
2004-09-29 to 2005-01-14	PSM006930	si23-302_v3.xls	uppward velocity
		si23-302_sen.xls	T, cond and p
	PSM006931	si24_2m.xls	T, cond, S
		si24_10m.xls	T, cond, S
		si24_17.5m.xls	T, cond, S
		AaT3040 Si24T.xls	T
	PSM006932	Si25_3.xls	velocity direction and speed, depth, T, cond, S
2005-01-11 to 2005-04-13	PSM006928	Si21-4_AQD1358_v1.xls	northward velocity
		Si21-4_AQD1358_v2.xls	eastward velocity
		Si21-4_AQD1358_v3.xls	uppward velocity
		Si21-4_AQD1358_sen.xls	T and p
	PSM006927	Si21-4_SBE37-130_5m.xls	depth, T, cond, S
		Si21-4_SBE37-129_10m.xls	T, cond, S
		Si21-4_SBE37-124_17.5m.xls	T, cond, S
		Si21-4_SBE37-126_30m.xls	T, cond, S
	PSM006929	Si22-4_AaS3038-49m.xls	velocity direction and speed, T
		Si22-3-4_AaS3039.xls	velocity direction and speed, T, cond, S
	PSM006930	Si23-4_AWAC_v1.xls	northward velocity
		Si23-4_AWAC_v2.xls	eastward velocity
		Si23-4_AWAC_v3.xls	uppward velocity
		Si23-4_AWAC_sen.xls	T1, T2, cond, S and p
	PSM006931	Si24-4_SBE37-127_5m.xls	T, cond, S
		Si24-4_SBE37-128_10m.xls	T, cond, S
		Si24-4_SBE37-125_17.5m.xls	T, cond, S
	PSM006932	Si25-4_S4.xls	velocity direction and speed, T, cond, S

To be able to evaluate the measured time series, comparison measurements were conducted. At positions where temperature and salinity were measured frequently CTD-casts were done when instruments were recovered for data collection. Additional velocity transects were carried out along the survey areas boundaries. Appendix 3 shows plots of the CTD-casts grouped after position. The dates at which transects were conduced are found in Table 5-2 as well as the positions at which transects start and end.

Table 5-2. Transects.

lename	description	date	start N (RT90 2,5 gon W)	E (RT90 2,5 gon W)	stop N (RT90 2,5 gon W)	E (RT90 2,5 gon W)
Simp041	southern boundary	2004-04-28	6356897	1562892	6356807	1558915
Simp100	northern boundary	2004-10-20	6379133	1566044	6379210	1562781
Simp070	southern boundary	2004-07-07	se Simp041			
Simp006	northern boundary	2005-04-13	6378785	1562489	6379208	1566105
Simp007	eastern boundary	2005-04-13	6370201	1576547	6367085	1574601

References

/1/ **Fofonoff N P, Millard Jr R C, 1983.** Algorithms for computation of fundamental properties of seawater. Unesco technical papers in marine sciences 44.

Appendix 1

Rigs

SKB OceanSimpevarp
Station SI 21. Norra randen E.
Aqua Dopp-ADCP

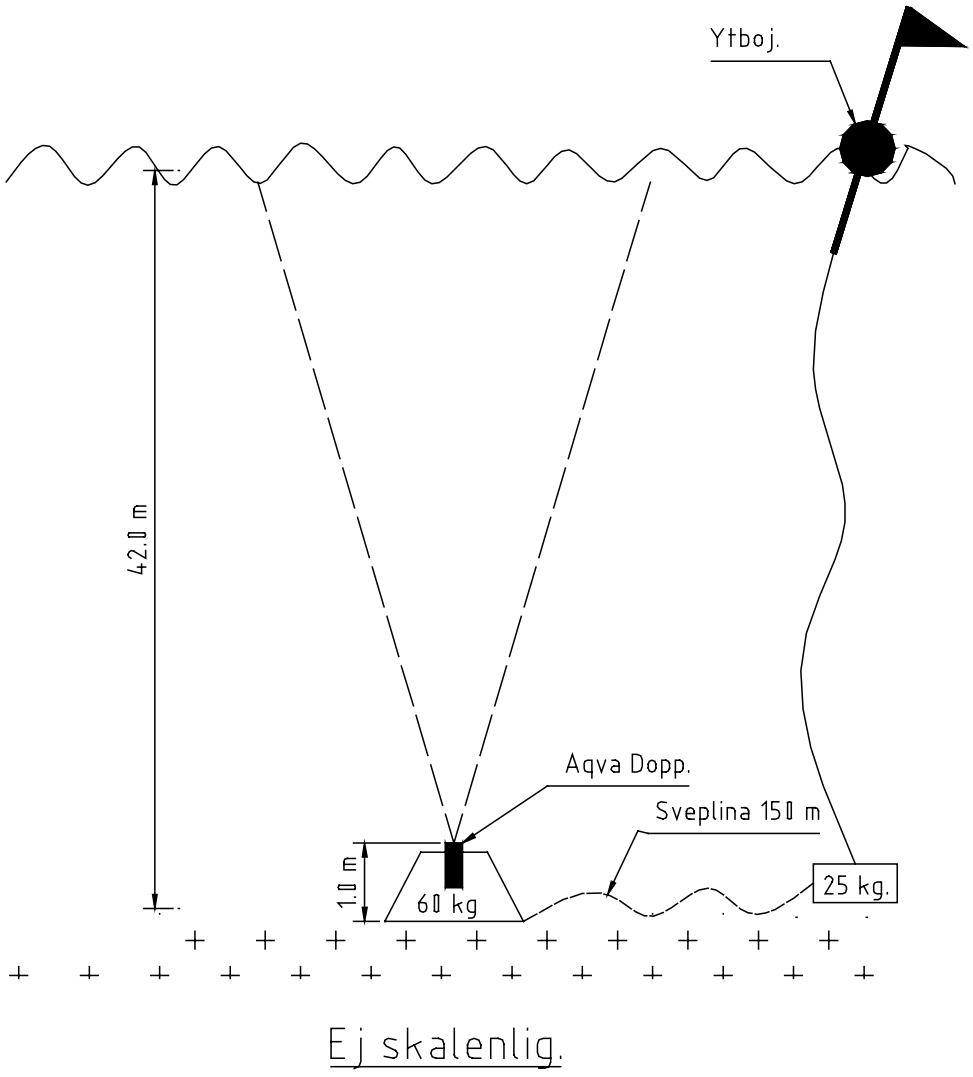

Figure A1-1. *ADCP rig at position PSM006928, not to scale.*

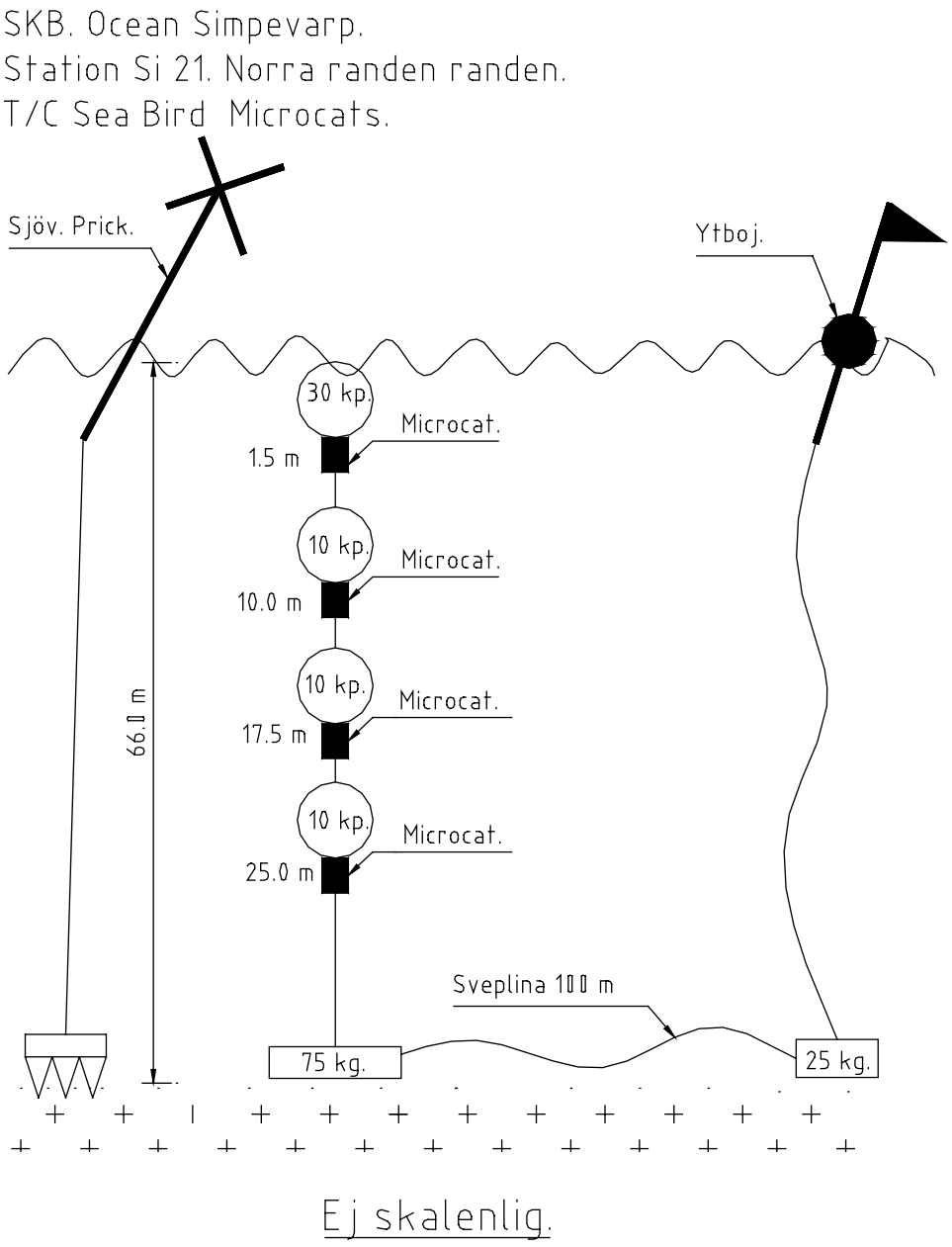

Figure A1-2. *Temperature and conductivity sensors at position PSM006927, not to scale.*

