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APPENDIX A:

Reference list of DHI applications of the MIKE model to power plants and marine outfalls

POWER, DESALINATION AND INDUSTRIAL PLANTS

Hydraulic and Environmental Investigations by DHI

Project	*Client*	*Year*
Shin-Kori Nuclear Power Plant #3&4, Korea ROK. Development and optimisation of cooling water intake and discharge systems. Establishment of alternative discharge systems concepts followed by an analysis and ranking of alternatives. The analyses focused on hydraulic and constructability aspects, such as for example intake of fish and sediments, diffusion and recirculation characteristics, pressure losses through system, wave and current impact forces on diffusor heads, scour protection and occurrence of surges in the overall system during operational and non-operational conditions. The analyses were carried out by physical scale model tests in combination with numerical modelling.	Korea Power Engineering Co, Inc, Korea	2003-04
Shin-Wolsong Nuclear Power Plant #1&2, Korea ROK. Development and optimisation of cooling water intake and discharge systems. Establishment of alternative discharge systems concepts followed by an analysis and ranking of alternatives. The analyses focused on hydraulic and constructability aspects, such as for example intake of fish and sediments, diffusion and recirculation characteristics, pressure losses through system, wave and current impact forces on diffusor heads, scour protection and occurrence of surges in the overall system during operational and non-operational conditions. The analyses were carried out by physical scale model tests in combination with numerical modelling.	Korea Power Engineering Co, Inc, Korea	2003-04
Benghazi North Combined Cycle Power Plant, Libya. The work included marine survey works of topographical and bathymetrical survey, seawater and seabed sediment sampling, oceanographic and meteorological observations and marine soil investigations. The results of the marine survey works were used for a numerical study for recommendation of suitable layout of intake/outfall configuration and for assessment of the potential of cooling water recirculation.	Daewoo Engineering and Construction Co Ltd, Korea for General Electricity Company of Libya (GECOL)	2003

Project	*Client*	*Year*
Kashagan Field, Caspian Sea. The work included an assessment of the thermal and chemical impact of the Caspian Sea environment associated with an effluent discharge from an artificial D-block Island, planned for construction in 2003 as part of the development of Kashagan Field. Numerical recirculation study, assessment of the risk on the marine ecosystem of main chemicals, assessment of chemical additive's dosing plans and development of outline monitoring plans for controlling the dosage of inhibitors.	Agip Kazakhstan North Caspian Operating Company N. V.	2003
Shin-Kori Nuclear Power Plant #1&2, Korea ROK. Development and optimisation of cooling water dicharge system. Establishment of alternative discharge systems concepts followed by an analysis and ranking of alternatives. The analyses focused on hydraulic and constructability aspects, such as for example diffusion and recirculation characteristics, pressure losses through system, wave and current impact forces on diffusor heads, scour protection and occurrence of surges in the overall system during operational and non-operational conditions. The analyses were carried out by physical scale model tests in combination with numerical modelling.	Korea Power Engineering Co, Inc, Korea	2002
UAE, Fujairah Desalination and Power Plant. Conduct of 2D/3D mathematical modelling of discharge of brine (excess salinity) and heat to study potential recirculation and environmental impact associated with alternative discharge schemes and recommendation of most feasible scheme.	Fichtner GmbH & Co., UAE Offsets Group, Abu Dhabi	2001
Gulf Power Plant, Sirte, Libya, G.S.P.L.A.J. Technical feasibility analysis of alternative cooling water intake locations and systems for 1,400 MW thermal power plant.	General Electricity Company of Libya (GECOL)	2001
Zawiya Combined Cycle Power Plant, Libya, G.S.P.L.A.J. Marine hydraulic investigations for and conceptual design of cooling water intake and outfall structures. The investigations comprised establishment of design hydrographic conditions, thermal recirculation by numerical model assessment of littoral transport conditions and conceptual layout of intake and outlet structures and their relative locations.	General Electricity Company of Libya (GECOL)	2001
Seawater Intake at Seraya-2, Singapore. Physical modelling of intake and pump station aiming at optimising the intake structure in order to obtain good flow approach to the pumps.	Frederic R Harris BV, The Hague, The Netherlands	2000

Project	Client	Year
Power plant cooling water recirculation study, Bangladesh. 2D (MIKE 21) and 3D (MIKE 3) modelling of cooling water discharge with a view to recommend most feasible cooling water scheme in regards recirculation. Assessment of design current and flood levels for power plant platform.	AES Meghnaghat Combined Cycle Power Plant, Bangladesh	2000
Tampa Bay, Florida, USA. Study of near-field impact of a new desalination plant to be integrated with an existing power plant. The plant, when completed, will be the largest desal facility in the western hemisphere; and the largest in the world located in an estuary environment.	S & W Water, USA.	2000
Shoaiba Power Plant, Stage 1, Saudi Arabia (Red Sea coast). Hydraulic model tests (stability and wave tranquillity) for optimisation of detailed design of the discharge channel and jetty structures. *)*	Saudi Archirodon Ltd. (SARCO), Jeddah, Saudi Arabia	1999
Meghnaghat Power Station, Meghna River, Bangladesh. Study of near-field cooling water dilution, carried out in association with Surface Water Modelling Centre, Dhaka.	ESG International, Canada, representing AES Corporation, USA	1999
Haripur Combined Cycle Power Plant, Shitalakhya River, Bangladesh. Study of design water level, sedimentation, scour, bank protection stability, and recirculation, carried out in association with Surface Water Modelling Centre, Dhaka.	Hyundai Engineering & Construction Co., Republic of Korea	1999
Aluminium Bahrain. Heat and salt recirculation study and environmental impact assessment for a desalination plant built as a part of a coke calcining plant.	Aluminium Bahrain BSC (c)	1998
Meghnaghat Power Station, Meghna River, Bangladesh. Study of hydraulic design conditions, recirculation, stability of bank protection and effects of dredging, carried out in association with Surface Water Modelling Centre, Dhaka.	Mott Ewbank Preece (now: Mott MacDonald), UK, representing Bangladesh Power Development Board, funded by Asian Development Bank.	1997
King George and Queen Elizabeth Docks, Hull, UK. 3D modelling of heat and salinity budgets (considering a 33 percent evaporation loss) as a part of a feasibility study of utilising the docks for abstraction and disposal of cooling water for a new power plant.	ABP Research, UK, representing Energy Power Group, UK	1997
Hamburg Harbour, Germany. Numerical modelling of excess temperatures and recirculation for a cooling water discharge by linked 1D and 2D models of the Elbe River.	Deutsche Shell AG, Germany	1997
Juncker's Industries, Boiler 8, Denmark. Assessment of compliance with environmental standards, and prediction of mixing zone and impact area.	Juncker's Industries, Denmark	1997
Ruwais General Utilities Plant, Abu Dhabi. Analysis of marine data, identification of normal and adverse design periods, and recirculation analysis by 2D and 3D modelling	UAE.Fluor Mideast Ltd. (USA), representing Abu Dhabi National Oil	1996

Project	Client	Year
for an 81m³/s cooling water discharge.	Company	
Asnæs Power Plant, Denmark. Impact study of using a new bitumen-based fuel, Orimulsion: Surface drift of bitumen, impact on beaches, and entrainment into the cooling water system.	SK Energy, Denmark	1995
Amagerværket Power Plant, Denmark. Design of real-time marine monitoring system for the approach channel.	Copenhagen Harbour Authority, Denmark	1995
Avedøre Power Station Unit 2, Denmark. Hydraulic basis for EIA; modelling of entrainment of organisms, recirculation, and excess temperatures.	Elkraft A.m.b.A., Denmark	1995
KONTEK power transmission project, Denmark. A marine power transmission link between Denmark and Germany, using seawater as one conductor. Hydraulic basis for environmental feasibility and EIA, near-field chlorine concentrations, and marine monitoring.	SEAS, Denmark	1994-97
Sonelgaz Power Station, Port d'Alger, Algeria. Investigation of the intake temperature for a modified intake necessitated by a planned extension of the harbour.	Portconsult (Denmark)	1994
Al Khobar Power and Desalination Plant, Saudi Arabia. Hydraulic investigations for the Phase III extension. 3D modelling of recirculation.	LG Mouchel & Partners (UK) on behalf of Hitachi Zosen (Japan)	1994
Lumut Power Station, Malaysia. Investigation of intake temperature and sediment entrainment for an extension of the intake structure.	HYDEC, Malaysia, on behalf of Lumut Power Station	1994
Neka Power Plant, Iran. Hydraulic concept study for design modifications of cooling water intake and sedimentation basin.	Water Research Center Co., Teheran, Iran	1993
Gdansk Northern Harbour, Gdansk, Poland. Investigation of environmentally sustainable and economically feasible management options for disposal of coal fly ash.	Zespol Elektrocieplowni, Poland, ECII, and the Danish Environmental Protection Agency	1993
Central Termica de Santurce (Santurce Power Plant), Bilbao, Spain. Identification of feasible relocation of the cooling water intake and outfall after the extension of Port of Bilbao. 2D and 3D modelling of dispersion and recirculation.	Iberdrola S.A., Spain, represented by HIDTMA SL, Spain	1992-96
Yenshui-Kang Power Plant, Taiwan, ROC. Hydraulic investigations. Conceptual design of the marine cooling water system, recirculation analysis, and compliance with national environmental standards.	Taiwan Power Corporation	1992-94
Morocco Nuclear Power Plant. 2D and 3D modelling of cooling water recirculation.	Le Laboratoire Public d'Essais et d'Etudes, Morocco	1992
Køge Bay, Denmark. Study of fly ash disposal on reclaimed land. Leachate dispersal, navigational impact, coastal morphology.	Elkraft A.m.b. A, Denmark	1992

Project	*Client*	*Year*
Sellafield Nuclear Power Plant, UK. Mathematical modelling of wave climate, tide, recirculation, and sediment transport with 2D and 3D models.	British Nuclear Fuels PLC, Warrington, England	1992
Kelang Power Station, Malaysia. Recirculation study based on numerical modelling.	HYDEC, Malaysia	1992
Jeddah Power and Desalination Plant, Saudi Arabia. Numerical 2D and 3D modelling of cooling water and brine dispersal, recirculation, and interaction with adjacent plants.	Fichtner Consulting Engineers, Germany	1992
Masinloc Thermal Power Plant, Philippines. Numerical modelling of excess temperatures and solutes, model transfer and training.	National Power Corporation, Philippines, financed by Asian Development Bank	1991-93
Morocco Nuclear Power Plant, Morocco. Storm surge study, and mathematical, Morocco modelling of far-field excess temperatures.	Le Laboratoire Public d'Essais et d'Etudes, Morocco	1991
Petacalco Power Plant, Mexico. Numerical modelling of leachate dispersal of fly ash.	Comision Federal de Electricidad, Mexico	1991
Jubail Power and Desalination Plant, Saudi Arabia. Feasibility study and conceptual design of seawater system.	Saline Water Conversion Corporation, Saudi Arabia	1991
Ría del Ferrol, Spain. Study of dispersal of coal dust in the marine environment.	Empresa Nacional de Electricidad, Spain, represented by Rambøll & Hannemann, Denmark	1991
Barranco de Tirajana and Granadilla Power Plants, Gran Canaria and Tenerife, Spain. Specialist services during initial planning.	HIDTMA S.A., Spain, representing Unión Eléctrica de Canarias S.A., Spain	1991
Hsinta Power Plant, Taiwan, ROC. Physical and mathematical modelling of cooling water dispersal, conceptual design of outfall channel.	Taiwan Power Co.	1990
Taichung Thermal Power Plant, Taiwan, ROC. Thermal diffusion, sedimentation, and coastal erosion study.	Taiwan Power Co.	1988-89
Stigsnæsværket Power Plant, Denmark. Field survey, mathematical modelling, coastal hydraulics.	Elkraft, Denmark	1988-89
Masnedøværket Power Plant, Denmark. Field survey, mathematical modelling.	Elkraft A.m.b.A., Denmark	1988
Asnæsværket, Denmark. Study of hydraulic performance and environmental effects of a submerged intake.	Elkraft A.m.b.A, Denmark	1988
Hsinta Power Plant, Taiwan, ROC. Mathematical modelling of sediment transport and excess temperatures.	Sinotech Consulting Engineers, Taiwan, ROC	1987-89
Baseline study of cooling water dispersal for seven Danish coal-fired power plants.	Elkraft A.m.b.A., Denmark	1986-87

Project	*Client*	*Year*
Morocco Nuclear Power Plant, Morocco. Tsunami hindcasts, and mathematical modelling of near-field excess temperatures.	Le Laboratoire Public d'Essais et d'Etudes, Morocco	1986-87
Asnæsværket, Denmark. Environmental monitoring of cooling water dispersal and excess temperature distribution.	Elektricitetsselskabet Isefjordsværket, Denmark	1986
Fynsværket, Denmark. Study of cooling water system, recirculation, and environmental impact. Field survey, numerical modelling.	Elkraft A.m.b.A., Denmark	1986
Skærbækværket, Denmark. Study of recirculation, excess temperature distribution, and environmental impact.	Skærbækværket, Denmark	1986
Neka Power Plant, Iran. Study of intake basin.	Consortium Mazandaran (NEKA), Iran	1985-86
Al Taweelah Power and Desalination Plant, Abu Dhabi. Physical and mathematical modelling of excess temperatures and sediments.	Water and Electricity Dept., Abu Dhabi	1985-86
Taichung Thermal Power Plant, Taiwan ROC. Physical and mathematical modelling of cooling water dispersal.	Taiwan Power Co.	1985
Misurata Power and Desalination Plant, Libya. Surge study, environmental study. Field survey, physical and mathematical modelling.	Hyundai Engineering and Construction Co., Republic of Korea	1983-84
Barsebäckverket, Sweden. Evaluation of sedimentation in the intake basin of a nuclear power plant.	Sydsvenska Kraftaktiebolaget, Sweden	1983
Angra Nuclear Power Plant, Brazil. Wave study, dimensioning of marine structures.	Nuclebràs Engenharia S.A., Brazil	1982
Al Wusail, Ras Laffan, Al Qatar. Field survey, mathematical modelling, and site evaluation.	Fichtner Consulting Engineers, Federal Republic of Germany	1982
Enstedværket Power Plant, Denmark. Field survey, mathematical modelling, environmental hydraulics.	Sønderjyllands Højspændingsværk, Denmark	1981, 1985-86
Carboneras Power Station, Spain. Field survey, mathematical modelling, siltation and cooling water study.	PUCARSA S.A., Spain	1981-82
Kifunga Hydropower Plant, Tanzania. Specialist services during feasibility stage.	Greenland Technical Organization, financed by DANIDA	1981
Mecca Taif Power and Desalination Plant, Saudi Arabia. Field survey, mathematical modelling, location analysis.	Fichtner Consulting Engineers, Federal Republic of Germany	1981
Ras Tanajib Power and Desalination Plant, Saudi Arabia. Field survey, mathematical modelling.	Aramco Overseas Co., Holland	1981
Garden Island, Port Jackson, Australia. Numerical modelling of jet dilution and recirculation in a harbour basin.	Lawson and Treloar/Dept. of Construction and Housing, Commonwealth of Australia	1980

Project	*Client*	*Year*
Al Khobar Power and Desalination Plant, Saudi Arabia. Field survey, physical and mathematical modelling, long-term monitoring of marine environmental impact.	Hyundai Engineering and Construction Co., Republic of Korea	1979-83
Vendsysselværket Power Plant, Denmark. Field survey, mathematical modelling.	I/S Nordkraft, Denmark	1979-81
Vestkraft Power Plant, Denmark. Field survey, mathematical modelling, environmental hydraulics.	I/S Vestkraft, Denmark	1979-80
Amagerværket Power Plant, Denmark. Field survey, mathematical modelling, environmental hydraulics.	Elkraft, Denmark	1979-80, 1985
Ruwais Utility Intake, Abu Dhabi. Field survey, study of waves and sedimentation in cooling water intake channel.	Fichtner Consulting Engineers, Federal Republic of Germany	1979
Stevns Nuclear Power Plant, Denmark. Field survey, mathematical modelling, environmental hydraulics.	Elkraft, Denmark	1978-79
Ghazlan Power Plant, Saudi Arabia. Field survey, mathematical modelling.	Aramco Overseas Co., Holland	1978
H. C. Ørstedsværket Power Plant, Denmark. Field survey, mathematical modelling, environmental hydraulics.	Københavns Belysningsvæsen, Denmark	1978
St. Lucie Power Plant, USA. Review of cooling water dilution.	Florida Power and Light, USA	1978
Maracaibo Power Plant, Venezuela. Site investigation, cooling water study.	Inelectra S.A., Venezuela	1978
Avedøreværket, Denmark. Field survey, coastal and environmental impact, as part of feasibility analysis and detailed design of a power plant in Copenhagen.	Kraftimport I/S and Elkraft A.m.b.A, Denmark	1977, 1981-84
South Dade Power Plant, Florida. Hurricane study, hydraulic design basis.	Brown & Root, Inc., Texas, USA, on behalf of Florida Power and Light, USA	1997
Stigsnæs Power Plant, Denmark. Hydraulic concept evaluation of a deepwater cooling water intake.	SEAS, Denmark	1977
Kilroot Power Station, Northern Ireland. Wave study, physical model tests.	Christiani and Nielsen, Denmark	1975
Prai Power Station, Malaysia. Field investigations, recirculation study.	MINCO Ltd., Malaysia	1975
Gylling Næs Nuclear Power Plant, Denmark. Study of recirculation, environmental, and coastal hydraulic aspects.	Elsam, Denmark	1974-77
Barsebäckverket, Sweden. Hydrographic monitoring during dredging operations for a nuclear power plant.	Sydsvenska Kraftaktiebolaget, Sweden	1972

Project	Client	Year
Barsebäckverket, Sweden. Hydraulic concept evaluation of intake and other marine structures, mapping of excess temperature distribution and cooling water plume dilution, and hydraulic model tests for design of cooling water intake and sedimentation basin for a nuclear power plant.	Sydsvenska Kraftaktiebolaget, Sweden	1969-70

APPENDIX B:

Report on calibration of wave hindcast data by Fugro Oceanor

PRDW South Africa

Calibration of Wave Spectra in 3 Positions off South Africa

Fugro OCEANOR Reference No: C55162 / rev 0
2008-03-10

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Calibration of Wave Spectra in 3 positions off South Africa: C55162 / rev 0				
Rev	**Date**	**Originator**	**Checked & Approved**	**Issue Purpose**
	2008-03-10	G. Mørk	S. F. Barstow	FINAL

Rev 0 – 2008-03-10	**Originator**	**Checked & Approved**
Signed:		

This report is not to be used for contractual or engineering purposes unless the above is signed where indicated by both the originator of the report and the checker/approver and the report is designated ‘FINAL’.

TABLE OF CONTENTS

SUMMARY

Time series of 15 years of wave spectra from the ECMWF WAM model for three positions off South Africa have been calibrated against available satellite altimeter data. The calibration procedure is described, and a comparison between calibrated wave heights and altimeter ground truth is given. Plots of time series of wave parameters derived from the spectra are presented.

All the calibrated data (wave spectra and time series of overall wave parameters) have been supplied to the client as text files.

1. Introduction

The purpose of the present report is to document the validation and calibration of time series of wave spectra for three locations off South Africa, at positions

S 34.0°, E 18.0°	W of Cape Town
S 35.0°, E 19.0°	WSW of Cape Agulhas
S 35.0°, E 24.5°	SW of Port Elisabeth

The time series span the period from 1990-11 to 2007-10 (inclusive). However, the two year period 1991-06 to 1993-05 are left out of the series, so that a total of 15 years of data is supplied in each point. A discussion on the data quality is given, and plots of some wave parameters are presented.

2. Data Sources

Two types of data have been used: Model data and satellite altimeter data.

2.1 WAM data

The basic source of data is the directional wave spectra data from the WAM (“WAve Model”) model run at the European Centre for Medium Range Weather Forecast (ECMWF). We have used 15 (effective) year series of spectra from WAM, merged from two types of WAM data:

- *ERA-40* (“Ecmwf ReAnalysis 40 year”) is a WAM hindcast series. In principle, this series should be as homogeneous as possible, because the same version of the wave model is used throughout the 40 years. However, in order to provide as accurate data as possible, satellite altimeter, SAR and scatterometer data have been assimilated into the model according to its availability (from 1991). This affects the homogeneity, with data after 1993 being more accurate. Unfortunately, ECMWF assimilated faulty altimeter data into the simulations for the period 1991-12 / 1993-05, and the quality of this 18-month period is therefore significantly lower than the rest of the series. (In 2007, ECMWF finished a rerun of the analysis for this period with corrected altimeter data. However, the new corrected hindcast is not yet released, as of December 2007.) To avoid the low-quality part of the hindcast, we have left out a full two year of the series. We have thus used ERA-40 data for the period 1990-11-01 / 1998-06-28, leaving out the gap from 1991-06 to 1993-05 (inclusive).

- The other type of WAM data comes from the *operational model*. As the operational model is steadily modified, the accuracy of these data has steadily become even better. In a study in the central North Sea we compared the operational WAM data against a long series from a buoy, and were able to demonstrate that there was a steadily decreasing scatter index and increasing correlation coefficient of the WAM wave heights relative to buoy data. We have used operational WAM data for the period 1998-06-29 / 2007-10-31.

The quality of the basic ECMWF data is due, first, to the fact that ECMWF has attracted some of the best European wave and atmospheric modellers. Secondly, the assimilation of over 20 different satellite-borne sensors into the model suite in recent years is unique and undoubtedly the main reason for the high level of accuracy attained on a global basis. This is particularly important in areas with sparse data, such as the Southern Ocean from which much of Chilean swell energy derives.

As part of the calibration procedure, the spectra were integrated to derive the following wave parameters:

- Significant wave height Hm0
- Mean wave direction MDir
- Peak direction at the peak period ThTp
- Peak period Tp
- Mean (energy) wave period Tm-10
- Mean wave period Tm01
- Mean wave period Tm02 (zero up-crossing period)

The spectral resolution (i.e. number of frequencies and number of directions) changes throughout the time series as shown in the table below:

Model type and spectral resolution				
Data type	*Start date*	*End date*	*Frequencies*	*Directions*
ERA-40	1990-11-01	1998-06-28	25	12
Operational	1998-06-29	2000-11-20	25	12
Operational	2000-11-20	2007-10-31	30	24

The delivered spectra have a temporal resolution of 6 hours, starting on 1990-11-01 T00, and ending on 2007-10-31 T18. As mentioned above, there is a gap in the series between 1991-05-31 T18 and 1993-06-01 T00. The ERA-40 data are given on a 1.5° grid, whereas the operational data are given on a 0.5° grid.

2.2 Satellite altimeter data

As of December 2007, data are available from the following satellite missions:

- *TOPEX* (from the US/French TOPEX/Poseidon mission). This satellite has been the most successful altimeter mission, delivering high quality data from September 1992 until late 2005. In August – September 2002 the satellite was moved to a new orbit, midway between its old ground tracks. (We have referred to these separate phases as TPX 1 and TPX 2, respectively, before and after its orbit change.)
- The *JASON* satellite was launched into the old TOPEX orbit when TOPEX was moved, and may be considered as a “Topex Follow-On”. It has been delivering data from September 2002.

- *GEOSAT* was operative between 1986 and 1989, and is thus not relevant in the present project. Later on, *GFO* ("Geosat Follow-On") was launched into the same orbit, and delivered data from January 2000.
- *EnviSat* from the European Space Agency (ESA) has been delivering data from October 2002.

The altimeter data (wave height and wind speed) from all the missions have been calibrated against a number of offshore buoys (mainly US, Canadian and Indian), and can be considered to have similar accuracy to buoy measurements.

We have used altimeter data from TOPEX (both TPX 1 and TPX 2), JASON, GFO and EnviSat for calibration of the wave spectra. Figure 1 shows a map of the area, with (approximate) satellite ground tracks and positions of the extracted altimeter data.

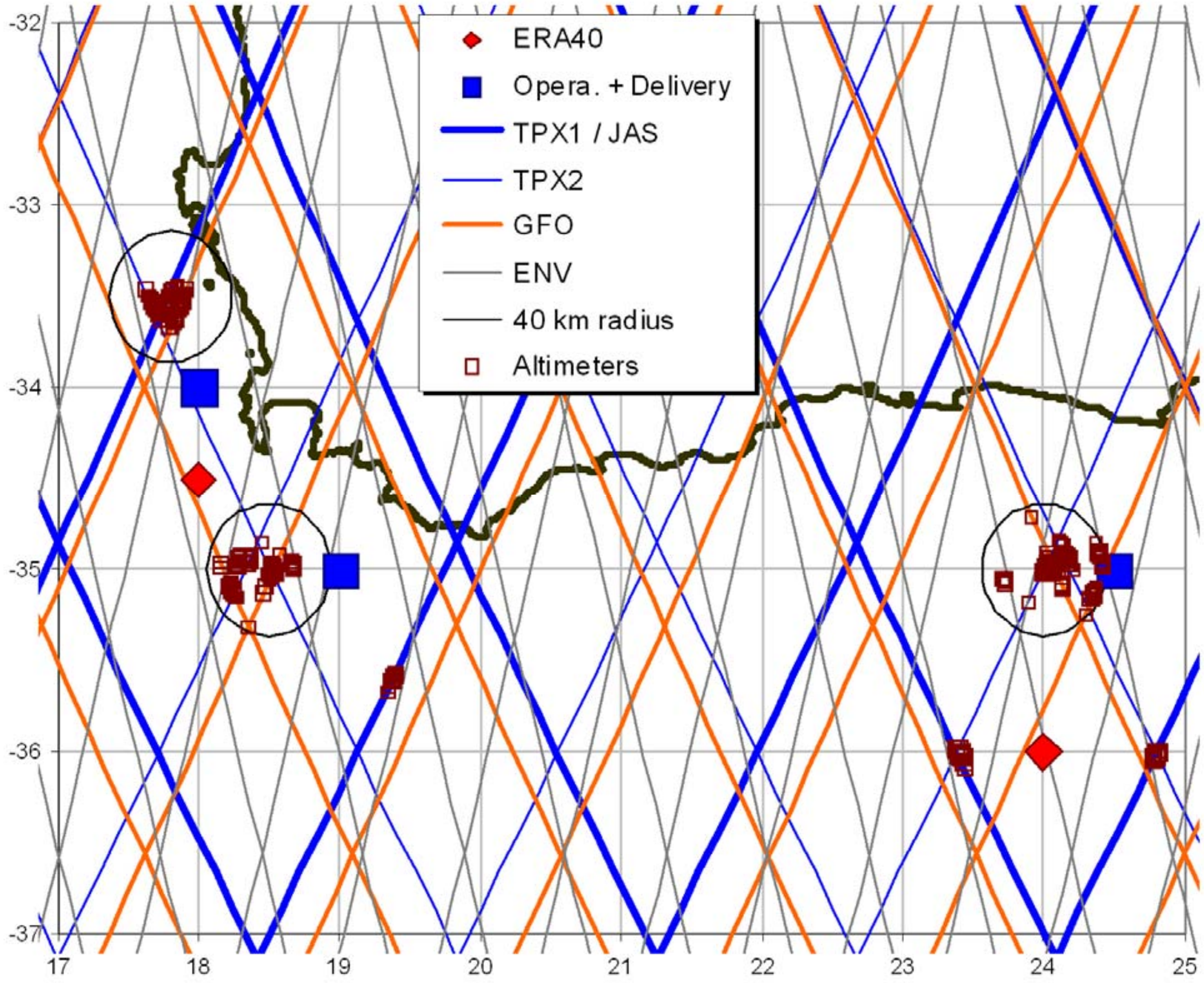

Figure 1 Map of the area with satellite tracks, positions of altimeter data and model data.

3. Calibration and validation

We used the altimeter data from all the available missions as the “ground truth” for calibrating the WAM data. Satellite altimeter data are extracted around the point in question. In practical terms, this means that each time the satellite passes (once every 10 – 35 days, depending on satellite), altimeter data are extracted for a location as close to the requested position as possible. Figure 1 shows the positions of the extracted altimeter data, as well as (approximate) ground tracks for the satellites.

The overall wave height is then matched and validated against the altimeter data, and a regression line is fit to the data. We have used QQ-regression lines (Quantile-Quantile graphs) to match the distributions as close to each other as possible. (This amounts to sorting each of the data series, plotting the sorted data against each other, and fitting a standard linear y-on-x regression line to the QQ-graph.) The linear regression lines are used to adjust the wave heights deduced from the spectra. The deduced wave periods are not adjusted and are left as is. Comparisons elsewhere show that this is a good assumption (apart from the period with faulty altimeter data referred to above).

Data from ERA-40 and the Operational data were validated and calibrated separately, as they may have different bias. As none of the requested positions lies on the 1.5° grid, spectral data from ERA-40 has to be obtained from a nearby position. In addition, only TPX1 can be used to calibrate ERA-40, because only TPX1 operated in the ERA-40 data period.

Target point	*Source point ERA-40*	*Source point Operational*
S 34.0°, E 18.0°	S 34.5°, E 18.0°	same as target
S 35.0°, E 19.0°	S 34.5°, E 18.0°	same as target
S 35.0°, E 24.5°	S 36.0°, E 24.0°	same as target

Note that, for the two westernmost target points, the ERA-40 data are taken from the *same* source point. However, the source data are adjusted differently, to “tune” them to the altimeter data relevant for the different target points. This means that, for these two positions (and up to 1998-06-28), the calibrated data will have the same directions and wave periods, but have different wave heights.

When satellite data were extracted to be used as ground truth, the positions were chosen primarily to be as close as possible to the target point. However, the water depth was also taken into account, to extract data, as far as possible, at approximately the same depth as the target point.

The different target positions are calibrated as follows (see Figure 1):

Target point	*Method*
S 34.0°, E 18.0° W of Cape Town	Altimeter data from TPX1, JASON, TPX2, GFO and EnviSat are extracted NW of the target position, and at approximately the same depth. Both the ERA-40 and the operational data are calibrated by means of altimeter data around this position.
S 35.0°, E 19.0° WSW of Cape Agulhas	Altimeter data from TPX2, GFO and EnviSat are extracted just W of the target position, and used to calibrate the operational data. Altimeter data from TPX1 and JASON are extracted on the track SE of the target, at approximately the same depth. These data are used to calibrate the ERA-40 data.
S 35.0°, E 24.5° SW of Port Elisabeth	Altimeter data from TPX2, GFO and EnviSat are extracted just W of the target position, and used to calibrate the operational data. The ERA-40 data are calibrated in two steps: (1) Altimeter data from TPX1 and JASON are extracted at latitude S 36°, and used to estimate non-biased data *at this latitude*. (2) The GFO satellite is used to estimate the difference between wave heights at latitudes S 36° and S 35°. The calibrated non-biased data from S 36° are then adjusted for the horizontal gradient to give non-biased data representative of latitude S 35°.

Figure 2 to Figure 6 show scatter plots of calibrated Hm0 versus altimeter measurements. A QQ-graph is shown on each figure, together with a corresponding white regression line and its formula. Boxes on the figures also give the number of points n, the correlation coefficient (rho), the root mean square error (RMSE) and mean values of the altimeter and model data. The RMSE has been estimated as

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_{1,i} - x_{2,i}\right)^2}$$

where point no i in the scatter plot has coordinates $\left(x_{1,i}, x_{2,i}\right)$. Although it is not given on the figures, one useful goodness-of-fit parameter may be estimated as the so-called Scatter Index = RMSE/Mean.

A summary of the some statistical parameters is given below: (Note that the regression line in Figure 5 should not be y = x, because the calibrated model data is representative of latitude S 35°, whereas the altimeter data are for S 36°.)

Target point	*Model*	*Correlation*	*RMSE (m)*	*Scatter Index (RMSE / Mean x)*
S 34.0°, E 18.0°	ERA40 + Operational	0.925	0.392	15.2%
S 35.0°, E 19.0°	ERA40	0.852	0.642	20.0%
S 35.0°, E 19.0°	Operational	0.936	0.395	13.3%
S 35.0°, E 24.5°	ERA40	0.909	0.633	18.8%
S 35.0°, E 24.5°	Operational	0.856	0.737	22.7%

Figure 7 to Figure 12 present time series plots of wave parameters deduced from the calibrated spectra. (The thick orange lines are the monthly means.) For each target position, there are two figures: One with significant wave height Hm0, mean direction MDir and peak direction at peak wave period ThTp. The second figure displays wave periods: Peak period Tp, mean period Tm-10 (= energy period) and mean period Tm02 (= Tz, zero up-crossing period). Note that the last wave period is the one most sensitive to the high-frequency part of the spectrum.

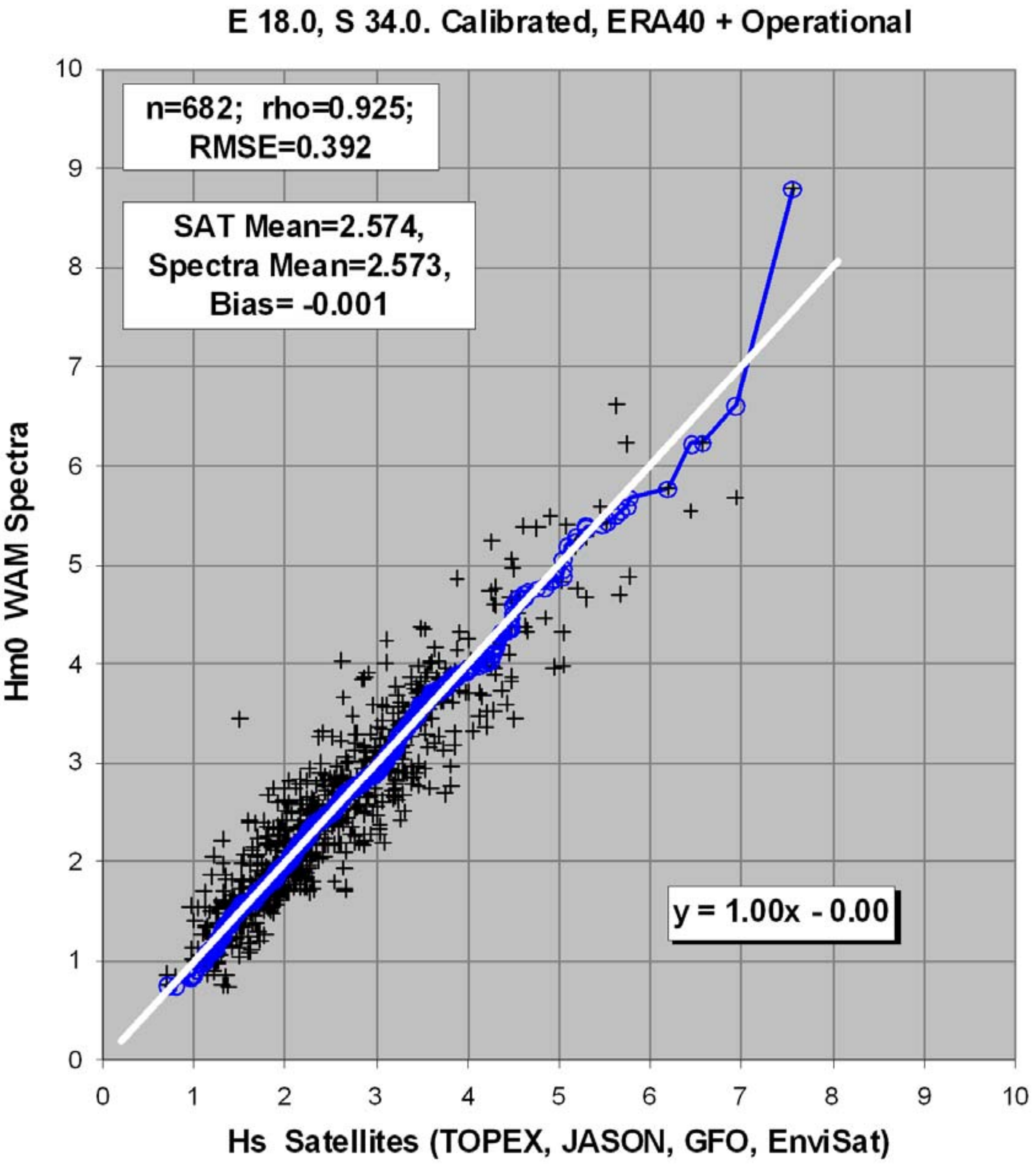

Figure 2 S 34.0°, E 18.0°, ERA-40 + Operational. Validation of calibrated Hm0 versus altimeter data. Black crosses are actual data, blue line is QQ-graph, with white regression line.

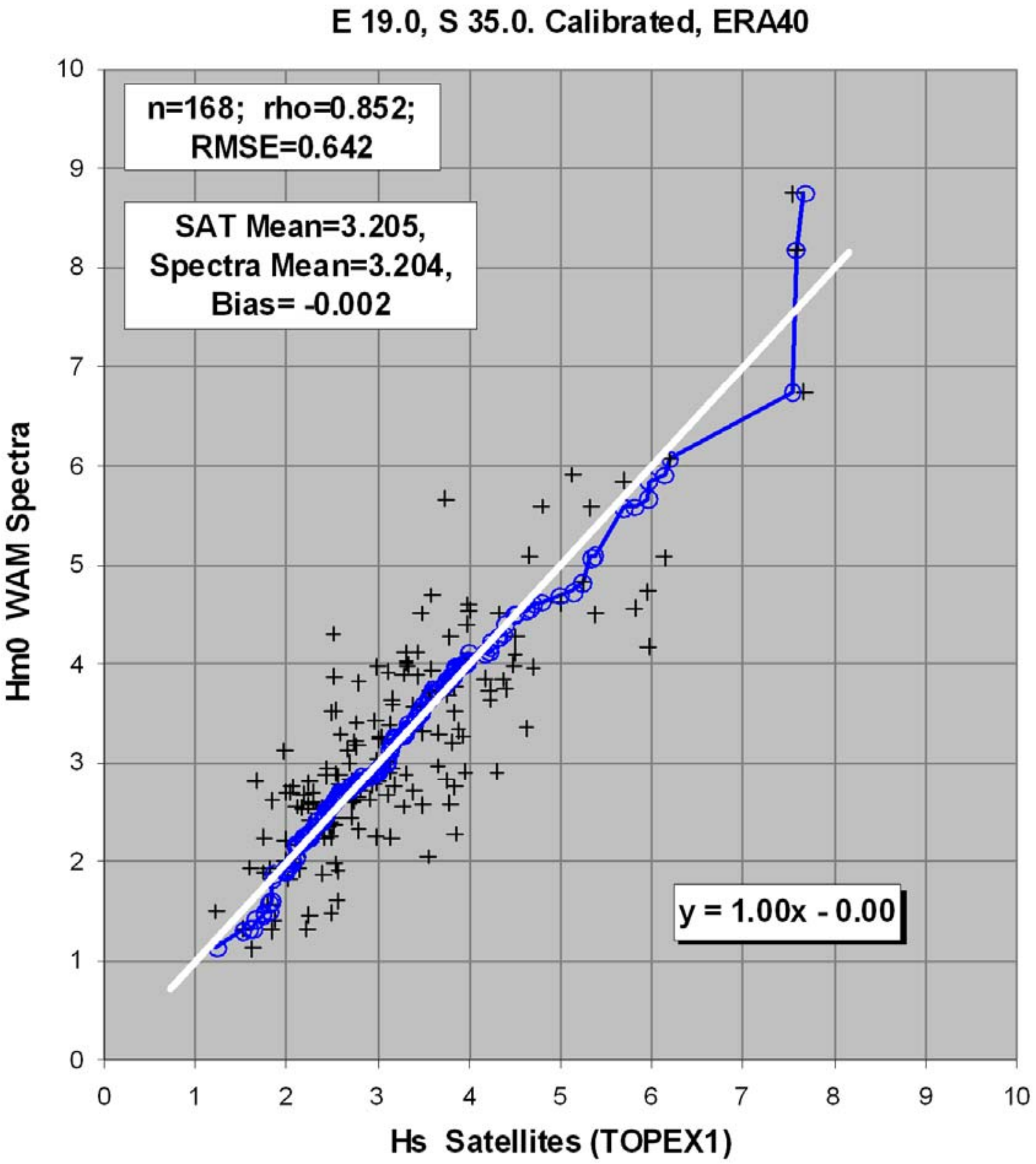

Figure 3 S 35.0°, E 19.0°, ERA-40. Validation of calibrated Hm0 versus altimeter data. Black crosses are actual data, blue line is QQ-graph, with white regression line.

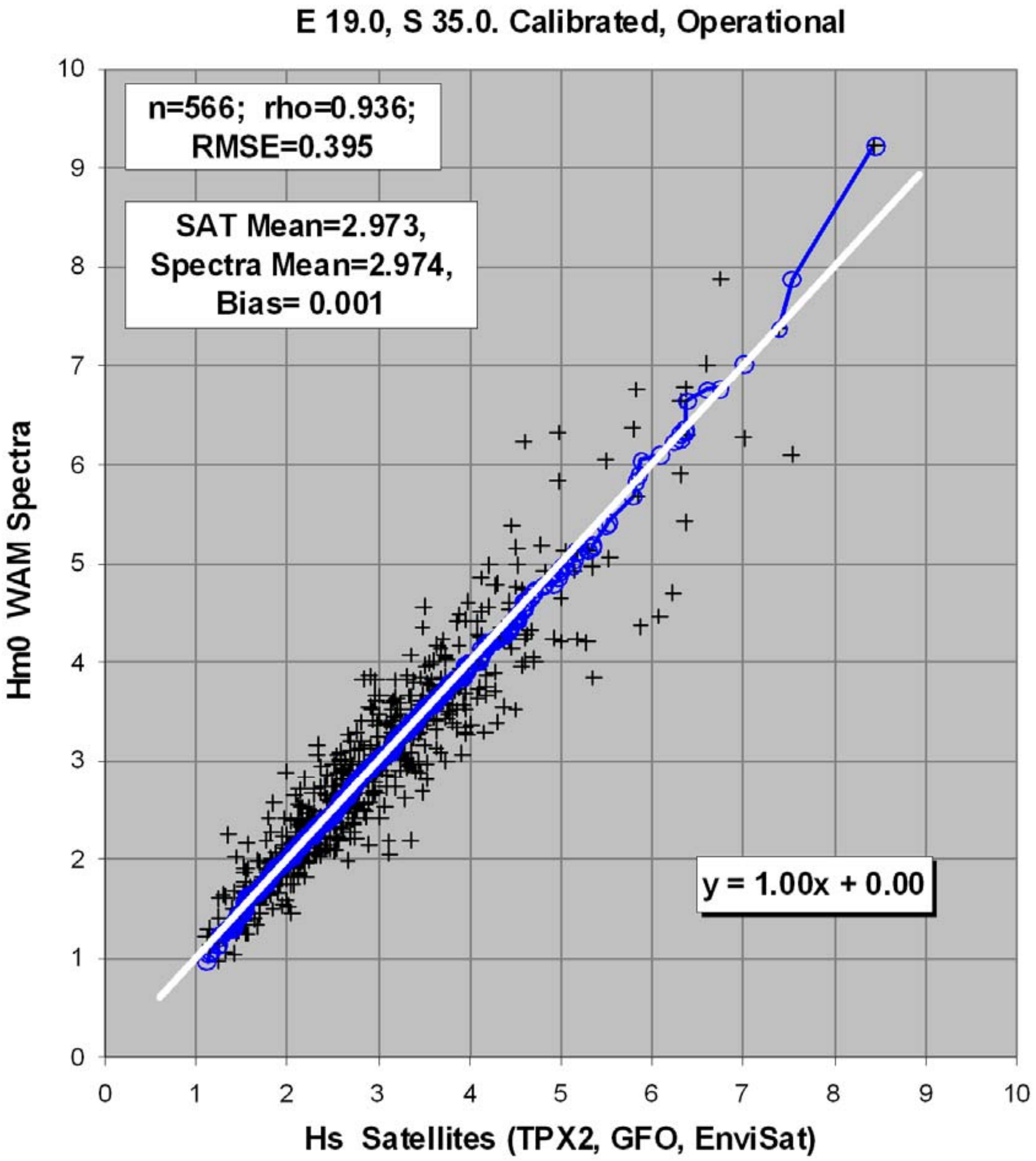

Figure 4 S 35.0°, E 19.0°, Operational. Validation of calibrated Hm0 versus altimeter data. Black crosses are actual data, blue line is QQ-graph, with white regression line.