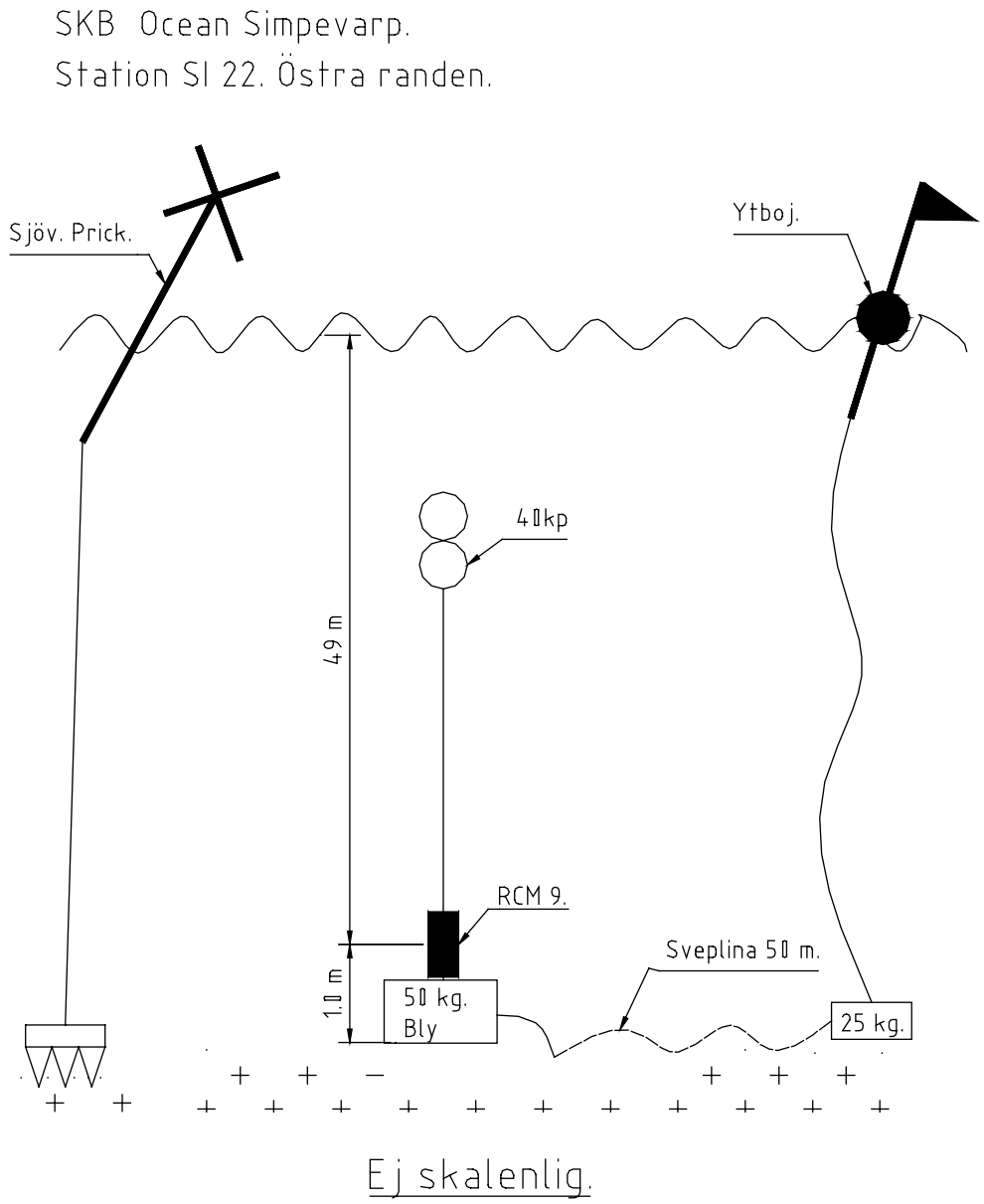

Figure A1-3. *Current, temperature and conductivity sensors at position PSM006929, not to scale.*

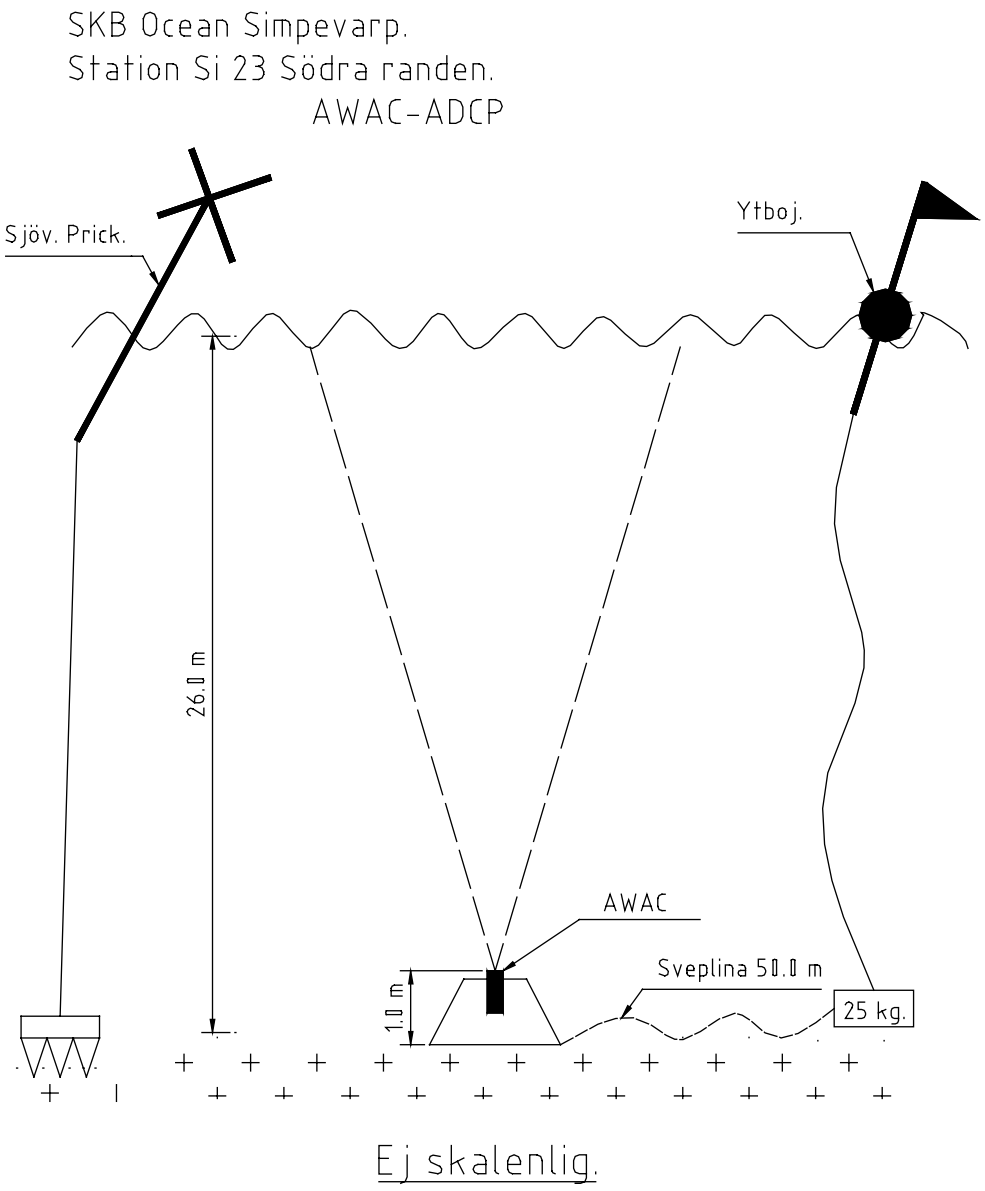

Figure A1-4. *ADCP rig at position PSM006930, not to scale.*

SKB Ocean Simpevarp.
Station SI 24 T. Endast icke islagd period.
AaTR 7.