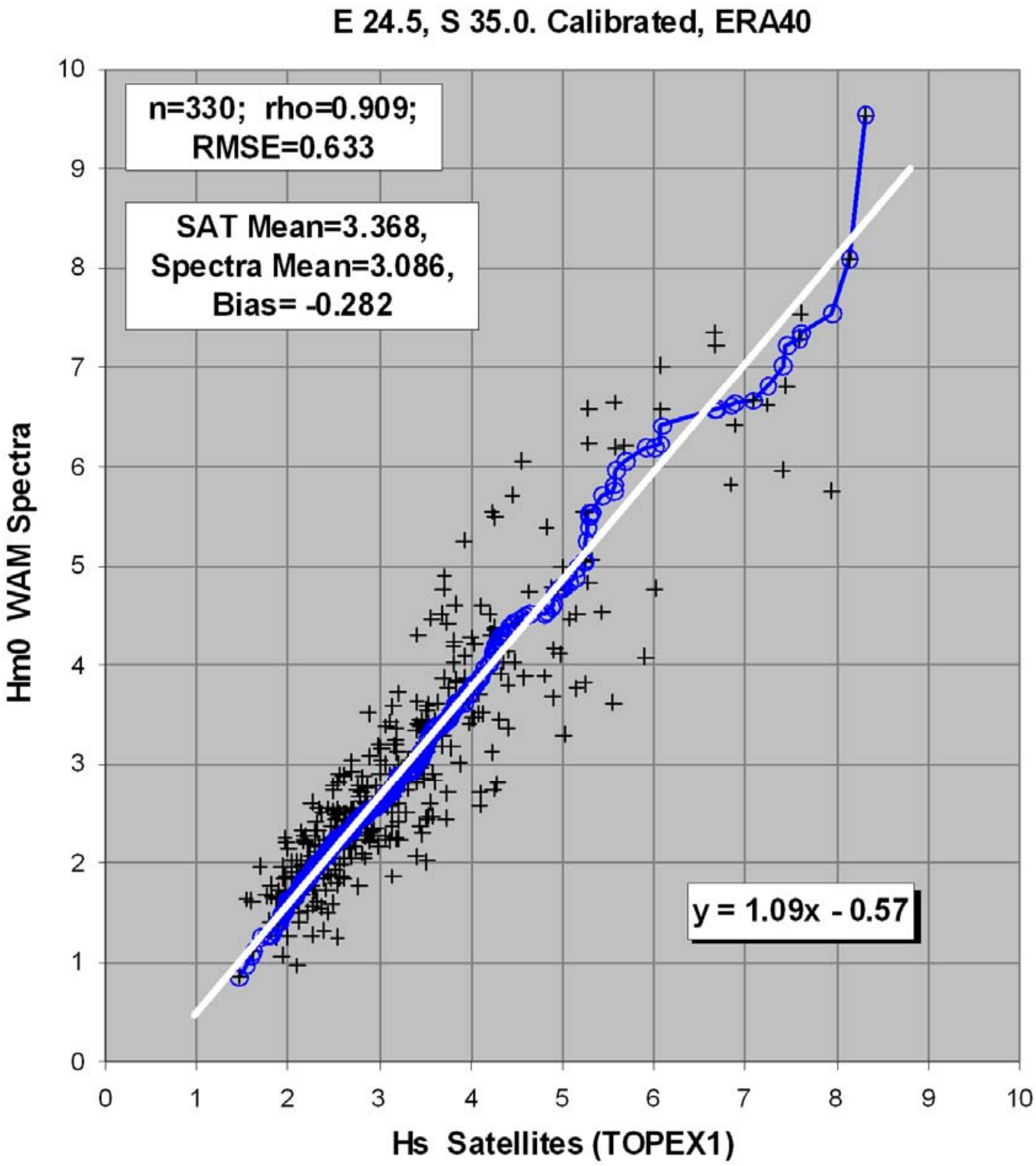

Figure 5 S 35.0°, E 24.5°, ERA-40. Validation of calibrated Hm0 versus altimeter data. Black crosses are actual data, blue line is QQ-graph, with white regression line. (Note: Altimeter data applies to S 36°, spectra data to S 35°.)

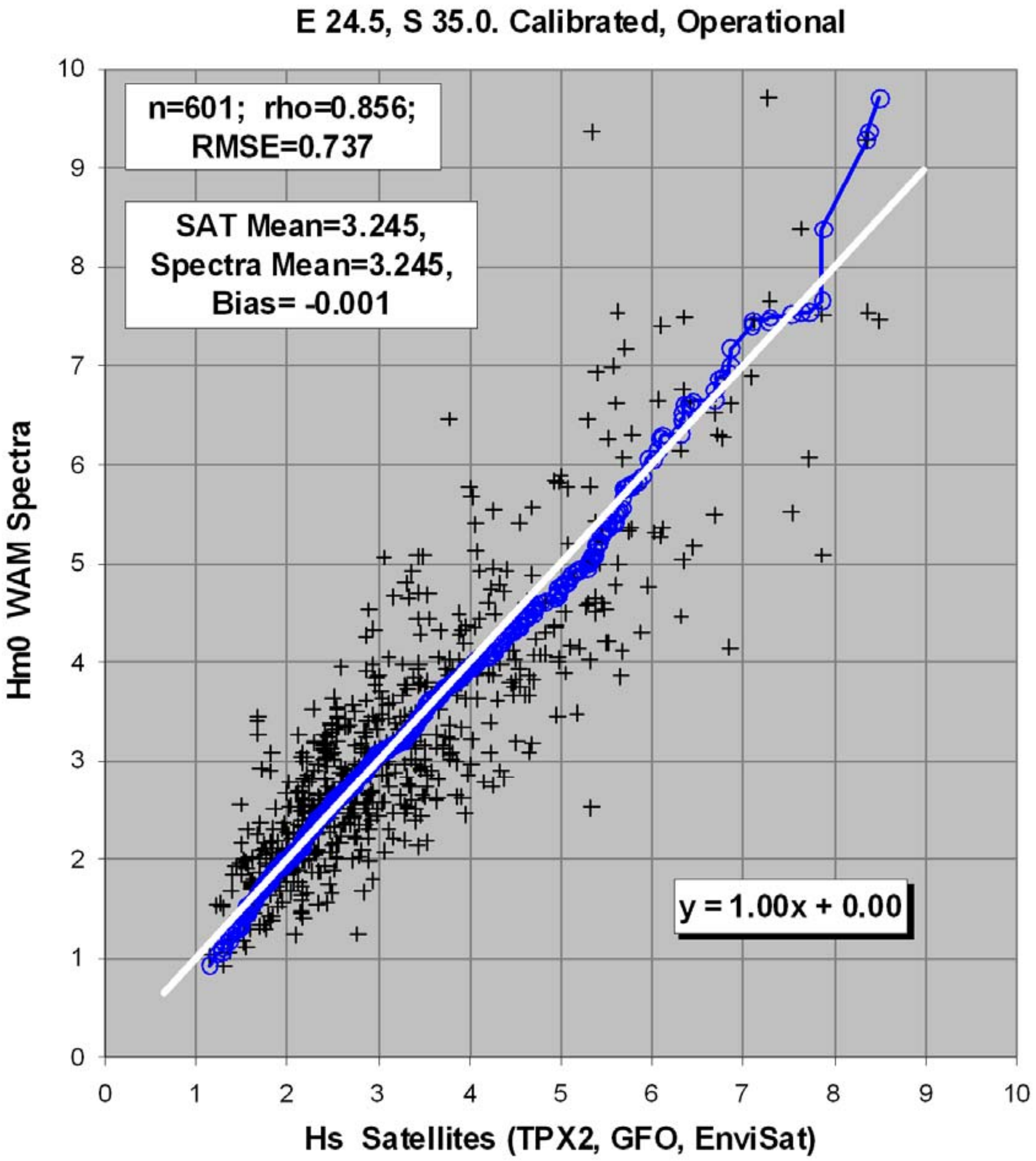

Figure 6 S 35.0°, E 24.5°, Operational. Validation of calibrated Hm0 versus altimeter data. Black crosses are actual data, blue line is QQ-graph, with white regression line.

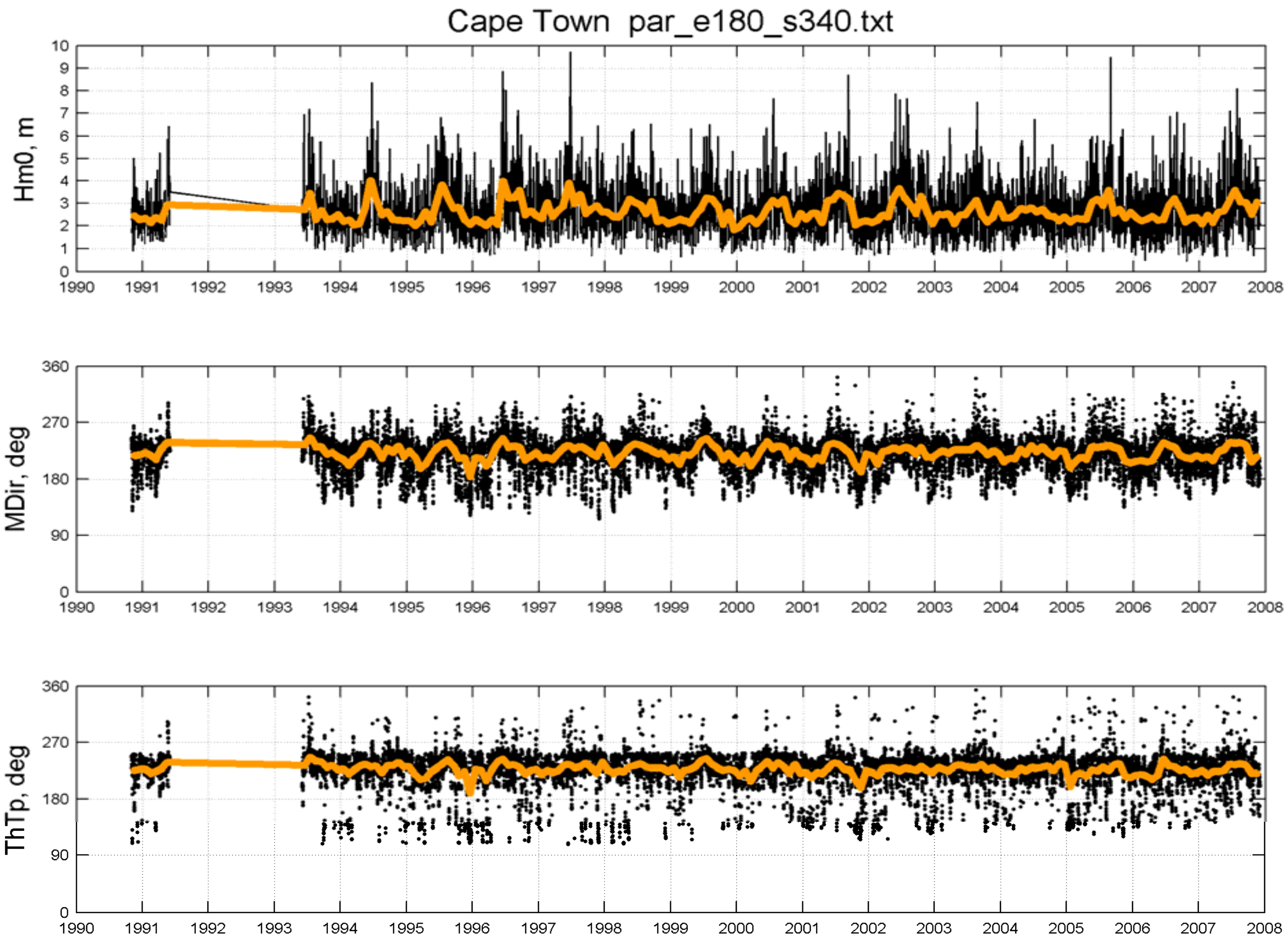

Figure 7 Time series of significant wave height and directions. S 34.0°, E 18.0°.

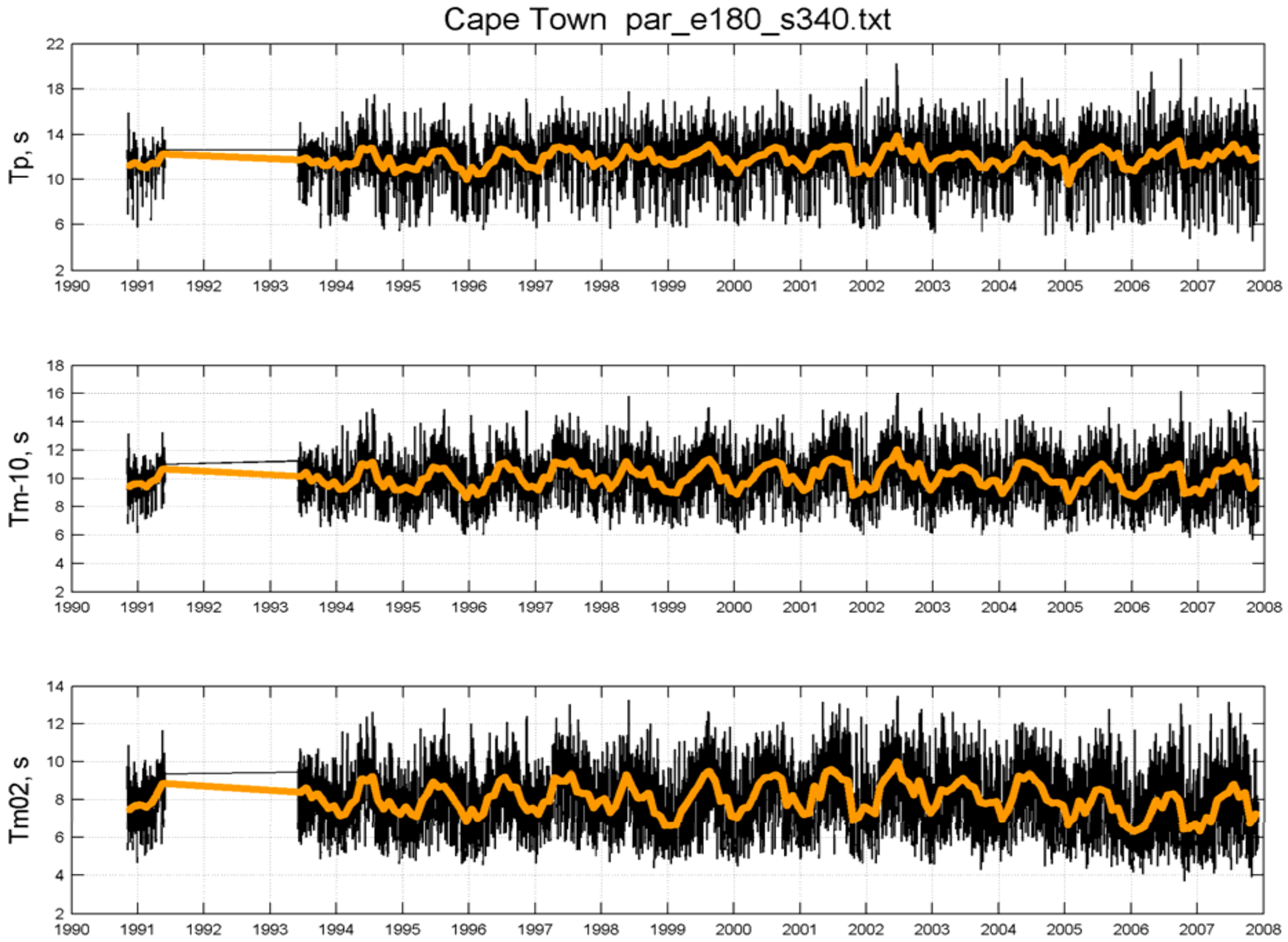

Figure 8 Time series of wave periods. S 34.0°, E 18.0°.

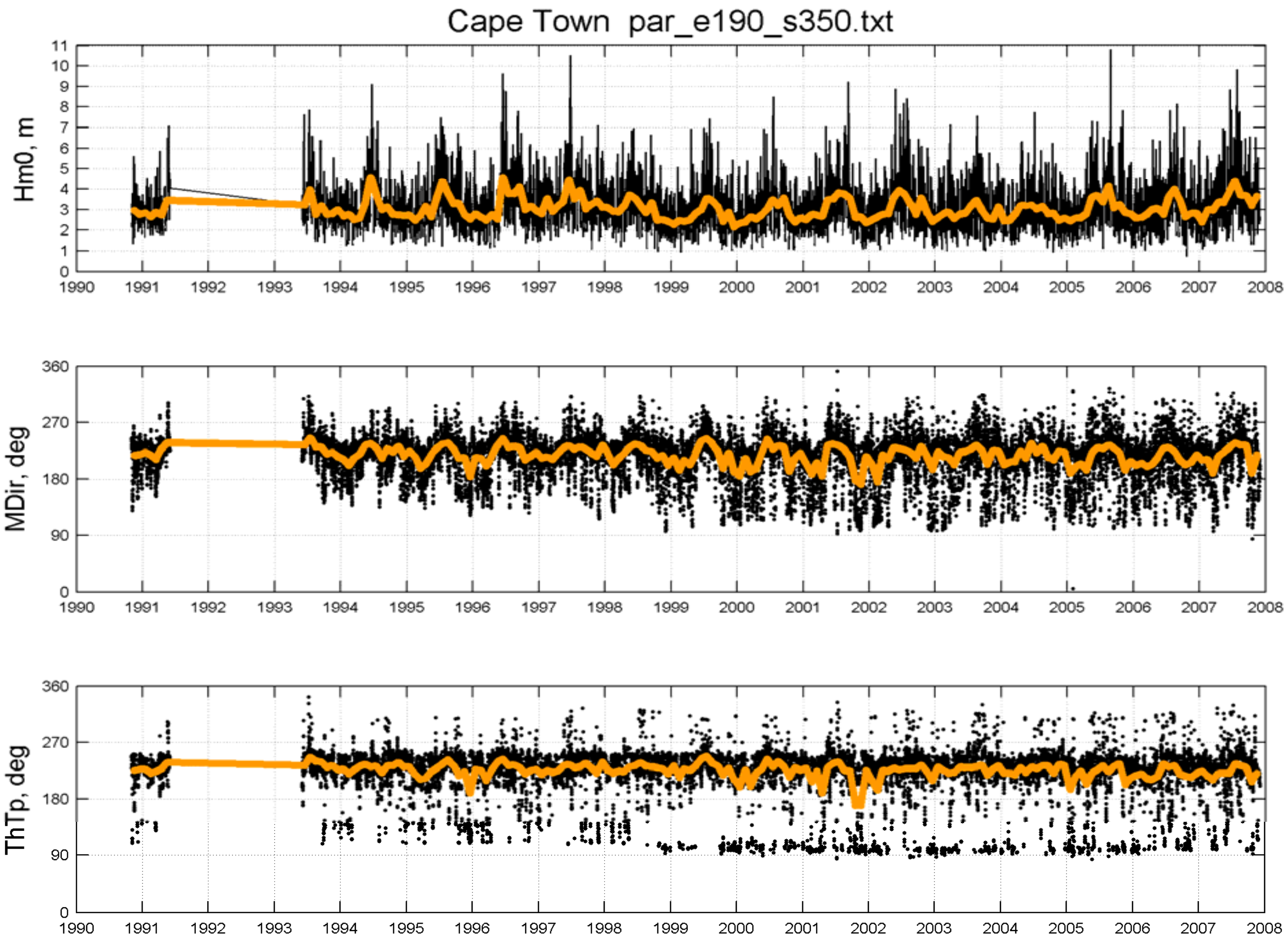

Figure 9 Time series of significant wave height and directions. S 35.0°, E 19.0°.

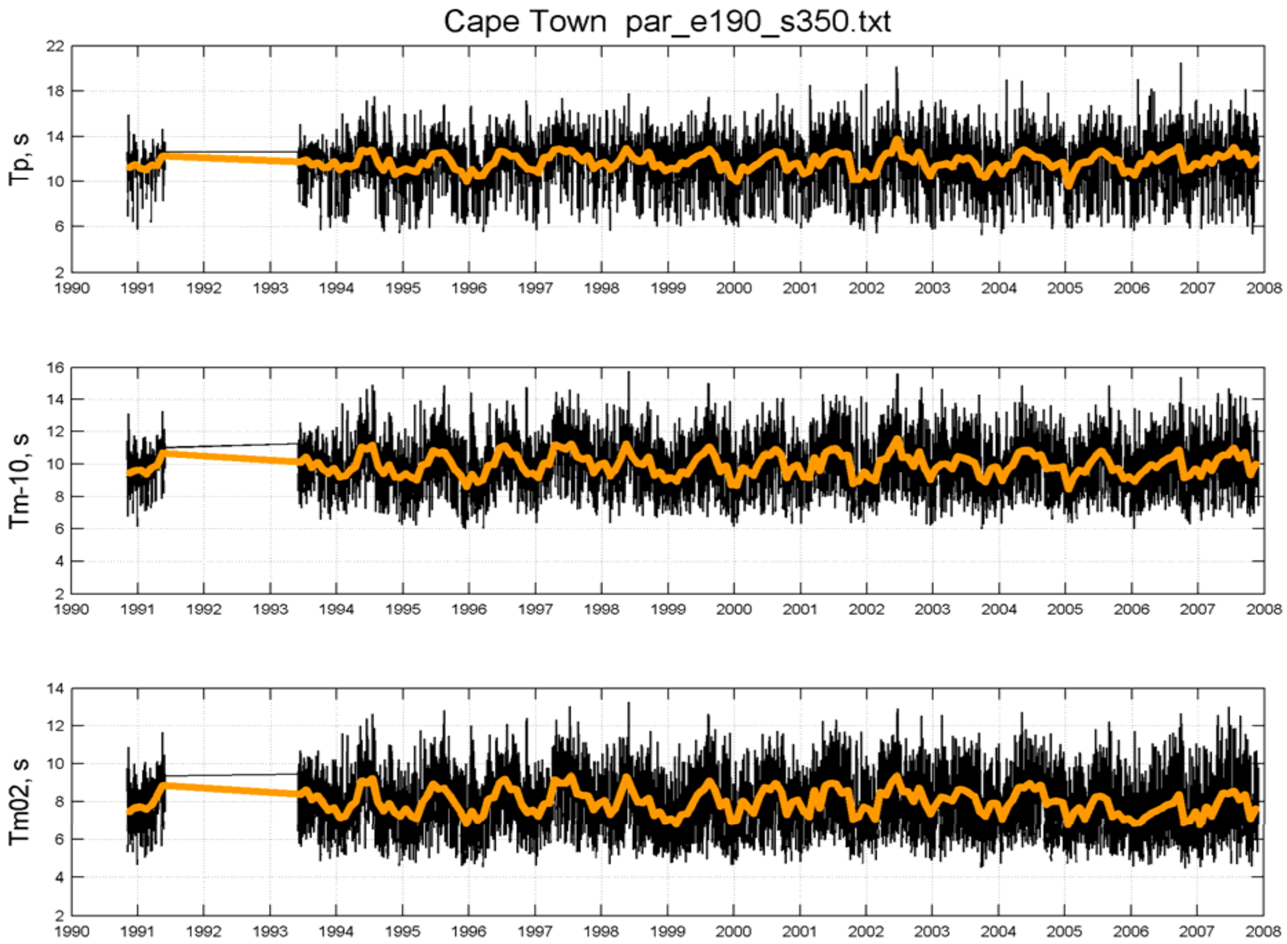

Figure 10 Time series of wave periods. S 35.0°, E 19.0°.

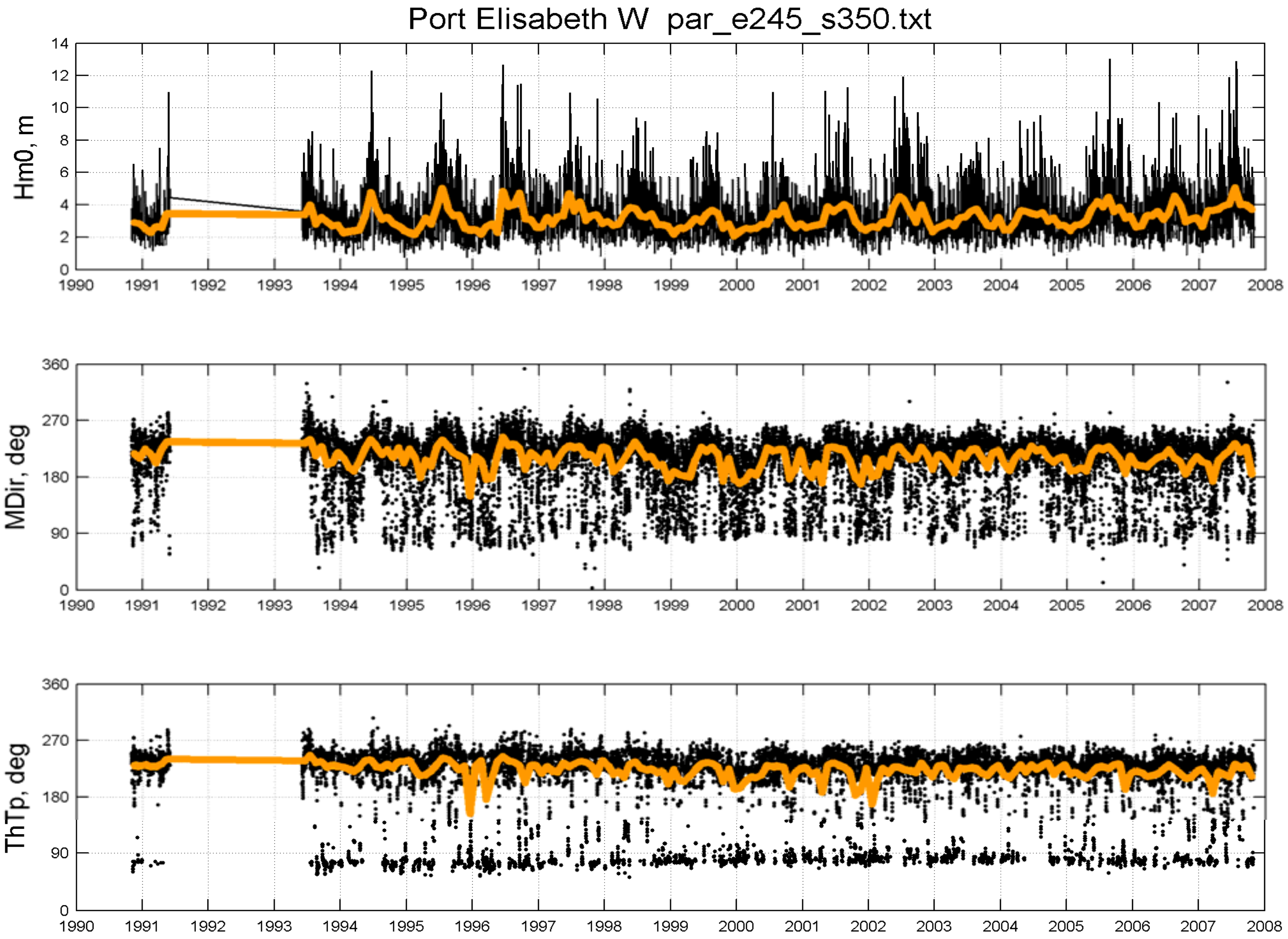

Figure 11 Time series of significant wave height and directions. S 35.0°, E 24.5°.

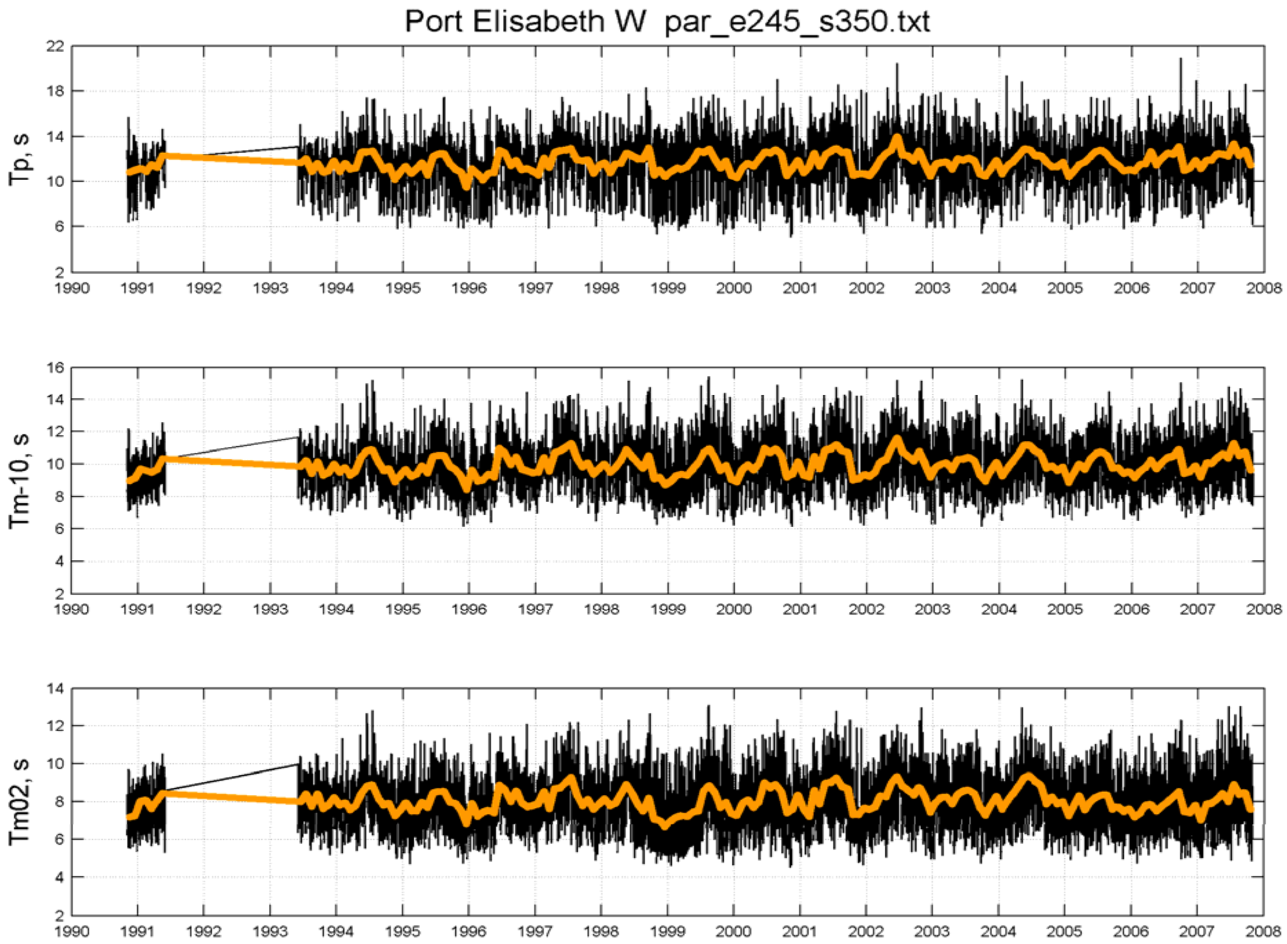

Figure 12   Time series of wave periods. S 35.0°, E 24.5°.

APPENDIX C:

Council for Geoscience Report: A Probabilistic Tsunami Hazard Assessment for Coastal South Africa from Distant Tsunamogenic areas

Revision 2

A Probabilistic Tsunami Hazard Assessment for Coastal South Africa from Distant Tsunamogenic areas

By

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Definition of Terms, Symbols and Abbreviations

Acceleration	The rate of change of particle velocity per unit time. Commonly expressed as a fraction or percentage of the acceleration due to gravity (g), where g = 9,81 m/s^2.
Acceleration Response Spectra (ARS)	Spectral acceleration is the movement experienced by a structure during an earthquake.
Annual Probability of Exceedance	The probability that a given level of seismic hazard (typically some measure of ground motions, e.g., seismic magnitude or intensity), or seismic risk (typically economic loss or casualties)
Area-specific mean seismic activity rate (λ_A)	Mean rate of seismicity for the whole selection area in the vicinity of the site for which the PSHA is performed.
Attenuation	A decrease in seismic-signal amplitude as waves propagate from the seismic source. Attenuation is caused by geometric spreading of seismic-wave energy and by the absorption and scattering of seismic energy in different earth materials.
Attenuation law (relationship)	A mathematical expression that relates a ground motion parameter, such as the peak ground acceleration, to the source and propagation path parameters of an earthquake such as the magnitude, source-to-site distance, fault type, etc. Its coefficients are usually derived from statistical analysis of earthquake records. It is a common engineering term for a ground motion relation.
b-value (*b*)	A coefficient in the frequency-magnitude relation, log $N(m) = a – bm$, obtained by Gutenberg and Richter (1941; 1949), where m is the earthquake magnitude and $N(m)$ is the number of earthquakes with magnitude greater than or equal to m. Estimated *b*-values for most seismic zones fall between 0,6 and 1,1.
Capable fault	A mapped fault that is deemed a possible site for a future earthquake with magnitude greater than some specified threshold.
Catalogue	A chronological listing of earthquakes. Early catalogues were purely descriptive, i.e., they gave the date of each earthquake and some description of its effects. Modern catalogues are usually quantitative, i.e., earthquakes are listed as a set of numerical parameters describing origin time, hypocenter location, magnitude, focal mechanism, moment tensor, etc.
CGS	Council for Geoscience
Power Plant ping	In vibration analysis, a term that indicates the mechanism for the dissipation of the energy of motion. Viscous Power Plant ping, which is proportional to the velocity of motion and is described by linear equations, is used to define different levels of response spectra and is commonly used to approximate the energy dissipation in the lower levels of earthquake response.
Design Earthquake	The postulated earthquake (commonly including a specification of the ground motion at a site) that is used for evaluating the earthquake resistance of a particular structure.
Elastic design spectrum (or spectra)	The specification of the required strength or capacity of the structure plotted as a function of the natural period or frequency of the structure and of the Power Plant ping appropriate to earthquake response at the required level. Design spectra are often composed of straight line segments (Newmark and Hall,

	1982) and/or simple curves, for example, as in most building codes, but they can also be constructed from statistics of response spectra of a suite of ground motions appropriate to the design earthquake(s). To be implemented, the requirements of a design spectrum are associated with allowable levels of stresses, ductilities, displacements or other measures of response.
Earthquake	Ground shaking and radiated seismic energy caused most commonly by sudden slip on a fault, volcanic or magmatic activity, or other sudden stress changes in the Earth.
Epicenter	The epicenter is the point on the earth's surface vertically above the hypocenter (or focus).
Epicentral distance (Δ)	Distance from the site to the epicenter of an earthquake.
Fault	A fracture or fracture zone in the Earth along which the two sides have been displaced relative to one another parallel to the fracture. The accumulated displacement may range from a fraction of a meter to many kilometres. The type of fault is specified according to the direction of this slip. Sudden movement along a fault produces earthquakes. Slow movement produces aseismic creep.
Focal depth (h)	Focal depth is the vertical distance between the hypocentre and epicentre.
Frequency	The number of cycles of a periodic motion (such as the ground shaking up and down or back and forth during an earthquake) per unit time; the reciprocal of period. Hertz (Hz), the unit of frequency, is equal to the number of cycles per second.
Ground motion	The movement of the earth's surface from earthquakes or explosions. Ground motion is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface.
Ground motion parameter	A parameter characterizing ground motion, such as peak acceleration, peak velocity, and peak displacement (peak parameters) or ordinates of response spectra and Fourier spectra (spectral parameters).
Heterogeneity	A medium is heterogeneous when its physical properties change along the space coordinates. A critical parameter affecting seismic phenomena is the scale of heterogeneities as compared with the seismic wavelengths. For a relatively large wavelength, for example, an intrinsically isotropic medium with oriented heterogeneities may behave as a homogeneous anisotropic medium.
Hypocenter	The hypocenter is the point within the earth where an earthquake rupture starts. The epicenter is the point directly above it at the surface of the Earth. Also commonly termed the focus.
Hypocentral distance (r)	Distance from the site to the hypocenter of an earthquake.
Induced earthquake	An earthquake that results from changes in crustal stress and/or strength due to man-made sources (e.g., underground mining and filling of a high Power Plant), or natural sources (e.g., the fault slip of a major earthquake). As defined less rigorously, “induced” is used interchangeably with “triggered” and applies to any earthquake associated with a stress change, large or small.

Local Magnitude (M_L)	A magnitude scale introduced by Richter (1935) for earthquakes in southern California. M_L was originally defined as the logarithm of the maximum amplitude of seismic waves on a seismogram written by the Wood-Anderson seismograph (Anderson and Wood, 1925) at a distance of 100 km from the epicenter. In practice, measurements are reduced to the standard distance of 100 km by a calibrating function established empirically. Because Wood-Anderson seismographs have been out of use since the 1970s, M_L is now computed with a simulated Wood-Anderson records or by some more practical methods.
Magnitude	In seismology, a quantity intended to measure the size of earthquake and is independent of the place of observation. Richter magnitude or local magnitude (M_L) was originally defined in Richter (1935) as the logarithm of the maximum amplitude in micrometers of seismic waves in a seismogram written by a standard Wood-Anderson seismograph at a distance of 100 km from the epicenter. Empirical tables were constructed to reduce measurements to the standard distance of 100 km, and the zero of the scale was fixed arbitrarily to fit the smallest earthquake then recorded. The concept was extended later to construct magnitude scales based on other data, resulting in many types of magnitudes, such as body-wave magnitude (m_b), surface-wave magnitude (M_S), and moment magnitude (M_W). In some cases, magnitudes are estimated from seismic intensity data, tsunami data, or duration of coda waves. The word "magnitude" or the symbol *M*, without a subscript, is sometimes used when the specific type of magnitude is clear form the context, or is not really important.
Maximum Regional Earthquake Magnitude ($m_{\max}$)	Upper limit of magnitude for a given seismogenic zone or entire region. Also referred to as the maximum credible earthquake (MCE).
Operating Basis Event (OBE)	Event with an average return period in the order of 145 years i.e. 50 % probability of exceedance in 100 years.
Oscillator	In earthquake engineering, an oscillator is an idealized damped mass-spring system used as a model of the response of a structure to earthquake ground motion. A seismograph is also an oscillator of this type
Parameter of the distribution of ln(PGA) (γ)	$\gamma = \beta / c_2$, where $\beta = b$ ln(10) [see "***b*-value**"] , and c_2 is a coefficient related to the attenuation relationship.
Peak Ground Acceleration (PGA)	The maximum acceleration amplitude measured (or expected) of an earthquake.
Probabilistic Seismic Hazard Analysis (PSHA)	Available information on earthquake sources in a given region is combined with theoretical and empirical relations among earthquake magnitude, distance from the source and local site conditions to evaluate the exceedance probability of a certain ground motion parameter, such as the peak acceleration, at a given site during a prescribed period.
Response spectrum	The response of the structure to a specified acceleration time series of a set of single-degree-of-freedom oscillators with chosen levels of viscous damping, plotted as a function of the undamped natural period or undamped natural frequency of the system. The response spectrum is used for the prediction of the earthquake response of buildings or other structures.
Seismic Hazard	Any physical phenomena associated with an earthquake (e.g., ground motion, ground failure, liquefaction, and tsunami) and

	their effects on land use, man-made structure and socio-economic systems that have the potential to produce a loss. It is also used without regard to a loss to indicate the probable level of ground shaking occurring at a given point within a certain period of time.
Seismic Wave	A general term for waves generated by earthquakes or explosions. There are many types of seismic waves. The principle ones are body waves, surface waves, and coda waves.
Seismic zone	An area of seismicity probably sharing a common cause.
Seismogenic	Capable of generating earthquakes.
Site-specific mean activity rate (λ_S)	Mean activity rate of the selected ground motion parameter experienced at the site.
Strong ground motion	A ground motion having the potential to cause significant risk to a structure's architectural or structural components, or to its contents. One common practical designation of strong ground motion is a peak ground acceleration of 0.05g or larger.

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1. Introduction

The Council for Geoscience (CGS) was requested to provide probabilistic seismic hazard analyses (PSHA) for the areas of Calcutta, Karachi, South Sandwich and Sumatra. It is assumed that these are tsunamogenic areas, which can produce tsunami generating earthquakes that can affect coastal areas of South Africa. The objective of the PSHA is to obtain long-term probabilities of the occurrence of ground motion of a specified size in a given time interval. Several mutations of are known. The Parametric-Historic PSHA procedure is applied in this work as described by Kijko and Graham (1998; 1999), Kijko (2004), (Appendix A).

The results are given in terms of mean return periods and probabilities of being exceeded, for specified earthquake magnitudes. Appendices C, D, E and F show the results of the calculations for each of the areas. These contain details of the computations, input data and respective hazard parameters.

2. The Area-Specific Hazard

The area-specific parameters that have to be determined, i.e. the mean seismic activity rate (λ_A), the Gutenberg-Richter parameter (*b)* and the maximum possible earthquake magnitude ($m_{\max}$), are obtained by application of the K-S-B procedure (Kijko and Graham, 1998; Kijko, 2004), described in Appendix B. The activity rate (λ_A) is the expected number of earthquakes of a given magnitude and stronger that will occur per unit time (e.g. per year). The Gutenberg – Richter *b*-value gives the slope of the frequency–magnitude curve and defines the ratio between the number of large and small earthquake occurrences. The maximum possible regional characteristic earthquake magnitude ($m_{\max}$), is the upper limit of magnitude for a given seismogenic source zone or entire region. The characteristic seismic hazard is expressed in terms of the probability of occurrence of an earthquake of a particular magnitude and its associated mean return period.

2.1. Karachi Area

2.1.1. The Area-Specific Hazard Parameters

The calculations are based on a catalogue spanning approximately 570 years (Appendix D), we obtained a maximum credible earthquake magnitude, $\hat{m}_{\max}$ = 8.44 ± 0.29, the Gutenberg-Richter parameter $\hat{b}$ = 0.90 ± 0.07, and a mean area-characteristic seismic activity rate, $\hat{\lambda}_A$ = 2.52 ± 0.46 per year (for $m_{\min}$ = 5.0).

2.1.2. Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

The input parameters and the results of the PSHA are given in Appendix D. The range of expected magnitudes is specified from 5 to 8.4. For each magnitude, the calculated activity rate, return period, and probabilities of exceedance in 1, 50, 100 and 1 000 years are listed (Appendix D). For instance, a magnitude 6.0 earthquake is expected to occur once every 2.85 years in the area.

2.1.3. Plots of Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

Figure 1 shows the probability for a given magnitude to be exceeded in one year. As an example, the probability for a magnitude equal to or greater than 6.0 to occur in one year is approximately 0.29 (29 %).

Figure 2 shows the mean return period of earthquakes with magnitudes in the range 5 to 8.4 units. Thus one can expect a magnitude 8 event to occur approximately every 162 years.

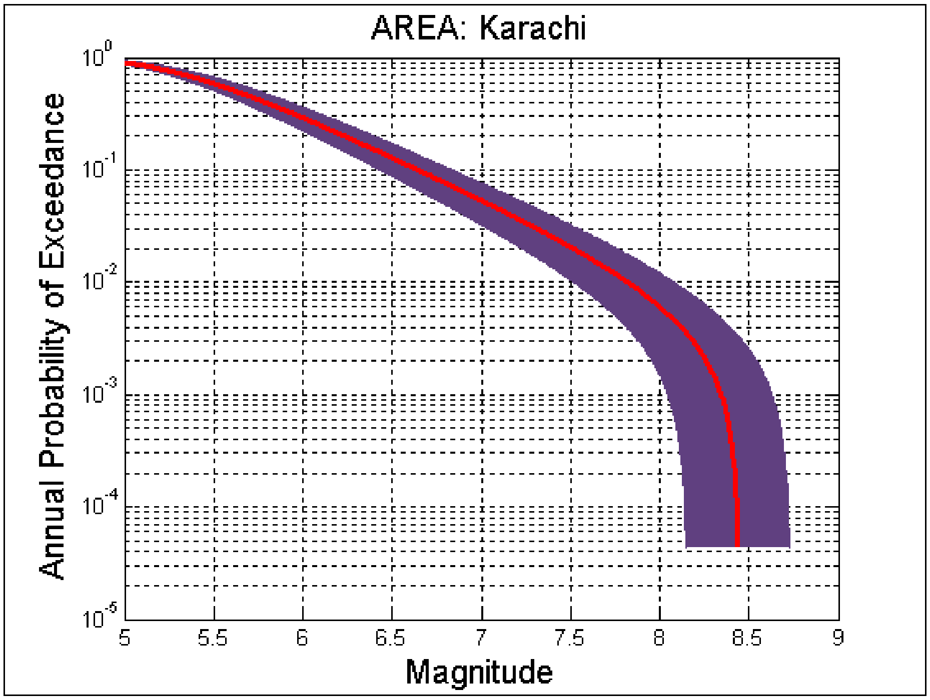

Figure 1. The annual probability of exceeding the specified magnitude. The red curve shows the mean probability, while the two blue curves indicate the mean probability plus and minus the standard deviation.

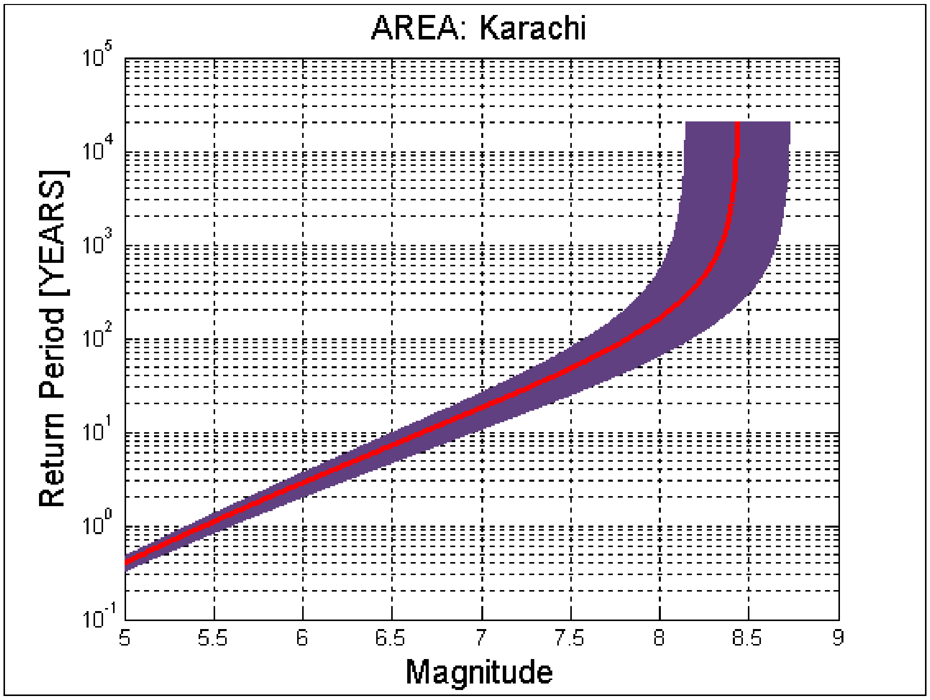

Figure 2. The mean return periods for earthquakes of magnitude 5 to 8.4 units .The red curve shows the mean return period, while the two blue curves indicate the mean return periods plus and minus the standard deviation.

2.2. South Sandwich Area

2.2.1. The Area-Specific Hazard Parameters

The calculations are based on a catalogue spanning approximately 32 years (Appendix E). We obtained for the area, a maximum credible earthquake magnitude, $\hat{m}_{\max}$ = 7.64 ± 0.24, the Gutenberg-Richter parameter $\hat{b}$ = 1.07 ± 0.09, and a mean area-characteristic seismic activity rate for the area $\hat{\lambda}_A$ = 8.42 ± 2.14 per year (for $m_{\min}$ = 5.5).

2.2.2. Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

The input parameters and results of the PSHA are given in Appendix E. The range of expected magnitudes is specified from 5.5 to 7.6. For each magnitude the calculated activity rate, return period, and probabilities of exceedance in 1, 50, 100 and 1 000 years are listed in Appendix E. For instance, a magnitude 6.5 earthquake is expected to occur once every 1.3 years in the area.

2.2.3. Plots of Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

Figure 3 shows the probability for a given magnitude to be exceeded in one year. As an example, the probability for a magnitude equal to or greater than 6.5 to occur in one year is approximately 0.53 (53 %).

Figure 4 shows the mean return period of earthquakes with magnitudes in the range 5.5 to 7.6 units. For instance, one can expect a magnitude 7 event to reoccur approximately every 4.64 years.

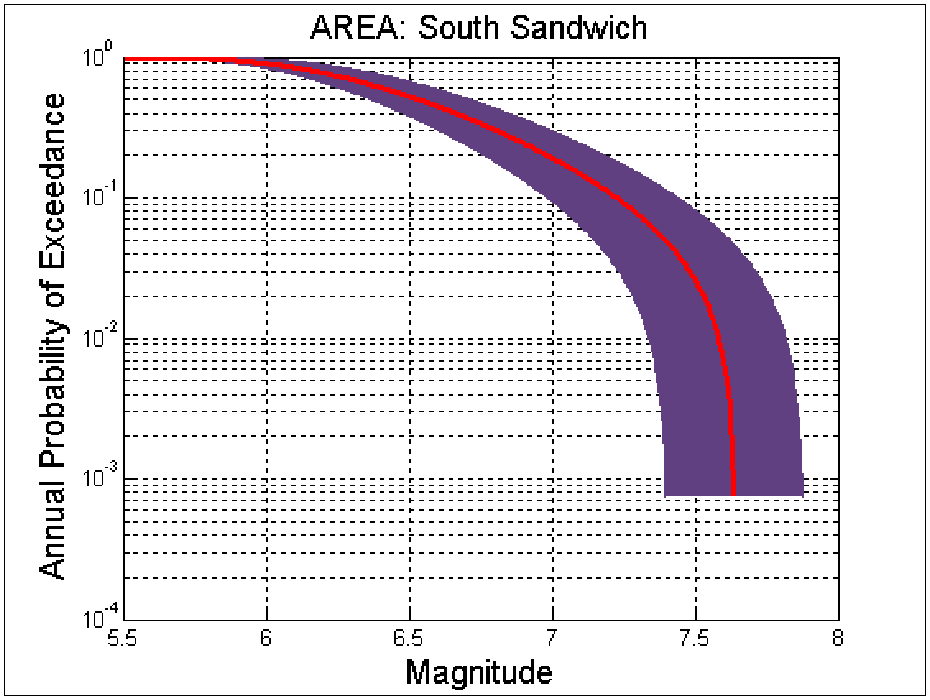

Figure 3. The annual probability of exceeding the specified magnitude. The red curve shows the mean probability, while the two blue curves indicate the mean probability plus and minus the standard deviation.

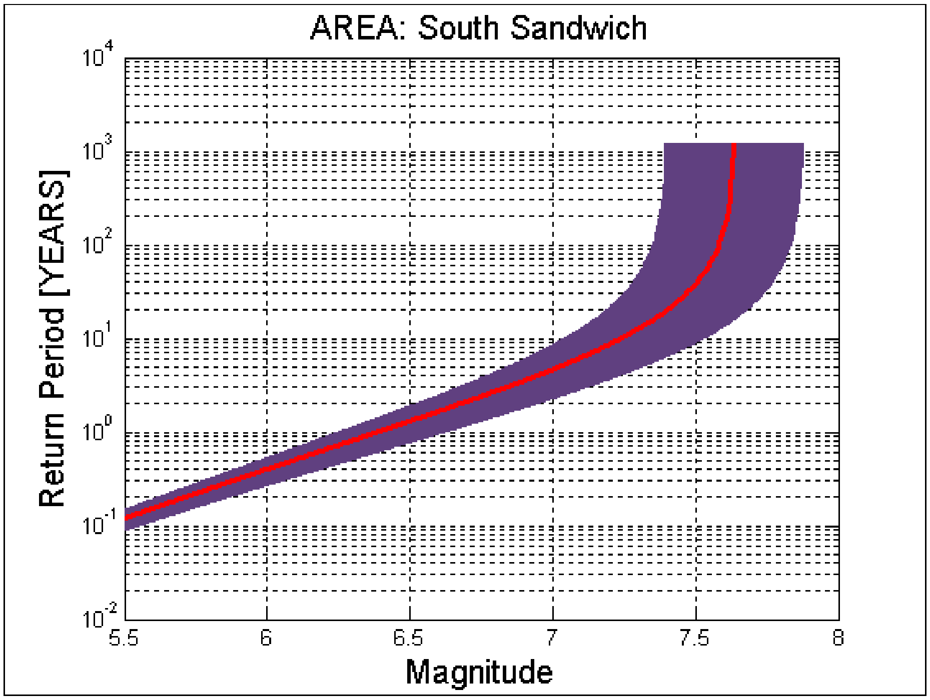

Figure 4. The mean return periods for earthquakes of magnitude 5.5 to 7.6 units .The red curve shows the mean return period, while the two blue curves indicate the mean return periods plus and minus the standard deviation.

2.3. Sumatra Area

2.3.1. The Area-Specific Hazard Parameters

Based on a catalogue spanning approximately 32 years (Appendix F), we obtain for the area, a maximum credible earthquake magnitude, $\hat{m}_{\max}$ = 9.20, the Gutenberg-Richter parameter $\hat{b}$ = 1.03 ± 0.09, and a mean area-characteristic seismic activity rate, $\hat{\lambda}_A$ = 9.18 ± 2.12 per year (for $m_{\min}$ = 5.5).

2.3.2. Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

The input parameters and the results of the PSHA are given in Appendix F. The range of expected magnitudes is specified from 5.5 to 9.2. For each magnitude, the calculated activity rate, return period, and probabilities of exceedance in 1, 50, 100 and 1 000 years are listed in Appendix F. For instance, a magnitude 7.0 earthquake is expected to occur once every 2.73 years.

2.3.3. Plots of Earthquake Magnitude Exceedance Probabilities and Mean Return Periods

Figure 5 shows the probability for a given magnitude to be exceeded in one year. As an example, the probability for a magnitude equal to or greater than 7.0 to occur in one year is approximately 0.3 (30 %).

Figure 6 shows the mean return period of earthquakes with magnitudes in the range 5.5 to 9.2 units. For instance, one can expect a magnitude 8 event to occur after approximately every 19.3 years.

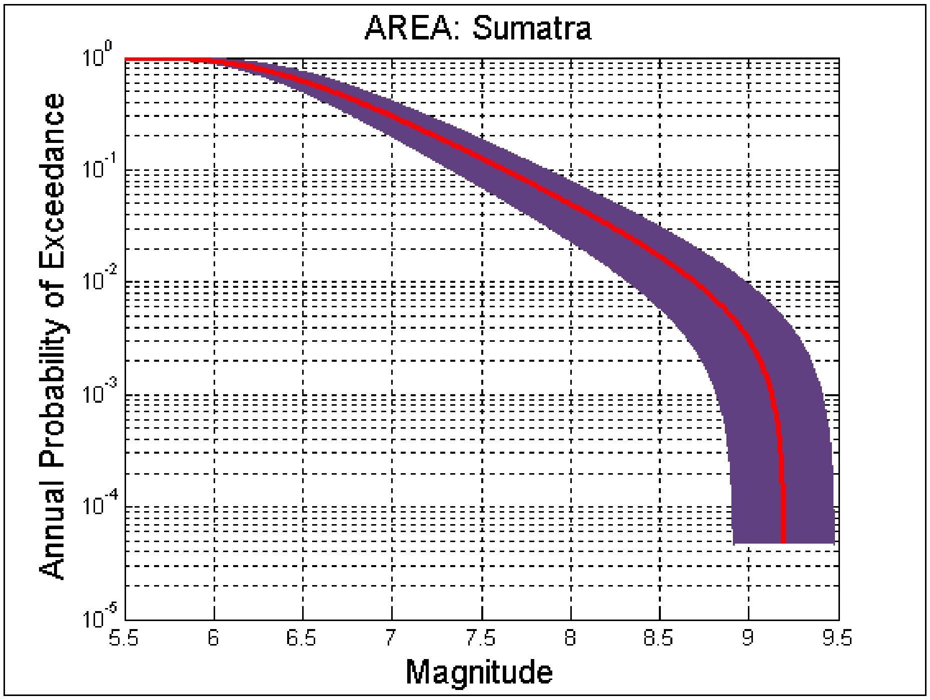

Figure 5. The annual probability of exceeding the specified magnitude . The red curve shows the mean probability, while the two blue curves indicate the mean probability plus and minus the standard deviation.

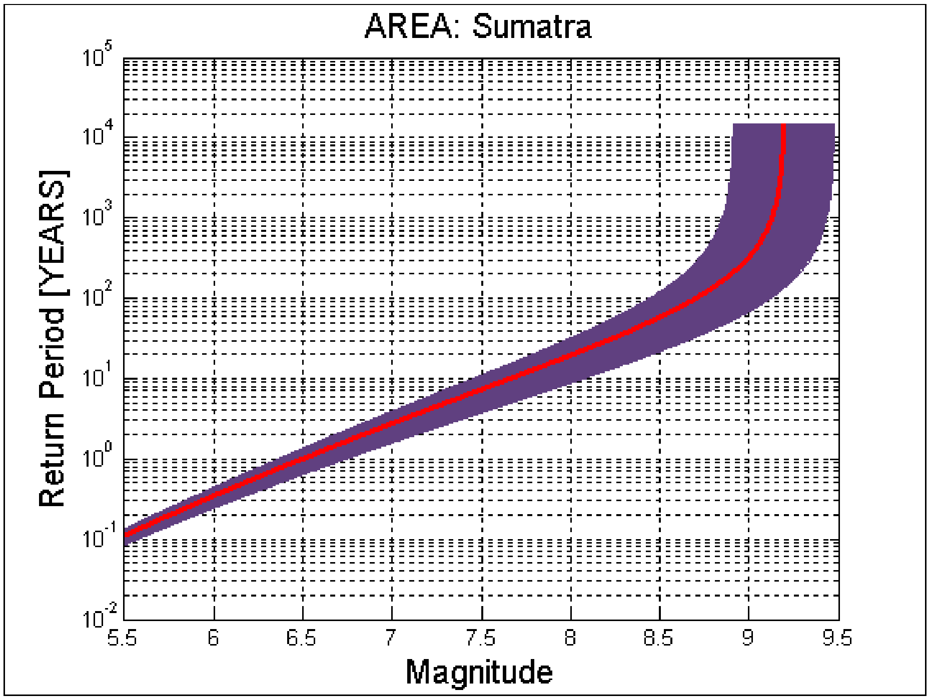

Figure 6. The mean return periods for earthquakes of magnitude 5,5 to 9,2 units .The red curve shows the mean return 33period, while the two blue curves indicate the mean return periods plus and minus the standard deviation.

3. Surface Fault Displacement

Relations used for the mean displacement, fault length and fault width (Table 1) were obtained from Papazachos *et al.,* (2004), which were determined for dip-slip faults from regions of lithospheric subduction. These were selected because regions (Karachi, South Sandwich and Sumatra) under discussion fall in regions of subduction. The relations are valid for a magnitude range of $6.7 \leq M \leq 9.2$.

Table 1: Moment magnitude and corresponding fault parameters obtained using equations 1, 2 and 3.

Region	M_{max}	Mean Displacement (m)	Fault Length (km)	Fault Width (km)	Location
Karachi	8.44	4.18	283.1	96.92	24.5^0N 63.0^0E
South Sandwich	7.64	1.29	102.8	54.75	55.1^0S 27.3^0W
Sumatra	9.20	12.82	741.3	166.72	03.3^0N 95.8^0E

Since we are considering worst case scenarios, the largest expected magnitude values (M_{max}), as estimated in this report, were used for all the areas.

$$\text{Log}(u) = 0.64M - 2.78 \quad (1)$$

Where u is the mean displacement and M is moment magnitude.

$$\text{Log}(L) = 0.55M - 2.19 \quad (2)$$

Where L is the fault length and M is moment magnitude.

$$\text{Log}\ (w) = 0.31M - 0.63 \quad (3)$$

Where w is the fault width and M is the moment magnitude.

Table 2. Fault plane parameters for Sumatra (McCloskey *et al.*, 2008; Singh, 2006), Karachi (Engdahl and Villasenor, 2002; Byrne *et al.*, 1992) and South Sandwich (USGS, 2006) subduction regions

Region	**Dip angle** (degrees)	**Depth** (km)
Karachi	7 (2 – 27)	25 - 27
South Sandwich	50	<50
Sumatra	8 - 15	25 - 30

The dip angles and fault plane depths given in Table 2 are based on available information on past tsunami – generating earthquakes as well as from projects to predict future tsunamis (e.g. McCloskey *et al.*, 2008).

4. Conclusion

The information used in determining the relations used to calculate mean displacement, fault length and fault width was obtained from aftershock distribution and fault modelling. Therefore, there are no direct measurements of fault displacement. It is beyond the scope of this work to give actual locations of predicted earthquake origins as the earthquakes can occur anywhere along the plate boundaries in the areas discussed. Thus we gave locations of either the northernmost point of the boundary or previous location of a large earthquake that caused a tsunami (Sumatra region). It is also recommended that different strike angles be used in the tsunami wave modelling to determine the fault strike that produces the worst case in combination with other parameters.

It is important to note that not all earthquakes of quoted magnitudes in the areas discussed generate tsunamis. Rather, only a small fraction of them do. Thus, the calculated activity rates need to be corrected by multiplying by the fraction, estimated to be approximately 1%. Certainly more investigations are required to determine a realistic fraction. Therefore, this study should be treated as a very preliminary one.

4. References

Anderson J. A. and Wood H. O., (1925). Description and Theory of the Torsion Seismometer *Bul. Seismol. Ssoc. Am.*, **15**, 1-72.

Byrne, D., Sykes, L. R. and Davis, D. M., (1992). Great thrust earthquakes and aseismic slip along the plate boundary of the Makran subduction zone*, J. Geophys. Res.*, **97** (B1), 449 – 478.

Engdahl, E. R. & Villasenor, A. (2002). Global seismicity: 1900-1999. In *International Handbook of Earthquakes and Engineering Seismology*. Elsevier Science Ltd.

Gutenberg, B. and Richter, C. F., (1941). Seismicity of the Earth, *Geol. Soc. Amer. Spec. Pap.,* **34**, 1-131.

Gutenberg, B., Richter, C.F., (1949). Seismicity of the Earth and Associated Phenomena. Princeton University Press, Princeton.

Kijko**,** A. (2004). Estimation of the maximum earthquake magnitude $m_{\max.}$ *Pure Appl. Geophys,* **161**, 1-27.

Kijko, A. and Graham, G. (1998). "Parametric-Historic" procedure for probabilistic seismic hazard analysis. Part I: Assessment of maximum regional magnitude $m_{\max}$, *Pure Appl. Geophys*, **152**, 413-442

Kijko, A. and Graham, G. (1999). "Parametric-Historic" procedure for probabilistic seismic hazard analysis. Part II. Assessment of seismic hazard at specified site, *Pure Appl. Geophys*. **154**, 1-22.

McCloskey, J., Antonioli, A., Piatanesi, A., Sieh, K., Steacy, S., Nalbant, S., Cocco, M., Giunchi, C., Huang, J. and Dunlop, P., (2008). Tsunami threat in the Indian Ocean from a future megathrust earthquake west of Sumatra, *Ear. Pl. Sci. Let.,* **265**, 61 – 81.

Newmark, N.M., and Hall, W.J., (1982), *Earthquake Spectra and Design*, Earthquake Engineering Research Institute, Berkeley, Calif., pp. 29-37.

Papazachos, B. C., Scordilis, E. M., Panagiotopoulos, D. G., Papazochos, C. B. and Karakaisis G. F. (2004). Global relations between seismic fault parameters and moment magnitude of earthquakes, *Bull. Geol. Soc. Greece*, **XXXVI**, 1482 – 1489.

Richter, C. F. (1935). An instrumental earthquake magnitude scale. *Bul. Seismol. Soc. Am*., **25**, 1 – 32.

Singh, S. (2006). Seismic investigation of the Great Sumatra – Andaman earthquake, *First Break*, **24**, 37 – 40.

USGS, (2006).M7.0 South Sandwich Islands, Scotia Sea, Earthquake of 20 August 2006, Earthquake summary map.

Appendix A:

Outline of the Parametric-Historic Procedure for Probabilistic Seismic Hazard Assessment

The aim of this outline is to provide the reader with key elements of the Parametric-Historic probabilistic seismic hazard analysis procedure. In addition, in all calculations, uncertainty of the employed seismicity models has been incorporated, by incorporation of the Bayesian formalism.

The objective of seismic hazard assessment is to obtain long-term probabilities of the occurrence of seismic events of a specified size in a given time interval.

In this report, the seismic hazard was assessed in terms of PGA using the Parametric-Historic procedure described in Kijko and Graham (1998, 1999). Seismic hazard analysis was done on the basis of the whole seismological record available for area, including historical observations as well as the instrumental data recorded during the past decades, covering a period of almost two millennia. The maximum possible PGA value for the site was obtained by applying the (floating) earthquake procedure, assuming the occurrence of the strongest possible earthquake at very close distance from the site. The probabilities of exceedance of the maximum possible PGA values were also calculated to illustrate the uncertainty of maximum PGA estimation.

The method used to estimate the level of seismic hazard in terms of PGA has been described in detail in Kijko and Graham (1998, 1999), and Kijko (2004).

The statistical techniques that can be used for the evaluation of the maximum regional earthquake magnitude, $m_{\max}$ is described in papers Kijko and Graham (1998) and Kijko (2004). The work by Kijko and Graham (1999) delineates a methodology for probabilistic seismic hazard assessment at a given site.

Site-specific analyses of seismic hazard require a knowledge of the attenuation of the selected ground-motion parameter a, usually PGA, as a function of distance. According to the adopted methodology, the attenuation law of PGA is assumed to be of the type,

$$\ln(a) = c_1 + c_2 \cdot m + \phi(r) + \varepsilon, \tag{1}$$

where c_1 and c_2 denote empirical coefficients, m is the earthquake magnitude, $\phi(r)$ is a function of earthquake distance and ε is a normally distributed random error.

To express seismic hazard in terms of PGA, the aim would be to calculate the conditional probability that an earthquake of random magnitude, occurring at a random distance from the site, will cause a PGA value equal to, or greater than, the chosen threshold value, $a_{\min}$, at the site. We accept the standard assumption (e.g., Page, 1968) that the random earthquake magnitude, m, in the range of $m_{\min} \leq m \leq m_{\max}$, is distributed according to the doubly truncated Gutenberg-Richter relation

$$\log N(m) = a - b \cdot m, \tag{2}$$

where $N(m)$ is the number of earthquakes with magnitude m, and stronger, and a and b are parameters. (See Figure 1).

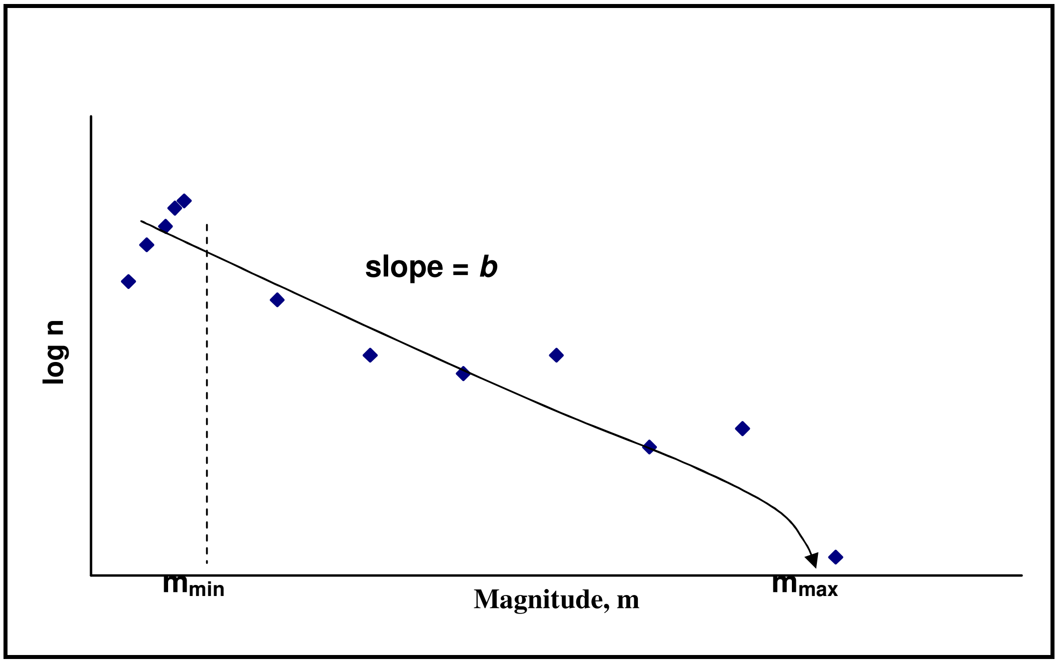

Figure 1. Schematic illustration of the doubly truncated frequency-magnitude Gutenberg-Richter relation. The slope of the curve is described by parameter b, known as b-value of the Gutenber-Richter. Value m_{min} is the minimum earthquake magnitude corresponding to acceleration a_{min}, which is the minimum value of PGA of engineering interest and m_{max} is the regional characteristic, maximum credible earthquake magnitude.

Acceptance of the classical frequency-magnitude Gutenberg-Richter relation (2) is equivalent to the assumption that the cumulative distribution function (CDF) of earthquake magnitude is of the form

$$F_M(m) = \frac{\exp(-\beta m_{\min}) - \exp(-\beta m)}{\exp(-\beta m_{\min}) - \exp(-\beta m_{\max})}. \tag{3}$$

In Figure B1 and equation (3), $m_{\min}$ is the minimum earthquake magnitude corresponding to acceleration $a_{\min}$, which is the minimum value of PGA of engineering interest at the site, m_{max} is the maximum credible (maximum possible) earthquake magnitude and $\beta = b$ ln10, where b is the parameter of the Gutenberg-Richter magnitude-frequency relation (2).

It can be shown (Kijko and Graham, 1999) that choosing equation (1) as a model for attenuation of PGA and equation (2) as a distribution of earthquake magnitude, is equivalent to the assumption that

$$\log N(x) = c - d \cdot x, \tag{4}$$

where $N(x)$ is the number of earthquakes recorded at the site, with PGA, a, equal to or exceeding $x = \ln(a)$, c and d are parameters and $d=b/c_2$, where c_2 is the coefficient related to the attenuation formula (1). Equation (4) schematically is illustrated in Figure B2.

From equation (4) it follows that CDF of the logarithm of PGA a, denoted as x, is of the form,

$$F_X(x) = \frac{\exp(-\gamma x_{\min}) - \exp(-\gamma x)}{\exp(-\gamma x_{\min}) - \exp(-\gamma x_{\max})}, \tag{5}$$

where, $x_{\min} = \ln(a_{\min})$, $x_{\max} = \ln(a_{\max})$, $a_{\max}$ is the maximum possible PGA at the site, $\gamma = \beta/c_2$ and β is the parameter of the Gutenberg Richter distribution of earthquake magnitude. It can be seen from formula (5) that the logarithm of the PGA at a given site follows the same type of distribution as the earthquake magnitude, i.e. doubly truncated negative exponential – the form of the Gutenberg-Richter distribution. The two distributions differ only in the value of their parameters. If the parameter of the magnitude distribution is equal to β, the parameter of the distribution of x = ln(PGA) is equal to β/c_2.

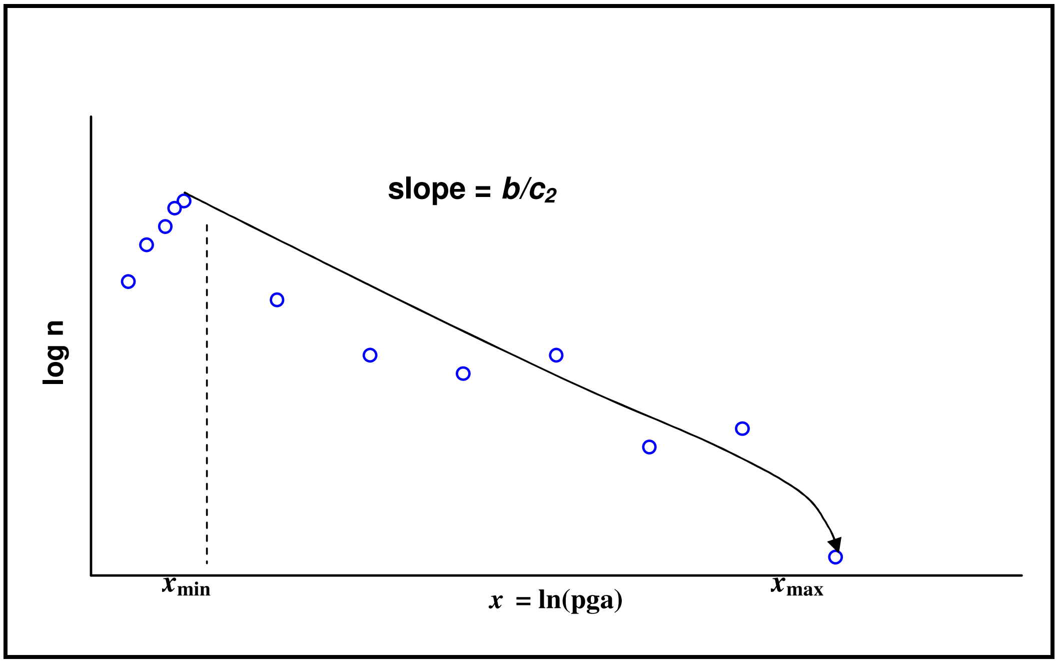

Figure 2 Schematic illustration of the distribution of the PGA. If earthquake magnitude follow a doubly truncated Gutenberg-Richter relation, the logarithm of the PGA at a given site follows the same type of distribution as the earthquake magnitude (2), i.e. doubly truncated negative exponential – the form of the Gutenberg-Richter distribution in equation (2). The two distributions differ only in the value of their parameters. If the parameter of the magnitude distribution is equal to b, the parameter of the distribution of x = ln(PGA) is equal to b/c2.

One should note that CDF (3) was derived under the condition that the no matter how diverse the spatial distribution of seismicity within the area surrounding the specified site is, the earthquake magnitude distribution described by parameters $m_{\max}$ and β remain the same.

Probabilistic seismic hazard, $H(a)$, is defined as the probability of a given value of PGA a (equal to, or greater than, the chosen threshold value, $a_{\min}$) being exceeded at least once at the site during a specified time interval t. Such a probability can be written as

$$H(x \mid t) = 1 - \exp\{-\lambda_s t[1 - F_X(x)]\} \qquad (6)$$

where λ is the site-specific activity rate of earthquakes that cause a PGA value, a, at the site, exceeding the threshold value $a_{\min}$. Clearly, a hazard curve so defined is doubly truncated: from below, by $x_{min} = \ln(a_{min})$, and from above, by $x_{max} = \ln(a_{max})$. The distribution in equation (4) was derived under the assumption that the earthquakes that cause a PGA value a, $a \geq a_{min}$, at the site, follow the Poisson process with mean activity rate $\lambda(x) = \lambda\,[1 - F_X\,(x)]$, with $x = \ln(a)$.

The maximum likelihood method is used to estimate the site-characteristic seismic hazard parameters λ and γ.

For a given value of $x_{\max}$ (or equivalently, the maximum possible PGA at the site), the maximum likelihood procedure leads to the determination of the parameters λ and γ. However, this procedure for the estimation of unknown hazard parameters is used only when the *b* parameter of the Gutenberg-Richter frequency-magnitude relationship is not known. When the *b* value is known, parameter γ is calculated as β/c_2 and the maximum likelihood search reduces to the estimation of the site-specific mean seismic activity rate λ.

REFERENCES TO PSHA METHODOLOGY OUTLINE

KIJKO, A. and G. GRAHAM (1998): Parametric-historic procedure for probabilistic seismic hazard analysis. Part I: Estimation of maximum regional magnitude $m_{\max}$, *Pageoph,* **152**, 413-442.

KIJKO, A. and G. GRAHAM (1999): ”Parametric-historic” procedure for probabilistic seismic hazard analysis. Part II: Assessment of seismic hazard at specified site, *Pageoph,* **154**, 1-22.

KIJKO, A. (2004). Estimation of the maximum earthquake magnitude $m_{\max}$. *Pageoph,* **161**, 1655-1681.

PAGE, R. (1968). Aftershocks and microaftershocks of the great Alaska earthquake. *Bull. Seismol. Soc. Am.*, **58**, 1131-1168.

Appendix B:

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K-S Hazard Area Methodology

Introduction

Following McGuire (1993), the existing procedures of probabilistic seismic hazard analysis (PSHA) fall into two main categories: deductive and historic. The Parametric-Historic Procedure is a combination of the deductive and historic procedures. Both these procedures along with their weak and strong points will be discussed first before introducing the Parametric-Historic Procedure.

The Deductive and Historic Procedures

The theoretical basis for the deductive method is provided by Cornell (1968). The approach permits the incorporation of geological and geophysical information to supplement the seismic event catalogues. Application of this procedure includes several steps. The initial step requires the definition of potential seismic sources, usually associated with geological or tectonic features (e.g. faults), and the delineation of potentially active regions (seismogenic source zones) over which all the available information is averaged. This is followed by determining the seismicity parameters for each seismogenic source zone. Use is made of the most common assumptions in engineering seismology that earthquake occurrences follow a Poisson process and that earthquake magnitudes follow a Gutenberg-Richter doubly-truncated distribution. Following this assumption the parameters obtained for each seismogenic source zone are: the mean seismic activity rate, λ (which is a parameter of the Poisson distribution), the level of completeness of the earthquake catalogue, $m_{\min}$, the maximum regional earthquake magnitude, $m_{\max}$, and the Gutenberg-Richter parameter, b. To assess the above parameters a seismic event catalogue containing origin times, size of seismic events and spatial locations is needed. With the selection of the ground-motion relation the distribution function for a required ground motion parameter can be calculated. The final step requires the integration of individual contributions from each seismogenic zone into a site-specific distribution.

Probably the strongest point of any deductive-type procedure of PSHA is its ability to account for all sorts of deviations from the "standard" model, i.e. it accounts for phenomena such as migration of seismicity, and seismic "gaps". This is possible because the procedure is parametric by nature. Unfortunately, the deductive procedure also has significantly weak points. The major disadvantage stems from the requirement of specifying seismogenic source zones. Often tectonic provinces or specific active faults have not been identified and mapped and the causes of seismicity are not well understood. In addition, with the Cornell-based seismic hazard assessment procedure, knowledge of the model parameters is required for each zone and these cannot always be determined reliably for areas that are small or have incomplete seismic histories.

The second category of PSHA consists of the so-called historic methods (Veneziano et al., 1984), which, in their original form, are non-parametric. These methods require, as input data, information about past seismicity only, and do not require specification of seismogenic zones. Based on spatial and temporal distribution of seismicity, the empirical distribution of the required seismic hazard parameter is estimated. By normalizing this distribution for the duration of the seismic event catalogue, one obtains an annual rate of the exceedance of the required hazard parameter.

The major advantage of this method is that a specification of seismogenic source zones is not needed. Furthermore, the approach does not require designation of the model used. By its nature, the historic method works well in areas of frequent occurrence of strong seismic events, when the record of past (historic) seismicity is "reasonably" complete. At the same time, the non-parametric historic approach has significant weak points. Its primary disadvantage is a rather poor reliability in estimating small probabilities for areas of low seismicity. The procedure is not recommended for an area where the seismic event catalogues are incomplete. In addition, in its present form, the procedure is not capable of making use of any additional geophysical or geological information to supplement the pure seismological data.

A procedure that accepts the varying quality of different parts of the catalogue and at the same time does not require specification of seismic source zones would be an ideal tool for analyzing and assessing seismic hazard. Bearing in mind both the weak and strong points of the above two approaches, the authors have developed an alternative procedure (Kijko and Graham, 1998, 1999), which, following the scheme of McGuire, could be classified as a parametric-historic approach. The approach combines the best of the deductive and non-parametric historic procedures and, in many cases, is free from the basic disadvantages characteristic of each of these procedures.

The Parametric-Historic Procedure

The applied PSHA procedure consists of two steps. The first step is applicable to the area in the vicinity of the site, for which the seismic hazard assessment is required. This is followed by a site-specific hazard assessment based on a selected ground motion parameter. The assessment in terms of peak ground acceleration (PGA) and acceleration response spectra (ARS) is described.

The maximum regional magnitude, $m_{\max}$, is of paramount importance in this approach, therefore a statistical technique that can be used for evaluating this important parameter is presented.

Input Data

The lack or incompleteness of data in earthquake catalogues is a frequent issue in a statistical analysis of seismic hazard. Contributing factors include the historical and socio – economic context, demographic variations and alterations in the seismic network. Generally, the degree of completeness is a monotonically increasing function of time, i.e. the more recent portion of the catalogue has a lower level of completeness. The methodology makes provision for the earthquake catalogue to contain three types of data: firstly, very strong prehistoric seismic events (paleo-earthquakes), which usually occurred over the last thousands of years. Secondly, the macro-seismic observations of some of the strongest seismic events that occurred over a period of the last few hundred years, and finally, complete recent data for a relatively short period of time. The complete part of the catalogue can be divided into several sub-catalogues, each of which is complete for events above a given threshold magnitude $m_{\min}^{(i)}$, and occurring in a certain period of time T_i where $i = 1,\ldots,s$ and s is the number of complete sub-catalogues. The approach permits 'gaps' (T_g) when records were missing or the seismic networks were out of operation. Uncertainty in earthquake magnitude is also taken into account in that an assumption is made that the observed magnitude is true magnitude subjected to a random error that follows a Gaussian distribution having zero mean and a known standard deviation. Figure 1 depicts the typical scenario confronted when conducting seismic hazard assessments.

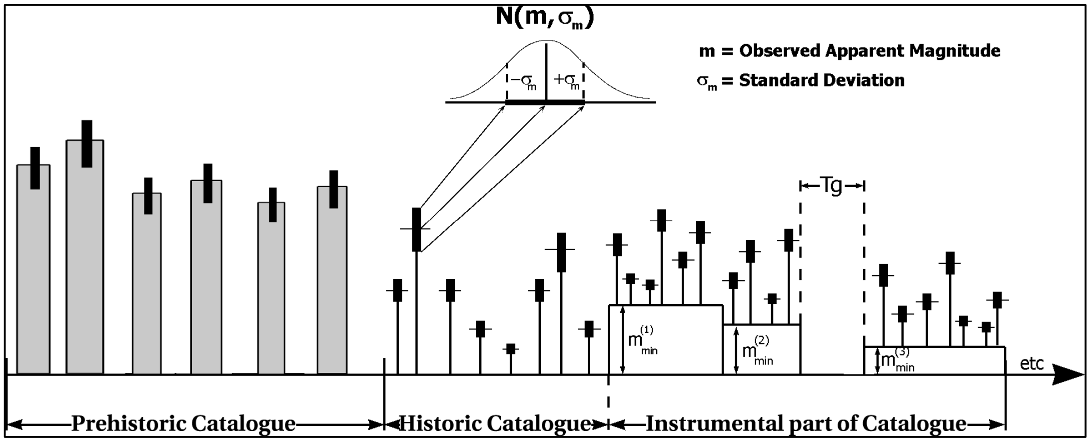

Figure 1 . Illustration of data which can be used by the seismic hazard assessment code developed at CGS.

Statistical Preliminaries

Basic statistical distributions and quantities utilised in the development of the methodology are briefly described in what follows.

The Poisson distribution is used to model the number of occurrences of a given earthquake magnitude or a given amplitude of a selected ground motion parameter being exceeded within a specified time interval.

$$p(n|\lambda,t) = P(N=n|\lambda,t) = \frac{(\lambda t)^n}{n!}e^{-\lambda t} \quad n=0,1,2,... \tag{1}$$

Note that λ here refers to the mean of the distribution, and describes the mean activity rate (mean number of occurrences).

The gamma distribution, given its flexibility, is used to model the distribution of various parameters in our approach and is given by,

$$f(x) = (x)^{q-1}\frac{p^q}{\Gamma(q)}e^{-px}, \qquad x>0 \ , \tag{2}$$

where $\Gamma(q)$ is the gamma function defined as,

$$\Gamma(q) = \int_0^\infty y^{q-1} e^{-y} dy, \quad q > 0, \tag{3}$$

The parameters p and q are related to the mean μ, and variance σ^2, of the distribution according to,

$$\mu_x = \frac{q}{p}, \tag{4}$$

$$\sigma_x{}^2 = \frac{q}{p^2}, \tag{5}$$

The coefficient of variation expresses the uncertainty related to a given parameter, and is given by,

$$COV_x = \frac{\sigma_x}{\mu_x}, \tag{6}$$

thus describing the variation of a parameter relative to it's mean value, with a higher value indicating a greater dispersion of the parameter.

Estimation of the Area-Specific Hazard

The standard assumption adopted is that the distribution of earthquakes with respect to their size obeys the classical Gutenberg-Richter relation,

$$\log N(m) = a - b \cdot (m - m_{\min}), \tag{7}$$

where $N(m)$ is the number of earthquakes of $m \geq m_{\min}$, occurring within a specified period of time, and a and b are parameters.

Epstein and Lomnitz (1966) found that equation (7) implied a singly truncated exponential distribution of the form,

$$\begin{aligned} F_M(m) &= P(M \leq m) \\ &= 1 - e^{-\beta(m - m_{\min})}, \end{aligned} \tag{8}$$

where $\beta = b\ln(10)$.

The earthquake occurrences over time in the given area are assumed to satisfy a Poisson process (1) having an unknown mean seismic activity rate λ_A.

The disregard of temporal variations of the parameters λ_A and b can lead to biased estimates of seismic hazard. An explicit assumption behind most hazard assessment procedures is that parameters λ_A and b and remain constant in time. However, examination of most earthquake catalogues indicates that there are temporal changes of the mean seismic activity rate λ_A as well as of the parameter b. For some seismic areas, the b-value has been reported to change (decrease/increase) its value before large earthquakes. Usually, such changes are explained by the state of stress; the higher the stress, the lower the b-value. Other theories connect the b-value with the homogeneity of the rock: the more heterogeneous the rock, the higher the b-value. Finally, some scientists connect the fluctuation of the b-value with the seismicity pattern and believe that the b-value is controlled by the buckling of the stratum. Whatever the mechanism, the phenomenon of b-value fluctuation is indubitable and well-known. A wide range of international opinions concerning changes of patterns in seismicity, together with an extensive reference list, are found in a monograph by Simpson and Richards (1981) and in a special two issue of the Pure and Applied Geophysics, (Seismicity Patterns …, 1999; Microscopic and Macroscopic …, 2000). Treating both parameters λ_A and b as random variables modelled by respective gamma distributions allows us to appropriately account for the statistical uncertainty in these important parameters. In practice, the adoption of the gamma distribution does not really introduce much limitation, since the gamma distribution can fit a large variety of shapes. Combining the Poisson distribution (1) together with the gamma distribution (2) with parameters p_λ and q_λ, we obtain the probability related to a certain number of earthquakes, n, per unit time t, for randomly varying seismicity,

$$P(n|t) = \int_0^\infty p(n|\lambda_A, t) f(\lambda_A) d\lambda_A$$
$$= \frac{\Gamma(n+q_\lambda)}{n!\Gamma(q_\lambda)}\left(\frac{p_\lambda}{t+p_\lambda}\right)^{q_\lambda}\left(\frac{t}{t+p_\lambda}\right)^n, \tag{9}$$

where $p_\lambda = \bar{\lambda}_A / \sigma_\lambda^2$, $q_\lambda = \bar{\lambda}_A^2 / \sigma_\lambda^2$ and $\Gamma(\cdot)$ is the Gamma function (3). $\bar{\lambda}_A$ denotes the mean of the distribution of λ_A.

Similarly, combining the exponential distribution (8) with the gamma distribution for β with parameters p_β and q_β, and normalising (e.g. Campbell 1982) upon introducing an upper limit $m_{\max}$ for the distribution of earthquake magnitudes, we obtain the CDF of earthquake magnitudes,

$$F_M(m|m_{\min}) = C_\beta\left[1-\left(\frac{p_\beta}{p_\beta + m - m_{\min}}\right)^{q_\beta}\right], \tag{10}$$

where $p_\beta = \bar{\beta}/\sigma_\beta^2$ and $q_\beta = \bar{\beta}^2/\sigma_\beta^2$. The symbol $\bar{\beta}$ denotes the mean value of parameter β, σ_β denotes the standard deviation of β and the normalizing coefficient C_β is given by,

$$C_\beta = \left[1-\left(\frac{p_\beta}{p_\beta + m - m_{\min}}\right)^{q_\beta}\right]^{-1}, \tag{11}$$

Noting that $q_\lambda = \bar{\lambda}_A \cdot p_\lambda$ and $q_\beta = \bar{\beta} \cdot p_\beta$, equations (9) and (10) may alternatively be written respectively as,

$$P(n|t) = \frac{\Gamma(n+q_\lambda)}{n!\Gamma(q_\lambda)}\left(\frac{q_\lambda}{\bar{\lambda}_A t + q_\lambda}\right)^{q_\lambda}\left(\frac{\bar{\lambda}_A t}{\bar{\lambda}_A t + q_\lambda}\right)^n, \tag{12}$$

and

$$F_M\left(m|m_{\min}\right)=C_\beta\left[1-\left(\frac{q_\beta}{q_\beta+\beta(m-m_{\min})}\right)^{q_\beta}\right], \tag{13}$$

with

$$C_\beta=\left[1-\left(\frac{q_\beta}{q_\beta+\beta(m_{\max}-m_{\min})}\right)^{q_\beta}\right]^{-1}, \tag{14}$$

Note that $q_\beta = \left(COV_\beta{}^{-1}\right)^2$ and $q_\lambda = \left(COV_\lambda{}^{-1}\right)^2$. Upon specification of the COV, the parameters $\overline{\lambda}_A$ and $\overline{\beta}$, referred to as hyper-parameters of the respective distributions are estimated on the basis of observed data by applying the maximum likelihood procedure.

Extreme Magnitude Distribution as Applied to Prehistoric (Paleo) and Historic Events

Let us build the likelihood function of desired seismicity parameters $\boldsymbol{\theta} = (\overline{\lambda}_A, \overline{\beta})$, based on the prehistoric (paleo) and historic parts of the catalogue, containing the strongest events only. In this section we will only discuss the details of the likelihood function based on historic earthquakes, since except for a few details, the likelihood function based on prehistoric events is built in a similar manner.

By the Theorem of the Total Probability (see e.g. Cramér, 1961), the probability that in time interval t either no earthquake occurs, or all occurring earthquakes have magnitude not exceeding m, may be expressed as (Epstein and Lomnitz, 1966; Gan and Tung, 1983; Gibowicz and Kijko, 1994)

$$F_M^{\max}\left(m\,|\,m_0,t\right)=\sum_{i=0}^{\infty}P(i|t)\left[F_M\left(m\,|\,m_0\right)\right]^i, \tag{15}$$

Relation (15) can be expressed in a much more simpler form (e.g. Campbell, 1982), which, in our notation, may be written as

$$F_M^{\max}\left(m \middle| m_0, t\right) = \left[\frac{q_\lambda}{q_\lambda + \bar{\lambda}_0\, t \left[1 - F_M\left(m \middle| m_0\right)\right]} \right]^{q_\lambda} , \tag{16}$$

In relations (15) and (16), m_0 is the threshold magnitude for the prehistoric or historic part of the catalogue ($m_0 \geq m_{\min}$). Magnitude $m_{\min}$ plays the role of the 'total' threshold magnitude and has a rather formal character. The only restriction on the choice of its value is that $m_{\min}$ may not exceed the threshold magnitude of any part, prehistoric, historic or complete, of the catalogue.