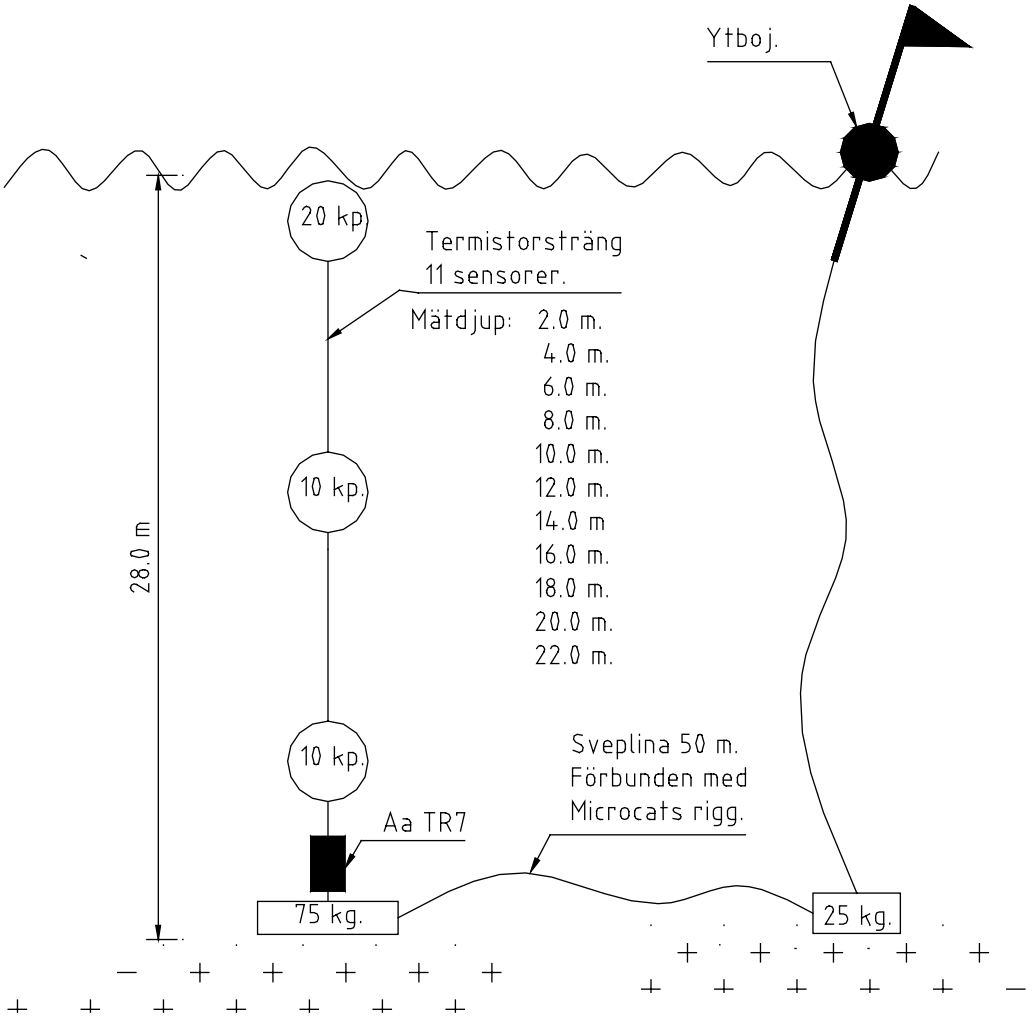

Figure A1-5. *Temperature rig at position PSM006931, not to scale.*

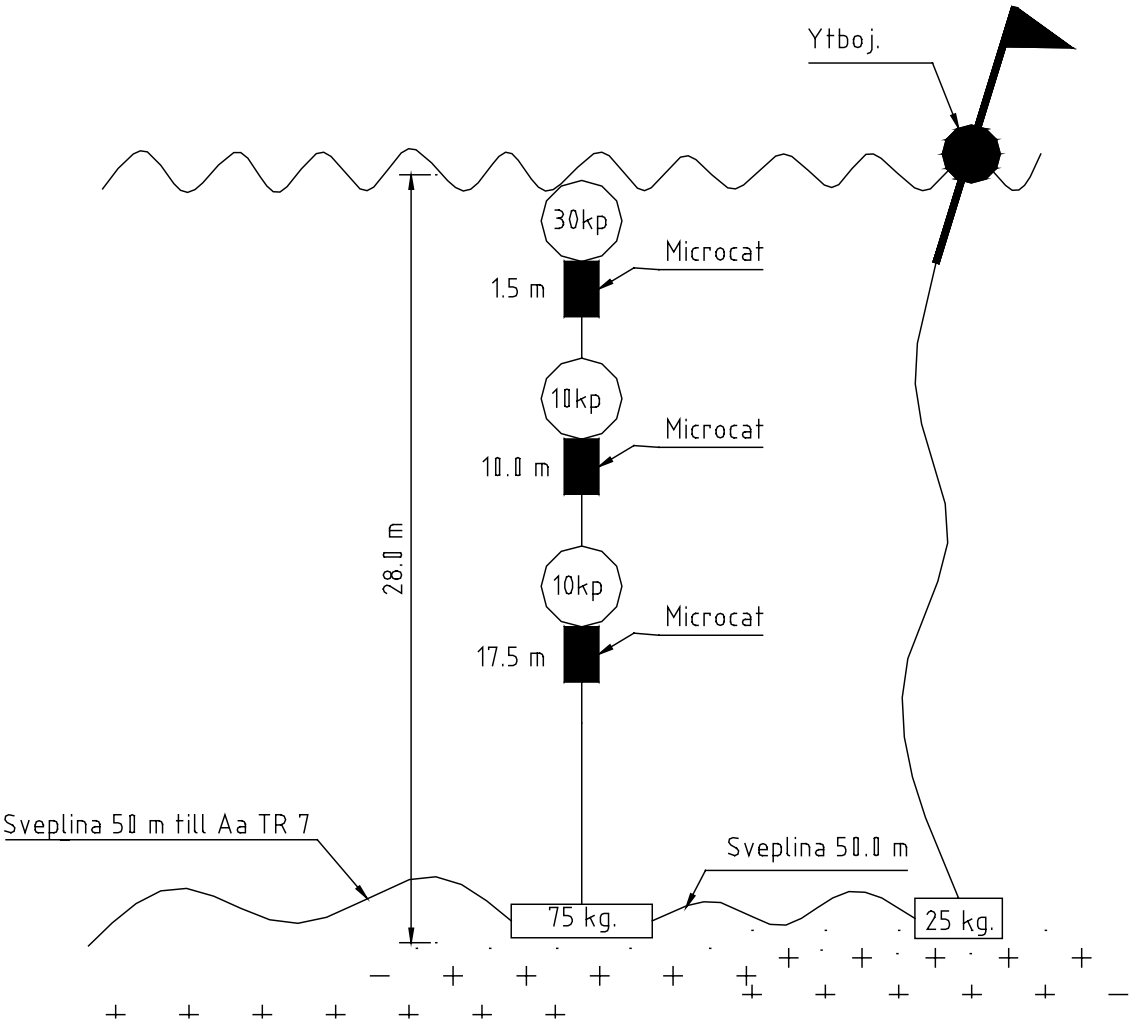

Figure A1-6. *Temperature and conductivity sensors at position PSM006931, not to scale.*

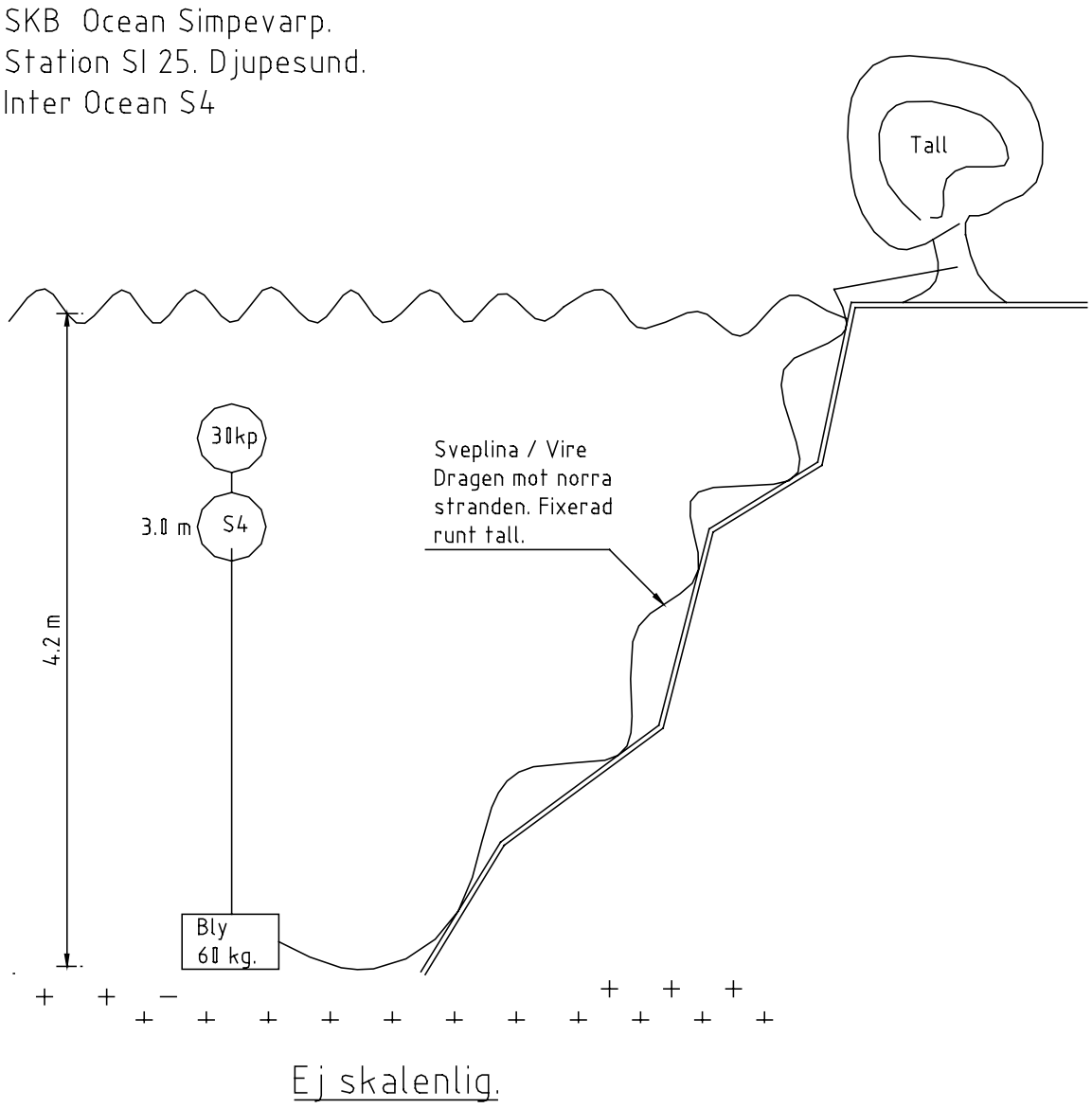

Figure A1-7. *Current, temperature and conductivity sensors at position PSM006932, not to scale.*

Appendix 2

Temperature and salinity plots

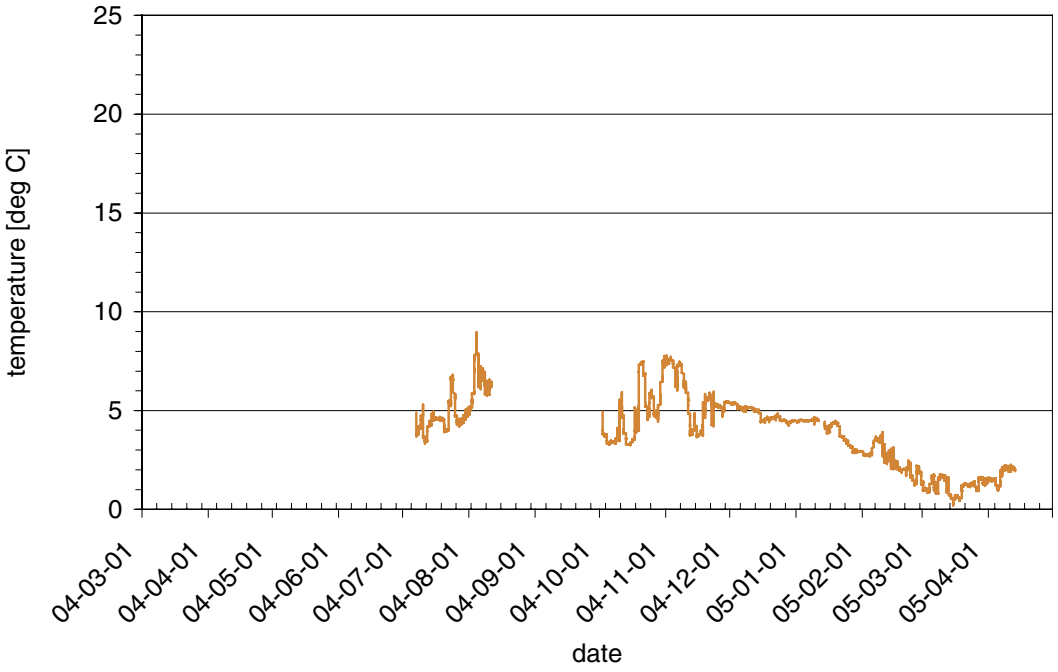

Figure A2-1. *Temperature at station PSM006928 (at 40–45 m depth).*

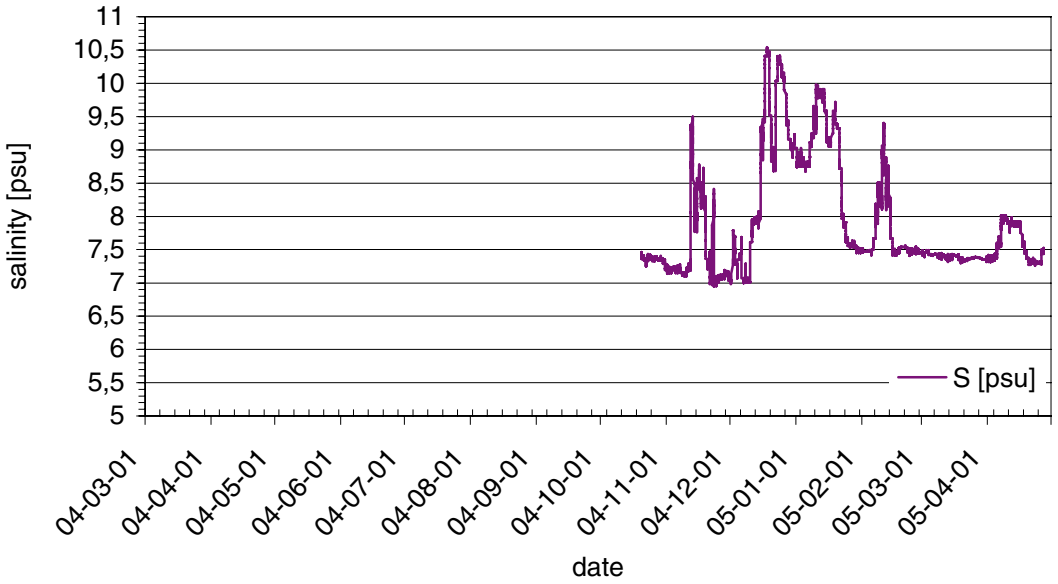

Figure A2-2. *Temperature at station PSM006929 (at 58 m depth).*[2]

[2] During a short period in march 2005 there were two instruments deployed at roughly the same position, see 4.5.2 6).

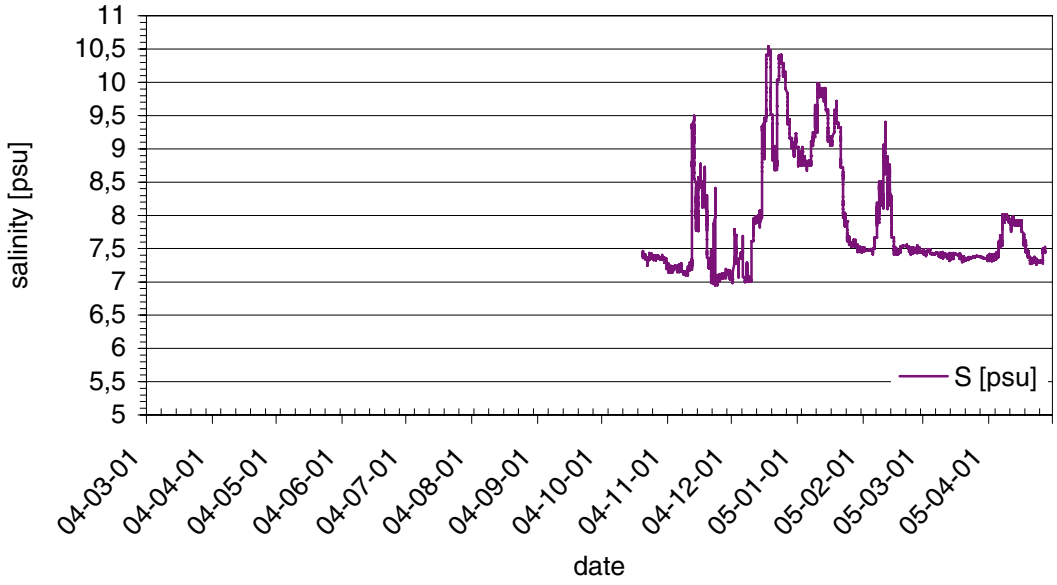

Figure A2-3. *Salinity at station PSM006929 (at 58 m depth).*

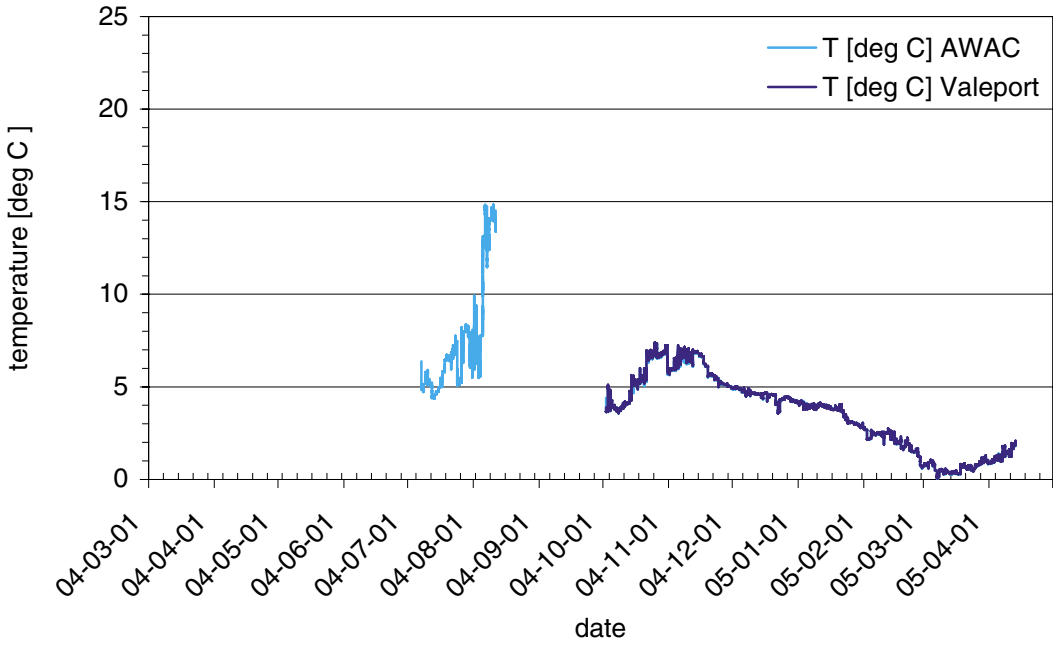

Figure A2-4. *Temperature at station PSM006930 (at 30 m depth).*[3]

[3] AWAC and Valeport refers to two different types of instrument deployed at this station. During some periods both instruments were deployed at the same time, but the measured values aren't distinguishable in the graph.