It follows from relation (16) that the probability density function (PDF) of the largest earthquake magnitudes m within a period t is,

$$f_M^{\max}(m \mid m_0, t) = \frac{\bar{\lambda}_0\, t q_\lambda f_M(m \mid m_0) F_M^{\max}(m \mid m_0, t)}{q_\lambda + \bar{\lambda}_0\, t[1 - F_M(m \mid m_0)]} , \tag{17}$$

$\bar{\lambda}_0$ represents the mean of the distribution of the mean activity rate for earthquakes with magnitudes not less than m_0 , and is given by,

$$\bar{\lambda}_0 = \bar{\lambda}_A \left[1 - F_M\left(m \middle| m_0\right)\right] , \tag{18}$$

where $\bar{\lambda}_A$, as defined above, is mean of the distribution of the mean activity rate corresponding to magnitude value $m_{\min}$. $f_M\left(m \middle| m_0\right)$ is the PDF of earthquake magnitudes. Based on (13) and the definition of the probability density function, it takes the following form:

$$f_M(m) = C_\beta\, \bar{\beta} \left(\frac{q_\beta}{q_\beta + \bar{\beta}(m - m_0)} \right)^{q_\beta + 1} , \tag{19}$$

After introducing the PDF (17) of the largest earthquake magnitude m within a period t, the likelihood function of unknown parameters $\boldsymbol{\theta}$, becomes:

$$L_0\left(\boldsymbol{\theta} \middle| \boldsymbol{m}_0, \boldsymbol{t}_0, \boldsymbol{cov}\right) = \prod_{i=1}^{n_0} f_M^{\max}\left(m_{0i} \middle| m_0, t_i\right) , \tag{20}$$

In order to build the likelihood function (20), three kinds of input data are required: $\boldsymbol{m}_0$, $\boldsymbol{t}$, and $\boldsymbol{cov}$, where $\boldsymbol{m}_0$ is vector of the largest magnitudes, $\boldsymbol{t}$ denotes vector of the time intervals within which the largest events occurred and vector $\boldsymbol{cov} = (\mathrm{cov}_\lambda, \mathrm{cov}_\beta)$, consists of the coefficients of variation (amount of dispersion (/ uncertainty) relative to the mean) of the unknown parameters $\boldsymbol{\theta} = (\overline{\lambda}_A, \overline{\beta})$.

Combination of Extreme and Complete Seismic Catalogues with Different Levels of Completeness

Let us assume that the third, complete part of the catalogue, can be divided into s sub-catalogues (Figure 1). Each of them has a span T_i and is complete starting from the known magnitude $m_{\min}^{(i)}$. For each sub-catalogue i, $\boldsymbol{m}_i$ is used to denote n_i earthquake magnitudes m_{ij}, where $m_{ij} \geq m_{\min}^{(i)}$, $i = 1, \ldots, s$, and $j = 1, \ldots, n_i$. Let $L_i(\boldsymbol{\theta}|\boldsymbol{m}_i)$ denote the likelihood function of the unknown $\boldsymbol{\theta} = (\overline{\lambda}_A, \overline{\beta})$, based on the i-th complete sub-catalogue. If the size of seismic events is independent of their number, the likelihood function $L_i(\boldsymbol{\theta}|\boldsymbol{m}_i)$ is the product of two functions, $L_i(\overline{\lambda}_A|\boldsymbol{m}_i)$ and $L_i(\overline{\beta}|\boldsymbol{m}_i)$.

The assumption that the number of earthquakes per unit time is distributed according to (12), means that $L_i(\overline{\lambda}_A|\boldsymbol{m}_i)$ has the following form:

$$L_i(\overline{\lambda}_A|\boldsymbol{m}_i) = const \cdot \left(\overline{\lambda}_A^{(i)} t + q_\lambda\right)^{-q_\lambda} \left(\frac{\overline{\lambda}_A^{(i)} t}{\overline{\lambda}_A^{(i)} t + q_\lambda}\right)^{n_i}, \tag{21}$$

where $const$ does not depend on $\overline{\lambda}_A$ and $\overline{\lambda}_A^{(i)}$ is the mean activity rate corresponding to the threshold magnitude $m_{\min}^{(i)}$ and is given by,

$$\overline{\lambda}_A^{i} = \overline{\lambda}_A \left[1 - F_M\left(m_{\min}^{(i)} \mid m_{\min}\right)\right], \tag{22}$$

Following the definition of the likelihood function based on a set of independent observations, and (19), $L_i(\beta|\boldsymbol{m}_i)$ takes the form,

$$L_i\left(\bar{\beta}\middle|\boldsymbol{m}_i\right)=\left[C_\beta\,\bar{\beta}\right]^{n_i}\prod_{j=1}^{n_i}\left[1+\frac{\bar{\beta}}{q_\beta}\left(m_{ij}-m_{\min}^{(i)}\right)\right]^{-\left(q_\beta+1\right)}, \tag{23}$$

Relations (21) and (23) define the likelihood function of the unknown parameters $\boldsymbol{\theta} = (\bar{\lambda}_A, \bar{\beta})$ for each complete sub-catalogue.

Finally, $L(\boldsymbol{\theta})$, the joint likelihood function based on all data, i.e. the likelihood function based on the whole catalogue, is calculated as the product of the likelihood functions based on prehistoric, historic and complete data.

The maximum-likelihood estimates of the required hazard parameters $\boldsymbol{\theta} = (\bar{\lambda}_A, \bar{\beta})$, are given by the value of $\boldsymbol{\theta}$ which, for a given maximum regional magnitude $m_{\max}$, maximizes the likelihood function $L(\boldsymbol{\theta})$. The maximum of the likelihood function is obtained by solving the system of two equations $\frac{\partial \ell}{\partial \bar{\lambda}_A}=0$ and $\frac{\partial \ell}{\partial \bar{\beta}}=0$, where $\ell=\ln[L(\boldsymbol{\theta})]$.

A variance-covariance matrix, $D(\boldsymbol{\theta})$, of the estimated hazard parameters, $\hat{\bar{\lambda}}_A$ and $\hat{\bar{\beta}}$, is calculated according to the formula (Edwards, 1972):

$$\mathrm{D}(\theta)=-\begin{bmatrix}\frac{\partial^2\ell}{\partial\bar{\lambda}_A{}^2} & \frac{\partial^2\ell}{\partial\bar{\lambda}_A\partial\bar{\beta}}\\ \frac{\partial^2\ell}{\partial\bar{\beta}\partial\bar{\lambda}_A} & \frac{\partial^2\ell}{\partial\bar{\beta}^2}\end{bmatrix}^{-1}, \tag{24}$$

where derivatives are calculated at the point $\bar{\lambda}_A=\hat{\bar{\lambda}}_A$ and $\bar{\beta}=\hat{\bar{\beta}}$.

Estimation of the Maximum Regional Earthquake Magnitude $m_{\max}$

Suppose that in the area of concern, within a specified time interval T, there are n main seismic events with magnitudes $m_1,\ldots,m_n$. Each magnitude $m_i \geq m_{\min}$ ($i=1,\ldots,n$), where $m_{\min}$ is a known threshold of completeness (i.e. all events having magnitude greater than or equal to $m_{\min}$ are recorded). It is further assumed that the seismic event magnitudes are independent, identically distributed, random variables with CDF described by equation (13).

From the condition that compares the largest observed magnitude $m_{\max}^{obs}$ and the maximum expected magnitude during a specified time interval T, we obtain the maximum regional magnitude $m_{\max}$ (Kijko and Graham, 1998; Kijko, 2004)

$$m_{\max} = m_{\max}^{obs} + \frac{\delta^{1/q} \exp\left[nr^{q} / \left(1 - r^{q}\right)\right]}{\bar{\beta}} \left[\Gamma\left(-1/q, \delta r^{q}\right) - \Gamma\left(-1/q, \delta\right)\right], \qquad (25)$$

where $\delta = nC_{\beta}$ and $\Gamma(\cdot,\cdot)$ is the complementary incomplete gamma function. The approximate variance of the above estimator is equal to (Kijko, 2004)

$$\sigma_{m_{\max}}^{2} \cong \sigma_{M}^{2} + \left\{ \frac{\delta^{1/q} \exp\left[nr^{q} / \left(1 - r^{q}\right)\right]}{\bar{\beta}} \left[\Gamma\left(-1/q, \delta r^{q}\right) - \Gamma\left(-1/q, \delta\right)\right] \right\}^{2}, \qquad (26)$$

where σ_M is the standard error in determination of the largest observed magnitude $m_{\max}^{obs}$.

References

Ambraseys, N.N. (1995)	**The prediction of earthquake peak ground acceleration in Europe**, Earthquake Eng. Struct. Dyn. **24**, 467-490.
Atkinson, G.M. and D.M. Boore (1997)	**Some comparisons between recent ground-motion relations**, Seism. Res. Lett. **68**, 24-40.
Bender, B. (1984)	**Incorporating acceleration variability into seismic hazard analysis**, Bull. Seism. Soc. Am. **74**, 1451-1462.
Bender, B. and D.M. Perkins (1993)	**Treatment of parameter uncertainty for a single seismic hazard map**, Earthquake Spectra, **9**, 165-194.
Bender, B. (1984)	**A two-state Poisson model for seismic hazard estimation**, Bull. Seism. Soc. Am., **74**, 1463-1468.
Benjamin, J.R. and C.A. Cornell (1970)	**Probability, Statistics and Decision for Civil Engineers** , McGraw-Hill, New York.
Benjamin, J.R. (1968)	**Probabilistic models for seismic forces design**, J. Struct. Div., ASCE **94**, 5T5, 1175-1196.
Boore, D.M. and W.B. Joyner (1982)	**The empirical prediction of ground motion**, Bull. Seism. Soc. Am. **72**, S43-S60.
Campbell, K.W. (1977)	**The use of seismotectonics in the Bayesian estimation of seismic risk,** School of Engineering and Applied Science, University of California, Los Angeles, Report UCLA - ENG – 7744
Campbell, K.W. (1982)	**Bayesian analysis of extreme earthquake occurrences. Part I. Probabilistic hazard model**, Bull. Seism. Soc. Am., **72**, 1689-1705
Campbell, K.W. (1983)	**Bayesian analysis of extreme earthquake occurrences. Part II. Application to the San Jacinto Fault zone of southern California**, Bull. Seism. Soc. Am., **73**, 1099-1115.
Chou, I.H., W.J. Zimmer and J.T.P. Yao (1971)	**Likelihood of strong motion earthquakes**, Bureau of Engineering Research, University of New Mexico, Technical Report CE **27** (71).
Cornell, C.A. (1968)	**Engineering seismic risk analysis**, Bull. Seism. Soc. Am. **58**, 1583-1606.
Cornell, C.A. (1971)	**Bayesian statistical decision theory and reliability-based design**, Proceedings of the International Conference on Structural Safety and Reliability, A.M. Freudenthal, Editor, April 9-11, 1969, Washington, D.C.,

Smithsonian Institute, 47-66.

Cosentino, P., V. Ficara, and D. Luzio (1977) **Truncated exponential frequency-magnitude relationship in the earthquake statistics**, Bull. Seism. Am. **67,** 1615-1623.

Cramér, H. (1961) **Mathematical Methods of Statistics**, Princeton University Press. Princeton.

Dong, W.M., A.B. Bao and H.C. Shah (1984 a) **Use of maximum entropy principle in earthquake recurrence relationships**, Bull. Seism. Soc. Am., **74**, 725-737.

Dong, W.M., H.C. Shah and A.B. Bao (1984 b) **Utilization of geophysical information in Bayesian seismic hazard model**, Soil Dynamics and Earthquake Engineering, **3**,103-111.

Edwards, A.W.F. (1972) **Likelihood**, Cambridge University Press, New York, p. 235.

Epstein, B. and C. Lomnitz (1966) **A model for occurrence of large earthquakes**, Nature, **211**, 954-956.

Fukushima, Y. and T. Tanaka (1990) **A new attenuation relation for peak horizontal acceleration of strong earthquake ground motion in Japan,** Bull. Seism. Soc. Am. **80**, 757-778.

Gan, Z.J. and C.C. Tung (1983) **Extreme value distribution of earthquake magnitude**, Phys. Earth Planet. Inter. **32**, 325-330.

Gibowicz, S.J. and A. Kijko (1994) **An Introduction to Mining Seismology***,* Academic Press, San Diego.

Guttorp, P. and D. Hopkins (1986) **On estimating varying *b*-values**, Bull. Seism. Soc. Am., **76**, 889-895

Johnson, N.L. (1957) **Uniqueness of a result of the theory of accident proneness**, Biometrika, **44**, 530-531.

Kijko**,** A. (2004) **Estimation of the maximum earthquake magnitude** $m_{\max.}$ Pure Appl. Geophys, **161**, 1-27.

Kijko, A. and G. Graham (1998) **"Parametric-Historic" procedure for probabilistic seismic hazard analysis. Part I: Assessment of maximum regional magnitude** $m_{\max,}$ Pure Appl. Geophys, **152**, 413-442

Kijko, A. and M.A. Sellevoll (1992) **Estimation of earthquake hazard parameters from incomplete data files, Part II, Incorporation of magnitude heterogeneity**, Bull. Seism. Soc. Am. **82**, 120-134

Kijko, A. and G. Graham (1999) **"Parametric-Historic" procedure for probabilistic seismic hazard analysis. Part II. Assessment of seismic hazard at specified site**, Pure Appl. Geophys. **154**, 1-22.

Kijko, A. and M.A. Sellevoll (1992) **Estimation of earthquake hazard parameters from incomplete data files. Part II. Incorporation of magnitude heterogeneity**, Bull. Seism. Soc. Am. **82**, 120-134.

McGuire, R.M. (1993) **Computation of seismic hazard**, Ann. Di Geofisica, **36**, 181-200.

McGuire, R.K. (1977) **Effects of uncertainty in seismicity on estimates of seismic hazard for the east coast of the United States**, Bull. Sesm. Soc. Am., **67**, 827-848**.**

McGuire, R.K. (1978) **Seismic ground motion parameters**, Proc. Am. Soc. Civil Eng. J. Geotech. Eng. Div. **104**, 481-490.

Microscopic and Macroscopic Simulation: Towards Predictive Modelling of the Earthquake Process, Editors: P. Mora, M. Matsu'ura, R. Madariaga and J-B. Minster, Pure and Applied Geophysics, **157**, pp. 1817-2383, 2000.

Morgat, C.P. and H.C. Shah (1979) **A Bayesian model for seismic hazard mapping**, Bull. Seism. Soc. Am., **69**, 1237-1251.

Page, R. (1968) **Aftershocks and microaftershocks**, Bull. Seism. Soc. Am. **58**, 1131-1168.

Pisarenko, V.F. and A.A. Lyubushin, Jr. (1999) **A Bayesian approach to Seismic Hazard Estimation: Maximum Values of Magnitudes and Peak Ground Accelerations**, Earthquake Research in China, **13**, 45-57.

Seismicity Patterns, their Statistical Significance and Physical Meaning, Editors: M. Wyss, K. Shimazaki and A. Ito, Pure and Applied Geophysics, **155**, pp. 203-726, 1999.

Simpson, D.W. and P.G. Richards (1981) **Earthquake Prediction, An International Review**, Maurice Ewing series IV, Eds: D. W. Simpson, and P.G. Richards. American Geophysical Union, Washington, D.C., 680 pp.

Stavrakasis, G.N. and G.A. Tselentis (1987) **Bayesian probabilistic prediction of strong earthquakes in the main seismic zones of Greece**, Bull. Geof. Teor. Appl., **29**, 51-63.

Tinti, S. and F. Mulargia (1985) **Effects of magnitude uncertainties in the Gutenberg-Richter frequency-magnitude law**, Bull. Seism. Soc. Am. **75**, 1681-1697.

Toro, G.R., N.A. Abrahamson and J.F. Schneider (1997) **Model of strong ground motions from earthquakes in Central and Eastern North America: best estimates and uncertainties**, Seism. Res. Lett. **68**, 41-57.

Veneziano, D., C.A. Cornell and T. O'Hara (1984) **Historic method for seismic hazard analysis**, Elect. Power Res. Inst., Report, NP-3438, Palo Alto.

Appendix C: Area-Specific Hazard Information File: Calcutta Area

```
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 File       : Calcutta_ha2_160408.doc
 Created on : 16-Apr-2008 10:49:19
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 SEISMIC HAZARD ASSESSMENT FOR SELECTED AREA
 FROM PRE-HISTORIC, HISTORIC, and INCOMPLETE DATA
 ORIGIN TIME OF PRE-HISTORIC EVENTS CAN BE UNCERTAIN

 FLOW OF SEISMIC EVENTS IS MODELED BY BAYESIAN-BASED EQUATIONS
 WHICH ACCOUNT UNCERTAINTY OF SEISMIC HAZARD MODEL

 HAZARD PARAMETERS BEATA AND LAMBDA ARE CALCULATED SIMULTANEOUSLY
 MAGNITUDE ERRORS ARE DISTRIBUTED NORMALLY
 RANGE OF MAGNITUDE INTEGRATION : < m_min, m_max >

 REGONAL MAXIMUM MAGNITUDE CAN BE ESTIMATED ACCORDING TO :

     (1) Gibowicz-Kijko (1994)
     (2) Gibowicz-Kijko-Bayes
     (3) Kijko-Sellevoll (1989)
     (4) Kijko-Sellevoll-Bayes
     (5) Tate-Pisarenko
     (6) Tate-Pisarenko-Bayes
     (7) Non-Parametric (Gaussian) procedure

 Theory of the HAZARD evaluation procedure is given in:

    "Estimation of earthquake hazard parameters
     from Incomplete data files", Part II.
     by A. Kijko and M.A. Sellevoll (1992)
     Bull. Seism. Soc. Am. vol.82, p.120-134.

  and

    "Parametric-Historic" procedure for probabilistic
     seismic hazard analysis. Part I. Assessment
     of maximum regional magnitude m_max.
     by A. Kijko and G. Graham (1998),
     Pure App. Geophys, vol. 152, p.413-442.

=====================================================================
 PROGRAM NAME     : HA2 (H = Hazard; A = Area)
 WRITTEN          : 15 AUG 1999 by A.Kijko
 REVISION 1       : 21 MAR 2005 by A.Kijko
 REVISION 2       : 25 JUL 2005 by J.Ramperthap
 REVISION 3       : 15 AUG 2005 by J.Ramperthap
 REVISION 4       : 22 JUN 2006 by A.Kijko
 VERSION          : 2.05
=====================================================================

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            jasonr@geoscience.org.za

=====================================================================

 NAME OF THE AREA: Calcutta


                       HISTORIC DATA:
                    ********************

 NAME OF HISTORIC DATA FILE: e

 BEGINING OF HISTORIC DATA (Y-M-D) = 1755 1 1
 END      OF HISTORIC DATA (Y-M-D) = 2005 1 18
 NUMBER OF HISTORIC EQ-s           = 103
 "THRESHOLD" MAG. OF HISTORIC EQ-s = 5
```

```
STANDARD ERROR OF EQ-e MAGNITUDE  = 0.25

1764   6   4  6.0
1816   5  26  8.0
1826  10  29  6.0
1833   8  26  8.0
1843   4  11  5.0
1846   5  27  6.5
1866   5  23  7.0
1868   6  30  7.5
1870   4  11  6.7
1897   6  12  8.5
1901   2  15  6.0
1906   8  31  7.0
1908  12  12  8.2
1909   2  17  5.0
1911  12   7  5.0
1912   5  23  8.0
1916   8  28  7.5
1917   4  12  6.0
1918   7   8  7.6
1920   8  15  6.0
1923   9   9  7.1
1924   1  30  6.0
1925  11   6  6.0
1926   5  10  6.2
1927   3  15  6.5
1928   7   9  6.0
1929   3  25  6.0
1930  12   3  7.3
1931   1  27  7.6
1932   3  24  6.0
1933   3   6  5.8
1934   1  15  8.2
1935   3  21  6.3
1936   5  10  6.0
1937   3   9  6.0
1938   1  29  6.0
1939   5  27  6.7
1940   2  13  6.0
1941   1  21  6.7
1942   8  19  6.0
1943  10  23  7.2
1944  12  24  6.0
1945   5  19  6.0
1946   9  12  7.5
1947   7  29  7.7
1948   6  27  6.3
1949  12  10  6.0
1950   8  15  8.5
1951   4   7  6.8
1952   1  15  6.0
1953   2  23  6.0
1954   3  21  7.2
1955   5   4  6.0
1956   7  16  7.0
1957   7   1  7.2
1958   3  22  6.5
1959   2  14  6.0
1960   7  29  6.5
1961   9  29  6.0
1962   9  22  6.2
1963   6  19  6.2
1964   7  12  6.7
1965   1  12  6.1
1966   6  27  6.1
1967   3  14  5.9
1968   5  31  5.7
1969   4  14  6.0
1970   7  29  6.5
1971   2   2  5.4
1972   8  21  5.1
1973   5  31  5.9
1974   3  24  5.7
1975   7   8  6.5
1976   5  29  7.0
1977   5  12  5.7
1979   1   1  5.3
1979  10   3  5.6
```

```
 1980   7  29  6.6
 1981   4  25  5.7
 1982   4   8  5.5
 1983   8  30  5.6
 1984   4  23  5.9
 1985   1   7  5.6
 1986   1  10  5.4
 1987   5  18  5.9
 1988   8   6  7.3
 1989   4  15  6.2
 1990   1   9  6.1
 1991   1   5  7.3
 1992   4  23  6.5
 1993   3  20  6.2
 1994   5  29  6.5
 1995   7  11  7.1
 1996  11  11  6.0
 1997  11  21  6.1
 1998   9   3  5.6
 1999   4   5  5.6
 2000   6   7  6.5
 2001   4  12  5.6
 2002  12   4  5.6
 2003   9  21  6.9
 2004  12  26  5.8
 2005   1  18  5.0

 LARGEST EQ IN HISTORIC CATALOG = 8.5


 PROVISION FOR INDUCED SEISMICITY : NOT REQUIRED
 ===============================================


                        ***

 TIME SPAN OF WHOLE CATALOG            = 250.04 [Y]
 MAXIMUM MAGNITUDE IN THE CATALOG      = 8.5
 SD OF MAXIMUM OBSERVED MAGNITUDE      = 0.25
 MODEL UNCERTAINTY OF BETA             = 25 [per cent]
 MODEL UNCERTAINTY OF LAMBDA           = 25 [per cent]

 CALCULATIONS ARE PERFORMED FOR MINIMUM MAGNITUDE Mmin = 5.00


 PRIOR VALUE OF PARAMETER b            = 1
 SD OF PRIOR b-VALUE                   = 0.1

                     RESULTS
                  *************

 BETA   = 1.98 +-  0.14 (b = 0.86 +- 0.06)
 LAMBDA = 4.301 +- 0.658 (for Mmin = 5.00)
 Mmax   = 8.71 +- 0.33  (for Mmax obs. = 8.50 +- 0.25)

 Maximum Regional Magnitude Mmax is calculated
 according to procedure by Kijko-Sellevoll-Bayes


Mag      Lambda         RP          Prob(T = 1  50   100   1000)

5.0   4.3007e+000   2.33e-001   0.97783   1.00000   1.00000   1.00000
5.1   3.5294e+000   2.83e-001   0.95880   1.00000   1.00000   1.00000
5.2   2.9031e+000   3.44e-001   0.93060   1.00000   1.00000   1.00000
5.3   2.3933e+000   4.18e-001   0.89251   1.00000   1.00000   1.00000
5.4   1.9772e+000   5.06e-001   0.84498   1.00000   1.00000   1.00000
5.5   1.6368e+000   6.11e-001   0.78952   1.00000   1.00000   1.00000
5.6   1.3577e+000   7.37e-001   0.72833   1.00000   1.00000   1.00000
5.7   1.1283e+000   8.86e-001   0.66389   1.00000   1.00000   1.00000
5.8   9.3937e-001   1.06e+000   0.59861   1.00000   1.00000   1.00000
5.9   7.8341e-001   1.28e+000   0.53459   1.00000   1.00000   1.00000
6.0   6.5438e-001   1.53e+000   0.47342   1.00000   1.00000   1.00000
6.1   5.4742e-001   1.83e+000   0.41624   1.00000   1.00000   1.00000
6.2   4.5856e-001   2.18e+000   0.36372   1.00000   1.00000   1.00000
6.3   3.8460e-001   2.60e+000   0.31618   1.00000   1.00000   1.00000
6.4   3.2292e-001   3.10e+000   0.27364   0.99999   1.00000   1.00000
6.5   2.7138e-001   3.68e+000   0.23594   0.99995   1.00000   1.00000
6.6   2.2824e-001   4.38e+000   0.20278   0.99982   1.00000   1.00000
6.7   1.9205e-001   5.21e+000   0.17379   0.99946   1.00000   1.00000
```

```
6.8   1.6164e-001   6.19e+000   0.14856   0.99856   0.99999   1.00000
6.9   1.3605e-001   7.35e+000   0.12670   0.99655   0.99995   1.00000
7.0   1.1447e-001   8.74e+000   0.10780   0.99250   0.99982   1.00000
7.1   9.6242e-002   1.04e+001   0.09149   0.98511   0.99947   1.00000
7.2   8.0824e-002   1.24e+001   0.07746   0.97276   0.99856   1.00000
7.3   6.7758e-002   1.48e+001   0.06538   0.95372   0.99648   1.00000
7.4   5.6669e-002   1.76e+001   0.05500   0.92637   0.99218   1.00000
7.5   4.7242e-002   2.12e+001   0.04608   0.88955   0.98407   1.00000
7.6   3.9217e-002   2.55e+001   0.03841   0.84271   0.97003   1.00000
7.7   3.2374e-002   3.09e+001   0.03182   0.78604   0.94757   1.00000
7.8   2.6531e-002   3.77e+001   0.02616   0.72040   0.91412   1.00000
7.9   2.1534e-002   4.64e+001   0.02129   0.64725   0.86738   1.00000
8.0   1.7254e-002   5.80e+001   0.01710   0.56840   0.80575   0.99999
8.1   1.3584e-002   7.36e+001   0.01349   0.48583   0.72851   0.99995
8.2   1.0433e-002   9.59e+001   0.01038   0.40149   0.63603   0.99968
8.3   7.7226e-003   1.29e+002   0.00769   0.31720   0.52962   0.99817
8.4   5.3890e-003   1.86e+002   0.00537   0.23449   0.41141   0.99039
8.5   3.3770e-003   2.96e+002   0.00337   0.15462   0.28408   0.95330
8.6   1.6400e-003   6.10e+002   0.00164   0.07853   0.15055   0.79013
8.7   1.3853e-004   7.22e+003   0.00014   0.00690   0.01375   0.12884
```

Appendix D: Area-Specific Hazard Information File: Karachi Area

```
======================================================================
 File       : Karachi_ha2_160408.doc
 Created on : 16-Apr-2008 11:01:43
======================================================================

 SEISMIC HAZARD ASSESSMENT FOR SELECTED AREA
 FROM PRE-HISTORIC, HISTORIC, and INCOMPLETE DATA
 ORIGIN TIME OF PRE-HISTORIC EVENTS CAN BE UNCERTAIN

 FLOW OF SEISMIC EVENTS IS MODELED BY BAYESIAN-BASED EQUATIONS
 WHICH ACCOUNT UNCERTAINTY OF SEISMIC HAZARD MODEL

 HAZARD PARAMETERS BEATA AND LAMBDA ARE CALCULATED SIMULTANEOUSLY
 MAGNITUDE ERRORS ARE DISTRIBUTED NORMALLY
 RANGE OF MAGNITUDE INTEGRATION : < m_min, m_max >

 REGONAL MAXIMUM MAGNITUDE CAN BE ESTIMATED ACCORDING TO :

     (1) Gibowicz-Kijko (1994)
     (2) Gibowicz-Kijko-Bayes
     (3) Kijko-Sellevoll (1989)
     (4) Kijko-Sellevoll-Bayes
     (5) Tate-Pisarenko
     (6) Tate-Pisarenko-Bayes
     (7) Non-Parametric (Gaussian) procedure

 Theory of the HAZARD evaluation procedure is given in:

    "Estimation of earthquake hazard parameters
     from Incomplete data files", Part II.
     by A. Kijko and M.A. Sellevoll (1992)
     Bull. Seism. Soc. Am. vol.82, p.120-134.

  and

    "Parametric-Historic" procedure for probabilistic
     seismic hazard analysis. Part I. Assessment
     of maximum regional magnitude m_max.
     by A. Kijko and G. Graham (1998),
     Pure App. Geophys, vol. 152, p.413-442.

======================================================================
 PROGRAM NAME     : HA2 (H = Hazard; A = Area)
 WRITTEN          : 15 AUG 1999 by A.Kijko
 REVISION 1       : 21 MAR 2005 by A.Kijko
 REVISION 2       : 25 JUL 2005 by J.Ramperthap
 REVISION 3       : 15 AUG 2005 by J.Ramperthap
 REVISION 4       : 22 JUN 2006 by A.Kijko
 VERSION          : 2.05
======================================================================

 For more information, contact A.Kijko or M.Bejaichund or J.Ramperthap,
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 Phone  :  +(27) 12 8411201, 8411454 or 8411180
 Fax    :  +(27) 12 8411224
 E-mail :   kijko@geoscience.org.za, mayshree@geoscience.org.za or
            jasonr@geoscience.org.za

======================================================================

 NAME OF THE AREA: Karachi


                        HISTORIC DATA:
                     ********************

 NAME OF HISTORIC DATA FILE: e

 BEGINING OF HISTORIC DATA (Y-M-D) = 1435 1 1
 END      OF HISTORIC DATA (Y-M-D) = 2005 1 15
 NUMBER OF HISTORIC EQ-s           = 55
```

```
"THRESHOLD" MAG. OF HISTORIC EQ-s = 5
STANDARD ERROR OF EQ-e MAGNITUDE  = 0.25

1440   6  15  6.5
1483   2  18  7.7
1819   6  16  8.3
1853   5   4  6.5
1909  10  20  7.2
1923   9  22  6.9
1925  12  18  5.5
1928   3   8  5.0
1935   5  30  7.5
1945  11  27  8.3
1947   8   5  7.6
1949   4  24  6.5
1954   8  20  5.0
1956  10  31  6.8
1960   4  24  6.0
1961   6  11  7.2
1962  11   6  5.5
1963   7  29  5.2
1965   6  21  6.0
1968   6  23  5.3
1970   3  23  5.1
1971   4  12  6.0
1972   4  10  7.1
1973   1  20  5.6
1974  10   4  5.9
1975  10   3  6.7
1976   4  22  6.0
1977   3  21  7.0
1978   3  16  5.9
1979   1  10  6.1
1980  11  28  5.5
1981   7  28  7.3
1982  12  19  5.9
1983   4  18  6.5
1984   8   6  5.7
1985   5   6  5.6
1986   7  12  5.7
1987   4  29  5.9
1988   8  11  6.1
1989   5  27  5.8
1990  11   6  6.7
1991   5  22  5.7
1992   4  24  6.2
1993  11  16  5.6
1994   2  24  6.3
1995   5  31  5.6
1996   2  26  5.5
1997   2  27  7.3
1998   3  14  6.9
1999   3   4  6.6
2000   6   4  6.0
2001   1  26  8.0
2002   7  13  5.8
2003  12  26  6.8
2004   1  14  5.4

LARGEST EQ IN HISTORIC CATALOG = 8.3


PROVISION FOR INDUCED SEISMICITY : NOT REQUIRED
===============================================


                        ***

TIME SPAN OF WHOLE CATALOG           = 570.03 [Y]
MAXIMUM MAGNITUDE IN THE CATALOG     = 8.3
SD OF MAXIMUM OBSERVED MAGNITUDE     = 0.25
MODEL UNCERTAINTY OF BETA            = 25 [per cent]
MODEL UNCERTAINTY OF LAMBDA          = 25 [per cent]

CALCULATIONS ARE PERFORMED FOR MINIMUM MAGNITUDE Mmin = 5.00


PRIOR VALUE OF PARAMETER b           = 1
SD OF PRIOR b-VALUE                  = 0.1
```

```
                    RESULTS
                 *************

  BETA   = 2.08 +-  0.16 (b = 0.90 +- 0.07)
  LAMBDA = 2.523 +- 0.456 (for Mmin = 5.00)
  Mmax   = 8.44 +- 0.29  (for Mmax obs. = 8.30 +- 0.25)

  Maximum Regional Magnitude Mmax is calculated
  according to procedure by Kijko-Sellevoll-Bayes


 Mag      Lambda         RP          Prob(T = 1  50   100   1000)

 5.0   2.5234e+000   3.96e-001   0.90397   1.00000   1.00000   1.00000
 5.1   2.0505e+000   4.88e-001   0.85476   1.00000   1.00000   1.00000
 5.2   1.6705e+000   5.99e-001   0.79585   1.00000   1.00000   1.00000
 5.3   1.3641e+000   7.33e-001   0.72993   1.00000   1.00000   1.00000
 5.4   1.1166e+000   8.96e-001   0.66018   1.00000   1.00000   1.00000
 5.5   9.1598e-001   1.09e+000   0.58964   1.00000   1.00000   1.00000
 5.6   7.5301e-001   1.33e+000   0.52089   1.00000   1.00000   1.00000
 5.7   6.2028e-001   1.61e+000   0.45587   1.00000   1.00000   1.00000
 5.8   5.1192e-001   1.95e+000   0.39583   1.00000   1.00000   1.00000
 5.9   4.2324e-001   2.36e+000   0.34147   1.00000   1.00000   1.00000
 6.0   3.5050e-001   2.85e+000   0.29299   0.99999   1.00000   1.00000
 6.1   2.9069e-001   3.44e+000   0.25030   0.99997   1.00000   1.00000
 6.2   2.4141e-001   4.14e+000   0.21306   0.99988   1.00000   1.00000
 6.3   2.0071e-001   4.98e+000   0.18083   0.99959   1.00000   1.00000
 6.4   1.6703e-001   5.99e+000   0.15309   0.99879   0.99999   1.00000
 6.5   1.3910e-001   7.19e+000   0.12933   0.99690   0.99996   1.00000
 6.6   1.1588e-001   8.63e+000   0.10905   0.99288   0.99984   1.00000
 6.7   9.6558e-002   1.04e+001   0.09178   0.98529   0.99948   1.00000
 6.8   8.0435e-002   1.24e+001   0.07710   0.97234   0.99852   1.00000
 6.9   6.6958e-002   1.49e+001   0.06463   0.95216   0.99628   1.00000
 7.0   5.5672e-002   1.80e+001   0.05406   0.92318   0.99158   1.00000
 7.1   4.6203e-002   2.16e+001   0.04509   0.88443   0.98273   1.00000
 7.2   3.8245e-002   2.61e+001   0.03748   0.83574   0.96759   1.00000
 7.3   3.1544e-002   3.17e+001   0.03102   0.77781   0.94381   1.00000
 7.4   2.5893e-002   3.86e+001   0.02554   0.71203   0.90927   1.00000
 7.5   2.1118e-002   4.74e+001   0.02088   0.64031   0.86243   1.00000
 7.6   1.7078e-002   5.86e+001   0.01692   0.56477   0.80262   0.99999
 7.7   1.3653e-002   7.32e+001   0.01355   0.48752   0.73022   0.99995
 7.8   1.0746e-002   9.31e+001   0.01068   0.41048   0.64655   0.99973
 7.9   8.2734e-003   1.21e+002   0.00824   0.33529   0.55365   0.99873
 8.0   6.1681e-003   1.62e+002   0.00615   0.26322   0.45404   0.99458
 8.1   4.3725e-003   2.29e+002   0.00436   0.19519   0.35039   0.97905
 8.2   2.8389e-003   3.52e+002   0.00283   0.13179   0.24527   0.92671
 8.3   1.5270e-003   6.55e+002   0.00153   0.07334   0.14099   0.76741
 8.4   4.0332e-004   2.48e+003   0.00040   0.01995   0.03948   0.32855
```

Appendix E: Area-Specific Hazard Information File: South Sandwich Area

```
======================================================================
 File       : South_Sandwich_ha2_21042008.doc
 Created on : 21-Apr-2008 08:53:00
======================================================================

 SEISMIC HAZARD ASSESSMENT FOR SELECTED AREA
 FROM PRE-HISTORIC, HISTORIC, and INCOMPLETE DATA
 ORIGIN TIME OF PRE-HISTORIC EVENTS CAN BE UNCERTAIN

 FLOW OF SEISMIC EVENTS IS MODELED BY BAYESIAN-BASED EQUATIONS
 WHICH ACCOUNT UNCERTAINTY OF SEISMIC HAZARD MODEL

 HAZARD PARAMETERS BEATA AND LAMBDA ARE CALCULATED SIMULTANEOUSLY
 MAGNITUDE ERRORS ARE DISTRIBUTED NORMALLY
 RANGE OF MAGNITUDE INTEGRATION : < m_min, m_max >

 REGONAL MAXIMUM MAGNITUDE CAN BE ESTIMATED ACCORDING TO :

     (1) Gibowicz-Kijko (1994)
     (2) Gibowicz-Kijko-Bayes
     (3) Kijko-Sellevoll (1989)
     (4) Kijko-Sellevoll-Bayes
     (5) Tate-Pisarenko
     (6) Tate-Pisarenko-Bayes
     (7) Non-Parametric (Gaussian) procedure

 Theory of the HAZARD evaluation procedure is given in:

    "Estimation of earthquake hazard parameters
     from Incomplete data files", Part II.
     by A. Kijko and M.A. Sellevoll (1992)
     Bull. Seism. Soc. Am. vol.82, p.120-134.

  and

    "Parametric-Historic" procedure for probabilistic
     seismic hazard analysis. Part I. Assessment
     of maximum regional magnitude m_max.
     by A. Kijko and G. Graham (1998),
     Pure App. Geophys, vol. 152, p.413-442.

======================================================================
 PROGRAM NAME     : HA2 (H = Hazard; A = Area)
 WRITTEN          : 15 AUG 1999 by A.Kijko
 REVISION 1       : 21 MAR 2005 by A.Kijko
 REVISION 2       : 25 JUL 2005 by J.Ramperthap
 REVISION 3       : 15 AUG 2005 by J.Ramperthap
 REVISION 4       : 22 JUN 2006 by A.Kijko
 VERSION          : 2.05
======================================================================

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 E-mail :   kijko@geoscience.org.za, mayshree@geoscience.org.za or
            jasonr@geoscience.org.za

======================================================================

 NAME OF THE AREA: South Sandwich


                      HISTORIC DATA:
                   ********************

 NAME OF HISTORIC DATA FILE: e

 BEGINING OF HISTORIC DATA (Y-M-D) = 1973 1 1
```

```
 END      OF HISTORIC DATA (Y-M-D) = 2005 1 8
 NUMBER OF HISTORIC EQ-s           = 26
 "THRESHOLD" MAG. OF HISTORIC EQ-s = 5.5
 STANDARD ERROR OF EQ-e MAGNITUDE  = 0.1

 1973  10   6  7.5
 1974  11  20  6.5
 1975  11  29  6.2
 1977   8  26  7.1
 1982   5   7  6.7
 1983  10  22  7.0
 1985   5  15  6.5
 1986   4  14  6.3
 1987   1  30  7.0
 1988  11   1  6.1
 1990   5   9  6.5
 1991  12  27  7.2
 1992  11  21  6.6
 1993   3  10  6.7
 1994   7  25  6.6
 1995   4  14  6.5
 1996   1  22  6.2
 1997  10   5  6.3
 1998   8  29  6.0
 1999  10  18  6.6
 2000  11   7  6.8
 2001   4  13  6.2
 2002  11  15  6.6
 2003   9  30  6.0
 2004   9   6  6.9
 2005   1   8  6.0

 LARGEST EQ IN HISTORIC CATALOG = 7.5


 PROVISION FOR INDUCED SEISMICITY : NOT REQUIRED
 ===============================================


                        ***

 TIME SPAN OF WHOLE CATALOG           = 32.02 [Y]
 MAXIMUM MAGNITUDE IN THE CATALOG     = 7.5
 SD OF MAXIMUM OBSERVED MAGNITUDE     = 0.2
 MODEL UNCERTAINTY OF BETA            = 25 [per cent]
 MODEL UNCERTAINTY OF LAMBDA          = 25 [per cent]

 CALCULATIONS ARE PERFORMED FOR MINIMUM MAGNITUDE Mmin = 5.50


 PRIOR VALUE OF PARAMETER b           = 1
 SD OF PRIOR b-VALUE                  = 0.1

                      RESULTS
                   *************

 BETA   = 2.47 +-  0.22 (b = 1.07 +- 0.09)
 LAMBDA = 8.415 +- 2.140 (for Mmin = 5.50)
 Mmax   = 7.64 +- 0.24  (for Mmax obs. = 7.50 +- 0.20)

 Maximum Regional Magnitude Mmax is calculated
 according to procedure by Kijko-Sellevoll-Bayes


Mag      Lambda         RP          Prob(T = 1  50   100   1000)

5.5   8.4153e+000   1.19e-001   0.99884   1.00000   1.00000   1.00000
5.6   6.5678e+000   1.52e-001   0.99593   1.00000   1.00000   1.00000
5.7   5.1409e+000   1.95e-001   0.98841   1.00000   1.00000   1.00000
5.8   4.0347e+000   2.48e-001   0.97262   1.00000   1.00000   1.00000
5.9   3.1738e+000   3.15e-001   0.94472   1.00000   1.00000   1.00000
6.0   2.5014e+000   4.00e-001   0.90213   1.00000   1.00000   1.00000
6.1   1.9743e+000   5.07e-001   0.84459   1.00000   1.00000   1.00000
6.2   1.5598e+000   6.41e-001   0.77425   1.00000   1.00000   1.00000
6.3   1.2326e+000   8.11e-001   0.69500   1.00000   1.00000   1.00000
6.4   9.7358e-001   1.03e+000   0.61136   1.00000   1.00000   1.00000
6.5   7.6785e-001   1.30e+000   0.52763   1.00000   1.00000   1.00000
6.6   6.0395e-001   1.66e+000   0.44724   1.00000   1.00000   1.00000
6.7   4.7298e-001   2.11e+000   0.37257   1.00000   1.00000   1.00000
```

```
6.8   3.6801e-001   2.72e+000   0.30500   1.00000   1.00000   1.00000
6.9   2.8365e-001   3.53e+000   0.24509   0.99996   1.00000   1.00000
7.0   2.1566e-001   4.64e+000   0.19283   0.99974   1.00000   1.00000
7.1   1.6071e-001   6.22e+000   0.14778   0.99851   0.99999   1.00000
7.2   1.1619e-001   8.61e+000   0.10932   0.99296   0.99984   1.00000
7.3   8.0020e-002   1.25e+001   0.07672   0.97187   0.99848   1.00000
7.4   5.0565e-002   1.98e+001   0.04923   0.90438   0.98765   1.00000
7.5   2.6519e-002   3.77e+001   0.02615   0.72025   0.91403   1.00000
7.6   6.8404e-003   1.46e+002   0.00682   0.28710   0.48820   0.99664
```