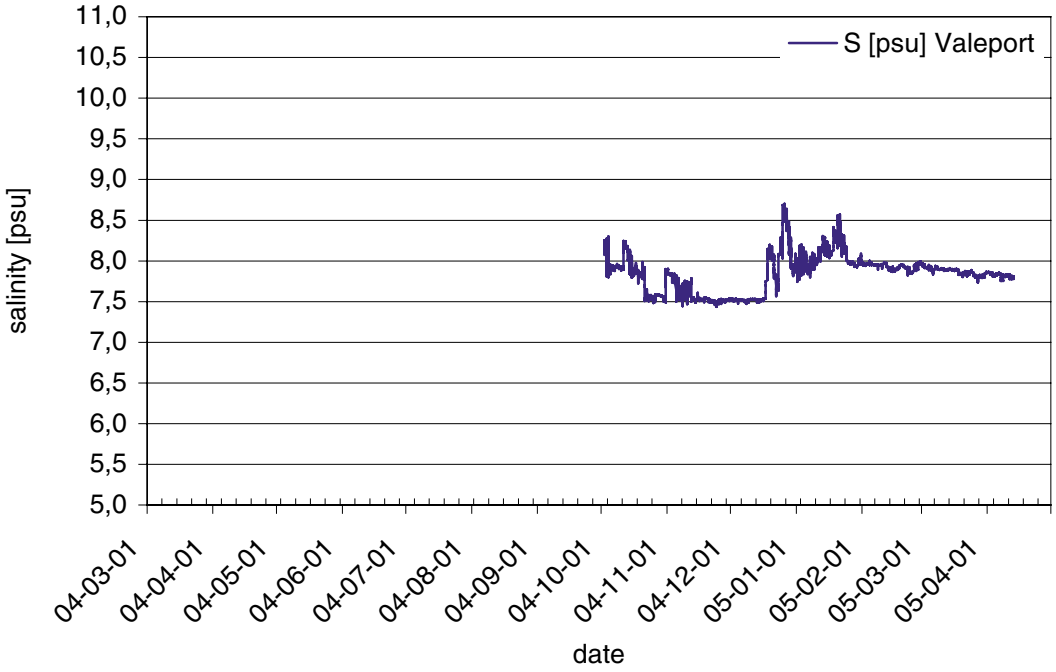

Figure A2-5. *Salinity at station PSM006930 (at 30 m depth).*

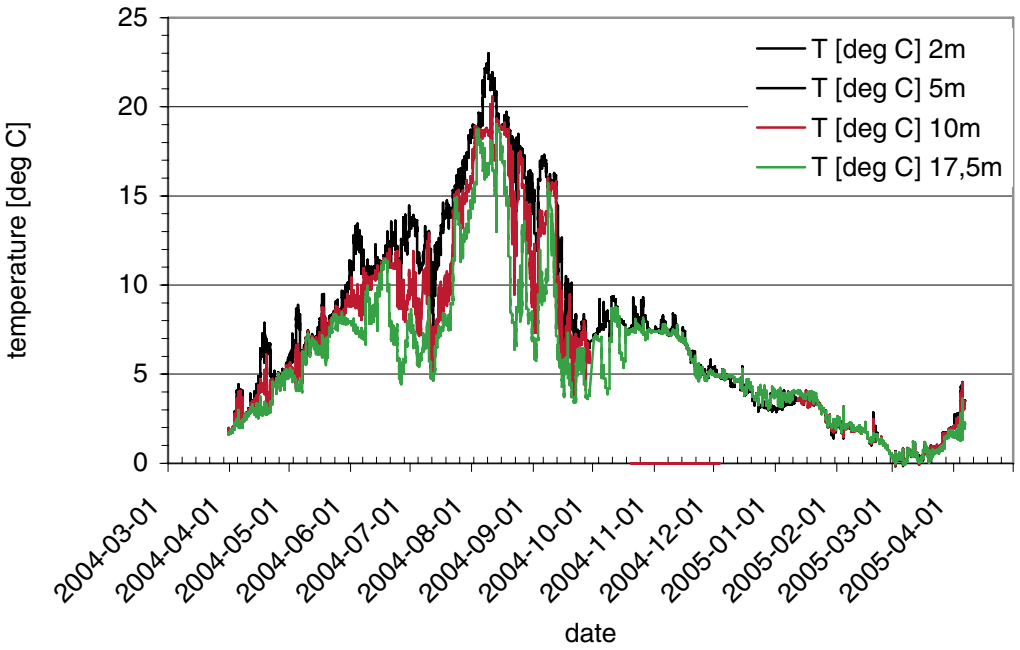

Figure A2-6. *Temperature at station PSM006931.*

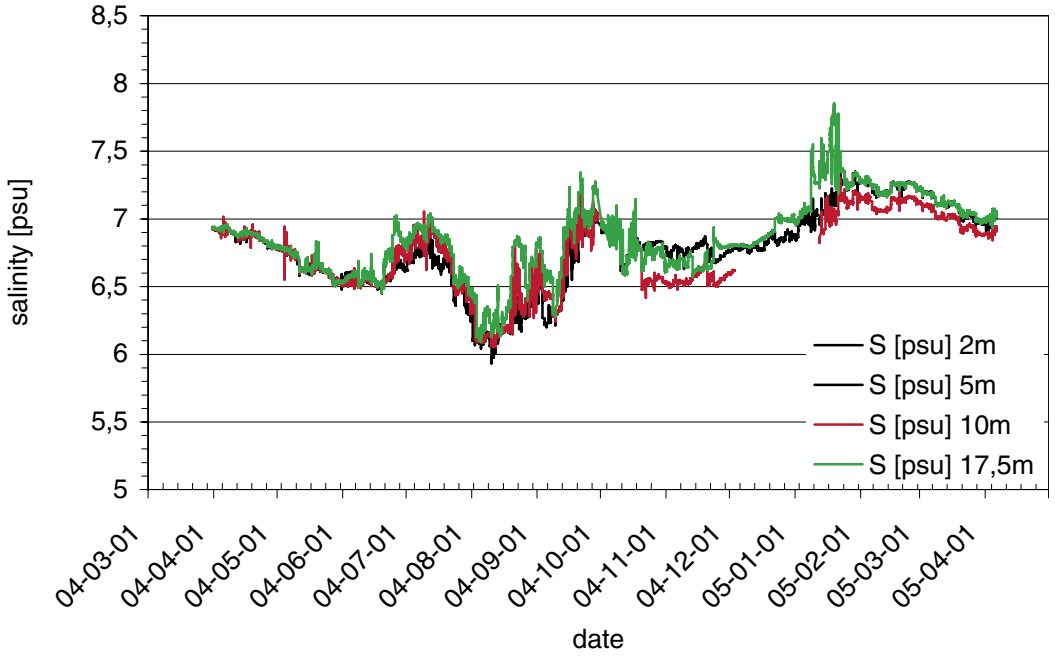

Figure A2-7. *Salinity at station PSM006931.*

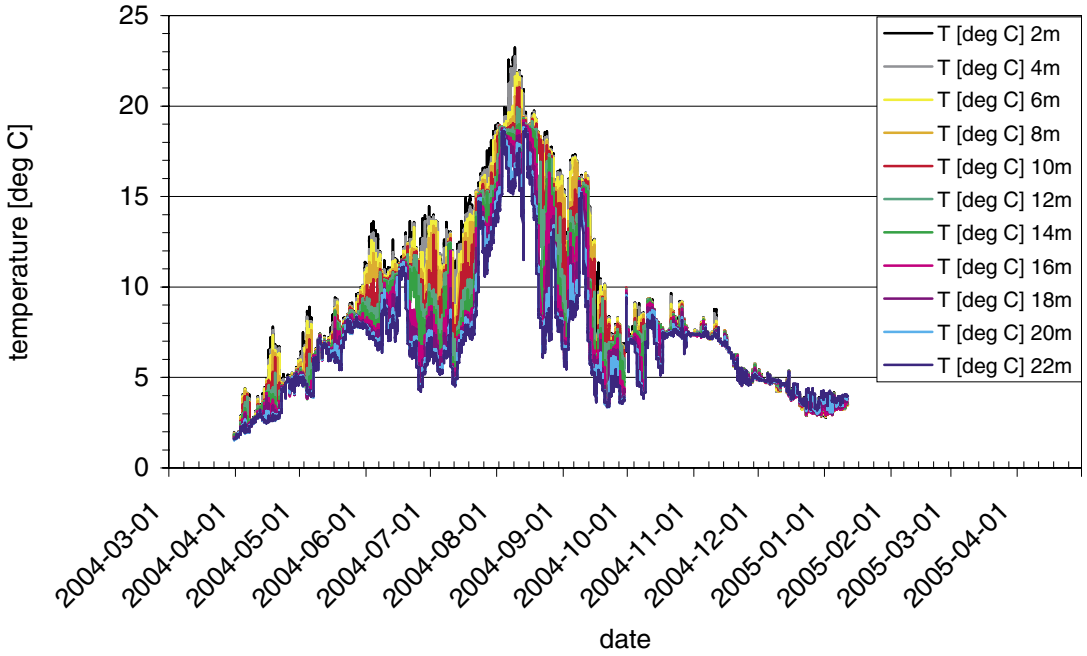

Figure A2-8. *Temperature at station PSM003931.*

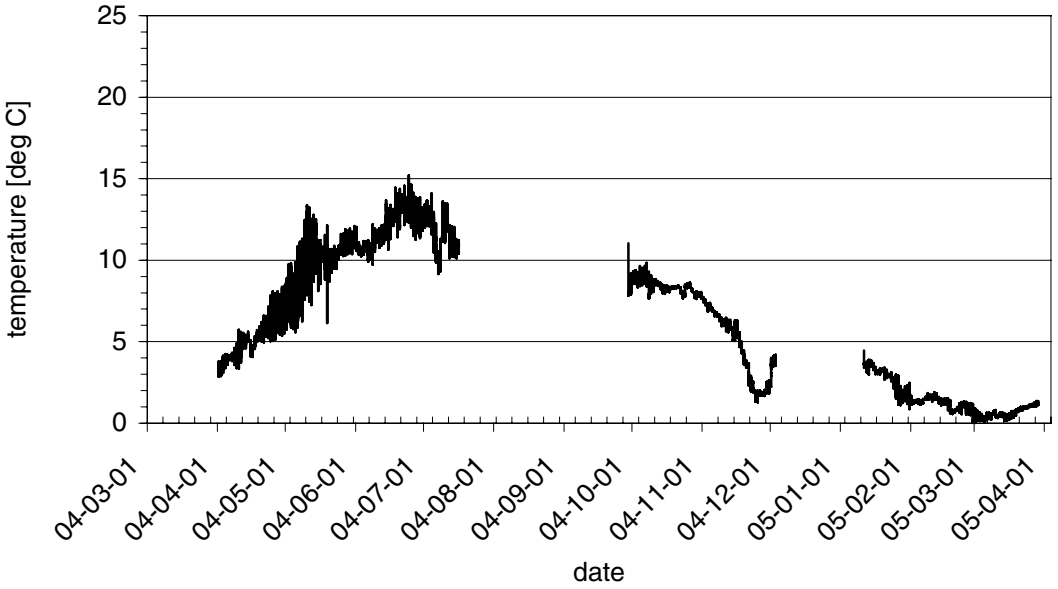

Figure A2-9. *Temperature at station PSM006932 (at 4.2 m depth).*

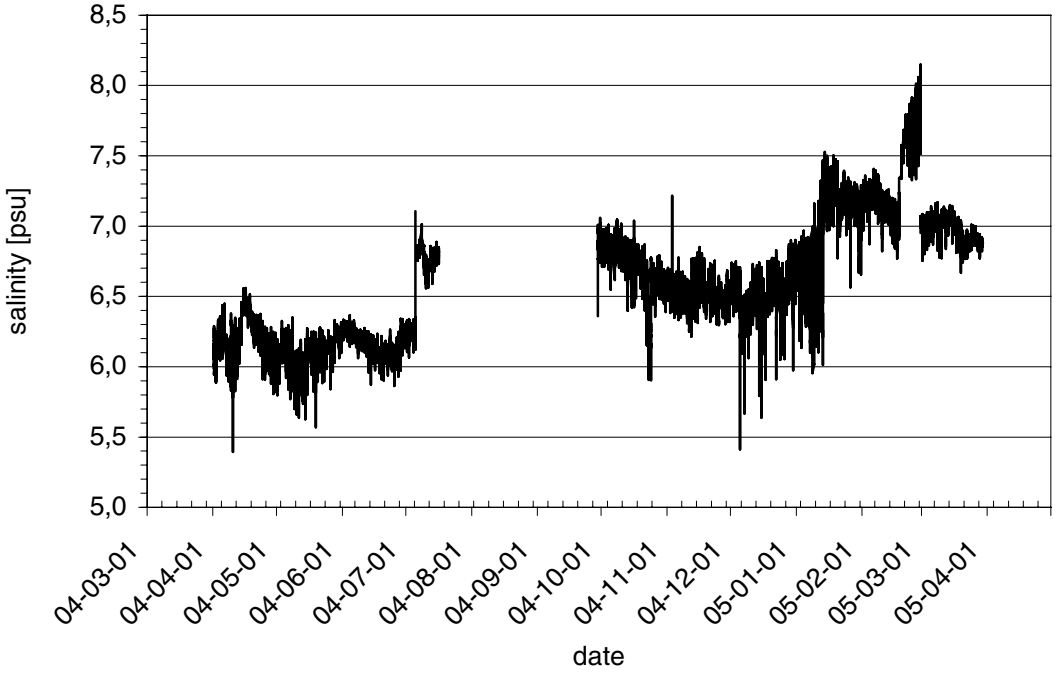

Figure A2-10. *Salinity at station PSM006932 (at 4.2 m depth).*

Appendix 3

CTD-casts

For comparison with the continuously measured temperatures and salinities, a CTD-probe was frequently lowered from the boat when equipment was deployed, checked or when memory was read out during the campaign. Data from these measurements are displayed in this appendix grouped after station (Figures A3-1 to A3-5). Sometimes two CTD casts are conducted at the same day, the first one usually was done when the rig was recovered, the second one when it once again was deployed. In the method description (SKB MD 364.0009e) the required accuracies for temperature and salinity are given as 0.1°C and 0.1 psu respectively. The Tables A3-1 to A3-6 list temperature and salinity values as measured at a station at the beginning and end of a period as close in time to the CTD casts as possible (headings PSM0069xx-S, PSM0069xx-T respectively). Columns marked CTD-S and CTD-T show temperature and salinity as measured by the CTD probe at the same depth as the probes on the rig ore close to it. Comparison between results from the CTD-probe and data collected continuously shows that the above mentioned accuracies were achieved in most cases. If they aren't that doesn't necessary mean that instruments are faulty. One reason may be barnacles on the salinity sensor. Strong layering may be a reason for higher differences in temperature measurements (an example can be found at station PSM006931). An exact correlation of times and depths isn't possible at all times, and can with strong layering circumstances vary on short space and time scales.

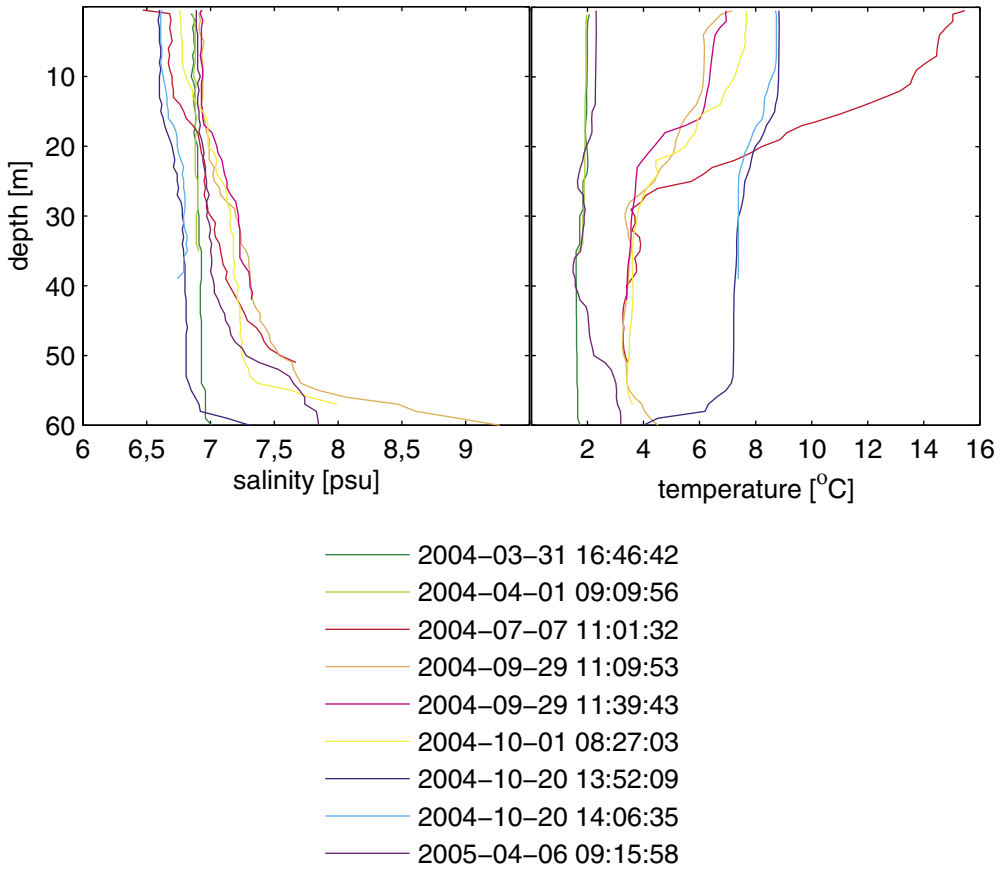

Figure A3-1. *Salinity and temperature versus depth at station PSM006927/PSM006928, northern boundary.*

Table A3-1. Comparison of temperature and salinity as measured by CTD/rig respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-1. Measurements conducted at station PSM006927/PSM006928.

2004-03-31 16:46	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	2	6,880	6,981	2,01	2,01
	10	6,850	6,978	1,99	1,99
	17	6,880	–	1,93	–
	30	6,910	6,977	1,72	1,66

2004-04-01 09:09	Depth	CTD-S	PSM0006928-S	CTD-T	PSM006928-T
	2	6,870	6,976	1,96	1,87
	10	6,870	6,980	1,95	1,85
	17	6,880	–	1,92	–
	30	6,890	7,004	1,83	1,64

2004-07-07 11:01	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	2	6,690	6,660	15,04	14,64
	10	6,700	6,668	13,61	13,63
	17	6,860	6,920	9,65	9,37
	30	7,000	6,887	3,69	3,60
	42	7,210		3,35	4,90

2004-09-29 11:09	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	2	6,920	6,927	6,53	6,06
	10	6,940	6,972	6,14	6,16
	17	6,960	7,005	5,34	5,31
	30	7,200	–	3,33	6,35

2004-09-29 11:39	Depth	CTD-S	PSM0006928-S	CTD-T	PSM006928-T
	2	6,940	–	6,96	–
	10	6,940	–	6,36	–
	17	6,950	–	5,49	–
	30	7,220	–	3,58	–

2004-10-01 08:27	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	2	6,770	6,720	7,67	8,44
	10	6,810	6,868	7,25	7,03
	17	6,980	6,965	5,91	6,45
	30	7,160	7,174	3,79	3,96

2004-10-20 13:52	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	2	6,590	6,616	8,84	8,85
	10	6,600	6,621	8,82	8,83
	17	6,640	6,671	8,38	8,37
	30	6,780	6,791	7,40	7,45

2004-10-20 14:06	Depth	CTD-S	PSM0006928-S	CTD-T	PSM006928-T
	2	6,610		8,74	
	10	6,630		8,58	
	17	6,710		8,04	
	30	6,790		7,39	
	45		–		7,44

2005-04-06 09:15	Depth	CTD-S	PSM0006927-S	CTD-T	PSM006927-T
	5	6,900	4,225	2,31	1,79
	10	6,920	6,998	2,30	2,25
	17	6,920	2,258	2,16	2,26
	30	6,970	7,070	1,88	1,37
	40	7,030	–	1,57	2,13

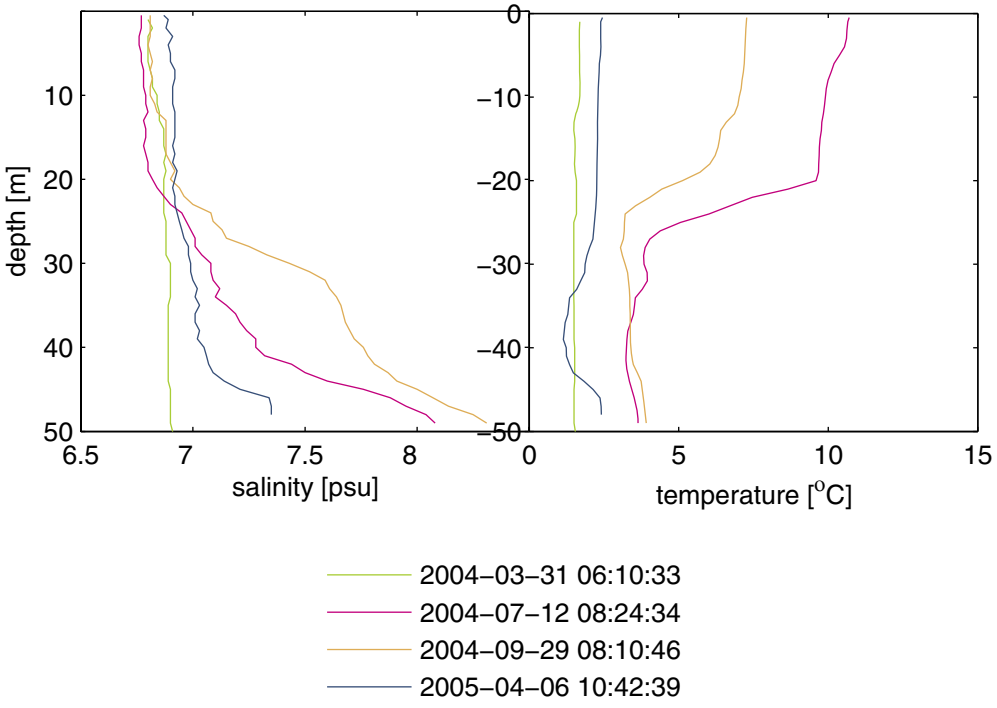

Figure A3-2. *Salinity and temperature versus depth at station PSM006929, eastern boundary.*

Table A3-2. Comparison of temperature and salinity as measured by CTD/rig respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-2. Measurements conducted at station PSM006929.