Appendix F: Area-Specific Hazard Information File: Sumatra Area

```
======================================================================
 File       : Sumatra_ha2_21042008.doc
 Created on : 21-Apr-2008 08:47:29
======================================================================

 SEISMIC HAZARD ASSESSMENT FOR SELECTED AREA
 FROM PRE-HISTORIC, HISTORIC, and INCOMPLETE DATA
 ORIGIN TIME OF PRE-HISTORIC EVENTS CAN BE UNCERTAIN

 FLOW OF SEISMIC EVENTS IS MODELED BY BAYESIAN-BASED EQUATIONS
 WHICH ACCOUNT UNCERTAINTY OF SEISMIC HAZARD MODEL

 HAZARD PARAMETERS BEATA AND LAMBDA ARE CALCULATED SIMULTANEOUSLY
 MAGNITUDE ERRORS ARE DISTRIBUTED NORMALLY
 RANGE OF MAGNITUDE INTEGRATION : < m_min, m_max >

 REGONAL MAXIMUM MAGNITUDE CAN BE ESTIMATED ACCORDING TO :

     (1) Gibowicz-Kijko (1994)
     (2) Gibowicz-Kijko-Bayes
     (3) Kijko-Sellevoll (1989)
     (4) Kijko-Sellevoll-Bayes
     (5) Tate-Pisarenko
     (6) Tate-Pisarenko-Bayes
     (7) Non-Parametric (Gaussian) procedure

 Theory of the HAZARD evaluation procedure is given in:

    "Estimation of earthquake hazard parameters
     from Incomplete data files", Part II.
     by A. Kijko and M.A. Sellevoll (1992)
     Bull. Seism. Soc. Am. vol.82, p.120-134.

  and

    "Parametric-Historic" procedure for probabilistic
     seismic hazard analysis. Part I. Assessment
     of maximum regional magnitude m_max.
     by A. Kijko and G. Graham (1998),
     Pure App. Geophys, vol. 152, p.413-442.

======================================================================
 PROGRAM NAME     : HA2 (H = Hazard; A = Area)
 WRITTEN          : 15 AUG 1999 by A.Kijko
 REVISION 1       : 21 MAR 2005 by A.Kijko
 REVISION 2       : 25 JUL 2005 by J.Ramperthap
 REVISION 3       : 15 AUG 2005 by J.Ramperthap
 REVISION 4       : 22 JUN 2006 by A.Kijko
 VERSION          : 2.05
======================================================================

 For more information, contact A.Kijko or M.Bejaichund or J.Ramperthap,
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 E-mail :   kijko@geoscience.org.za, mayshree@geoscience.org.za or
            jasonr@geoscience.org.za

======================================================================

 NAME OF THE AREA: Sumatra


                       HISTORIC DATA:
                    ********************

 NAME OF HISTORIC DATA FILE: e

 BEGINING OF HISTORIC DATA (Y-M-D) = 1973 1 1
 END      OF HISTORIC DATA (Y-M-D) = 2005 2 2
 NUMBER OF HISTORIC EQ-s           = 33
```

```
"THRESHOLD" MAG. OF HISTORIC EQ-s = 5.5
STANDARD ERROR OF EQ-e MAGNITUDE  = 0.1

1973   4   7  6.6
1974  12   4  6.9
1975  10   1  7.0
1976   6  20  7.0
1977   5  25  6.0
1978   6  24  6.4
1979   9  29  6.8
1980  10   8  6.3
1981  11   8  5.8
1982   1  20  6.3
1983   4   4  6.8
1984  11  17  7.4
1985  12  27  6.6
1986   6  19  5.9
1987   4  25  6.6
1988   8  17  6.1
1989   7  20  5.9
1990  11  15  6.8
1991   7   2  6.2
1992   9   2  6.7
1993   8   4  6.5
1994   2  15  7.0
1995  11   8  7.1
1996  10  10  6.3
1997   3  17  6.4
1998   4   1  7.0
1999  12  21  6.5
2000   6   4  8.3
2001   2  13  7.4
2002  11   2  7.6
2003   5  14  6.0
2004  12  26  9.0
2005   1   1  6.7

LARGEST EQ IN HISTORIC CATALOG = 9


PROVISION FOR INDUCED SEISMICITY : NOT REQUIRED
===============================================


                        ***

TIME SPAN OF WHOLE CATALOG           = 32.09 [Y]
MAXIMUM MAGNITUDE IN THE CATALOG     = 9
SD OF MAXIMUM OBSERVED MAGNITUDE     = 0.2
MODEL UNCERTAINTY OF BETA            = 25 [per cent]
MODEL UNCERTAINTY OF LAMBDA          = 25 [per cent]

CALCULATIONS ARE PERFORMED FOR MINIMUM MAGNITUDE Mmin = 5.50


PRIOR VALUE OF PARAMETER b           = 1
SD OF PRIOR b-VALUE                  = 0.1

                     RESULTS
                  *************

BETA   = 2.36 +-  0.20 (b = 1.03 +- 0.09)
LAMBDA = 9.183 +- 2.116 (for Mmin = 5.50)
Mmax   = 9.20  (for Mmax obs. = 9.00 +- 0.20)

Maximum Regional Magnitude Mmax is calculated
according to procedure by Kijko-Sellevoll-Bayes

Attempt to assess Mmax by chosen procedure was UNSUCCESFUL


Mag      Lambda         RP          Prob(T = 1  50   100   1000)

5.5   9.1830e+000   1.09e-001   0.99929   1.00000   1.00000   1.00000
5.6   7.2626e+000   1.38e-001   0.99749   1.00000   1.00000   1.00000
5.7   5.7629e+000   1.74e-001   0.99271   1.00000   1.00000   1.00000
5.8   4.5876e+000   2.18e-001   0.98229   1.00000   1.00000   1.00000
5.9   3.6633e+000   2.73e-001   0.96307   1.00000   1.00000   1.00000
6.0   2.9341e+000   3.41e-001   0.93239   1.00000   1.00000   1.00000
```

```
6.1   2.3568e+000   4.24e-001   0.88904   1.00000   1.00000   1.00000
6.2   1.8983e+000   5.27e-001   0.83369   1.00000   1.00000   1.00000
6.3   1.5331e+000   6.52e-001   0.76871   1.00000   1.00000   1.00000
6.4   1.2414e+000   8.06e-001   0.69747   1.00000   1.00000   1.00000
6.5   1.0076e+000   9.92e-001   0.62360   1.00000   1.00000   1.00000
6.6   8.1969e-001   1.22e+000   0.55039   1.00000   1.00000   1.00000
6.7   6.6828e-001   1.50e+000   0.48040   1.00000   1.00000   1.00000
6.8   5.4595e-001   1.83e+000   0.41541   1.00000   1.00000   1.00000
6.9   4.4684e-001   2.24e+000   0.35642   1.00000   1.00000   1.00000
7.0   3.6634e-001   2.73e+000   0.30386   1.00000   1.00000   1.00000
7.1   3.0079e-001   3.32e+000   0.25769   0.99998   1.00000   1.00000
7.2   2.4728e-001   4.04e+000   0.21760   0.99989   1.00000   1.00000
7.3   2.0349e-001   4.91e+000   0.18308   0.99962   1.00000   1.00000
7.4   1.6758e-001   5.97e+000   0.15356   0.99882   0.99999   1.00000
7.5   1.3806e-001   7.24e+000   0.12844   0.99678   0.99995   1.00000
7.6   1.1374e-001   8.79e+000   0.10715   0.99230   0.99981   1.00000
7.7   9.3662e-002   1.07e+001   0.08916   0.98355   0.99937   1.00000
7.8   7.7046e-002   1.30e+001   0.07398   0.96831   0.99814   1.00000
7.9   6.3269e-002   1.58e+001   0.06119   0.94424   0.99516   1.00000
8.0   5.1822e-002   1.93e+001   0.05042   0.90942   0.98877   1.00000
8.1   4.2292e-002   2.36e+001   0.04136   0.86276   0.97654   1.00000
8.2   3.4342e-002   2.91e+001   0.03372   0.80428   0.95545   1.00000
8.3   2.7698e-002   3.61e+001   0.02729   0.73505   0.92227   1.00000
8.4   2.2135e-002   4.52e+001   0.02188   0.65704   0.87421   1.00000
8.5   1.7468e-002   5.72e+001   0.01731   0.57276   0.80946   0.99999
8.6   1.3546e-002   7.38e+001   0.01345   0.48489   0.72756   0.99995
8.7   1.0245e-002   9.76e+001   0.01019   0.39602   0.62954   0.99964
8.8   7.4605e-003   1.34e+002   0.00743   0.30840   0.51769   0.99781
8.9   5.1085e-003   1.96e+002   0.00509   0.22385   0.39520   0.98813
9.0   3.1184e-003   3.21e+002   0.00311   0.14373   0.26570   0.94210
9.1   1.4317e-003   6.98e+002   0.00143   0.06894   0.13284   0.74621
9.2   2.2204e-016   4.50e+015   0.00000   0.00000   0.00000   0.00000
```

APPENDIX D:

Council for Geoscience Report: Potential Sources of Tsunami Along the South African Coast

POTENTIAL SOURCES OF TSUNAMI ALONG THE SOUTH AFRICAN COAST

By: D.L. Roberts

CGS Report Number: 2008 - 0220

CONFIDENTIAL

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	COUNCIL FOR GEOSCIENCE **(Western Cape Unit)**	REFERENCE: CGS REPORT 2008 - 0220
	NUCLEAR SITING INVESTIGATION PROGRAMME	REVISION 1
COPY No.	**POTENTIAL SOURCES OF TSUNAMI ALONG THE SOUTH AFRICAN COAST**	DATE OF RELEASE: 19/09/2008
		CONFIDENTIAL

AUTHORS			
			REVIEWED BY:
DR. D.L. ROBERTS			
ACCEPTED BY:	ACCEPTED BY:	ACCEPTED BY:	AUTHORISED BY:

REVISION	DESCRIPTION OF REVISION	DATE	MINOR REVISIONS APPROVAL
0		09-09-2008	
1	Minor changes on request by Stephan Luger, PRDW	19-09-2008	

Index ***Page***

Figures

Figure 1. *Locality map showing*

Figure 2. *Global DEM showing potential sources of tsunami along the South African coast.*

Figure 3. *Dwarskersbos on the west coast (see Figure 1 for location), scene of a possible tsunami in 1969.*

Figure 4. *Tide gauge records for Cape Town, Saldanha and Port Nolloth*

Figure 5. *The residual values of expected/measured tidal data from the west coast.*

Figure 6. *An example of atmospheric gravity waves enhanced by sunglint conditions.*

Figure 7. *Five minute interval data from SAWS's automatic weather station at Port Nolloth showing atmospheric gravity waves.*

Figure 8. *Tide gauge records for Coega Harbour on the southeast coast for the 2004 Sumatran seismogenic tsunami.*

Figure 9. *DEM showing the disposition of steep hillslopes comprising highly fractured and jointed Palaeozoic quartzites, possible sources of tsunamigenic rockfalls.*

Figure 10. *Precipitous cliffs comprising highly fractured and jointed Palaeozoic quartzites at the entrance to Hout Bay.*

Figure 11. *Major late Holocene landslide into the estuary of the Knysna River.*

1. Scope of the Study

The Council for Geoscience was requested by Prestedge Retief Dresner Wijnberg (Pty) Ltd to provide a report on the potential sources of tsunami along the coastline of South Africa. Special focus is on the west and southern coasts where planned nuclear facilities are to be sited. Sources of significant tsunamigenic capacity on global as well as regional and local scales are considered. The study specifically addresses the following questions:

- What is the relative magnitude of the threat posed by the various sources of tsunami?
- What segments of the coastline are at highest risk?

- To what extent can tsunami be predicted?

- What is the warning period(s) for tsunami?

- What actions can be taken in mitigation/adaptation to the threat posed by tsunami?

2. Introduction

The catastrophic tsunami of 26th December 2004 was caused by the massive earthquake on the Sumatra-Andaman Subduction Zone with moment magnitude (Mw) ~9.3. In total about 160 000 people were killed and more than 1 million displaced in South Asia and East Africa, reaffirming the devastating character of these phenomena (Iwan, 2006; Synolakis et al., 2007). Over the past few decades, several other significant global to regional scale tsunami have been recorded (Geist, 1998; Iwan, 2006). None approached the severity of the Sumatra event, but nonetheless have served to further emphasise the threat.

Numerical modelling designed to predict the sources, frequency and amplitude of tsunami that could impinge on the southern African coastal belt has been undertaken (Hartnady, 2005; Hartnady and Okal, in press). South Africa also participates in the

Intergovernmental Coordination Group with respect to the Indian Ocean Tsunami Warning and Mitigation System (IOTWS) initiative (A. Kijko, pers. comm.). The chief focus of previous work in southern Africa has been the threat represented by remote submarine seismicity, volcanicity and submarine slumps along the east coast (Kijko, pers. comm.; Hartnady and Okal, in press). This study extends and supplements this work by a consideration of submarine slumps along the west and southern coasts, in addition to cosmic impacts and the tsunamigenic threat posed by major rockfalls and landslides. The relationship between the coastal seismic record and submarine slumps in particular is examined.

3. Coastal Seismicity

Since earthquakes, whether directly or indirectly are the major trigger of tsunami (e.g. Salamon et al., 2007), it is appropriate to briefly review the seismic setting and history of events along the southern African coastline. The stable intraplate, trailing edge tectono-seismic model determined for the southern African coastline (Fig. 1) dictates general seismic quiescence (De Swardt, and Bennet, 1974; De Beer, 1983; Goedhart, 2007). However, in common with similar settings elsewhere a low frequency, low intensity background seismicity prevails (Fernandez and Shapiro, 1989; Theron, 1974). The current neotectonism is inherited from the complex early geodynamic history of southern Africa and modern seismicity tends to be concentrated along ancient lineaments of crustal weakness (De Beer, 1983; Hälbich, 1983; Partridge and Maud, 2000; Goedhardt, 2007).

Figure 1 summarises the modern and historic distribution of seismicity up to 1998 and prediction of future risk. A region of enhanced seismic activity centres around Cape Town, corresponding with the intense fracturing of the Cape Syntaxis northeast of this city, where faults are capable of at least Mw 6.3 events (Theron, 1974). Along the east coast two regions of notably enhanced seismic activity are apparent. In the south the zone of activity around the Mzimvubu River may be linked with the Mellville Thrust in the Namaqua-Natal tectonic province and shear zones of the Margate Terrain described by Thomas (1989). In the north around Sodwana Bay, the major Tugela Thrust Front is also spatially linked with modern seismicity (Fig. 1). In both instances, the onshore areas of enhanced seismicity coincide with offshore counterparts.

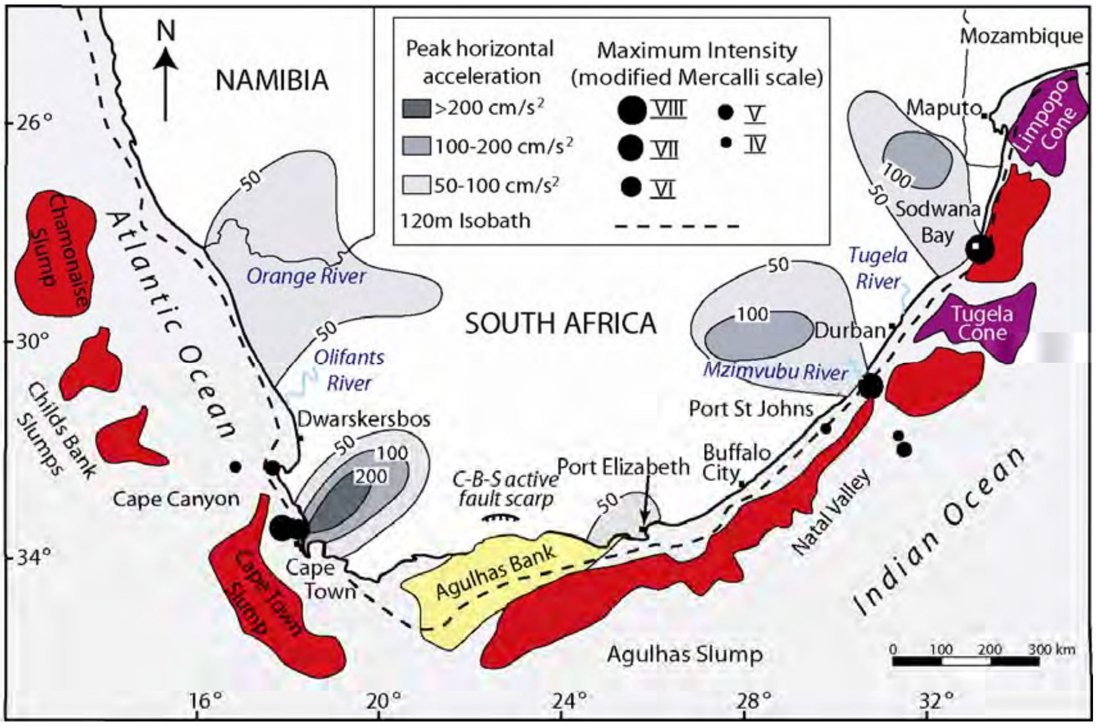

Figure 1. *Locality map showing offshore slumps and historical seismicity, illustrated by the contours of 10% probability of exceeding peak horizontal ground acceleration within 50 years (data from Fernandez and Shapiro, 1989). Historical offshore earthquake magnitude and location is indicated by solid circles. The slumps occur further offshore along the west coast owing to the greater width of the continental shelf.*

The historic and modern seismic record is currently being supplemented by deterministic palaeoseismic data (Goedhardt, 2007). Attention has focussed on the Ceres-Baviaanskloof-St. Croix fault system (C-B-S) that traverses the Cape Fold Belt for ~700 kilometres (Fig. 1), from Ceries in the west to Port Elizabeth in the east, before extending offshore to merge with the Agulhas-Falkland fracture zone (Goedhardt, 2007). West of Port Elizabeth, a scarp several metres high marks surface rupture along the C-B-S Fault recording a major early Holocene (~10 ka) seismic event of ~Mw7 (Hill, 1975; Goedhardt, 2007). Isostatic imbalances along the eastern segment of the fault may in the future give rise to large damaging earthquakes with accompanying surface rupture. Thus the entire southern coast is vulnerable to future seismicity (Goedhardt, 2007) and the risk is probably higher than indicated by Fernandez and Shapiro (1989) as shown in Figure 1.

4. Potential Sources of Tsunamigenesis

4.1 Cosmic impact

The catastrophic tsunamigenic capability of cosmic impacts is well documented e.g. the K-T event on the Yucatan Peninsula, which caused a major end-Createaceous global extinction (Smit et al., 1992). The geographic range is indiscriminate, posing an equal threat around the globe. Impacts by meteorites asteroids and comets of various scales and ages ranging from billions of years in the case of the massive Vredefort Dome in South Africa, to as recently as the Tunguska event in Siberia in 1908 have been reported (Turco et al., 1982; Bisschof, 1999). Although cosmic impacts large enough to cause significant tsunami are relatively rare, the recent Tunguska event, caused by the atmospheric explosion of a comet or meteorite, felled an estimated 80 million trees over 2,150 km^2. This served as a reminder that visitations from space constitute a major, potentially devastating threat (Turco et al., 1982).

New asteroids are identified and their orbital parameters quantified on an ongoing basis by NASA's Near-Earth Object Program (see NASA website at http://neo.jpl.nasa.gov/risk/). The maximum detected hazard is rated according to the Torino Impact Hazard Scale. According to this ten-point scale, a rating of zero indicates the event has "no likely consequences." A Torino Scale rating of 1 indicates an event that "merits careful monitoring” and higher ratings indicates progressively higher risk. The ‘Sentry System’ is a highly automated collision monitoring system that continually scans the current asteroid catalogue for possibilities of future impact with Earth over the next 100 years. Currently, no asteroids with a rating exceeding 0 (and therefore of significant tsunamigenic risk) are catalogued.

4.2 Remote Submarine Seismicity

This category of tsunamigenisis refers to waves generated by rapid displacement along submarine faults. Because of the quiescent trailing edge, intra-plate tectonic setting of the subcontinent (see section 3), it would appear that teletsunami from remote sources (plate boundaries) pose the greatest threat (Synolakis et al., 2007). The earliest reported tsunami by remote submarine seismicity that impinged on South African shores was spawned by the ~Mw 9.5 earthquake off the Chilean coast on May 22, 1960 (the strongest ever recorded). The Chilean event was recorded globally, including Mossel Bay, South Africa and in the Atlantic Ocean at Luderitz, Namibia (Van Dorn, 1987). The most imminent threat to the southeastern South African seaboard is posed by major earthquakes (Mw > 9 2) along the fast-moving convergent plate-boundaries at the Sunda Trench between Indonesia and Burma, and the Makran Trench bordering Pakistan and Iran (Fig. 2). It has also been suggested that there is a particularly high probability that a large seismic event in the southern part of the Sumatra Subduction Zone off the Mentawai Islands may source a large teletsunami (McCloskey et al., 2006; Okal et al., 2007; Hartnady and Okal, in press).

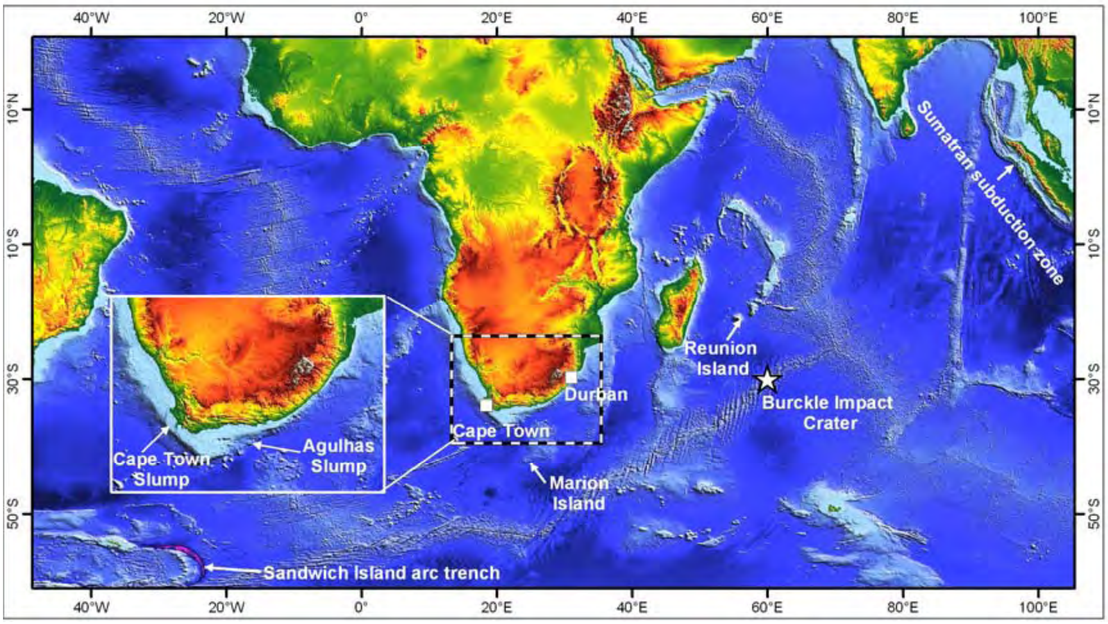

Figure 2. *Global DEM showing potential sources of tsunami along the South African coast. These include subsea seismogenic, volcanogenic, bolide impact and submarine slumps. The Cape Town and Agulhas slumps are apparent (inset).*

The Sumatran Subduction Zone generated the tsunami of 26th December 2004, significant waves from which were recorded by South African tide gauges on the Indian Ocean coast, with a maximum of wave height of ~2.7 m at Port Elizabeth. Apparently, the actual wave height was even higher but the wave crest was truncated due to instrumention factors (Rabinovich and Thomson, 2007). Lesser waves arrived at Richards Bay (1.5 m) ~100 km south of Sodwana Bay, Buffalo City (1.3 m) and 1.6 m at Mossel Bay 180 km west of Port Elizabeth (Fig. 1). Maximum wave heights on the Atlantic coast were much smaller, with 0.75 m at Cape Town, dwindling to 0.5 m at Port Nolloth, 80 km south of the Orange River (Fig. 1). These waves coincided with the calculated arrival time of the Sumatran tsunami (Rabinovich, and Thomson, 2007). Numerous anecdotal accounts of abnormal high tides on beaches and bores moving upstream in rivers were reported in the media. Anomalous drawdown of sea level was experienced at Port Elizabeth, resulting in the drowning of a person, the most distant fatality recorded from the Sumatran tsunami (Rabinovich, and Thomson, 2007).

The Sumatran event has emphatically demonstrated that seismogenic teletsunami from remote sources can impinge on the southern African coastline with telling effect. Although little damage was reported, had the largest amplitude wave arrival coincided with abnormal high tides (astronomical/storm surge), the resulting cumulative inundation could well have been significant. (Okal et al., 2007).

The recent tsunamigenic Bengkulu Earthquake (Mw 8.4) of 12 September 2007 generated an extended series of waves over the period 12-14 September 2007, reaching a maximum amplitude of ~0.4 m at Port Elizabeth. This tsunami was predictively modelled in real-time during its propagation across the Indian Ocean, (Hartnady and Okal, in press).

The intra-oceanic South Sandwich Island subduction zone (SSSZ) and associated forearc is situated in the southwestern Atlantic (Fig. 2). It represents the closest source of high-frequency, high-intensity subsea seismicity which could threaten the west coast of southern Africa. The SSSZ shows a high frequency of earthquakes greater than Mw 5. A large earthquake (~Mw 7.3) with an epicentre on the South Sandwich Fracture Zone occurred on 2 January 2006, ~400km southeast of the South Sandwich Islands (USGS, 2006).

This fault forms part of the boundary between the South American and Antarctic Plates. Since the major displacement was horizontal, no tsunami ensued and as yet no historical tsunami have been reported from this source (USGS, 2006). However, a multichannel seismic transect across the mid-forearc revealed a 1.2 km-high fault scarp associated with a 20 km wide tilted block, indicating large-scale gravitational collapse (Larter et al., 2003). This suggests possible past tsunamigenic capacity, but a tectonic environment of relatively low regional interplate stress may mitigate this propensity (Larter et al., 2003). The threat posed by seismicity in the intra-oceanic South Sandwich Island Arc and associated forearc subduction zone is uncertain and requires further assessment.

4.3 Submarine slides and slumps

4.3.1 Global events

Many reports have indicated that submarine slides and slumps can induce large and damaging tsunami on local to regional scales (Bugge et al., 1988; Bondevik et al. 1997; Tippin et al., 2003). It is instructive to briefly review an example from the literature of a tsunami produced by offshore slumping. The Storegga submarine slump off Norway is chosen here, as this should illuminate the threat posed by tsunamigenic offshore sediment slumping in the southern African context (Dingle et al. 1983).

The Storegga submarine slump situated in the North Sea off the passive Norwegian coast is one of the largest known Holocene examples (Brugge et al., 1988; Bondevik et al. 1997). Approximately 3500 km^3 of sediment was displaced, generating a tsunami that caused widespread inundations in Norway, the Faroe Islands, the Shetlands Islands and Scotland, dated to ~8100 calendar years BP. The maximum estimated runup exceeded 20 m, recorded in the Shetlands Islands (Bondevik et al., 1997). Seismicity was considered to have been the direct triggering mechanism of the slump.

4.3.2 South African submarine slumps

Seismic profiles along the southern African continental shelf have revealed widespread episodic injections of allochthonous masses into the deep sedimentary basins, including submarine slides and slumps (Dingle 1971; 1977; Summerhayes et al., 1979). Various phases of slumping on massive scales including late Mesozoic (148 Ma-65 Ma), early to late Tertiary (65 Ma-1.8 Ma) and possibly Quaternary (1.8 Ma-present), have been documented (Fig. 1) and have been largely instrumental in the morphogenesis of the continental margin (Dingle, 1977; Dingle, et al.1987; Ben-Avraham and Rogers,1992; Niemi, et al., 2000;. Reznikov et al., 2005).

Sediment is readily transported across the steep and narrow eastern shelf to be deposited in the adjacent Natal Valley, via a complex variety of processes including the migration of large bedforms, slumping, debris flow, turbidity currents and slope wasting. Widespread canyon development aids the sediment transfer. In contrast; little sediment from the few perennial rivers crosses the broader west coast shelf and sedimentation into the deep ocean basin is dominated by submarine slides and slumping; canyon development is muted, with the exception of the Cape Canyon (Dingle, 1977; Dingle, et al.1987; Ben-Avraham and Rogers,1992; Niemi, et al., 2000;. Reznikov et al, 2005.). However, during relative sea level lowstands rivers deposit their load nearer the shelf break, enhancing instability and propensity to slope failure. The shoreline during the Last Glacial Maximum (LGM) was at 120 m below sea level (Rogers, 1982), indicated in Figure 1 as the 120 m isobath. This shows that rivers debouched closer to the regions of intense slumping on the southern and east coasts than on the west coast. Other possible triggers of offshore slumps include overpressured formations and erosion by geostrophic currents (Dingle, 1977; Dingle, et al.1987; Westall, 2006).

Along the coastal stretch from the Orange River in the northwest to Cape Agulhas in the southeast, Dingle (1980) and Dingle et al. (1987) identified four major foci of submarine slides and slumps (Fig. 1): the Chamaise Slump relating to the Orange River allochthonous sediment pile; the Childs Bank Slumps; the Cape Town Slump which is associated with the Cape Canyon; and the massive Agulhas Slump. In the latter, about 340, 000 km^2 of continental rise and slope have been affected by relatively recent (late Cenozoic: 25 Ma-present) slumping. Over large areas of the Chamais, Cape Town and Agulhas slumps, notable thicknesses of sediment ranging up to 750 m are were involved. Because of their proximity to populated areas, attention here is focussed on the Cape Town and Agulhas structures.

The elongate Cape Town slump is only ~120 km wide (Fig. 1), but extends for least 400 km off the southwestern extremity of southern Africa (Dingle, 1980). It is associated with the Cape Canyon (Fig. 1) whose origin may stem from the late Tertiary (45 Ma-1.8 Ma) confluence of the Orange and Olifants Rivers, exiting near the present Olifants River Mouth. Typical cross sections of the Cape Town slump show an oversteepened continental slope with large rotated blocks up to 450 m thick and several kilometres in width at the foot. Extensive sediment fans have shifted the foot of the continental slope some 130 km basinwards (Dingle 1977, 1980).

The elongate Agulhas Slump on the southern coast is one of the largest in the world, extending for ~750 km (Fig. 1), with a displaced volume of ~20, 000 km^3 (Dingle, 1977, 1980). The structure is dammed on the western aspect by the Alguhas-Falkland fracture zone ridge and distally has spilled into the oceanic basin (Natal Valley). The Agulhas Slump is considered a geologically instantaneous feature, involving Mesozoic (148 Ma-65 Ma) and Cenozoic (65 Ma-present) strata (Dingle 1977, 1980).

According to Dingle (1977, 1980) the Agulhas and Cape Town slumps both involved Pliocene sediments and may therefore be Quaternary (1.8 Ma-present) in age (further supported by the 'fresh' appearance of slumped material, with little modification by subsequent erosion). Wigley and Compton (2006) suggested that the main slumping associated with the Cape Town structure dated to the late Quaternary (~120 ka-present). Slumps north of Luderitz off the Namibian coast were dated by radiocarbon to 50,000-25,000 years BP i.e. Late Pleistocene (~130 ka-10 ka) (Summerhayes et al., 1979). It appears likely, therefore, that much of the slumping along the west and southwest coasts relates to the latter part of the late Cenozoic (25 Ma-present).

In the offshore stretch from Port Elizabeth to Port St. Johns (Fig. 1) a relatively narrow belt of slumping is evident. In the latter region, a lineament with a right lateral offset of ~3 km plays a major role in the development of the slumping (Dingle et al., 1987). Some of these features may date from the Quaternary (1.8 Ma-present) (Dingle and Robson, 1985). Northwards from Port St. Johns extending up to Maputo, a series of large slumped areas and sediment cones related to major river mouths are developed. These formed in response to the large size and high sediment load of the east-flowing rivers along this humid subtropical coastal stretch.

4.3.3 Tsunami risk from submarine slumping

As noted above, seismicity has been widely implicated in triggering of submarine slumping in the global context (Bugge et al., 1988 Bondevik et al. 1997; Tippin et al., 2003; Salomon et al., 2007) and probably locally (Dingle 1980; Summerhayes et al.,1979). Both onshore and offshore earthquakes may be involved with possible ancillary factors such as overpressure from gas hydrates, undercutting by ocean currents and fluvial deposition on the distal shelf during glacio-eustatic lowstands (Dingle 1977; 1980; Summerhayes et al., 1979; Wigley and Compton, 2006). The high rates of terrigenous sediment input and steepness of the sheared margin further augments predisposition for mass sediment mobilisation along the east coast (Hartnady, 2005).

The Cape Slump ranks among the largest along the west coast and coincides with the seismically most active region in South Africa, both on- and offshore (Fig. 1). Onshore earthquakes in this region which exceeded Mw 6 in magnitude took place in 1809 and 1969 (Theron 1974; Goedhart, 2007) and offshore seismicity is also evident (Fig. 1). Thus the confluence of several considerations elevate the vulnerability of the coastal segment around Cape Town to slump-generated tsunami, including: evidence for major (possibly Quaternary: 1.8 Ma-present) submarine slumping; evidence for possible recent slump-generated tsunamigenesis; the exceptional intensity and frequency of seismicity in the southern African context; the low relief coastal plain in some areas; and high population density. The Chamaise Slump off the Orange River is associated with moderate seismicity (Fig. 1) and taking cognisance of the low population density is a relatively low risk area.

As noted above, the Agulhas Slump on the southern coast is one of the largest in the world. Seismicity related to the adjacent Algulhas-Falkland fracture zone may have triggered this massive slope failure (Dingle 1977). Although the southern coast is not a focus of historical seismicity (Fig. 1), the C-B-S fault system that traverses the Cape Fold Belt along the southern coast has been seismogenic during the Holocene (Goedhart. 2007) and the eastern sector in particular could produce large future earthquakes, as noted previously (Hill, 1975; Goedhart, 2007). Dingle (1980) drew an analogy between the geometry and submarine setting of the Agulhas Slump and the Storrega Slump off Norway. The latter, with a displaced volume of only ~3500 km^3 produced a tsunami with a runup exceeding 20 m (see section 3.3.1). The ~20, 000 km^3 displacement of the Agulhas Slump may likewise have generated a significant tsunami, even if slumping was not entirely instantaneous. Given the evidence for major seismic activity, allied with the low relief coastal plain and several populated centres, the southern coast represents a region of notable tsunami threat from submarine slumping.

As noted above, along the east coast the high rates of terrigenous sediment input and steepness of the sheered margin increases the predisposition for mass sediment mobilisation (Dingle, 1977; Hartnady, 2005). The southern sector around Port Elizabeth where the C-B-S fault merges with the Algulhas-Falkland fracture zone (Goedhart, 2007) may be a focus of higher seismicity than indicated in Figure 1. The coastal strip from Buffalo City to Port St.Johns (Wild Coast) was reported to be at high risk of slump-generated tsunamigenesis (Hartnady, 2002; 2005), possibly exacerbated by the offshore seismicity southeast of the Mzimvubu River (Fig. 1). The seismic zones south and north of Durban may likewise constitute areas of higher risk in view of the prominent regions of slumped areas (Fig. 1). The Tugela Cone may also be susceptible in view of the proximity of seismicity. The east coast represents a region of notable tsunami threat from submarine slumping in view of: the evidence for: extensive late Cenozoic (25 Ma-present) slumping; modern seismic activity; steepness of the sheered margin; high sedimentation rates; intermittent low relief coastal plain allowing large inland runups; and several densely populated centres.

4.3.4. Slump generated tsunami or meteotsunami?

Historical evidence for tsunami that may have been induced by offshore slumping along the South African coast is sparse. However, as pointed out previously this record is brief and small or localised events may have escaped notice.

A ‘tsunami’ centring on the west coast town of Dwarskersbos ~170 km north of Cape Town in the early hours of 26th August 1969, was reported in local South African newspapers, including *The Argus*. *Die Burger* (2005) provided a summary of eyewitness accounts of this event. The wave spilled over the ~2 m high beach ridge separating dwellings from the sea (Fig. 3), flooding houses and moving objects as large as motor vehicles. Eyewitness estimates of the tsunami amplitude was ~6 m, but this is probably an exaggeration. However, the reported runup which is less subjective and could be measured after the event was appreciable at ~100 m.

Figure 3. *Dwarskersbos on the west coast (see Figure 1 for location), scene of a possible tsunami in 1969. Gravelly each ridge is 2-3 m in height-view looking northwards.*

On 20/21 August 2008, a lengthy series of surges were observed by seemingly reliable witnesses in the harbours and estuaries of the west coast as reported in local newspapers such as the *Cape Times* and *Die Son* and summarised in SAWS (2008). The sea drew down well below MLW and then surged up again, each time rising well above MHW and in this aspect the event seemed similar to a tsunami. At Lamberts Bay, whirlpools were observed in the harbour and boats touched bottom, breaking anchor chains in some instances. A vehicle was swept away near the mouth of Berg River and at Sandy Point Harbour on the western side of St Helena Bay waterside buildings were flooded. At Hout Bay just south of Cape Town, the cruise launch *Circe* was reported to have been ‘sucked out’ of the mouth of the bay.

Tide gauge data from Walvis Bay in the north to Table Bay (Cape Town) in the south and at East London on the southeast coast were obtained from which the residual values of expected/measured tidal data are shown in (Figs 4 and 5). The most intense oscillations began in the earlier morning, ending around noon. Walvis Bay, situated furthest north showed little effect, but further south at Luderitz anomalies are evident, especially in the afternoon of 21/08/08. The earliest (before noon) and largest amplitude waves occurred at Port Nolloth. The waves varied in amplitude between 0.5 and 1.5m and the period from 60-15 minutes, and depending on location (Figs 4 and 5; SAWS, 2008); ~900 km coastline was affected. Data from east of Cape Point showed little or no effect and at East London on the southeast coast no anomalies can be seen.

An investigation of contemporaneous tide gauge records for the 1969 event at the Hydrographic Office at Silvermine, Cape Town also revealed aberrant tidal patterns from various sites along the sane stretch of the west coast (from Cape Town to Luderitz in Namibia, N. Flint, pers. com.). Thus the approximate magnitude and location of the 2008 event mirrors the Dwarskersbos 'tsunami' of 1969. For both the 1969 and 2008 events, no reports of large tsunami from remote sources could be found that may have produced a teletsunami along the west coast of southern Africa (USGS, 2008). Large conventional waves are known from the west coast, although the sea was reportedly calm at the time of both the 1969 and 2008 events. These considerations open the possibility that these events were localised tsunami, possibly triggered by an offshore sediment slump.

An alternative explanation of the west coast events is that they may represent atmospherically generated tsunami ('meteotsunami'). Atmospheric gravity waves exist by virtue of the stable density stratification of the atmosphere under gravity (Vibilic et al. 2006). Disturbances of a balanced state can result in excitation of atmospheric gravity waves with a variety of spatial and temporal scales. Gravity waves can transport energy and momentum from one region of the atmosphere to another and can initiate and modulate convection and subsequent hydrological processes. Gravity waves in the atmosphere can induce long wavelength oceanic oscillations, which when coastally trapped are referred to as 'edge waves' (Beer, 2007).

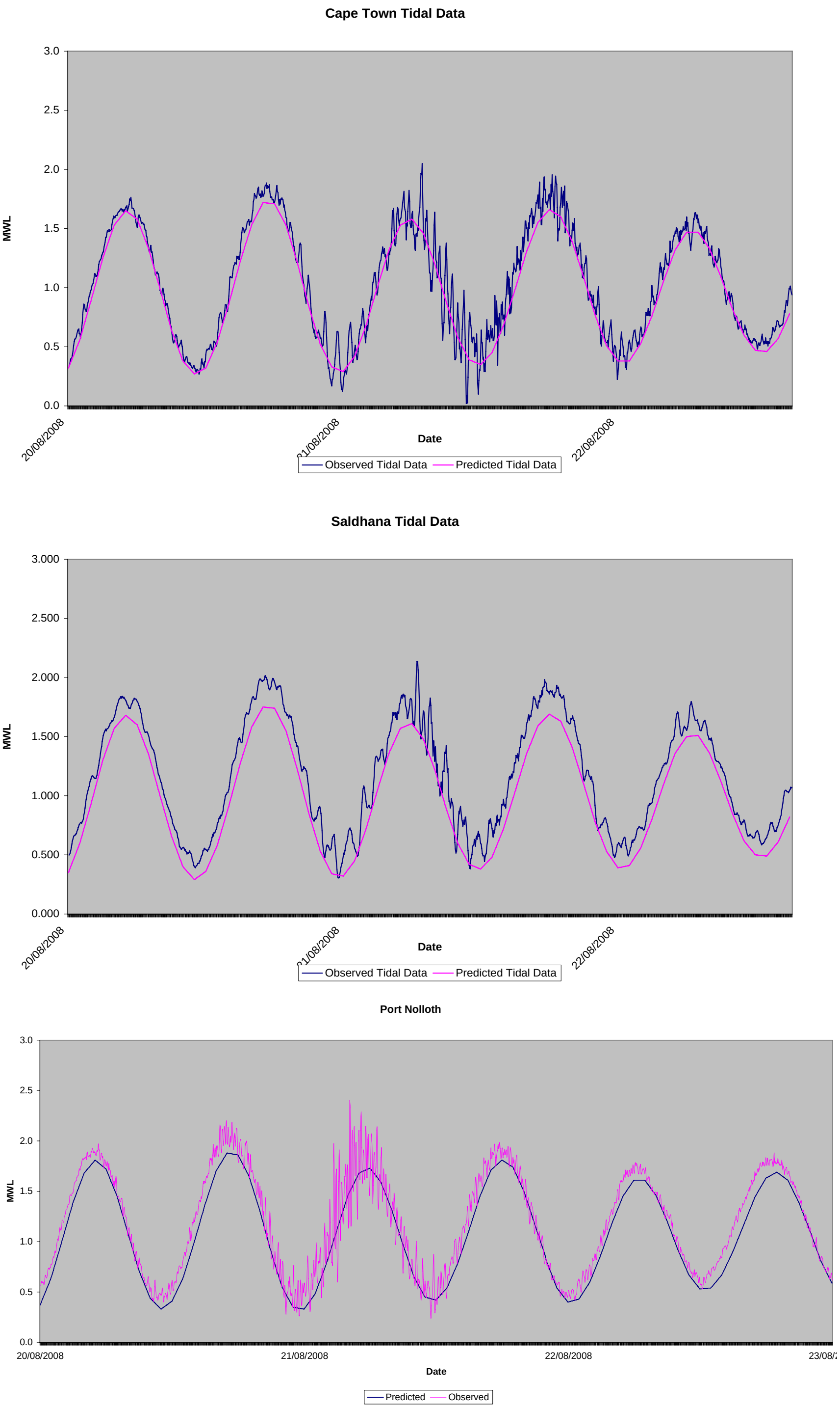

Figure 4. *Tide gauge records for Cape Town, Saldanha and Port Nolloth. All show marked anomalies over the same tidal cycle with lesser anomalies in adjacent cycles. Records from South African Hydrographic Office.*

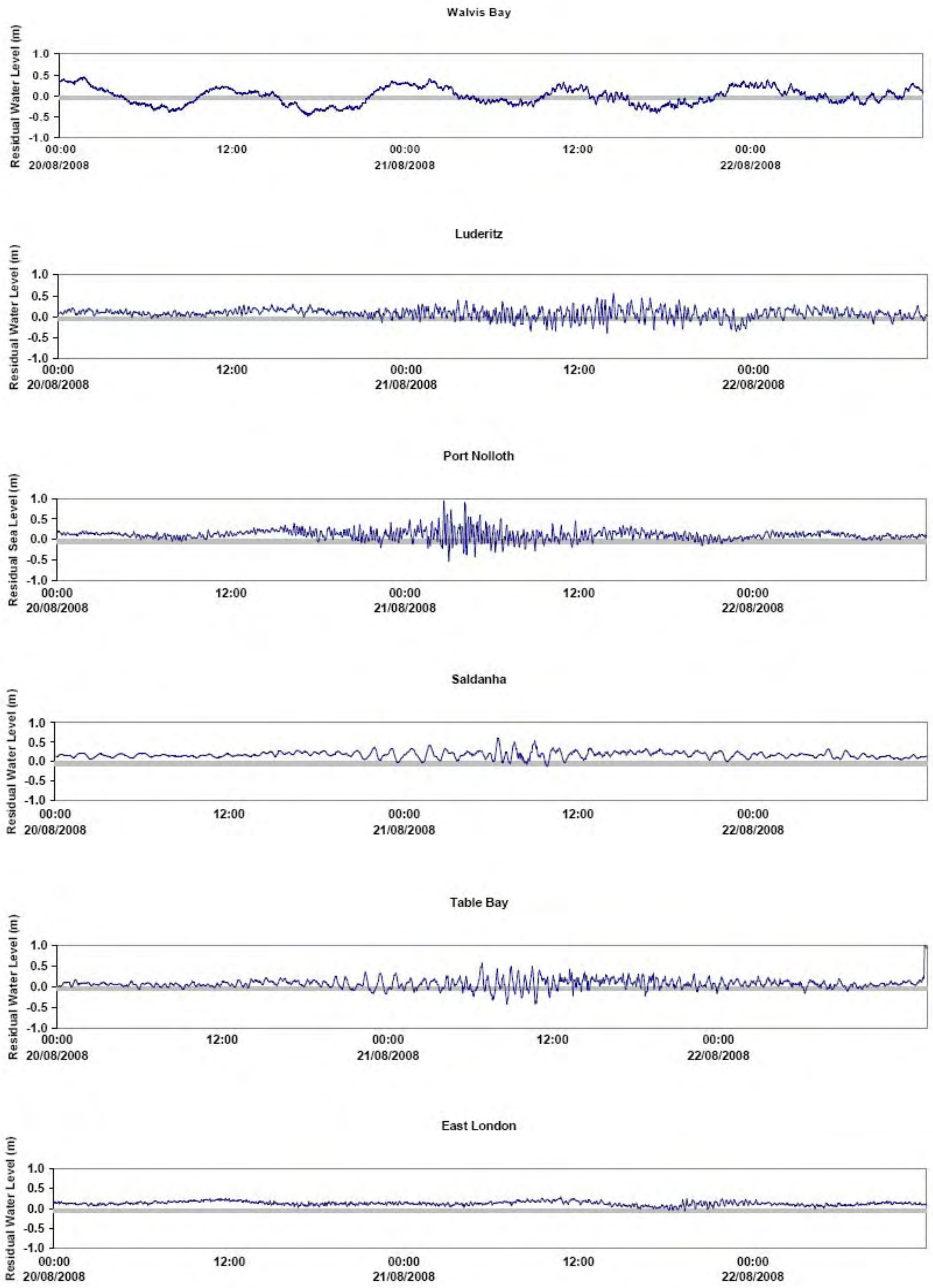

Figure 5. *The residual values of expected/measured tidal data from the west coast.*

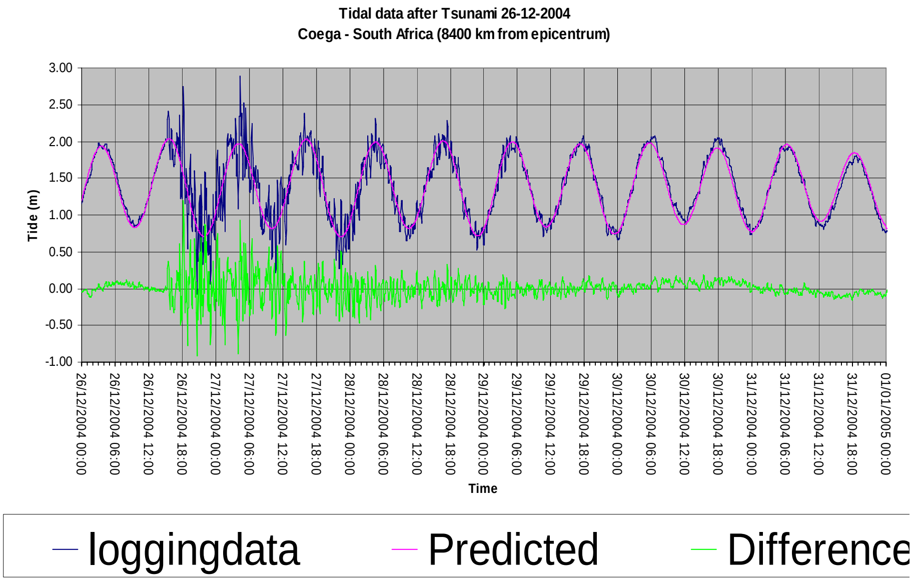

Figure 6. *Tide gauge records for Coega Harbour on the southeast coast for the 2004 Sumatran seismogenic tsunami. Note the similarity in pattern, amplitude and duration of the event in relation to the 2008 west coast tsunami.*

Meteotsunami may be modified and amplified by local topography, and can affect the coast in the same destructive manner as 'ordinary' tsunami waves, e.g. the magnitude 4 tsunami on the Sieberg-Ambrasey intensity scale estimated for the Middle Adriatic (Vibilic et al., 2006). There are several global localities where hazardous meteotsunamis occur regularly and have been given local names: 'rissaga' in the Balearic Islands, 'marubbio' in Sicily, 'milghuba' in Malta, and 'abiki' in Nagasaki Bay, Japan. Note that these mainly refer to relatively restricted marine environments rather than the open ocean.