2004-03-31 06:10	Depth	CTD-S	PSM006929-S	CTD-T	PSM006929-T
	48	6,900	–	1,50	–
	49	6,900	–	1,50	–
	50	6,910	–	1,54	–
	58		–		–

2004-07-12 08:24	Depth	CTD-S	PSM006929-S	CTD-T	PSM006929-T
	48	8,040	–	3,62	–
	49	8,080	–	3,64	–
	50		–		–
	58		–		–

2004-09-29 08:10	Depth	CTD-S	PSM006929-S	CTD-T	PSM006929-T
	48	8,250	–	3,88	–
	49	8,310	–	3,92	–
	50		–		–
	58		–		–

2005-04-06 10:42	Depth	CTD-S	PSM006929-S	CTD-T	PSM006929-T
	48	7,350	–	2,41	–
	49		–		–
	50		–		–
	58		7,632		2,41

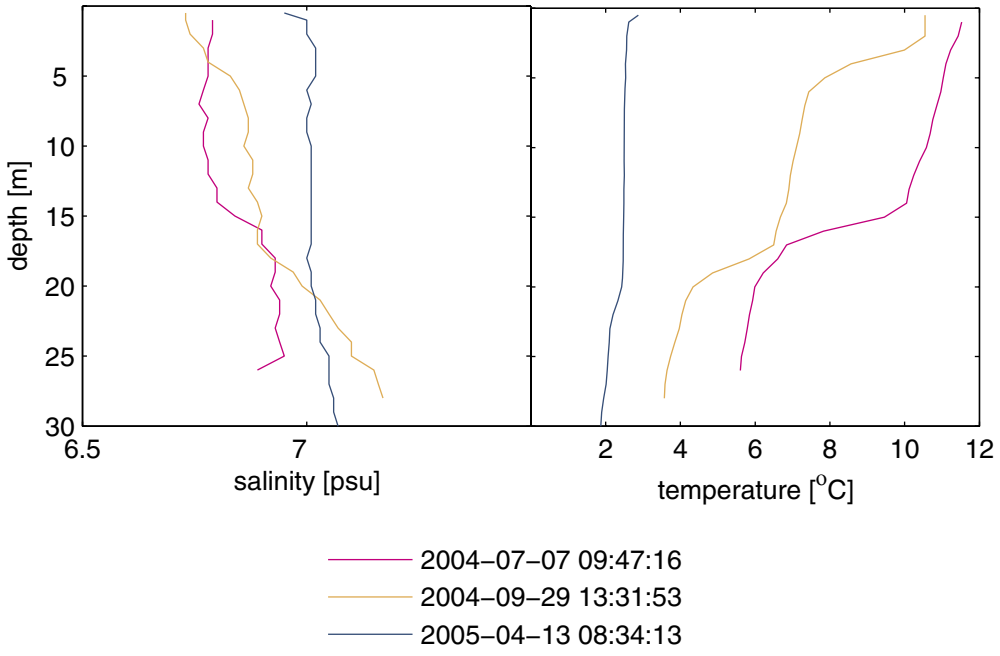

Figure A3-3. *Salinity and temperature versus depth at station PSM006930, southern boundary.*

Table A3-3. Comparison of temperature and salinity as measured by CTD/rig respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-3. Measurements conducted at station PSM006930.

2004-07-07 09:47	Depth	CTD-S	PSM006930-S	CTD-T	PSM006930-T
	26	6,890	–	5,61	6,37
	28				
	30				

2004-09-29 13:31	Depth	CTD-S	PSM006930-S	CTD-T	PSM006930-T
	26	7,150	–	3,64	–
	28	7,170	7,934	3,57	3,64
	30				

2005-04-13 08:34	Depth	CTD-S	PSM006930-S	CTD-T	PSM006930-T
	26	7,050	–	2,04	–
	28	7,060	–	1,95	–
	30	7,070	7,799	1,87	1,91

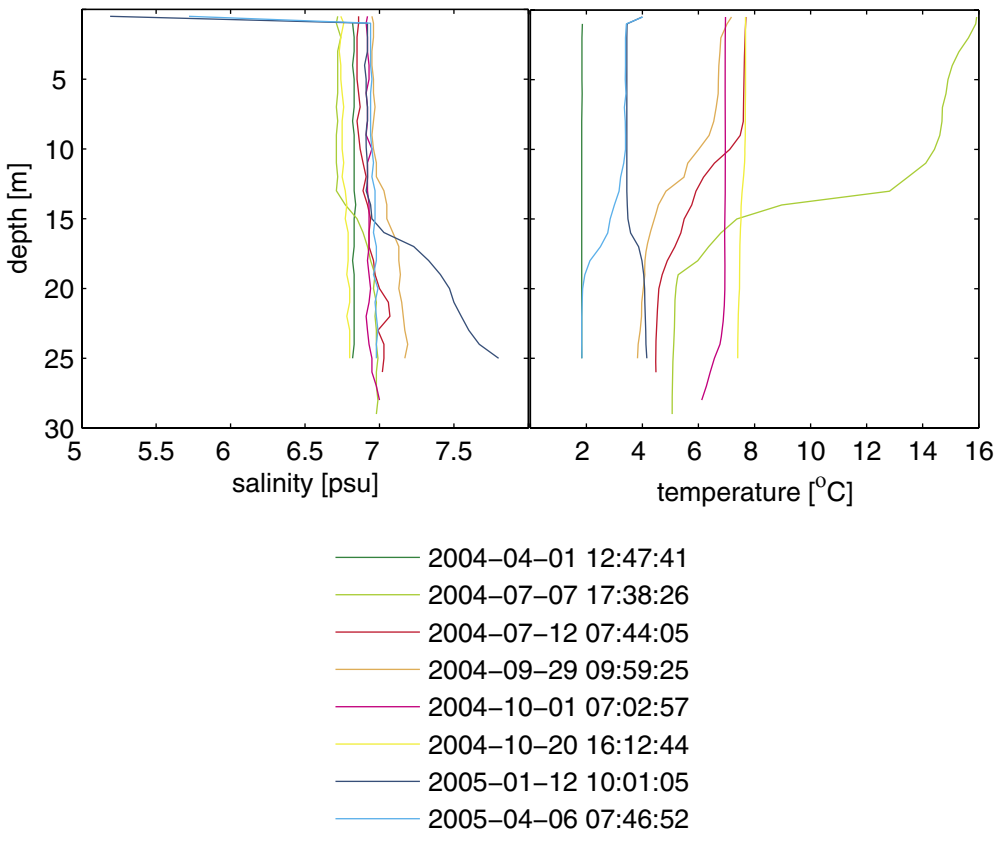

Figure A3-4. *Salinity and temperature versus depth at station PSM006931, inner point.*

Table A3-4. Comparison of temperature and salinity as measured by CTD/rig respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-4. Measurements conducted at station PSM006931.

2004-04-01 12:47	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,830	6,924	1,84	1,86
	10	6,830	6,928	1,84	1,84
	17	6,830	6,927	1,83	1,83

2004-07-07 17:38	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,740	6,763	15,63	11,79
	10	6,710	6,828	14,42	10,25
	17	6,920	6,918	6,36	7,29

2004-07-12 07:44	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,850	6,900	7,66	7,64
	10	6,870	6,869	7,11	7,28
	17	6,930	7,023	5,15	4,85

2004-09-29 09:59	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,960	6,984	6,80	6,80
	10	6,960	6,992	6,00	6,25
	17	7,130	4,019	4,16	7,19

2004-10-01 07:02	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,920	6,941	6,96	6,98
	10	6,950	–	6,95	–
	17	6,930	6,965	6,94	6,89

2004-10-20 16:12	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	2	6,740	6,762	7,68	7,71
	10	6,750	6,482	7,66	7,63
	17	6,790	6,620	7,48	7,47

2005-01-12 10:01	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	5	6,910	6,956	3,45	3,51
	10	6,910	6,826	3,44	3,50
	17	7,230	7,428	3,87	4,09

2005-04-06 07:46	Depth	CTD-S	PSM006931-S	CTD-T	PSM006931-T
	5	6,950	7,007	3,39	3,50
	10	6,950	6,937	3,40	3,32
	17	6,980	7,024	2,50	2,21

Table A3-5. Comparison CTD/thermistor-chain respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-5. Measurements conducted at station PSM006931.

2004-04-01 12:47

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,830	1,84	1,85
4	6,820	1,85	1,85
6	6,830	1,85	1,82
8	6,820	1,83	1,82
10	6,830	1,84	1,82
12	6,830	1,84	1,85
14	6,840	1,84	1,85
16	6,830	1,84	1,78
18	6,820	1,83	1,78
20	6,830	1,84	1,78
22			1,78

2004-07-07 17:38

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,740	15,63	12,12
4	6,720	15,05	11,47
6	6,720	14,83	11,19
8	6,720	14,69	10,93
10	6,710	14,42	10,52
12	6,720	13,47	10,08
14	6,770	8,97	7,68
16	6,890	6,80	7,55
18	6,940	5,97	7,45
20	6,960	5,19	6,54
22	6,970	5,15	6,11

2004-07-12 07:44

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,850	7,66	6,77
4	6,850	7,63	7,68
6	6,860	7,62	7,65
8	6,850	7,60	7,61
10	6,870	7,11	7,16
12	6,910	6,18	6,04
14	6,920	5,76	5,81
16	6,930	5,37	5,48
18	6,960	4,89	5,25
20	7,000	4,59	4,71
22	7,070	4,52	4,55

2004-09-29 09:59

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,960	6,80	6,90
4	6,950	6,72	7,74
6	6,960	6,70	6,63
8	6,960	6,55	6,57
10	6,960	6,00	6,44
12	6,980	5,48	5,58
14	7,050	4,57	4,98
16	7,090	4,28	4,24
18	7,130	4,10	4,18
20	7,130	4,03	3,87
22	7,160	3,97	3,91

2004-10-01 07:02

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,920	6,96	6,96
4	6,930	6,95	6,96
6	6,910	6,95	6,93
8	6,920	6,95	6,96
10	6,950	6,95	6,93
12	6,920	6,95	6,96
14	6,930	6,95	6,93
16	6,930	6,94	6,89
18	6,920	6,94	6,93
20	6,940	6,94	6,86
22	6,910	6,89	6,70

2004-10-20 16:12

Depth	CTD-S	CTD-T	PSM006931-T2
2	6,740	7,68	7,68
4	6,740	7,68	7,68
6	6,750	7,68	7,68
8	6,750	7,67	7,68
10	6,750	7,66	7,68
12	6,750	7,60	7,65
14	6,780	7,52	7,58
16	6,790	7,49	7,51
18	6,790	7,47	7,48
20	6,800	7,46	7,45
22	6,780	7,43	7,45

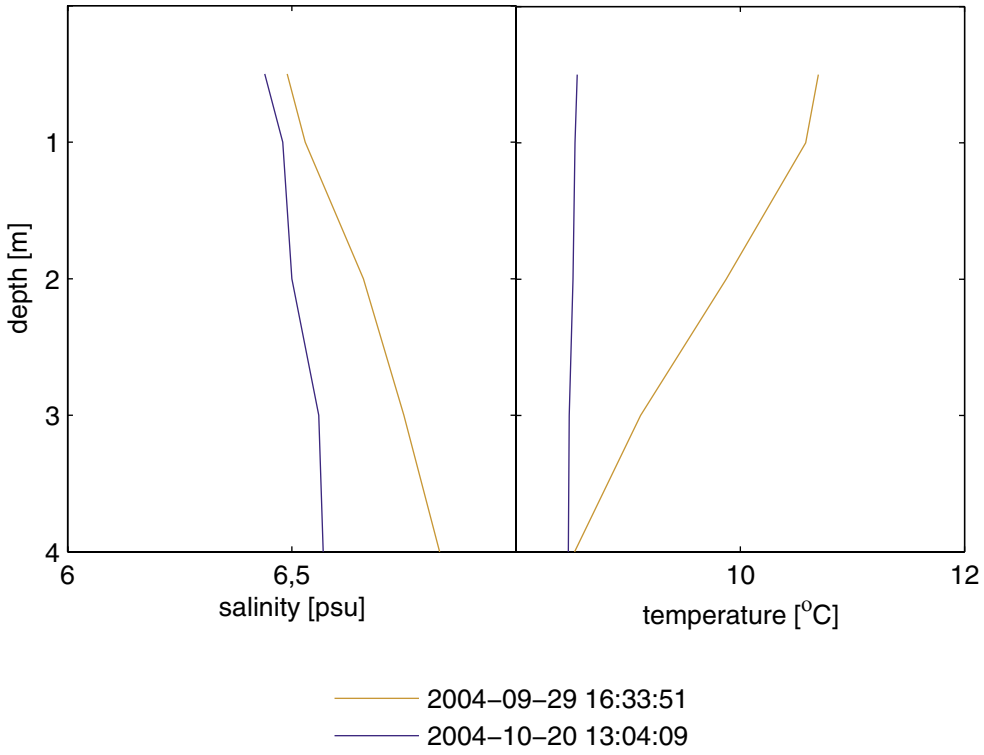

Figure A3-5. *Salinity and temperature versus depth at station PSM006932, Djupesund.*

Table A3-6. Comparison of temperature and salinity as measured by CTD/rig respectively at approximately identical times and depth. Times and depths given are for the CTD probe deployed. Each small table corresponds to one line in Figure A3-5. Measurements conducted at station PSM006932.

2004-09-29 16:33	Depth	CTD-S	PSM006932-S	CTD-T	PSM006932-T
	4	6,830	6,359	8,52	11,04

2004-10-20 13:04	Depth	CTD-S	PSM006932-S	CTD-T	PSM006932-T
	4	6,570	6,661	8,47	8,36

Table 4-1. Overview over all measurements conducted during the survey (sorted by station).

station	period [UTC]		position		instrument depth [m]	interval [min]	instrument	parameter	jamförelsemätningar	incidents and comments
	start	stop	north	east						
PSM006927, northern boundary (CT)	2004-03-31 15:00	2004-07-06 08:30	57 31.993	16 55.525	2 10 17.5 30	60	Seabird micro-cat SBE37	pressure, temperature, conductivity	CTD 2004-03-31 16:46	no data, see 4.5.1 1)
	2004-07-07 11:00	2004-09-30 09:00 2004-09-30 08:00 2004-09-30 08:30	57 31.993	16 55.525	2 10 17.5 30	60		pressure, temperature, conductivity	CTD 2004-07-07 11:01; CTD 2004-09-29 11:09	no data registered after 2004-07-23 02:15, see 4.5.1 1)
	2004-10-01 10:30	2005-01-11 16:30 2005-01-11 17:25 2005-01-11 18:00 2005-01-11 18:30	57 31.993	16 55.525	2 10 17.5 30	60		pressure, temperature, conductivity	CTD 2004-10-01 08:27; CTD 2004-10-20 13:52	buoyancy device att sea level damaged on nov 7th, see 4.5.1 3)
	2005-01-14 14:00	2005-04-07 09:00 2005-04-07 10:00 2005-04-07 10:30 2005-04-07 10:50	57 31.99	16 55.51	5 10 17.5 30	60		pressure, temperature, conductivity	CTD 2005-04-06 09:15	spikes in conductivity after 2005-03-31 04:00, battery problems?
PSM006928, northern boundary (ADCP)	2004-04-01 08:50	2004-07-06 08:10	57 31.981	16 54.464	41	30	AQD1358; Valeport Typ620	current	CTD 2004-04-01 09:09	
	2004-07-07 09:15	2004-08-11 12:45	57 31.808	16 54.449	42	30		current, pressure, temperature		Valeport sensor removed for tests at the SMHI
	2004-08-19 06:00	2004-09-29 11:20	57 31.808	16 54.449	42	30		current, pressure, temperature	CTD 2004-08-19 06:15; CTD 2004-09-29 11:39	reinstalled Valeport sensor.
	2004-10-02 13:25	2005-01-11 11:40	57 32.003	16 54.405	?	30		current, pressure, temperature	CTD 2004-10-20 14:06; strömkors 5m 18cm/s NNE; ADCP section Simp100 2004-10-20	
	2005-01-14 13:20	2005-04-13 12:40	57 31.972	16 54.555	41?	30		current, pressure, temperature	strömkors 5m 8cm/s E; ADCP section 2005-04-13	

station	period [UTC]		position		instrument depth [m]	interval [min]	instrument	parameter	jamförelsemätningar	incidents and comments
	start	stop	north	east						
PSM006929, eastern boundary	2004-03-31 05:50	2004-07-05 19:00	57 25.947	17 02.882	49		Aanderaa RCM9	current, pressure, temperature, conductivity	CTD 2004-03-31 06:10	instrument leak, see 4.5.2 4)
	2004-07-12 08:25	2004-09-29 06:50	57 25.947	17 02.882	49		Interocean Systems S4		CTD 2004-07-12 08:24; CTD 2004-09-29 08:10	clock error? See 4.5.2 5)
	2004-10-20 08:10	not recovered	57 25.935	17 02.927	49		Aanderaa RCM9	current, pressure, temperature, conductivity		rig dissappeared, see 4.5.2 6)
	2005-03-05 12:30	2005-04-06 10:30	57 25.936	17 03.029	49		Aanderaa RCM9	current, pressure, temperature, conductivity	CTD 2005-04-06 10:42; ADCP section 2005-04-13	leak
PSM006930, southern boundary	2007-03-31 16:15	2004-07-06 11:10	5720026	1648021	25	30	Nortek AWAC N-5078; Vale-port Typ620	current, pressure, temperature, conductivity	CTD 2004-07-07 09:47 (17:43 enl. logg); ADCP section Simp041 2004-04-28	see 4.5.3 7)
	2004-07-07 15:25	2004-08-11	57 20.027	16 48.068	33	30	Nortek AWAC N-5078; Vale-port Typ620	current		Valeport sensor removed for tests at the SMHI
	2004-08-11 12:45	2004-08-19 07:10	5720047	1648005		30	Nortek AWAC N-5078	current	CTD 2004-08-19 08:05 (07:50 enl. logg)	reinstalled Valeport sensor.
	2004-08-19 08:10	2004-09-29 13:20				30	Nortek AWAC N-5078; Vale-port Typ620	current, pressure, temperature, conductivity	CTD 2004-09-29 13:31 (13:25 enl. logg)	
	2004-10-02 12:00	2005-01-14 08:45	57 20.020	16 47.900	33	30	Nortek AWAC N-5078; Vale-port Typ620	current, pressure, temperature, conductivity		
	2005-01-14 09:45	2005-04-13 09:13	57 19.943	16 48.065	28	30	Nortek AWAC N-5078; Vale-port Typ620	current, pressure, temperature, conductivity		
PSM006931, inner point	2004-03-31 13:50	2004-07-06 10:00	5726479	1646748	2–22 (interval 2)	58	Aanderaa TR7	temperature	CTD 2004-04-01 12:47	rig deployed together with “microcat” rig, both are connected.
	2004-07-07 09:45	2004-09-29 09:50	57 26.492	16 46.768	2–22 (interval 2)	58	Aanderaa TR7	temperature	CTD 2004-07-07 17:38	

station	period [UTC]		position		instrument depth [m]	interval [min]	instrument	parameter	jamförelsemätningar	incidents and comments
	start	stop	north	east						
	2004-09-30 08:00	2005-01-11 10:35	57 26.490	16 46.772	2–22 (interval 2)	58	Aanderaa TR7	temperature		
PSM006931, inner point	2004-03-31 13:50	2004-07-06 10:00	5726498	1646737	2	60	Seabird micro-cat SBE37	pressure, temperature, conductivity		
					10					
					17.5					
	2004-07-07 09:45	2004-09-29 09:30	57 26.492	16 .46.768	2	60	Seabird microcat SBE37	pressure, temperature, conductivity	CTD 2004-09-29 09:59	
					10					
					17.5					
	2004-10-01 06:45	2005-01-11 09:35	57 26.490	16 46.772	2	60	Seabird micro-cat SBE37	pressure, temperature, conductivity	CTD 2004-10-01 07:02; CTD 2004-10-20 16:12	See 4.5.3 8)
	2004-09-30	2004-10-20			10					
	2004-10-01 06:45	2005-01-11 09:35			17.5					
	2004-10-20 09:30	2004-12-03 09:00	57 26.498	16 46.796	10	60				See 4.5.3 9)
	2004-12-03 09:20	2005-01-11 09:35	57 26.498	16 46.796	10	60				malfunction, see 4.5.3 10)
	2005-01-12 10:00	2005-04-06 07:50	57 26.48	16 46.86	5	60	Seabird micro-cat SBE37	pressure, temperature, conductivity	CTD 2005-01-12 10:01; CTD 2005-04-06 07:46	
					10					
					17.5					
PSM006932, Djupesund	2004-04-01 12:30	2004-07-05 15:15	57 26.882	16 40.964	3		Interocean Systems S4	currents, temperature, conductivity		
	2004-07-05 16:00	2004-09-28 13:00	57 26.882	16 40.964	3		Interocean Systems S4	currents, temperature, conductivity		only 11 days of data recovered, see 4.5.4 11)
	2004-09-29 16:30	2004-12-03 09:45	57 26.882	16 40.964	3		Interocean Systems S4	currents, temperature, conductivity	CTD 2004-09-29 16:33; 2004-12-03 10:00 3m: 15cm/sec 90deg	
	2004-12-03 10:05	2005-01-11 14:35	57 26.882	16 40.964	3		Interocean Systems S4	currents, temperature, conductivity	2005-01-11 0,5m above ground: 12cm/sec 45deg; 3m above ground: 20cm/sec 45deg	
	2005-01-11 14:45	2005-03-29 09:50	57 26.882	16 40.964	3		Interocean Systems S4	currents, temperature, conductivity		