Because of the cloud formations associated with them, atmospheric gravity waves may show up in satellite imagery as linear features (Fig. 6). Such features have previously been sighted in satellite imagery off the west coast of Africa (SAWS, 2008). Owing to the notable cloud cover, it was not possible to determine whether atmospheric gravity waves It is also noteworthy that rapid oscillations in air pressure were recorded at all west coast

SAWS stations from the late afternoon on August 20th (e.g. Fig. 7), through until the following morning. The observation that both the 1969 and 2008 events fell within the month of August is a further suggestion of metorological control.

Meteotsunami can also produce patterns in tide gauge records closely analogous to conventional tsunami, with multiple waves impinging on the coast for a number of hours. In accord with their long wavelength, they may cause a drawdown in the sea level followed by a surge, again analogous to conventional tsunami and reported by eyewitnesses at Lamberts Bay and other west coast localities (SAWS, 2008). Tide gauge records for Coega (southeast coast) for the 2004 Sumatran tsunami (Fig. 7) show a striking similarity in pattern, amplitude and duration of the event with the 2008 event (Figs 4 and 5).

Port Nolloth experienced the largest amplitude waves and the arrival time was earlier than the sites to the south. If the assumption of a point source was made, this suggests that the source was in the general region off Port Nolloth. However, it could also be contended that the atmospheric gravity waves manifested more strongly in this area and generated a more intense oceanographic response. In the view of the present author, the coincidence of atmospheric anomalies off the west coast coinciding with the onset of the August 20/21 event is compelling evidence of a meteogenic origin.

Anecdotal evidence exists of tsunamigenesis by a marine slump off Port St. Johns. A newspaper article read by Dr J. R. V. Reddering of the Council for Geoscience in 19xxx reported that a fisherman observed an instantaneous depression in the sea surface about X km offshore and a wave propagating outward from the depression. A large, unstable mud delta has developed off the Mzimvubu River mouth at Port St. Johnsref, lending some credence to this report.

There is therefore some (albeit tenuous) evidence for recent tsunami possibly caused by offshore slumping along the South African coast. The tsunamigenenic capacity of palaeoslumps on the scale of those on the Agulhas Bank and elsewhere on the shelf is clearly apparent by analogy with Holocene events. Ongoing seismicity, both on- and offshore could trigger further events representing a significant but as yet unquantified threat to the southern African coast.

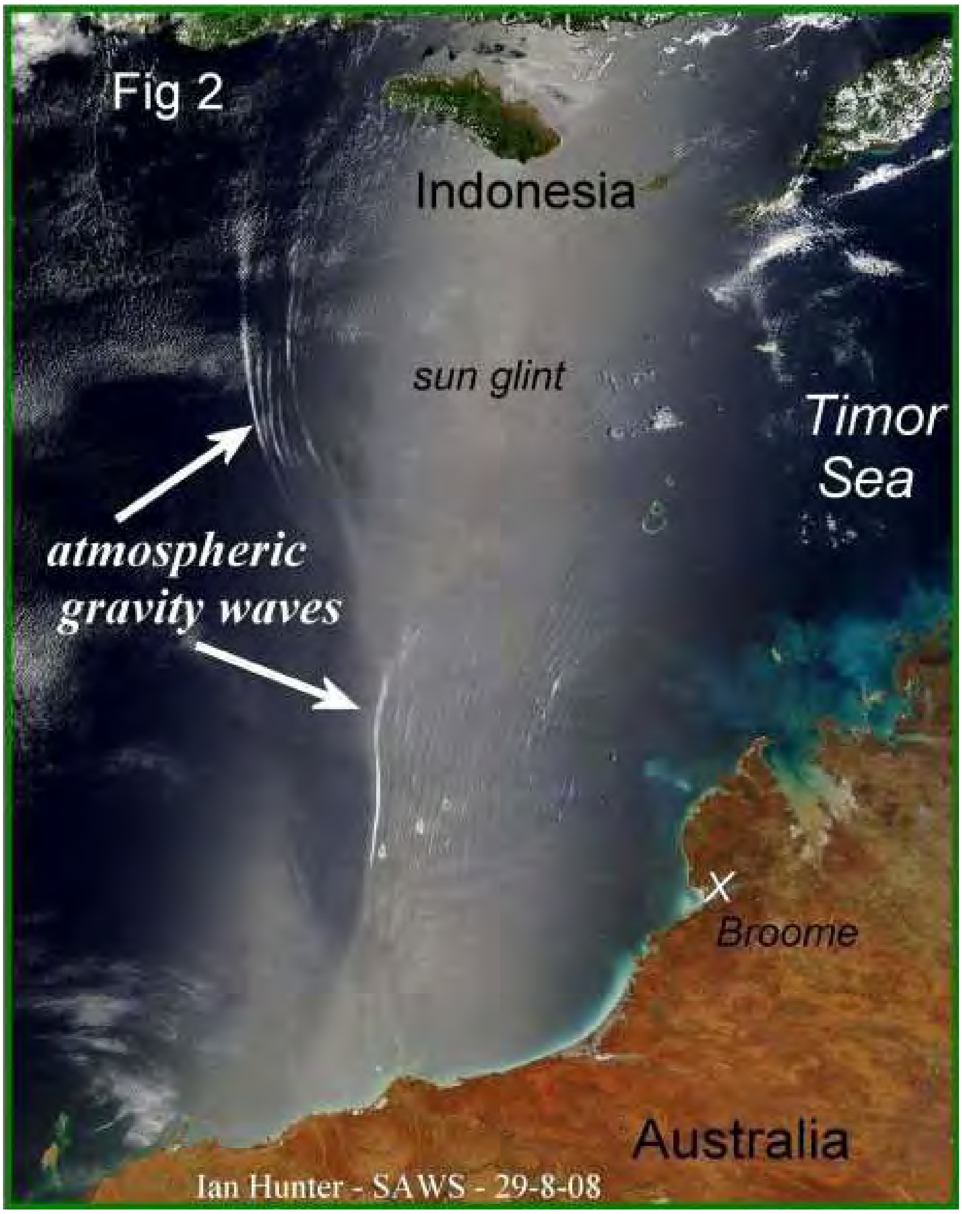

Figure 7. *An example of atmospheric gravity waves enhanced by sunglint conditions (when sunlight is reflected off a calm sea surface directly into the satellite sensor - in this case the MODIS sensor on NASA's Aqua satellite). Taken from SAWS (2008).*

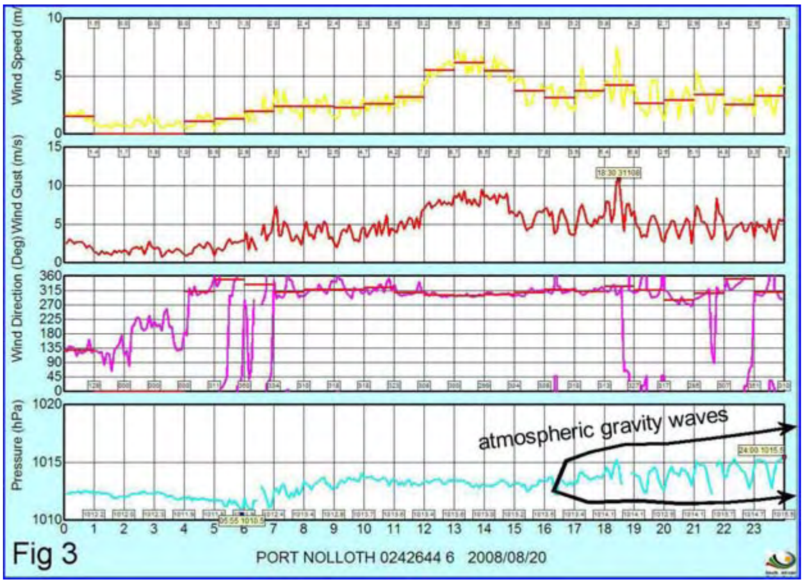

***Figure 8**. Five minute interval data from SAWS's automatic weather station at Port Nolloth. Note the appearance of the relatively large oscillations in air pressure at ~ 5pm on the 20th August. These rapid changes in air pressure were recorded at all the west coast SAWS's, through until the following morning. Taken from SAWS (2008).*

4.4 Volcanic activity

Catastrophic explosive tsunamigenic volcanism is well documented in historical times such as Thera in the Aegean and Krakatoa in the Indian Ocean (e.g. Verbeek, 1984). Krakatau caused the first recorded global tsunami and ships as distant as South Africa were rocked by the waves (Pelinovsky et al., 2005).

Volcanic edifice mass failures and associated submarine landslides have the potential of generating destructive local waves in confined bodies of water and also in the open ocean (e.g. Ward and Day, 2001; Pararas-Carayannis, 2004). Modelling has suggested that flank collapse on Las Palma in the Canary Islands off North Africa could generate local waves with heights of 900-500 m and transoceanic tsunami with wave heights exceeding 20 m at localities as distant as Florida USA and the north coast of South America. According to Hartnady (2005), the islands Karthala and Reunion off the southern African east coast represents the most imminent threat of tsunamigenic volcanism/edifice collapse to South Africa, whereas Marion Island fills this role in the southern Indian Ocean (Fig. 2).

Reunion is highly active at the present time, evinced by the major eruption of 2004. Flank instability is evident around the Piton De La Fournaise volcano which shows extensive erosion, subsidence and an arcuate coastline suggestive of subsea slope failure (Pararas-Carayannis, 2004). Numerous potentially tsunamigenic flank failures and landslides that occurred during the Pleistocene and Holocene have been mapped on the seafloor (Oehler et al., 2007)

Marion Island, South Africa's only historically active volcano, lies south of the Indian Ocean Ridge, about 1700 km from Port Elizabeth (Fig. 2). The Island comprises coalesced basaltic shield volcanoes with basaltic and trachybasaltic lavas predominating. The highest peak reaches 1230 m with about 150 cinder cones forming subsidiary peaks. Whereas the earliest dated eruptions took place about 450,000 years ago, much of the island is covered by Holocene lava flows. The first historical eruption was in 1980 and produced explosive activity and lava flows from a 5 km-long fissure (Verwoerd and Langenegger, 1967; Verwoerd et al.,1981).

4.5 Terrestrial landslides and rockfalls

This section refers to non-volcanogenic terrestrial landslides and rockfalls. The largest modern wave ever recorded occurred at Lutuya Bay, southeast Alaska in 1956 (Miller, 1960). An Mw 8.2 earthquake caused a massive slab of rock to collapse into the bay, giving rise to a wave with a run-up of over 500 m. This event presented poignant evidence of the threat posed by terrestrial landslides and rockfalls into restricted environments such as marine embayments. In the Cape Town environs and southern coasts of South Africa, the highly fractured and jointed quartzitic strata of the Palaeozoic Cape Supergroup form lofty and steep (near vertical) coastal cliffs on the seaward aspect, but with gentler slopes on the landward side (Figs 9 and 10). Relatively fresh scars on cliff faces illustrate large rockfalls in the recent past. At localities such as the town of Hout Bay situated in a marine embayment, potential large rockfalls from the 330 m high sheer cliffs of The Sentinel pose a significant threat to the low-lying areas in the densely populated areas fringing the bay (Fig. 10). Quartzite blocks as large as 13x8x3 m litter the northern entrance to the bay.

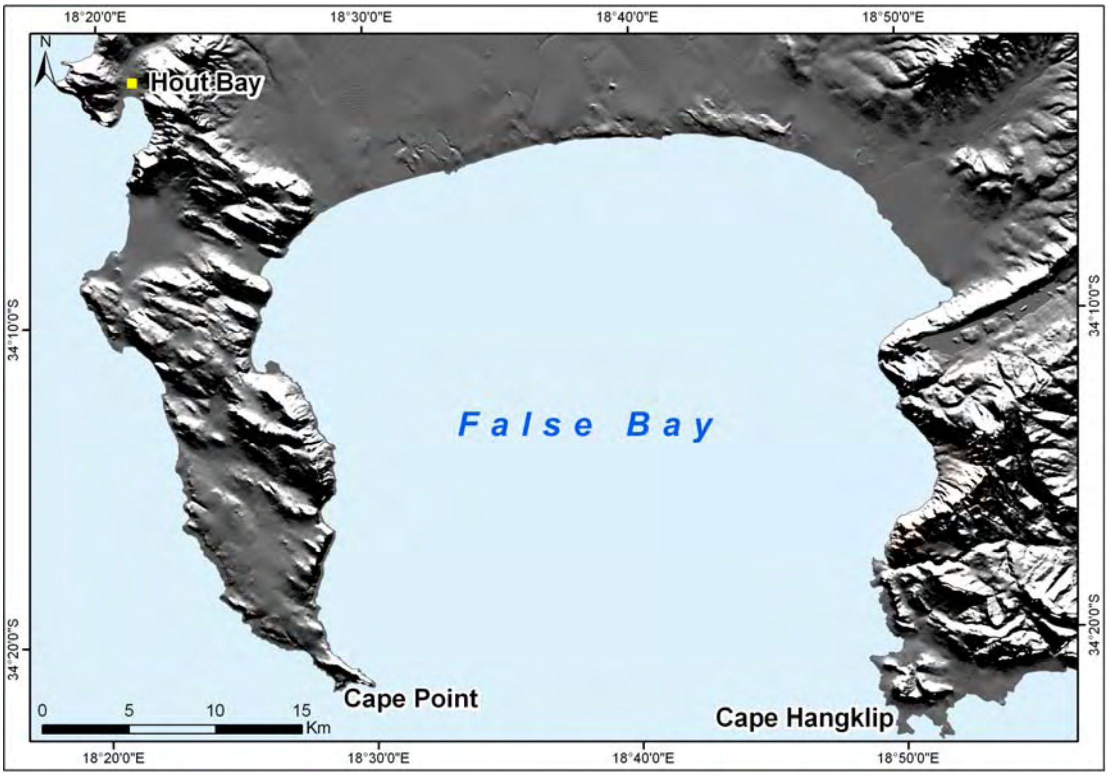

Figure 9. *DEM showing the disposition of steep hillslopes comprising highly fractured and jointed Palaeozoic quartzites, possible sources of tsunamigenic rockfalls. The town of Hout Bay is considered to be at greatest risk.*

Figure 10. *Precipitous cliffs comprising highly fractured and jointed Palaeozoic quartzites at the entrance to Hout Bay, posing a threat of tsunamigenic rockfalls to the town itself, with some dwellings and infrastructure at only 1.5 m asl.*

The large town of Knysna on the South Coast is clustered around the Knysna River estuary. Tertiary (65-1.8 Ma) to Quaternary (1.8 Ma-present) dune systems flanking the estuary range to ~250 m in height. Satellite imagery and aerial photos show evidence of massive landslides within these aeolian deposits. A large landslide about 1.3 km in diameter which deposited an estimated 75 million m^3 of sediment into the estuary is evident on the western side of the estuary at Brenton On Sea (Fig. 11). The age of the event is uncertain, but a later Holocene age is suggested by a platform at 2.5-2 m asl eroded along the distal margin of the landslide, probably recording the Mid-Holocene high sea level widely reported along the South African coast (Miller et al., 1998). The landslide still partly obstructs an estuarine channel, underpinning a young age for the feature. Further landslides of this scale in this area could have serious consequences as residential areas such as Dassen Island are situated as low as 3m asl.

Figure 11. *Major late Holocene landslide into the estuary of the Knysna River from hills comprising unstable coastal aeolianites. A repeat of an event of this order of magnitude would result in inundations of low-lying densely populated areas of the Knysna itself.*

5. Tsunami Prediction and warning time

Since seismicity on global or local scales is not predictable with any precision, it follows that tsunami generated directly or indirectly from earthquakes are not generally amenable to long term prediction either. Tsunami generated from remote submarine seismicity have predictable travel times based on known propagation velocities. Thus the arrival/warning time of known high potential sites such as the Sumatra/Anadaman subduction zone and South Sandwich Island Arc can readily be calculated and indeed this has been successfully done by computer modelling in the instance of the 2006 (Hartnady and Okal, In press).

Salomon et al. (2007) also modelled large magnitude onshore earthquakes in the northern Mediterranean region which showed that within five minutes of a strong earthquake, offshore slumps would produce a 4 to 6 m run-up that may inundate part of the Syrian, Lebanese, and Israeli coasts. The warning time for tsunami generated by local offshore slumps would be generally dependant on the width of the continental shelf at any point along the coastline. Thus along the west southern coast where the continental shelf is relatively wide, warning times would be notably longer than the east coast where the Agulhas/Falkland transform has greatly attenuated the shelf width (Fig. 2). The warning time at any point along the coast could be readily calculated from the known propagation rate of slump generated tsunami and the shelf width. The effects of the more detailed local topography of the shelf would also have to be taken account of. Satellite monitoring of oceanic wave patterns appears to be the only possible source of early warning in this instance.

The effects of tsunami generated by local landslides/rockfalls into restricted embayments would manifest quasi-contemporaneously with the event and warning time would effectively be zero. As noted in section 4.1, no cosmic impacts are currently anticipated in the foreseeable future. Even should ongoing monitoring alter this situation, the cosmic impact time and location could be calculated with some precision, as demonstrated with the Shoemaker-Levy comet impact on Jupiter in July 1994 Benner and McKinnon (1994). Possible tsunami generated from a marine impact could also be modelled.

6. Mitigation/adaptation

Short of civil engineering interventions, there seems to be little that can be done in terms of mitigation/adaptation for existing coastal infrastructure in the event of a tsunami. Such interventions would generally be of an *ad hoc* character and would depend on the situation and nature of the contruction and the modelled maximum tsunami amplitude for that region. For planned coastal infrastructure, both civil engineering modifications and location of the planned structure in terms of its elevation above sea level and distance inland are possible mitigative/adaptative actions. Again the steps taken would depend on the modelled maximum tsunami amplitude/runup for the region in question.

7. Summary and Recommendations

- This report provides a qualitative account of possible tsunamgenic sources that could threaten the South African coastline. To adequately assess the risk, a quantitative assessment of each source category is required.
- Offshore slump generated tsunami are considered the largest unknown risk factor. Holocene and recent historical records provide graphic evidence of their destructive capability on regional scales. Further research including all available stratigraphic/sedimentological/geomorphological data should be undertaken to better define the risk.
- Meteotsunami (edge waves) may well have been responsible for the 1969 and 2008 tsunami events along the southern African west coast. In depth research into the global frequency, locality and magnitude of meteotsunami should be undertaken to further quantify the risk. In particular, the atmospheric conditions along the west coast prior to the 1969 event should be compared with those of its 2008 counterpart.
- Worst case scenarios need to be defined. For instance, the potential impacts of the coincidence of maximum storm waves, storm surge, astronomical tides and meteotsunami should be modeled.
- Because of the relatively short history of tsunami records along the South African coast, the database should be extended by conducting an investigation of palaeotsunami in the stratigraphic record. No systematic work has yet been conducted along this coast. Areas of focus should be in the vicinity of planned nuclear facilities.

8. References

Beer, 2007. *Envrionmental Oceaography.* CRC Press, 78 pp.

Ben-Avraham, Z., and Rogers, J., 1992. Deep-Ocean Basins and Submarine Rises Off the Continental Margin of South-Eastern Africa: New Geological Research Developments. South African Journal of Science 88, 534-539.

Benner, L.A and McKinnon, W.B., 1994. "Pre-Impact Orbital Evolution of P/Shoemaker-Levy 9". Abstracts of the 25th Lunar and Planetary Science Conference, Houston, TX, March 14–18, p 93.

Bisschof A.A., 1999. The Geology of the Vredefort Dome. ISBN 1-875061-60-6, Council for Geoscience.

Bondevik, S., Svendsen, J. I., Mangerud, J., 1997. Tsunami sedimentary facies deposited by the Storegga tsunami in shallow marine basins and coastal lakes, western Norway. Sedimentology 44, 1115–1131.

Bugge, T., Belderson, R.H. & Kenyon, N.H. 1988: The Storegga slide. Philosophical Transactions of the Royal Society of London series A 325, 357-388.

De Beer, C.H., 1983. Geophysical studies in the southern Cape Province and models of the lithosphere in the Cape Fold Belt. In: Söhnge, A.P.G. and Hälbich, I.W. (Eds.), Geodynamics of the Cape Fold Belt, Special Publication Geological Society of South Africa 12: 75-64.

De Swardt, A.M.J., and Bennet, G. (1974). Structural and physiographic development of Natal since the late Jurassic. Transactions of the Geological Society of South Africa 77, 309-322.

Die Burger, Saturday, 19th March 2005, p 6.

Dingle, R.V., 1971. Tertiary sedimentary history of the continental shelf off southern Cape Province, South Africa. Transactions of the Geological Society of South Africa 74, 173-186.

Dingle, R.V., 1977. The anatomy of a large submarine slump on a sheared continental margin (SE Africa. Journal of the Geological Society of London 134; 293-310.

Dingle, R.V., 1980. Large allocthonous sediment masses and their role in the construction of the continental slope and rise off s

Dingle, R.V., Siesser, W.G., Newton, A.R., 1983. Mesozoic and Tertiary Geology of Southern Africa. Balkema, Rotterdam, 375pp.

R.V. Dingle and S. Robson, 1985. Slumps, canyons and related features on the continental margin off East London, SE Africa (SW Indian Ocean). Marine Geology 28, 89–106.

Dingle, R.V., Birch, G.F., Bremner, J.M., de Decker, R.H., du Plessis, A., Engelbrecht, J.C., Fincham, M.J., Fitton, T., Flemming, B.W., Gentle, R.I., Goodlad, S.W., Martin, A.K., Mills, E.G., Moir, G.J., Parker, R.J., Robson, S.H., Rogers, J., Salmon, D.A., Siesser, W.G., Simpson, E.S.W., Summerhayes, C.P., Westall, C.F., and Winter, A., 1987. Deep-sea sedimentary environments around southern Africa, South-East Atlantic and South-West Indian Oceans. Annals of the South African Museum 98, 1–27.

Fernadez LM and Shapira A, 1989. Maps of probabilities of earthquake occurrence in South Africa, Geological Survey, Pretoria.

Geist, E. L., 1998. Source characteristics of the July 17, 1998 Papua New Guinea tsunami: EOS, Transactions of the American Geophysical Union 79, p. 571.

Goedhart, M.L., 2007. Seismicity along the southern Cape Fold Belt, South Africa, association with geological structures, and early-Holocene reactivation of the Kango Fault. In: Catto, N.R., van Kolfschoten, T, and Rutter, N. (Eds), INQUA XVII 2007 Congress, Cairns, Australia. Quaternary International, 168, 142 -143.

Hälbich, I.W. 1983. A tectogenesis of the Cape Fold Belt, In: Söhnge, A.P.G. & Hälbich, I.W. (Eds.), Geodynamics of the Cape Fold Belt. Special Publication Geological Society of South Africa, 12, 165-176.

Hartnady, C.J.H., 2002. Earthquake hazard in Africa: perspectives on the Nubia-Somalia boundary. South African Journal of Science, 98, 425-428.

Hartnady, C.J.H, 2005. Tsunami potential on East African coast, western Indian Ocean island states. Disaster Reduction in Africa - ISDR Informs, Issue 5.

Hartnady, C.J.H and Okal E.A, In press. Mentawai tsunami effect at Port Elizabeth, South Africa on 12-14 Research Article/Letter for SA Journal of Science: 14 Dec 2007

Hill, R.S. 1975. The geology of the northern Algoa Basin, Port Elizabeth. Annals of the University of Stellenbosch, Series A1(1): 105-193.

Illenberger, W.K., 1996. The geomorphologic evolution of the Wilderness dune cordons, South Africa. Quaternary International 33, 11-20.

Iwan, W.D., 2006. Summary report of the Great Sumatra Earthquakes and Indian Ocean tsunamis of 26 December 2004 and 28 March 2005: Earthquake Engineering Research Institute, EERI Publication 2006-06.

Larter R.D., Vanneste L.E., Morris P. & Smythe D.K. 2003. Structure and tectonic evolution of the South Sandwich arc. (In Larter, R.D. & Leat, P.T., (Eds.) Intra-oceanic subduction systems: tectonic and magmatic processes. Geological Society Special Publication, 219. London.

McCloskey, J., Antonioli, A., Piantenesi, A.., Steacy, S., Nalbant, S., Cianetti, S., Giunchi, C., Cocco, M., Sieh, K., 2006. Potential tsunamigenesis from the threatened Mentawai Islands earthquake on the Sunda Trench. Geophysical Research Abstracts 8, 08603.

Miller, D. J., 1960. Giant Waves in Lituya Bay, Alaska. Geological Survey Professional Paper 354-C, U.S. Government Printing Office, Washington.

Miller, D.E., Yates, R.J., Parkington, J.E. and Vogel, J.C. 1993. Radiocarbon-dated evidence relating to a mid-Holocene relative high sea level on the southwestern Cape coast, South Africa. South African Journal of Science 89, 35-44.

NASA at http://neo.jpl.nasa.gov/risk/. Retrieved on 30/06/08.

Niemi, T.M., Ben-Avraham, Z., Hartnady, C.J.H., and Reznikov, M., 2000. Post-Eocene Seismic Stratigraphy of the Deep-Ocean Basin Adjacent to the Southeast African Continental Margin: A Record of Geostrophic Bottom-Current Systems. Marine Geology 162, 237-258.

Oehler, J-F. Lénat, J-F. and Labazuy P., 2007. Growth and collapse of the Reunion Island volcanos. Bulletin of Volcanology online.

Okal, E.A., Hartnady, C.J.H. and Hartmann, S., 2007. Modelling the tsunami hazard to African Union states in the Western Indian Ocean from the Mentawai (Indonesia) source zone. Workshop on Natural and Human-Induced Hazards and Disasters in Africa, Kampala (July 21-22), Uganda., 5 pp.

Pararas-Carayannis, G., 2004. Tsunamigenic efficiency of volcanically, seismically and gravitationally induced island edifice mass failures and of aerial and submarine landslides. Abstract of poster presentation. 32nd International Geological Congress, Florence, Italy.

Partridge, T.C. and Maud, R.R. 2000. Macro-scale geomorphic evolution of southern Africa. Partridge, T. C. and Maud, R. R. (editors) The Cenozoic of southern Africa. Oxford Monographs on Geology and Geophysics 40, 3-18.

Pelinovsky, E., Choi, B.H., Stromkov, A., Didenkulova, I., and Kim, H.S., 2005. Analysis of tide-gauge records of the 1883 Krakatau tsunami. In Tsunamis: Case Studies and Recent Developments (K. Satake Ed.), Springer, Dordrecht, 57–77.

Reddering, J. S. V., 1981. The sedimentology of the Keurbooms Estuary. M.Sc. Tesis (unpublished), University of Port Elizabeth, 131 pp.

Rabinovich, A.B. and Thomson, R. E., 2007. The 26 December 2004 Sumatra Tsunami: Analysis of Tide Gauge Data from the World Ocean Part 1. Indian Ocean and South Africa. Pure and Applied Geophysics 164, 261–308

Reznikov, M., Ben-Avraham, Z., Hartnady, C., and Niemi, T.M., 2005. Structure of the Transkei Basin and Natal Valley, Southwest Indian Ocean, From Seismic Reflection and Potential Field Data. Tectonophysics 397, 127-141.

Rogers, J. 1982. Lithostratigraphy of Cenozoic sediments between Cape Town and Eland's Bay. Palaeoecology of Africa 15, 121-137.

Salamon, A., Rockwell, T., Ward, S. N., Guidoboni, E. and Comastri, A., 2007. Tsunami hazard evaluation of the eastern Mediterranean: historical analysis and selected modelling. Bulletin of the Seismological Society of America 97, 705-724.

Smit, J., Montanari, A., Swinburne, N. H. M., Alvarez, W., Hildebrand, A. R., Margolis, S. V., Claeys, Ph., Lowrie, W. and Asaro, F., 1992. Tektite-bearing, deep-water clastic unit at the Cretaceous-Tertiary boundary in northeastern Mexico, Geology, 20, 99-103.

South Africa Weather Services (SAWS): www.weathersa.co.za. Retrieved on 29/08/08.

Summerhayes, C.P., Bornhold, B.D. and Embley, R.W., 1979. Surficial slides and slumps on the continental slopes and rises of Southwest Africa: a reconnaissance study. Marine Geology 31, 265-277.

Theron, J.N., 1974. Die seismiese geskiedenis van die suidwestelike Kaapprovinsie. p. 9-26. In: Van Wyk, W.L. and Kent, L.E. (1974). Die aardbewing van 29 September 1969 in die suidwestelike Kaapprovinsie, Suid-Afrika. Seismologiese Reeks 4, Geological Survey, Department of Mines, South Africa. 48 pp.

Thomas, R. J., 1989. A tale of two tectonic terranes. South African Journal of Geology 93, 306-321.

Turco, R. P.; Toon, O. B.; Park, C.; Whitten, R. C.; Pollack, J. B.; Noerdlinger, P., 1982. An analysis of the physical, chemical, optical, and historical impacts of the 1908 Tunguska meteor fall. Icarus, 50, 1-52.

USGS, 2006 online at http://earthquake.usgs.gov/regional/world/world_density.php. Retrieved on 29/08/08

Van Dorn, W.G., 1984. Some tsunami characteristics deducible from tide records, J. Physical Oceanography, 14, 353–363.

Verbeek, R. D. M., 1984. "The Krakatoa eruption". Nature 30, 10-15.

Verwoerd W J, Langenegger O, 1967. Marion and Prince Edward Islands geological studies. Nature 213, 231-232.

Verwoerd W J, Russell S, Berruti A, 1981. Volcanic eruption reported on Marion Island. Earth Planet Science Letters 54, 153-156

Vilibic, S. Monserrat, A. B. Rabinovich Meteotsunamis, 2006. Atmospherically induced destructive ocean waves in the tsunami frequency band Geophysical Research Abstracts, 8, 1pp.

Ward, S. N. and Day, S., 2001. Cumbre Vieja Volcano-Potential Collapse and Tsunami at La Palma, Canary Islands. Geophysical Research Letters, 28, 3397-3400.

Westall F., 2006. Quaternary continental margin sedimentation off the southeast coast of South Africa. Geological Journal 22, 563 – 578.

Wigley R. A. and Compton. J. S., 2006. Late Cenozoic evolution of the outer continental shelf at the head of the Cape Canyon, South Africa. Marine geology, 226, 1-23.

APPENDIX E:

Data Reports on Oceanographic Measurements by Lwandle Technologies (Pty) Ltd

Note:

This appendix contains the oceanographic data reports compiled by Lwandle Technologies after each service visit. The data contained in these data reports undergoes additional quality control procedures by PRDW, including combining the data from each service visit into a unified dataset. For this reason the data contained in these data reports should not be used for design purposes and only the quality controlled unified data described in the main report should be used.

LWANDLE MOBILISATION REPORT

BANTAMSKLIP: CURRENT, WAVE, TEMPERATURE, WATER LEVEL AND BIOFOULING MEASUREMENTS

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

27 February 2008

Job No: LT-JOB-50

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

LWANDLE TECHNOLOGIES (PTY) LTD

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Co Reg. No. 2003/015524/07

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1. PROJECT SUMMARY

Lwandle Technologies (Lwandle) have been contracted by Prestedge Retief Dresner Wijnberg (PRDW) to collect oceanographic data as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites: Koeberg, Bantamsklip and Thyspunt. Measurements of current, wave, water level, temperature and biofouling are being made at two (2) locations at the Bantamsklip site in approximately 10m and 30m water depth. For these measurements the following instruments have been installed:

- CURRENTS AND WAVES: TRDI 600kHz Acoustic Doppler Current Profiler (ADCP) fitted with temperature sensor, high resolution pressure sensor and waves firmware have been deployed in gimballed, stainless steel, bottom mounted frames. One unit has been deployed in 10m and the other 30m water depth.

- TEMPERATURE AND SALINITY: One temperature & salinity (T&C) string has been deployed in 30m water depth. The string will measure temperature and salinity at two depths (near surface and near bottom). For these measurements a mooring fitted with 2 x RBR XR 420CT conductivity and temperature loggers has been installed. The mooring has been attached to the ADCP frame via a polypropylene groundline.

- WATER LEVELS: An RBR TGR-1050HT vented recording tide gauge has been installed on a suitable structure at a suitable location. Information on the height from the top of the tide gauge sensor to the logger box needs to be provided to the surveyors for levelling at a later stage.

- BIOFOULING: Six (6) 50cm^2 asbestos plates have been deployed, three (3) plates at 3m depth and three (3) plates at 8m depth. At intervals of 3, 6 and 12 months one plate from each depth will be recovered, photographed, the thickness of marine growth measured and the plates then preserved in formalin for subsequent bio-analysis.

This report provides information about the deployment site, equipment used, a description of operations, problems encountered, log of events and the various completed equipment deployment sheets.

2. SITE LOCATION

The instruments have been deployed at the locations given in Table1 (positions are given in degrees and decimalised minutes) below:

Table 1 – Measurement locations

Instrument	Latitude	Longitude
Tide Gauge	34°42.462 S	19°32.080 E
10m ADCP	34°43.186 S	19°33.637 E
Biofouling	34°43.190 S	19°33.686 E
30m ADCP + T&C mooring	34°42.625 S	19°30.696 E

Figure 1 - Map of the project area

3. INSTRUMENTATION

For the current and wave measurements, two TRD Instruments 600KHz ADCPs have mounted inside a bottom mounted stainless steel frame c/w gimball assembly.

The temperature and salinity loggers (T&C loggers) have been fastened onto a galvanized steel strop (10mm) via cable ties, hose clamps and duct tape, with five (5) 11” floats on top to keep the line vertical.

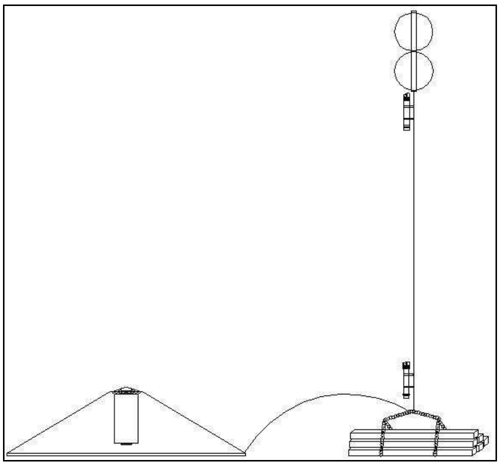


Figure 2- Temperature & salinity mooring attached to ADCP frame

The biofouling mooring line consisted of three (3) 11” floats for buoyancy, a 3m section of 12mm ski rope to which three (3) asbestos plates have been attached using cable ties, a 1m galvanized steel strop below this to which a 1.6m length of ski rope was attached, which held the bottom three plates.

An Edgetech acoustic release has been connected to the bottom of the mooring line, so that the biofouling mooring may be released separately from the ADCP and T&C mooring line. The detailed setup for the ADCP and T&C loggers can be found in the deployment sheets in Section 6, and these are summarised in Table 2, Table 3 and Table 4 below.

Table 2 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10100
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Table 3 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

Table 4 – Instrument configuration for T&C mooring line

Parameter	Configuration
XR 420 Temperature and Conductivity Logger	s/n 12994 (7m) and s/n 12998 (28m)
Sampling and Averaging	10min sampling and 1min averaging

Table 5 – Instrument configuration for the Tide Gauge

Parameter	Configuration
TGR 1050 HT	s/n 14005
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

Table 6 – Instrument configuration for Biofouling mooring line

Parameter	Configuration
Biofouling Plates	3 plates (50cmx50cm) at 3m and 3 plates (50cmx50cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

4. DESCRIPTION OF OPERATIONS

Lwandle engineers were mobilised from Cape Town to Pearly Beach for the deployment of the oceanographic equipment. A summary of the sequence of events associated with the mobilisation trip is given in Table 7 below.

Table 7 – Sequence of events

Date	Description
28 January 2008 09h30	Lwandle's engineers departed from Cape Town.
12h30	The engineers arrived at Pearly Beach accommodation and then they setup the vehicle with the necessary gear for the tide gauge deployment.
13h30	The engineers met with the Dive Team. They then arranged for a 4x4 vehicle for access to the site due to deep sand roads. All the kit was transferred to the 4x4 vehicle.
14h30	The engineers arrived at the proposed site for the tide gauge which was situated in a sheltered embayment. It was discovered that the proposed position was not suitable as it was very shallow and too far from the rocks. The engineers then scouted the next five (5) gullies towards the north in order to find a suitable position. The new position was 1.87m deep and located at 34°42.462 S and 19°33.080 E. The surveyors still need to level in the tide reference with a chart datum.
16h00	The engineers carried the tide gauge, H-frame and railway lines down to rocks. The frame was floated to position and levered onto exposed rocks to attach railway lines. The railway lines were then floated out. The railway lines were attached to the frame with galvanized wire and cable ties. The PVC pipe (stilling well with sensor inside) was attached to the H - frame. The H -frame was secured in position. The data cable was covered with hosing. Attached logger box to rocks via 4 bolts that were steel cemented onto rocks. Attached wire over box and cemented onto rocks. Tide gauge was set to start recording at 18h00. The unit hit the water at 19h10.
20h10	The engineers returned to the base camp.
29 January 2008 - 06h30	Assembled the ADCP frames, CART pop-ups, T&C, biofouling strings and set up the instruments.
09h00	The engineers left the base camp and met the boat operator and divers at Gansbaai.
09h30-11h00	The assembly of ADCP frames and fitting of instruments was completed.
12h00	The vessel was launched and it reached the ADCP deployment location in approximately 50 minutes.
13h00	The railway lines were attached to the T&C mooring line. Then the 50m groundline was attached between ADCP frame and T&C logger string.
13h10	The T&C logger string was lowered using the 50m groundline.

Date	Description
13h20	The ADCP frame was lowered to 30m (CART s/n 32383) 34°42.603 S and 19°30.655 E.
13h30	The divers attached 3 x chain sections to the ADCP frame. The 30m ADCP mooring was successfully deployed.
14h35	The vessel arrived at 10m site (~ 5kms away)
14h45	The Biofouling mooring was deployed (34°43.190 and 19°33.637).
15h00	The 10m ADCP (CART s/n 32380) was deployed (34°43.186 S and 19°33.637 E). The divers entered the water and attached 4 sections of rig chain and photographed the mooring.
16h30	The vessel arrived back at Kleinbaai Harbour.
Ranging	**30m ADCP Ranging** 1) 34°42.575 / 19°30.604 - 117m 2) 34°42.585 / 19°30.513 - 235m 3) 34°42.607 / 19°30.473 - 295m **10m ADCP Ranging** 1) 34°43.147 / 19°33.575 - 113m 2) 34°43.155 / 19°33.653 - 56m 3) 34°43.194 / 19°33.696 - 77m **Biofouling ranging** 1) 34°43.159 / 19°33.723 - 80m 2) 34°43.180 / 19°33.708 - 56m 3) 34°43.170 / 19°33.660 - 51m
30 January 2008 - 08h30	The engineers travelled to Gansbaai to purchase rock set cement and epoxy putty for tide gauge logger box.
10h30	The engineers arrived at the tide gauge site. The engineers checked the logger box and sensor frame (i.e. H-frame and stilling well) and it appeared to be fine. They then applied epoxy putty and rock fast cement to 4 x bolts on logger box.
11h30	The 4x4 vehicle was returned and the engineers proceeded back to Cape Town.
14h00	The engineers arrived back in Cape Town.

Figure 3- The tide gauge's logger box

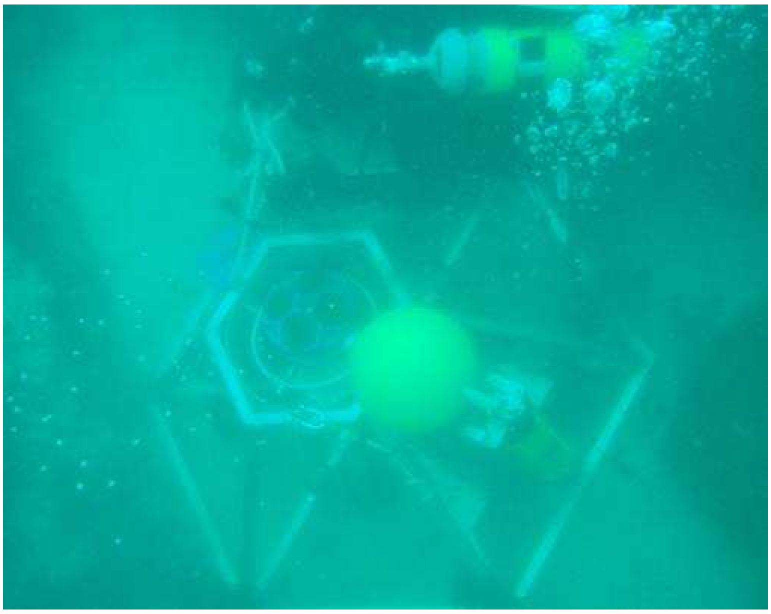


Figure 4- The ADCP in its frame

Figure 5-Stilling well protruding from the surface

5. PROBLEMS ENCOUNTERED AND MITIGATION MEASURES

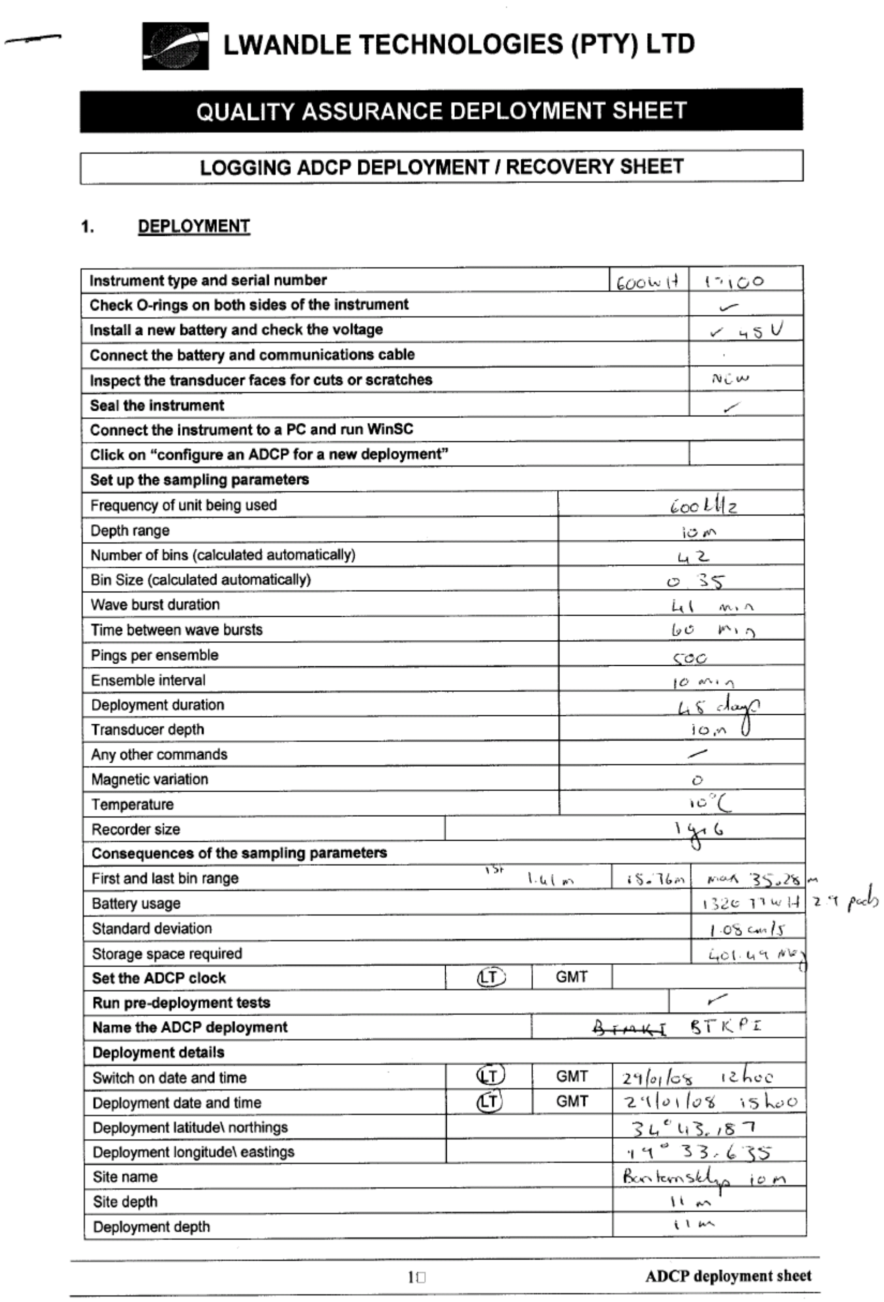
A list of problems experienced and mitigation measures taken have provided in Table 8.

Table 8 – Problems and mitigation measures

Problem	**Mitigation measure(s)**
The access to Tide Gauge site is 4x4 track.	Need to hire 4x4 from Cape Town for service visit.
Poachers dive in vicinity of tide gauge – they may steal the instrument.	Tried to camouflage instruments as best as possible.
Seimac beacons did not arrive in time for the initial installation and will be deployed at the first service visit.	

6. VARIOUS INSTRUMENT SHEETS

6.1 ADCP DEPLOYMENT SHEETS



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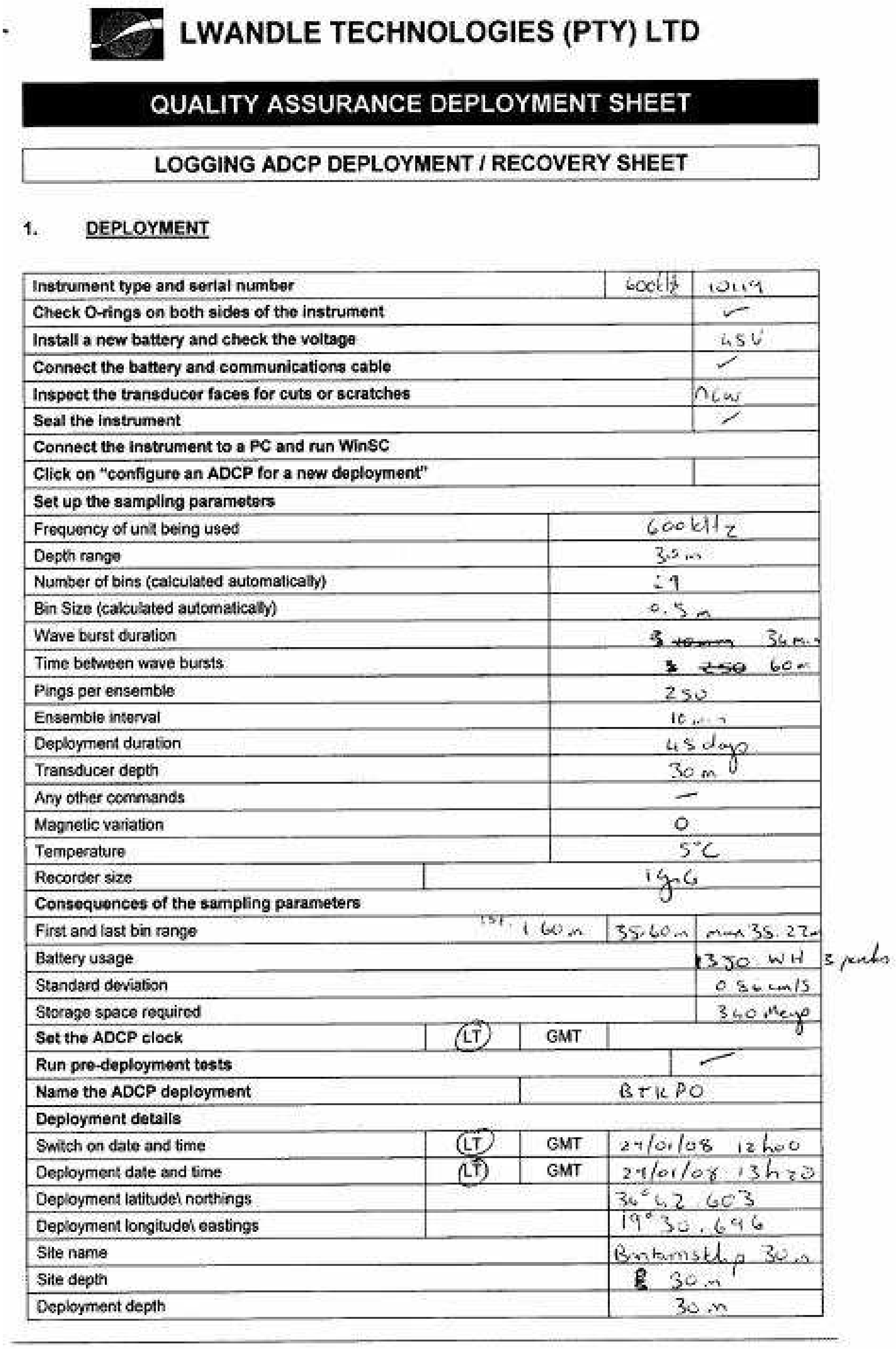
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. **DEPLOYMENT**

Instrument type and serial number		600WH	17100
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			✓ 45V
Connect the battery and communications cable			
Inspect the transducer faces for cuts or scratches			New
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used			600 kHz
Depth range			10 m
Number of bins (calculated automatically)			42
Bin Size (calculated automatically)			0 35
Wave burst duration			41 min
Time between wave bursts			60 min
Pings per ensemble			500
Ensemble interval			10 min
Deployment duration			48 days
Transducer depth			10 m
Any other commands			–
Magnetic variation			0
Temperature			10°C
Recorder size			1 gig
Consequences of the sampling parameters			
First and last bin range	1st 1.41 m	15.76 m	max 35.28 m
Battery usage			1320 77 WH 2.9 packs
Standard deviation			1.08 cm/s
Storage space required			401.49 Meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			~~BTAKI~~ BTKPI
Deployment details			
Switch on date and time	[✓ LT]	GMT	29/01/08 12h00
Deployment date and time	[✓ LT]	GMT	29/01/08 15h00
Deployment latitude\ northings			34° 43.187
Deployment longitude\ eastings			19° 33.635
Site name			Bontemsklip 10 m
Site depth			11 m
Deployment depth			11 m

1□ **ADCP deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

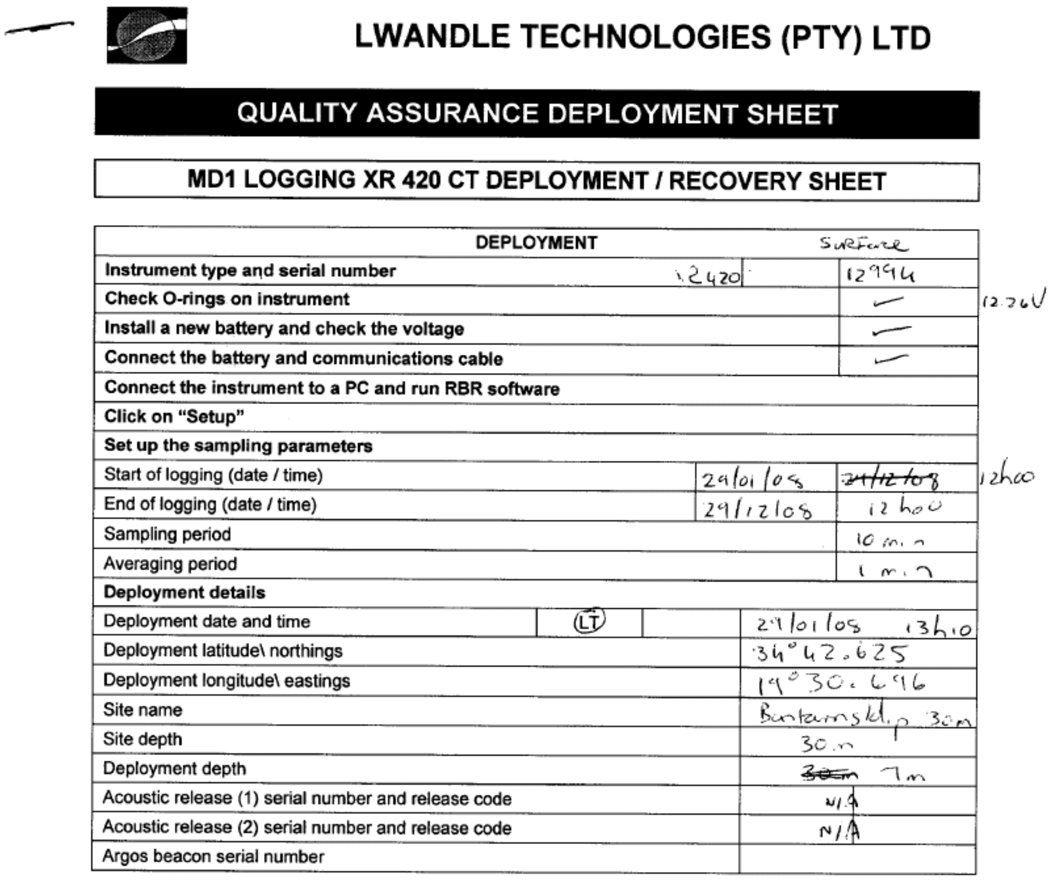
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number		600kHz	10119
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			45V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			new
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used			600kHz
Depth range			35 m
Number of bins (calculated automatically)			69
Bin Size (calculated automatically)			0.5 m
Wave burst duration			3 ~~40min~~ 36 min
Time between wave bursts			3 ~~250~~ 60 m
Pings per ensemble			250
Ensemble interval			10 min
Deployment duration			45 days
Transducer depth			30 m
Any other commands			–
Magnetic variation			0
Temperature			5°C
Recorder size			1 gig
Consequences of the sampling parameters			
First and last bin range		1st 1.60 m	35.60 m · max 35.22 m
Battery usage			1350 WH 3 packs
Standard deviation			0.36 cm/s
Storage space required			360 Meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			BTK P0
Deployment details			
Switch on date and time	[✓ LT]	GMT	24/01/08 12h00
Deployment date and time	[✓ LT]	GMT	24/01/08 13h20
Deployment latitude\ northings			34° 42.603
Deployment longitude\ eastings			19° 30.696
Site name			Bantamsklip 30 m
Site depth			30 m
Deployment depth			30 m

6.2 RBR LOGGER DEPLOYMENT SHEETS

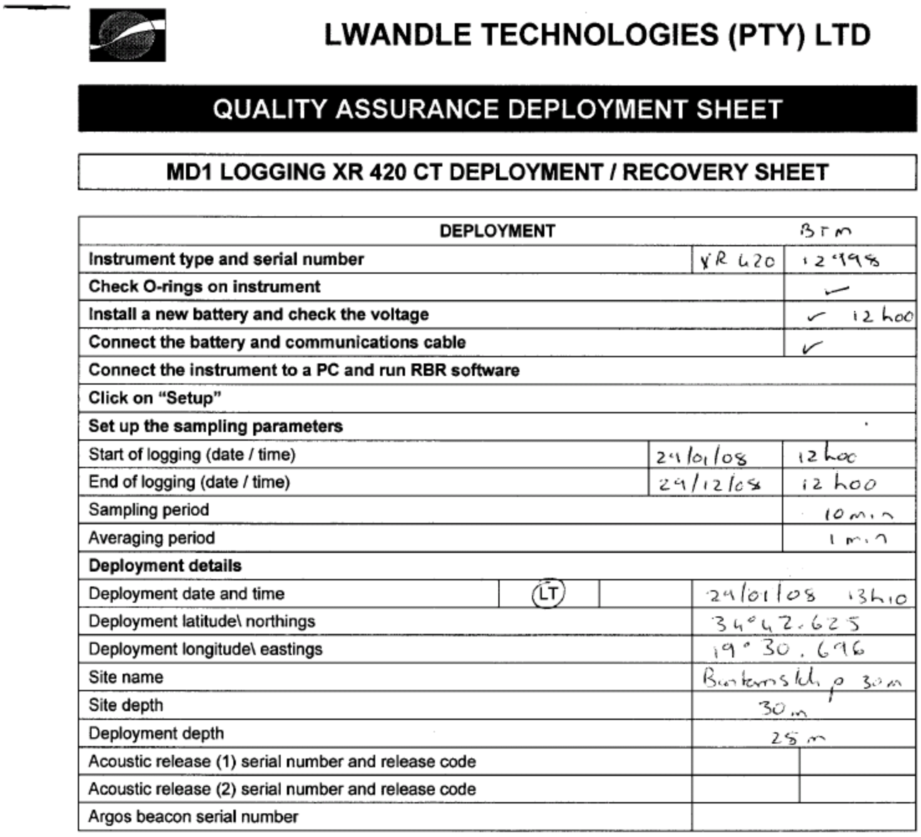


LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT		Surface	
Instrument type and serial number	12420	12994	
Check O-rings on instrument		✓	12.26V
Install a new battery and check the voltage		✓	
Connect the battery and communications cable		✓	
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)	29/01/08	~~24/12/08~~	12h00
End of logging (date / time)	29/12/08	12h00	
Sampling period		10 min	
Averaging period		1 min	
Deployment details			
Deployment date and time	(LT)	29/01/08 13h10	
Deployment latitude\ northings		34°42.625	
Deployment longitude\ eastings		19°30.696	
Site name		Bantamsklip 30m	
Site depth		30m	
Deployment depth		~~30m~~ 7m	
Acoustic release (1) serial number and release code		N/A	
Acoustic release (2) serial number and release code		N/A	
Argos beacon serial number			

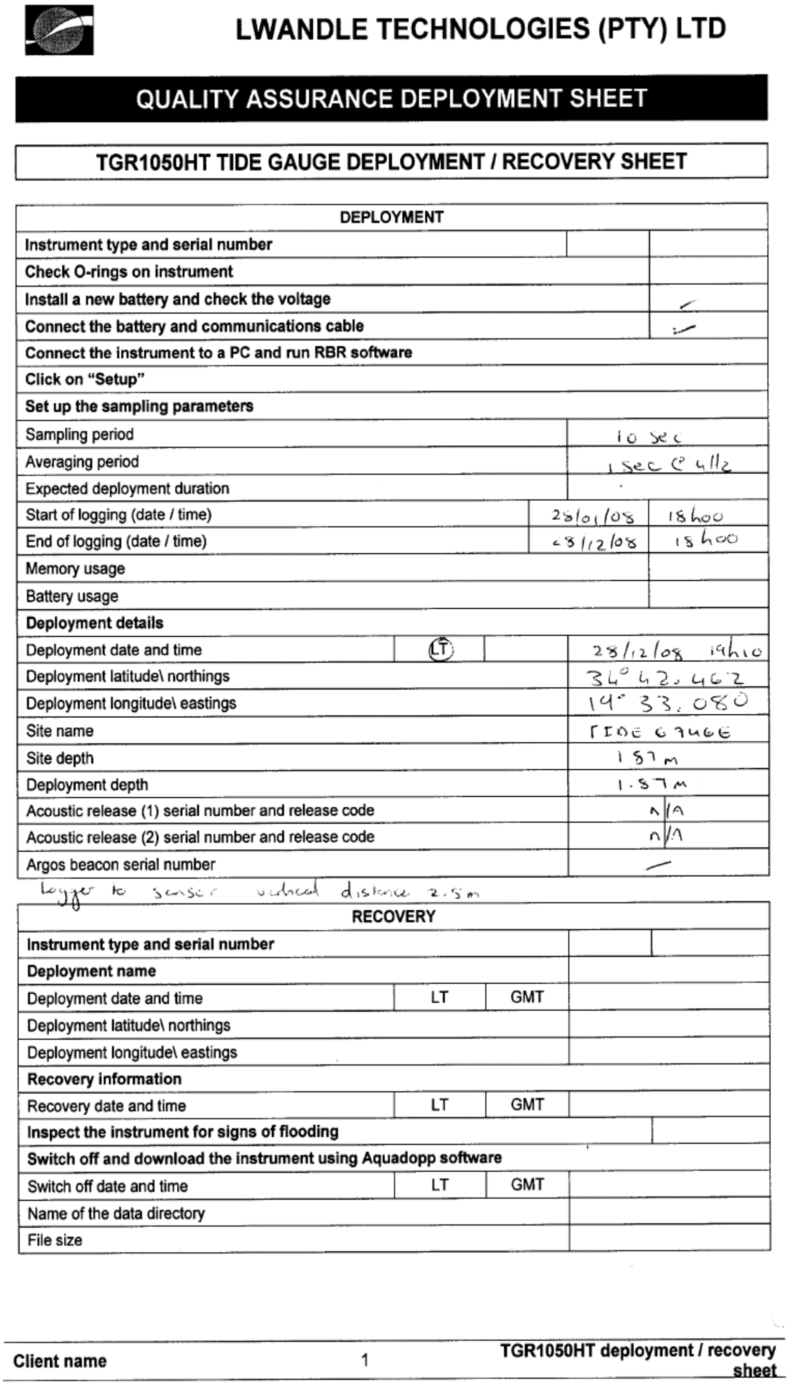


LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			BTM
Instrument type and serial number		XR 420	12998
Check O-rings on instrument			✓
Install a new battery and check the voltage			✓ 12h00
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		24/01/08	12h00
End of logging (date / time)		29/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	(LT)		24/01/08 13h10
Deployment latitude\ northings			34°42.625
Deployment longitude\ eastings			19°30.696
Site name			Bantamsklip 30m
Site depth			30m
Deployment depth			25m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

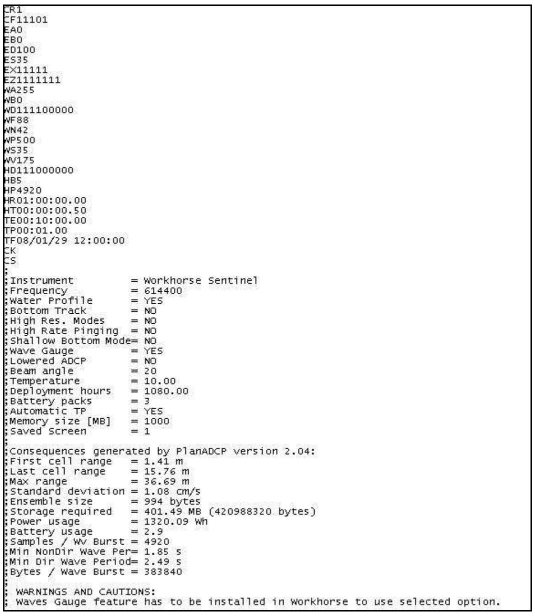
DEPLOYMENT			
Instrument type and serial number			
Check O-rings on instrument			
Install a new battery and check the voltage			✓
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period			10 sec
Averaging period			1 sec @ 4Hz
Expected deployment duration			
Start of logging (date / time)		28/01/08	18h00
End of logging (date / time)		28/12/08	18h00
Memory usage			
Battery usage			
Deployment details			
Deployment date and time	[✓ LT]		28/12/08 19h10
Deployment latitude\ northings			34° 42.462
Deployment longitude\ eastings			19° 33.080
Site name			TIDE G7466
Site depth			1.87 m
Deployment depth			1.87 m
Acoustic release (1) serial number and release code			n/A
Acoustic release (2) serial number and release code			n/A
Argos beacon serial number			—

logger to sensor vertical distance 2.5m

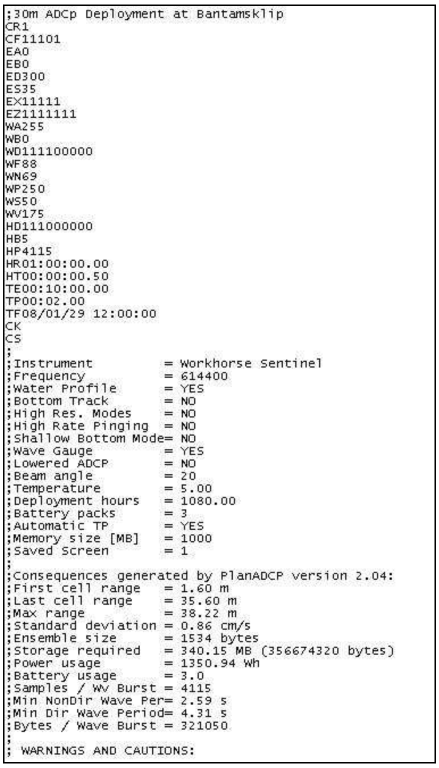
RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	
Inspect the instrument for signs of flooding			
Switch off and download the instrument using Aquadopp software			
Switch off date and time	LT	GMT	
Name of the data directory			
File size			

Client name 1 **TGR1050HT deployment / recovery sheet**

6.3 ADCP CONFIGURATION FILES

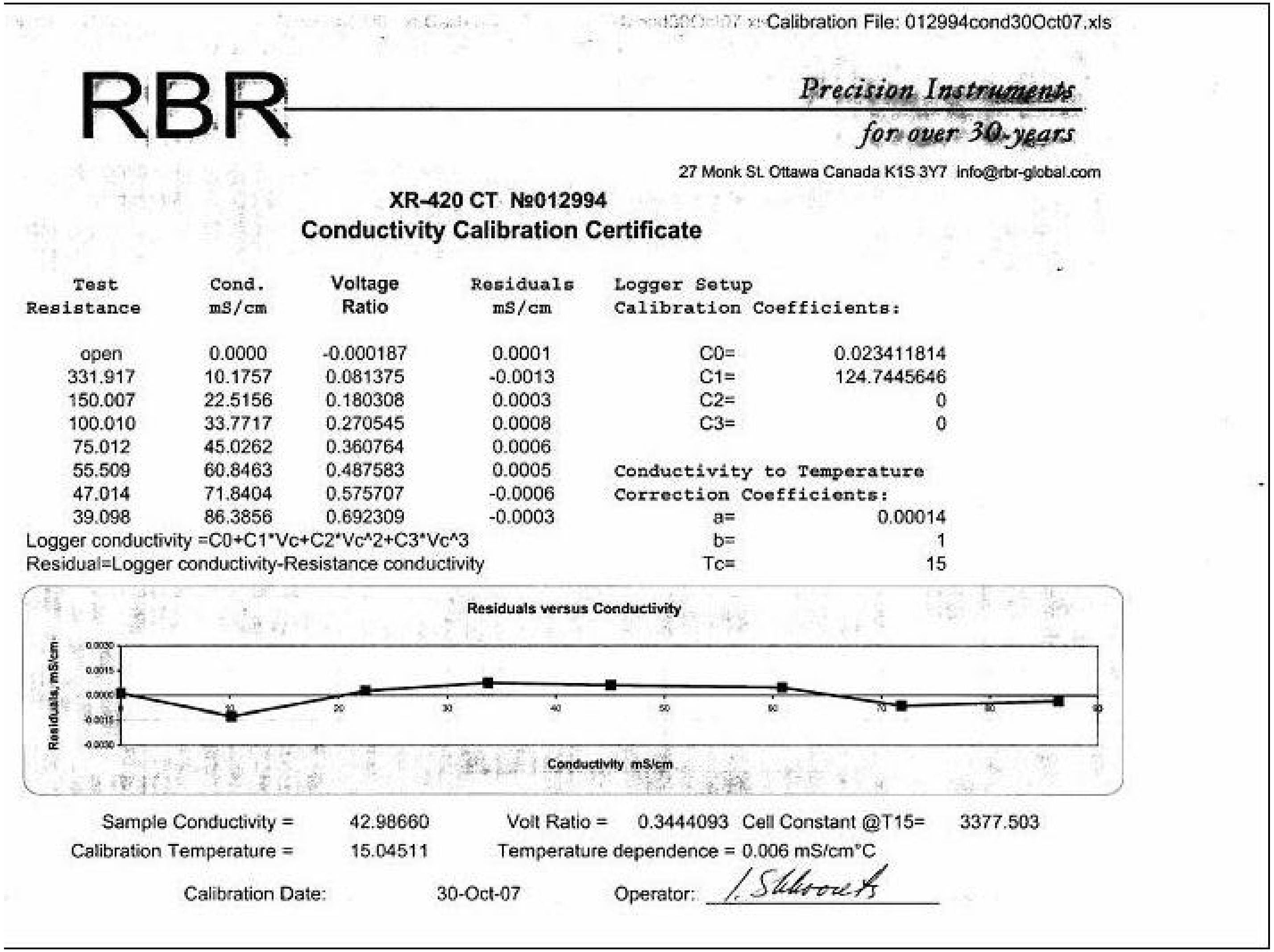


```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:01.00
TF08/01/29 12:00:00
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge         = YES
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 10.00
;Deployment hours   = 1080.00
;Battery packs      = 3
;Automatic TP       = YES
;Memory size [MB]   = 1000
;Saved Screen       = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range   = 1.41 m
;Last cell range    = 15.76 m
;Max range          = 36.69 m
;Standard deviation = 1.08 cm/s
;Ensemble size      = 994 bytes
;Storage required   = 401.49 MB (420988320 bytes)
;Power usage        = 1320.09 Wh
;Battery usage      = 2.9
;Samples / Wv Burst = 4920
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 383840
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use selected option.
```



```
;30m ADCp Deployment at Bantamsklip
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4115
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:02.00
TF08/01/29 12:00:00
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge         = YES
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 5.00
;Deployment hours   = 1080.00
;Battery packs      = 3
;Automatic TP       = YES
;Memory size [MB]   = 1000
;Saved Screen       = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range   = 1.60 m
;Last cell range    = 35.60 m
;Max range          = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size      = 1534 bytes
;Storage required   = 340.15 MB (356674320 bytes)
;Power usage        = 1350.94 Wh
;Battery usage      = 3.0
;Samples / Wv Burst = 4115
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 321050
;
; WARNINGS AND CAUTIONS:
```

6.4 RBR AND T&C CALIBRATION CERTIFICATES



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments
for over 30-years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

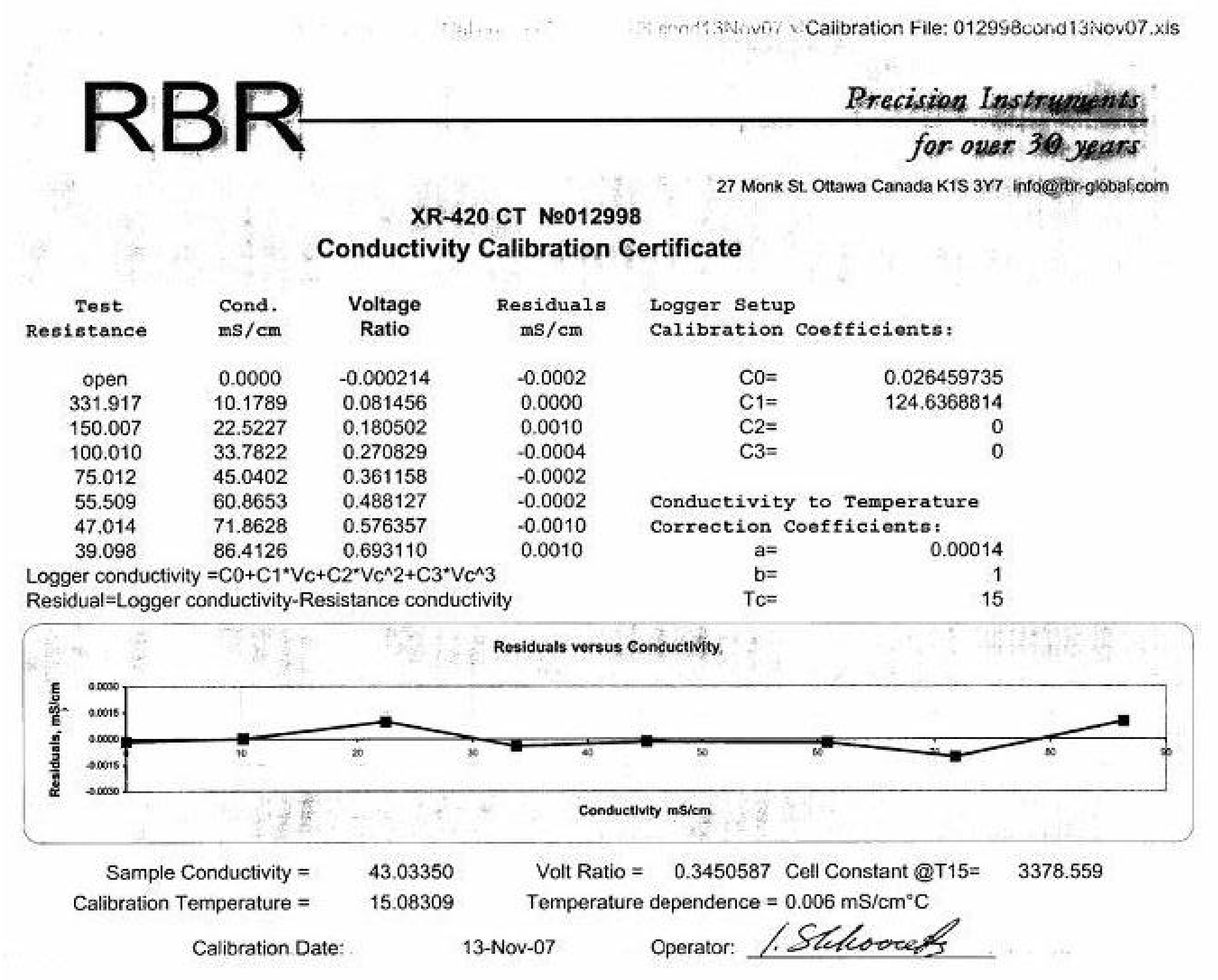
Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

Sample Conductivity = 42.98660 Volt Ratio = 0.3444093 Cell Constant @T15= 3377.503
Calibration Temperature = 15.04511 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07 Operator:



Calibration File: 012998cond13Nov07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012998
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000214	-0.0002
331.917	10.1789	0.081456	0.0000
150.007	22.5227	0.180502	0.0010
100.010	33.7822	0.270829	-0.0004
75.012	45.0402	0.361158	-0.0002
55.509	60.8653	0.488127	-0.0002
47.014	71.8628	0.576357	-0.0010
39.098	86.4126	0.693110	0.0010

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.026459735
C1= 124.6368814
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

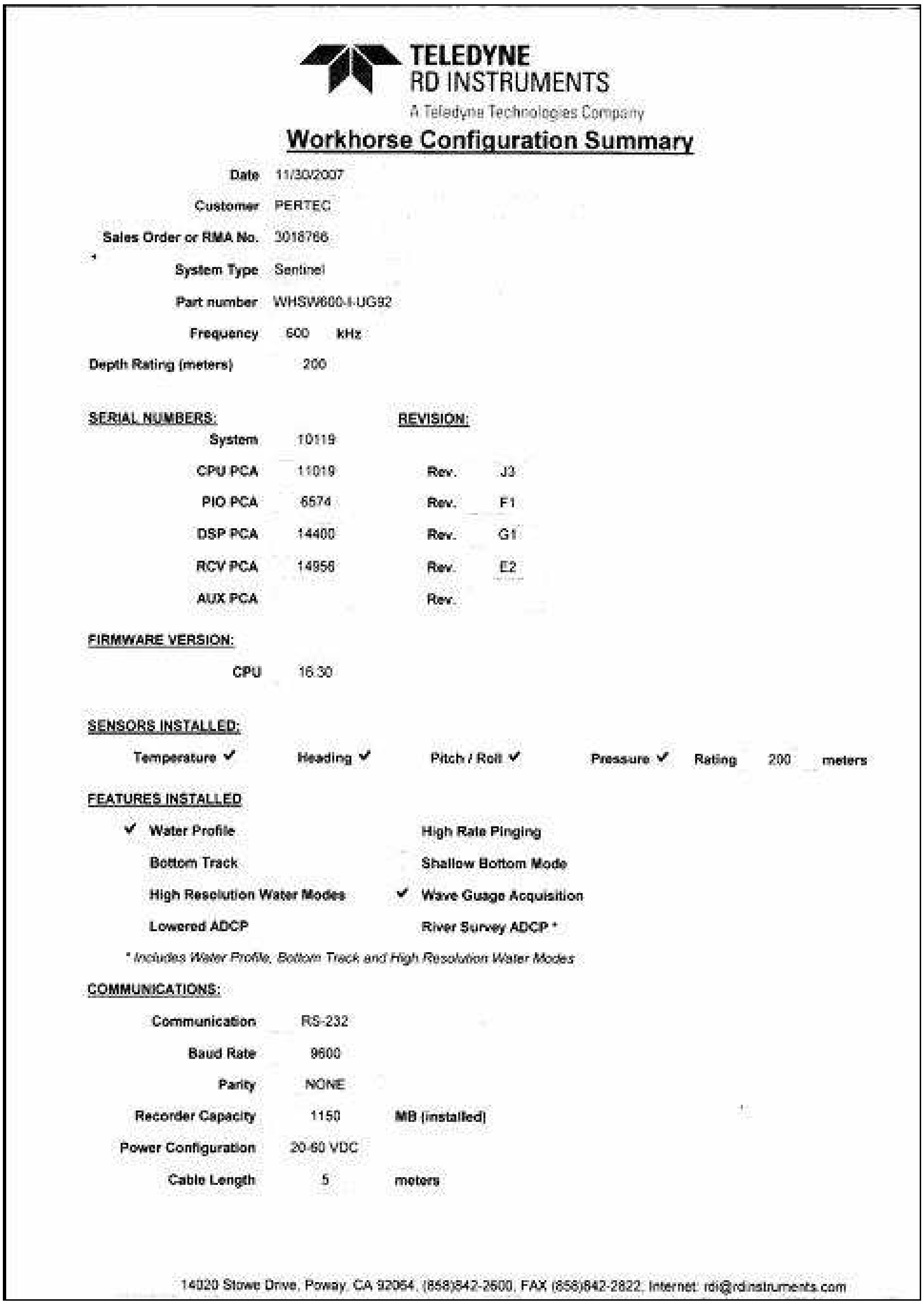
Sample Conductivity = 43.03350
Calibration Temperature = 15.08309

Volt Ratio = 0.3450587 Cell Constant @T15= 3378.559
Temperature dependence = 0.006 mS/cm°C

Calibration Date: 13-Nov-07

Operator: I. Stikooreck

6.5 TRDI ADCP CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007

Customer PERTEC

Sales Order or RMA No. 3018766

System Type Sentinel

Part number WHSW600-I-UG92

Frequency 600 **kHz**

Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10119		
CPU PCA	11019	**Rev.**	J3
PIO PCA	6574	**Rev.**	F1
DSP PCA	14400	**Rev.**	G1
RCV PCA	14956	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

- ✓ **Water Profile**
- **Bottom Track**
- **High Resolution Water Modes**
- **Lowered ADCP**
- **High Rate Pinging**
- **Shallow Bottom Mode**
- ✓ **Wave Guage Acquisition**
- **River Survey ADCP ***

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232

Baud Rate 9600

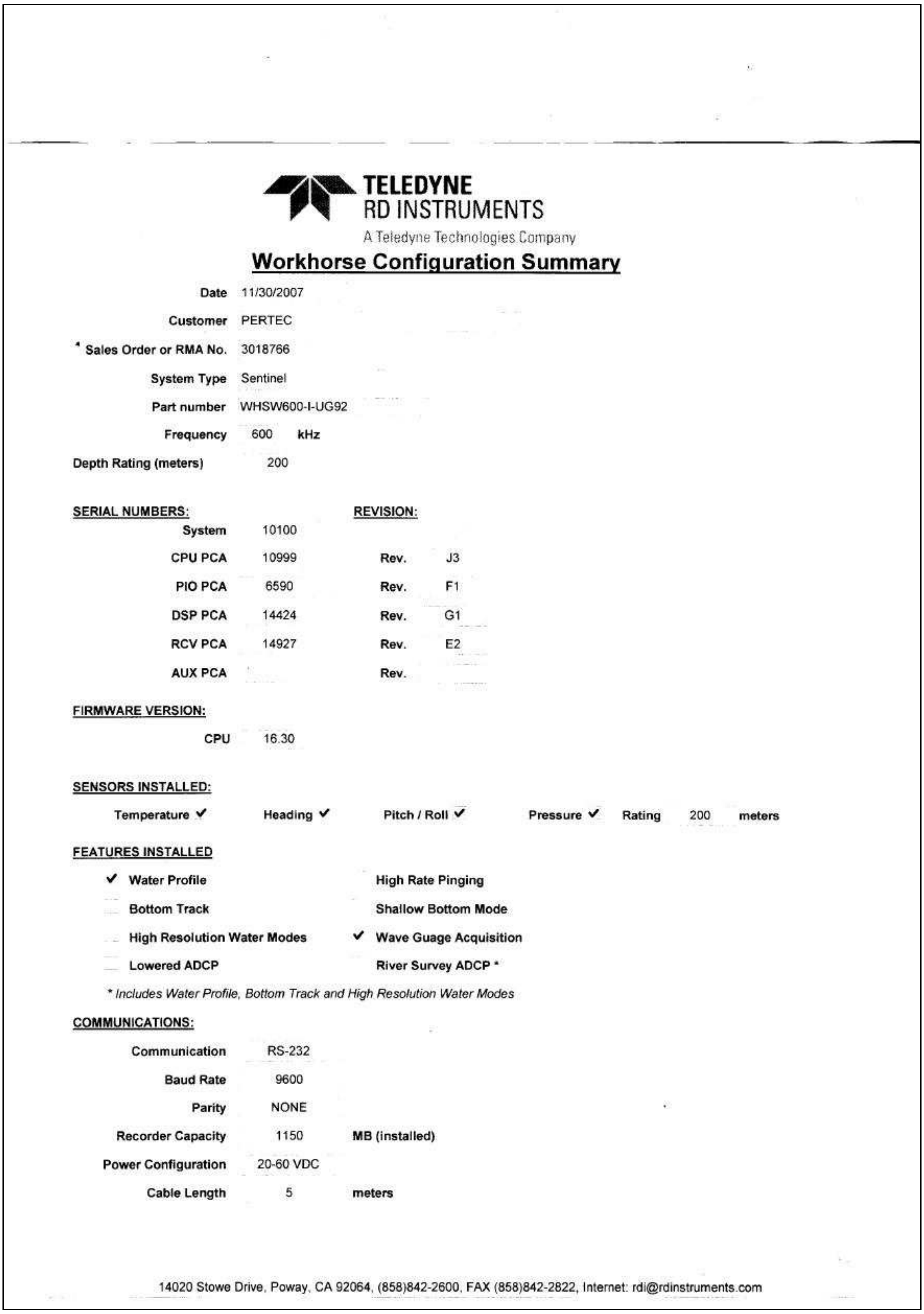
Parity NONE

Recorder Capacity 1150 **MB (installed)**

Power Configuration 20-60 VDC

Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
* **Sales Order or RMA No.** 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10100		
CPU PCA	10999	**Rev.**	J3
PIO PCA	6590	**Rev.**	F1
DSP PCA	14424	**Rev.**	G1
RCV PCA	14927	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

✓ **Water Profile**
Bottom Track
High Resolution Water Modes
Lowered ADCP
High Rate Pinging
Shallow Bottom Mode
✓ **Wave Guage Acquisition**
River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT ONE

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

17 June 2008

Job No: LT-JOB-50

LWANDLE TECHNOLOGIES (PTY) LTD

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

1st floor Gabriel Place, 1 Gabriel Road, Plumstead, 7800, South Africa

Co Reg. No. 2003/015524/07

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 1 are presented in this section together with an indication of the data return achieved.

Table 1 – Water temperature and salinity summary (surface)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	13.08	19.82	9.76
Conductivity	100	40.47	47.90	35.45
Salinity (psu)	100	34.41	35.15	32.20

Table 2 – Water temperature and salinity summary (surface)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	10.48	16.84	9.47
Conductivity	100	38.40	44.84	35.05
Salinity (psu)	99.55	34.86	35.25	34.51

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents tide, temperature and salinity data collected at Bantamsklip station for the period January 29th 2008 - March 26th 2008 (Period 1) as well as sediment, water and grab samples collected during Service Visit 1 (March 25th – 27th 2008).

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 3 for the Bantamsklip site.

Table 3 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 1050 HT Tide Gauge	1	1

2.3 MEASUREMENT LOCATION

The initial deployment location of the mooring is given in Table 4 and shown in Figure 1. Table 5 – Table 7 show the locations where water samples, grab samples and beach samples were taken respectively.

Figure 1 - Map of the project area.

Table 4 – Measurement locations

Instrument	Latitude (^oS)	Longitude (^oE)
Tide Gauge	34° 42.462’	19° 33.080’
10m ADCP	34° 43.186’	19° 33.637’
Biofouling	34° 43.190’	19° 33.686’
30m ADCP and T&C mooring	34° 42.625’	19° 30.690’

Table 5 – Locations where water samples were taken

Station 26 Mar 2008		Latitude (^oS)	Longitude (^oE)
S1	30m ADCP 4m	34° 42.603’	19° 30.696’
S2	30m ADCP 12m	34° 42.603’	19° 30.696’
S3	30m ADCP 20m	34° 42.603’	19° 30.696’
S4	30m ADCP 28m	34° 42.603’	19° 30.696’
S5	10m ADCP 4m	34° 43.187’	19° 33.635’
S6	10m ADCP 8m	34° 43.187’	19° 33.635’
S7		34° 43.141’	19° 33.710’
S8		34° 43.055’	19° 33.616’
S9		34° 42.938’	19° 33.445’
S10		34° 42.901’	19° 33.287’
S11		34° 42.860’	19° 33.149’

Table 6 – Locations where grab samples were taken

Station 26-27 Mar 2008	Latitude (^oS)	Longitude (^oE)
S1	34° 43.852’	19° 35.033’
S2	34° 44.107’	19° 35.007’
S3	34° 43.079’	19° 33.619’
S4	Reef	
S5	Reef	
S6	Reef	
S7	Reef	
S8	Reef	
S9	Reef	
S10	Reef	
S11	Reef	
S12	Reef	
S13	Reef	
S14	Reef	
S15	34° 41.869’	19° 32.011’
S16	34° 41.790’	19° 31.876’
S17	Reef	
S18	Reef	
S19	34° 40.904’	19° 31.079’
S20	34° 40.850’	19° 30.982’

Table 7 – Locations where beach samples were taken

25 Mar 2008	High water		Low water	
Station	Latitude (°S)	Longitude (°E)	Latitude (°S)	Longitude (°E)
S1	34° 39.944’	19° 29.517’	34° 39.948’	19° 29.508’
S2	34° 40.239’	19° 31.088’	34° 40.244’	19° 31.086’
S3	34° 40.347’	19° 31.298’	34° 40.354’	19° 31.294’
S4	34° 40.461’	19° 31.516’	34° 40.477’	19° 31.503’
S5	34° 40.618’	19° 31.718’	34° 40.627’	19° 31.705’
S6	34° 40.772’	19° 31.874’	34° 40.777’	19° 31.869’
S7	34° 41.049’	19° 31.949’	34° 41.056’	19° 31.940’
S8	34° 41.513’	19° 32.523’	34° 41.515’	19° 32.520’
S9	34° 41.777’	19° 32.768’	34° 41.780’	19° 32.763’
S10	34° 42.156’	19° 33.135’	34° 42.159’	19° 33.134’
S11	34° 42.646’	19° 33.532’	34° 42.655’	19° 33.527’
S12	34° 42.722’	19° 33.705’	34° 42.725’	19° 33.704’
S13	34° 42.809’	19° 33.873’	34° 42.813’	19° 33.872’
S14	34° 42.915’	19° 34.007’	34° 42.919’	19° 34.006’
S15	34° 43.059’	19° 34.132’	34° 43.062’	19° 34.133’
S16	34° 43.134’	19° 34.319’	34° 43.138’	19° 34.321’
S17	34° 43.475’	19° 35.370’	34° 43.477’	19° 35.369’
S18	34° 43.717’	19° 35.745’	34° 43.721’	19° 35.742’
S19	34° 43.811’	19° 35.788’	34° 43.814’	19° 35.781’
S20	34° 45.259’	19° 37.918’	34° 45.265’	19° 37.913’

3. OPERATIONS

3.1 SUMMARY OF EVENTS

A summary of events associated with the deployment of the moorings is given in Table 8. Service visit 1 was undertaken on March 25th – 27th 2008 and is detailed in Table 9.

Table 8 – Summary of events for the mobilisation of the equipment

Date	Description
28 January 2008 09h30	Lwandle's engineers departed from Cape Town.
12h30	The engineers arrived at Pearly Beach accommodation and then they setup the vehicle with the necessary gear for the tide gauge deployment.
13h30	The engineers met with the Dive Team. They then arranged for a 4x4 vehicle for access to the site due to deep sand roads. All the kit was transferred to the 4x4 vehicle.
14h30	The engineers arrived at the proposed site for the tide gauge which was situated in a sheltered embayment. It was discovered that the proposed position was not suitable as it was very shallow and too far from the rocks. The engineers then scouted the next five (5) gullies towards the north in order to find a suitable position. The new position was 1.87m deep and located at 34°42.462 S and 19°33.080 E. The surveyors still need to level in the tide reference with a chart datum.
16h00	The engineers carried the tide gauge, H-frame and railway lines down to rocks. The frame was floated to position and levered onto exposed rocks to attach railway lines. The railway lines were then floated out. The railway lines were attached to the frame with galvanized wire and cable ties. The PVC pipe (stilling well with sensor inside) was attached to the H - frame. The H -frame was secured in position. The data cable was covered with hosing. Attached logger box to rocks via 4 bolts that were steel cemented onto rocks. Attached wire over box and cemented onto rocks. Tide gauge was set to start recording at 18h00. The unit hit the water at 19h10.
20h10	The engineers returned to the base camp.
29 January 2008 06h30	Assembled the ADCP frames, CART pop-ups, T&C, biofouling strings and set up the instruments.
09h00	The engineers left the base camp and met the boat operator and divers at Gansbaai.
09h30-11h00	The assembly of ADCP frames and fitting of instruments was completed.
12h00	The vessel was launched and it reached the ADCP deployment location in approximately 50 minutes.
13h00	The railway lines were attached to the T&C mooring line. Then the 50m groundline was attached between ADCP frame and T&C logger string.
13h10	The T&C logger string was lowered using the 50m groundline.
13h20	The ADCP frame was lowered to 30m (CART s/n 32383) 34°42.603 S and 19°30.655 E.

Date	Description
13h30	The divers attached 3 x chain sections to the ADCP frame. The 30m ADCP mooring was successfully deployed.
14h35	The vessel arrived at 10m site (~ 5kms away)
14h45	The Biofouling mooring was deployed (34°43.190 and 19°33.637).
15h00	The 10m ADCP (CART s/n 32380) was deployed (34°43.186 S and 19°33.637 E). The divers entered the water and attached 4 sections of rig chain and photographed the mooring.
16h30	The vessel arrived back at Kleinbaai Harbour.
Ranging	**30m ADCP Ranging** • 34°42.575 / 19°30.604 - 117m • 34°42.585 / 19°30.513 - 235m • 34°42.607 / 19°30.473 - 295m **10m ADCP Ranging** • 34°43.147 / 19°33.575 - 113m • 34°43.155 / 19°33.653 - 56m • 34°43.194 / 19°33.696 - 77m **Biofouling ranging** • 34°43.159 / 19°33.723 - 80m • 34°43.180 / 19°33.708 - 56m • 34°43.170 / 19°33.660 - 51m
30 January 2008 - 08h30	The engineers travelled to Gansbaai to purchase rock set cement and epoxy putty for tide gauge logger box.
10h30	The engineers arrived at the tide gauge site. The engineers checked the logger box and sensor frame (i.e. H-frame and stilling well) and it appeared to be fine. They then applied epoxy putty and rock fast cement to 4 x bolts on logger box.
11h30	The 4x4 vehicle was returned and the engineers proceeded back to Cape Town.
14h00	The engineers arrived back in Cape Town.

Table 9 – Summary of events for Service Visit 1

Date	Description
25 March 2008 08h30	Lwandle's engineers departed from Cape Town.
11h00	The engineers arrived at Pearly Beach accommodation.
13h30	The engineers arrived at tide gauge site to download data. There was tampering with the pressure sensor cable into the logger box and water entered the plug. No data was recorded.
14h30	The engineers started with the beach sampling.
19h30	The engineers completed half of the beach sampling.
20h10	The engineers returned to the base camp.
26 March 2008 - 06h30	The engineers met up with the divers at the Kleinbaai slipway.
08h00	The vessel was launched and it reached the 30m ADCP deployment location in approximately 50 minutes.

Date	Description
09h15	The CART Pop-Up buoy was successfully released on the 30m mooring.
12h00	All diving operations were put on hold due to fact that a MCM patrol vessel requested a permit to dive in the area. Arrangements were made to have the fisheries inspector onboard to complete diving operations. The water sampling was completed, while waiting for the inspector.
13h00	The divers released the T&C line and detached the weights from the mooring. The 30m ADCP mooring was successfully retrieved.
14h00	The 10m ADCP mooring was successfully retrieved.
14h30	Started the sediment sampling using a Van Veen Grab. Half of the grab sampling was completed.
17h30	The vessel arrived back at Kleinbaai harbour.
18h00	The vessel was offloaded and the instruments taken back for servicing.
19h00	The instruments were cleaned up and setup to download the data. There was a problem on both the ADCP's. The units did initialize as per the setup procedure, but only recorded data for 5 hours, which was stored in multiple files
21h00	The instruments were serviced and setup for deployment.
27 March 2008 – 08h00	The vessel was launched and it reached the 30m ADCP deployment location in approximately 50 minutes.
09h30	The 30m ADCP and RBR logger string was successfully deployed.
11h00	The 10m ADCP was successfully deployed. A different unit was used – details in section 3.2.
11h30	The engineers completed the last of the grab sediment sampling.
12h30	The vessel arrived back at Kleinbaai harbour.
13h00	The vessel was offloaded and washed down.
15h00	The tide gauge logger box and pressure sensor was replaced.
19h00	The engineers depart for Cape Town.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given as an appendix (Section 7, page 23) to this report.

3.2.1 600kHz ADCP

Table 10 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10100
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Both ADCPs failed to record data. The reasons for this were uncertain at that point. As a result, it was decided that the 10m ADCP s/n 10100 would be replaced with a spare ADCP (s/n 10105) at service visit one.

Table 11 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

3.2.2 RBR XR420 CT LOGGER

Table 12 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (7m) and s/n 12998 (28m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

3.2.3 RBR TGR1050 HT TIDE GAUGE

Table 13 – Instrument configuration for the Tide Gauge

Parameter	**Configuration**
TGR 1050 HT	s/n 14005
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.4 Biofouling Mooring

Table 14 – Instrument configuration for Biofouling Mooring Line.

Parameter	**Configuration**
Biofouling Plates	3 plates (50cmx50cm) at 3m and 3 plates (50cmx50cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

Figure 2 – ADCP frame with 600KHz instrument.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed inside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water. The sensor cable was covered with garden hosing and laid out to the tide logger box which was cemented onto a nearby rocky outcrop.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods. Recovery of the biofouling mooring was not scheduled for the first service visit.

3.4 MALFUNCTIONS AND LESSONS LEARNT

A list of malfunctions experienced and consequent measures to be taken in future are provided in Table 15.

Table 15 – Lessons learnt and future mitigation measures

Problem	Mitigation measure(s)
Poachers dive in vicinity of tide gauge – they may steal the instrument.	Tried to camouflage instruments as best as possible. The equipment was tampered with and the tide gauge was replaced with the spare resulting in no data for the first period.
Seimac beacons did not arrive in time for the initial installation and will be deployed at the first service visit.	
ADCP failure due to multiple file creation.	Enter the RIO command in the setup file. The 10m ADCP (s/n 10100) was replaced with a spare unit (s/n 10105).

4. DATA QUALITY CONTROL

There was no data return from the 2 ADCPs.

4.1 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Salinity values less than 34.5psu were flagged for the bottom instrument.

4.2 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- The data were visually examined and spikes flagged (indexes 142183, 143247, 143248 and 161389).
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

4.3 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Biofouling sample was not taken at Bantamsklip during service visit 1.

4.4 SEDIMENTS AND WATER SAMPLE.

Sediments and water sample were collected and sent to the Council for Scientific and Industrial Research (CSIR) for analysis.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 RBR-CT LOGGER

5.1.1 Temperature and Salinity Data

5.1.1.1 Time series plot

Figure 3 and Figure 4 display time series plots for the surface and bottom loggers respectively. These consist of:

- The first panel is of the observed water temperature against time.
- The second panel is of the derived salinity against time.

5.1.1.2 Summary plot

Figure 5 and Figure 6 display summary plots for the surface and bottom loggers respectively. These consist of:

- The left hand panel is a histogram of the water temperature. This reflects the percentage of observations that fall within each temperature interval. Included on the plot are basic statistics for the distribution.
- The right hand panel is a histogram of the water salinity.

5.2 TIDE GAUGE

Figure 7 displays a time series plot of the tidal height.

- The first (upper) panel is of the observed height against time.
- The second panel is of the tidal height, calculated from the observed height, against time. The tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The third panel is of the residual height against time. The residual has been calculated as the observed height minus the tidal height.

Table 16 shows the tidal harmonics resulting from the analysis.

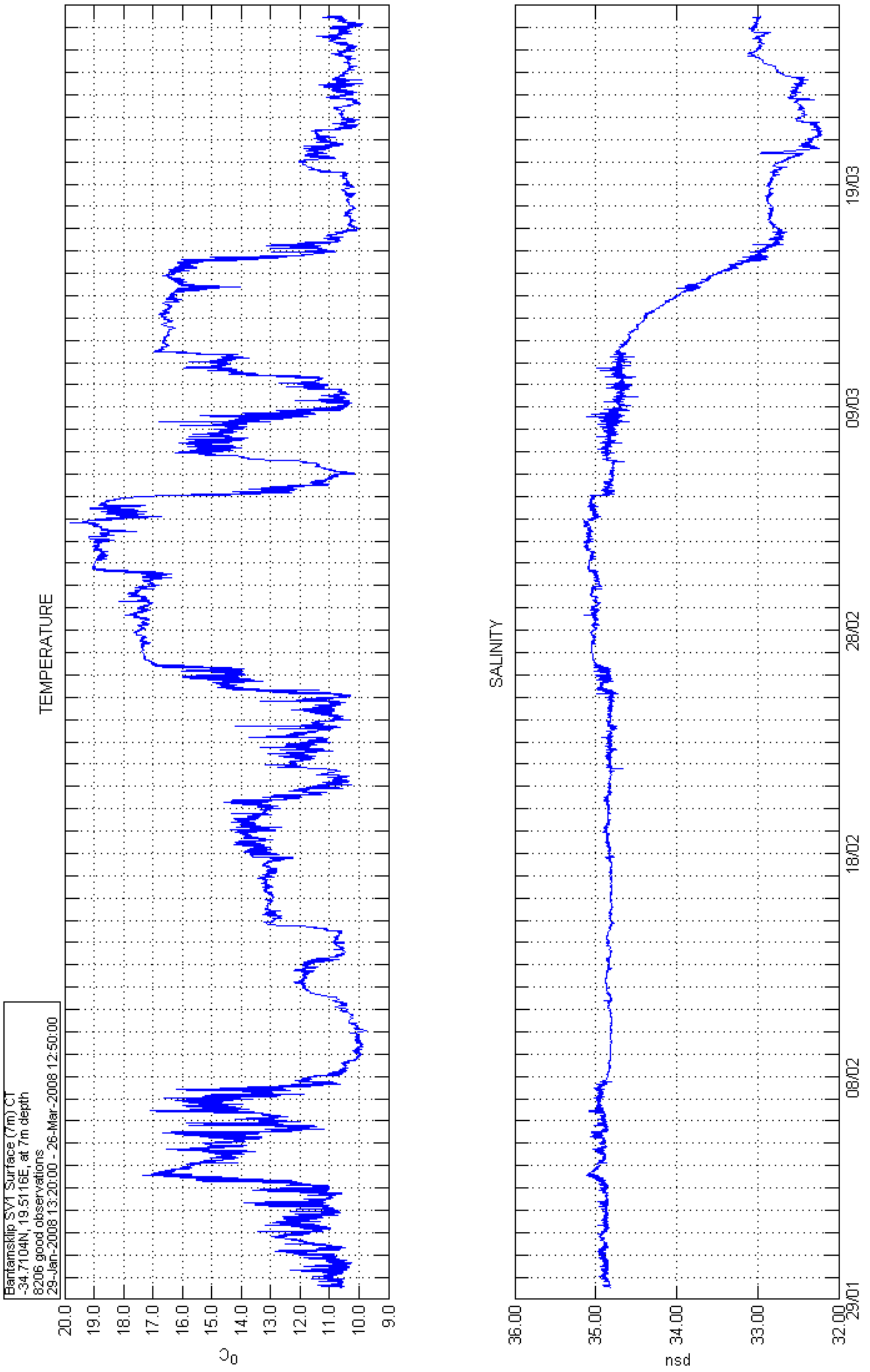


Figure 3: Time series of temperature and salinity from the surface RBR logger.

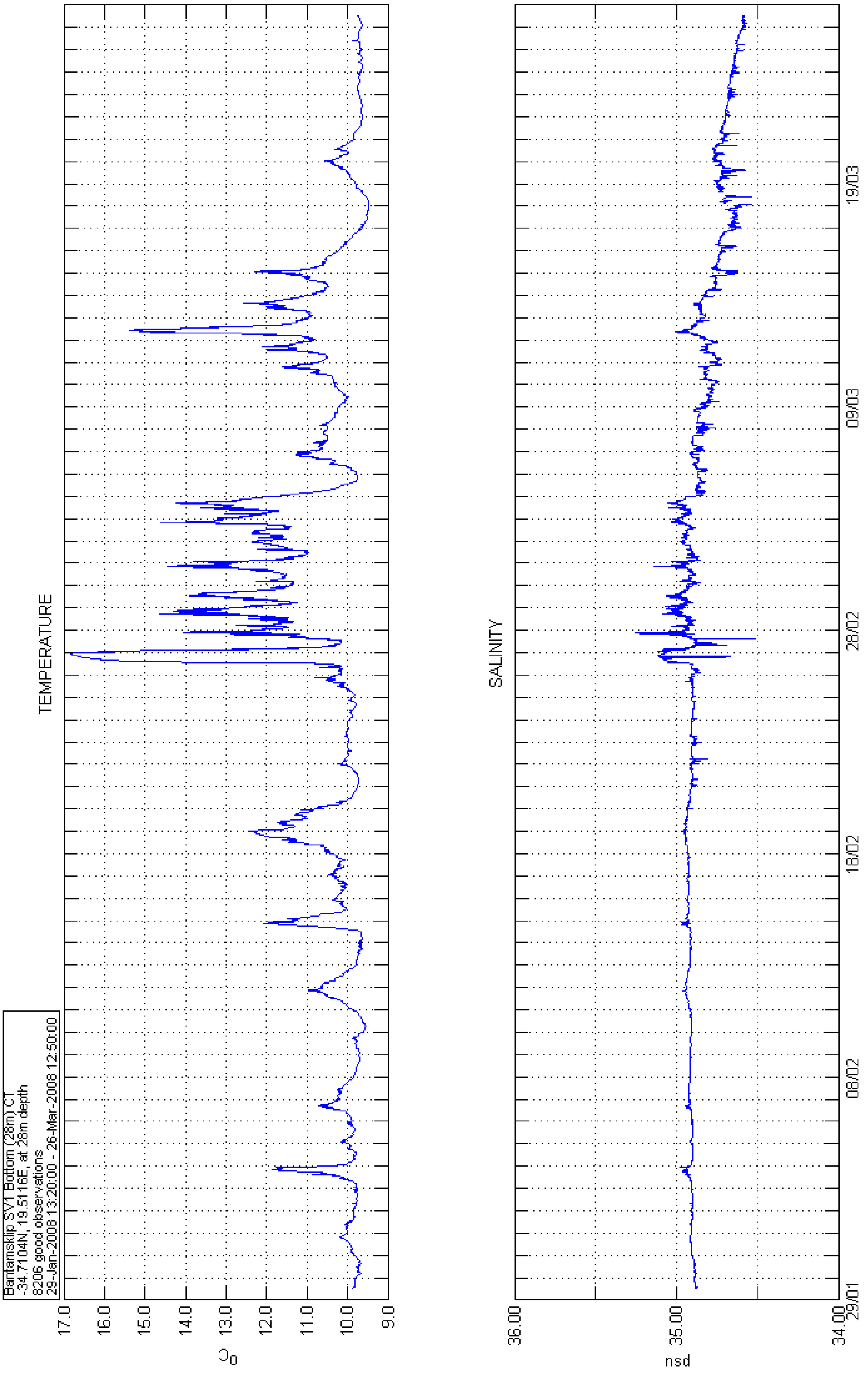


Figure 4: Time series of temperature and salinity from the bottom RBR logger.

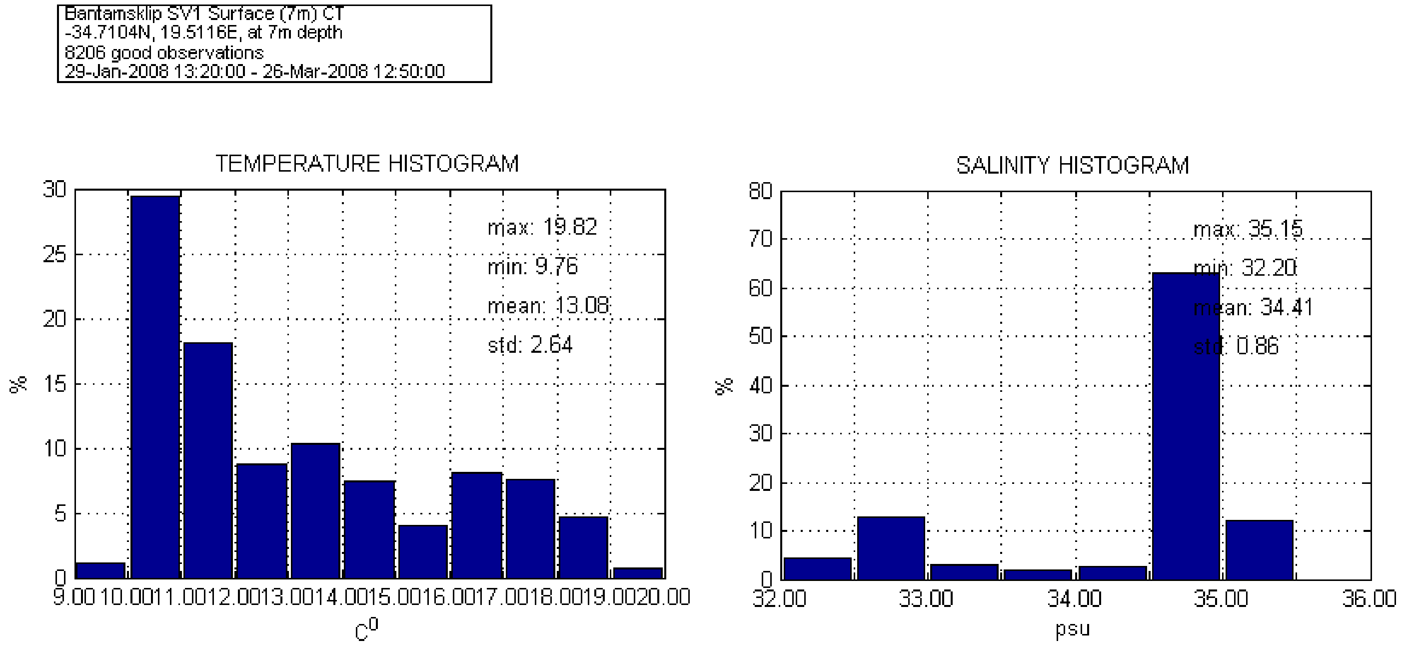


Figure 5: Summary histograms of temperature and salinity from the surface RBR logger.

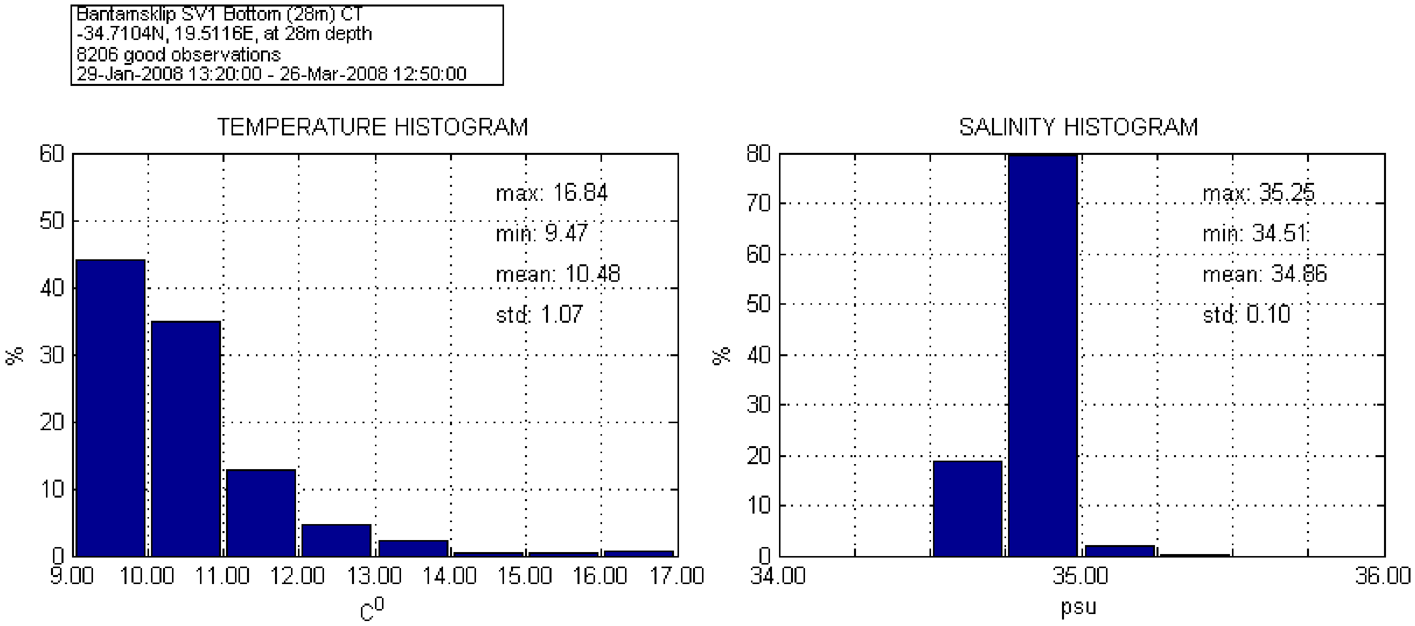


Figure 6: Summary histograms of temperature and salinity from the bottom RBR logger.

5.3 SEDIMENTS, BIOFOULING AND WATER SAMPLES.

Analysis of sediment and water samples were undertaken by the CSIR and results are presented as an appendage (Section 8, page 37).

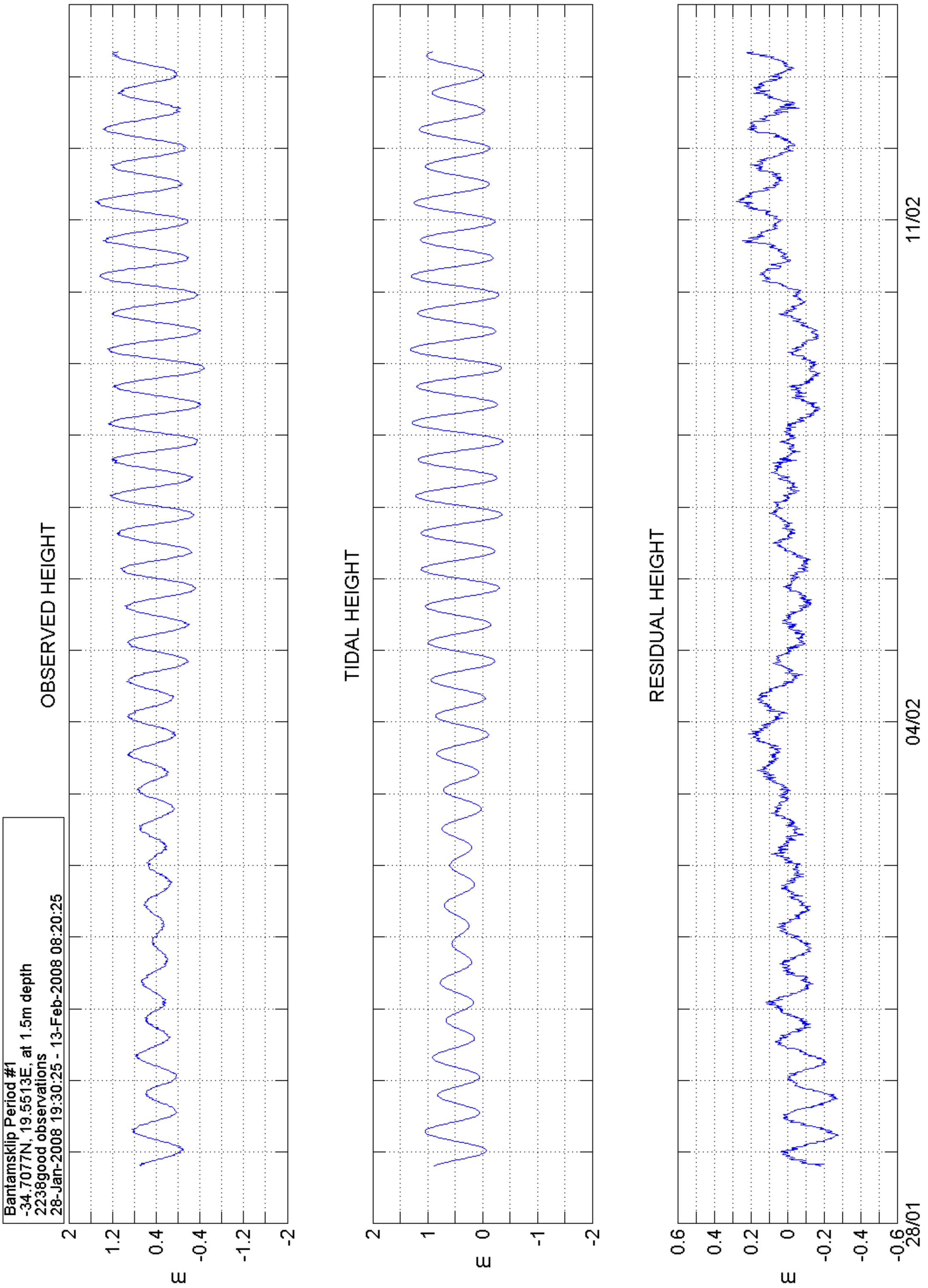


Figure 7: Tidal analysis.

Table 16: Tidal harmonics

Bantamsklip Period #1
-34.7077N, 19.5513E, in 1.5m depth
2238 good observations
28-Jan-2008 19:30:25 - 13-Feb-2008 08:20:25

HARMONIC COMPONENTS

Component	Amplitude (m)	Phase (deg)
MSF	0.05	111.23
O1	0.01	268.13
K1	0.07	169.92
M2	0.51	84.79
S2	0.29	130.98
M3	0.00	317.47
SK3	0.00	180.96
M4	0.01	134.60
MS4	0.00	238.74
S4	0.00	333.35
2MK5	0.00	170.71
2SK5	0.01	261.93
M6	0.00	120.71
2MS6	0.00	290.08
2SM6	0.00	101.44
3MK7	0.00	34.20
M8	0.00	245.03

6. DISCUSSION

The first set of oceanographic data collected off the coast of Bantamsklip for the period between January 29th and March 26th 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

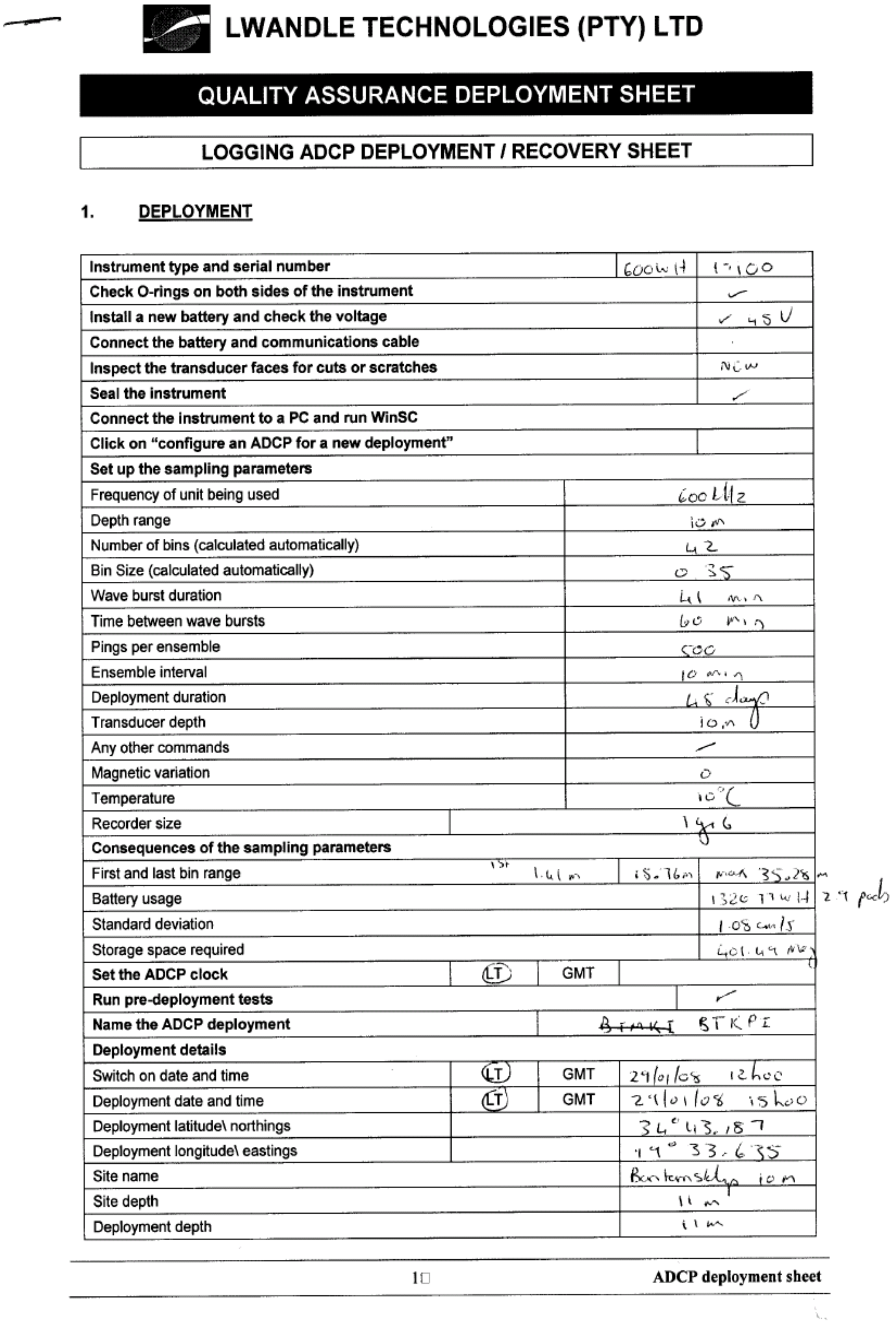
At the Bantamsklip site, 2 600 kHz ADCP, 2 RBR-CT loggers and 1 RBR tide gauge have been deployed to measure currents, waves, water temperature and salinity and tidal record. The ADCP is fixed on a frame at ~10m and ~30m and the RBR loggers are moored at ~7m and ~28m below the surface. During recovery of the data, undertaken during March 25th – 27th 2008, it was found that only the 2 RBR-CT loggers and tide gauge functioned properly. The ADCPs recorded 5 hours of data in multiple files and then switched off. Sediments, water and beach samples were also collected during the service visit and analysis was undertaken at the CSIR.

In Figure 3 shows that salinity values started to drift after February 20th 2008, reaching a minimum of ~29.0 psu on February 29th. This indicates some degree of biofouling.

Only two weeks of tidal data were available, which was not sufficient for a complete tidal analysis. The stilling well came loose off its frame during the deployment period. The engineer downloaded the data recorded, as a backup, while servicing the instrument. However, during service visit 1, the logger box and pressure sensor cable were tampered with and no further data were recorded.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT ONE

7.1 ADCPS MOBILISATION AND RE-DEPLOYMENT SHEETS



LWANDLE TECHNOLOGIES (PTY) LTD

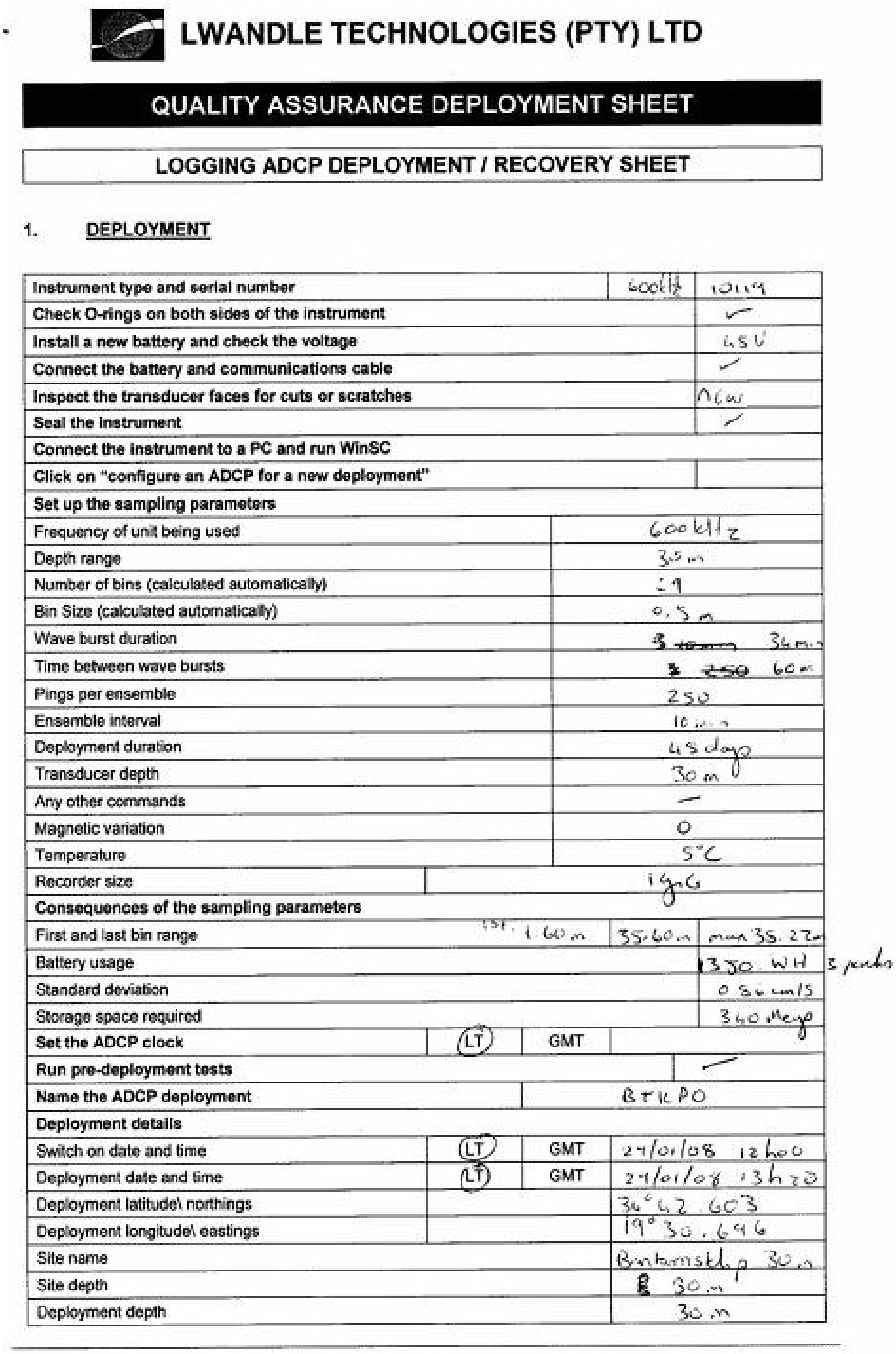
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number		600WH	17100
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			✓ 45 V
Connect the battery and communications cable			
Inspect the transducer faces for cuts or scratches			NEW
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used			600 kHz
Depth range			10 m
Number of bins (calculated automatically)			42
Bin Size (calculated automatically)			0 35
Wave burst duration			41 min
Time between wave bursts			60 min
Pings per ensemble			500
Ensemble interval			10 min
Deployment duration			48 days
Transducer depth			10 m
Any other commands			–
Magnetic variation			0
Temperature			10°C
Recorder size			1 Gig
Consequences of the sampling parameters			
First and last bin range	1st 1.41 m	18.76 m	max 35.28 m
Battery usage			1320 77 WH 2.9 packs
Standard deviation			1.08 cm/s
Storage space required			401.49 Meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			~~BTAKI~~ BTKPI
Deployment details			
Switch on date and time	[✓ LT]	GMT	29/01/08 12h00
Deployment date and time	[✓ LT]	GMT	29/01/08 15h00
Deployment latitude\ northings			34° 43.187
Deployment longitude\ eastings			19° 33.635
Site name			Bantamsklip 10 m
Site depth			11 m
Deployment depth			11 m

1□ **ADCP deployment sheet**



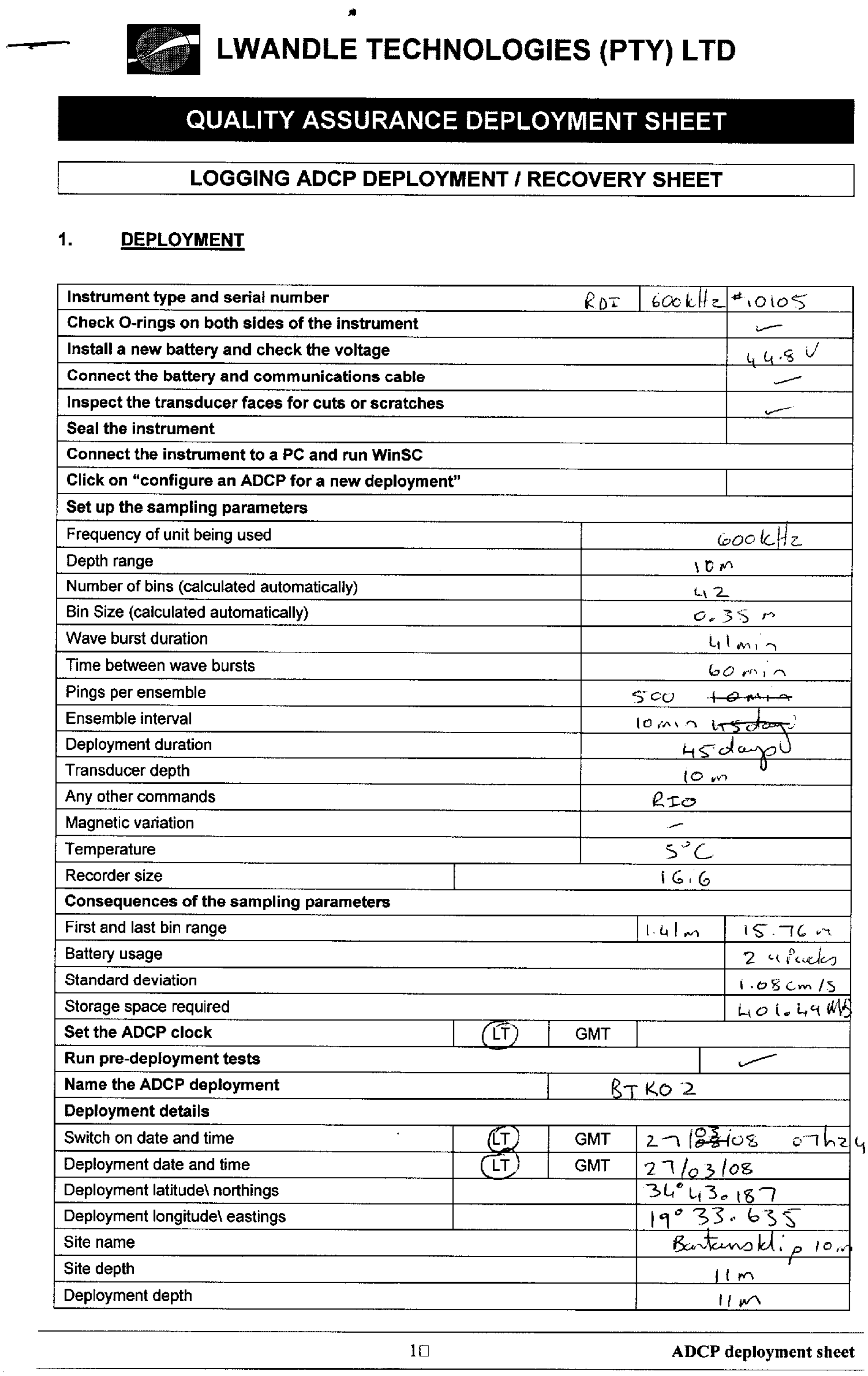
LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number		600kHz	10114
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			45V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			new
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used		600kHz	
Depth range		35 m	
Number of bins (calculated automatically)		69	
Bin Size (calculated automatically)		0.5 m	
Wave burst duration		3 ~~10 min~~ 36 min	
Time between wave bursts		3 ~~250~~ 60 min	
Pings per ensemble		250	
Ensemble interval		10 min	
Deployment duration		45 days	
Transducer depth		30 m	
Any other commands		–	
Magnetic variation		0	
Temperature		5°C	
Recorder size		1gig	
Consequences of the sampling parameters			
First and last bin range	1st. 1.60 m	35.60 m	max 35.22m
Battery usage			1350 WH 3 packs
Standard deviation			0.56 cm/s
Storage space required			360 Mega
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment		BTKPO	
Deployment details			
Switch on date and time	[✓ LT]	GMT	24/01/08 12h00
Deployment date and time	[✓ LT]	GMT	24/01/08 13h20
Deployment latitude\ northings			34°42.603
Deployment longitude\ eastings			19°30.696
Site name			Bantamsklip 30 m
Site depth			30 m
Deployment depth			30 m



LWANDLE TECHNOLOGIES (PTY) LTD

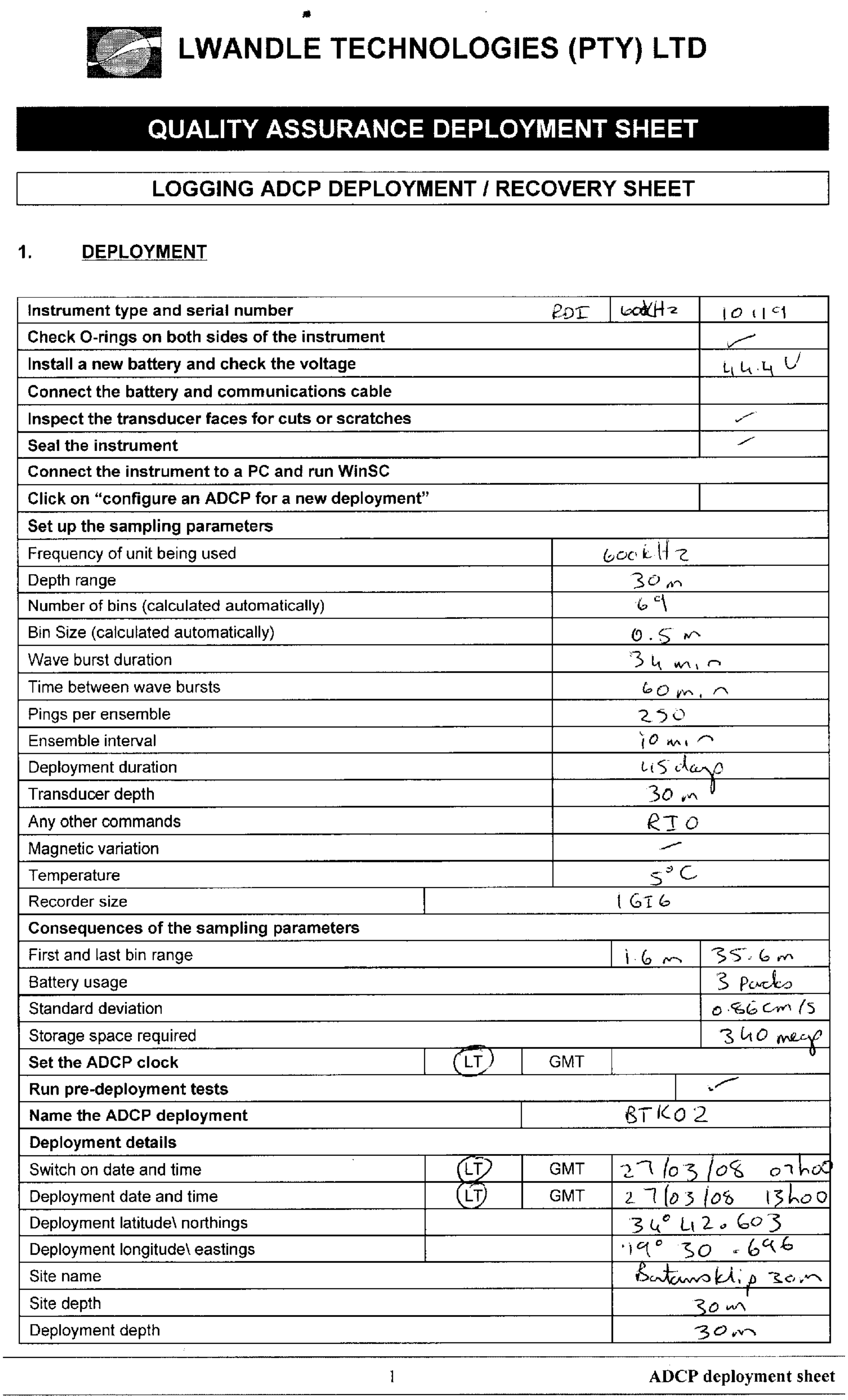
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number	RDI	600kHz	#10105
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.8 V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600kHz		
Depth range	10m		
Number of bins (calculated automatically)	42		
Bin Size (calculated automatically)	0.35 m		
Wave burst duration	41min		
Time between wave bursts	60 min		
Pings per ensemble	500 ~~10 min~~		
Ensemble interval	10 min ~~45 days~~		
Deployment duration	45 days		
Transducer depth	10 m		
Any other commands	RIO		
Magnetic variation	–		
Temperature	5°C		
Recorder size	16.6		
Consequences of the sampling parameters			
First and last bin range		1.41m	15.76 m
Battery usage			2 4 packs
Standard deviation			1.08 cm/s
Storage space required			401.49 MB
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment	BTK02		
Deployment details			
Switch on date and time	[✓ LT]	GMT	27/~~08~~ 03/08 07h24
Deployment date and time	[✓ LT]	GMT	27/03/08
Deployment latitude\ northings			34°43.187
Deployment longitude\ eastings			19° 33.635
Site name			Bantamsklip 10m
Site depth			11m
Deployment depth			11m

1□ **ADCP deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

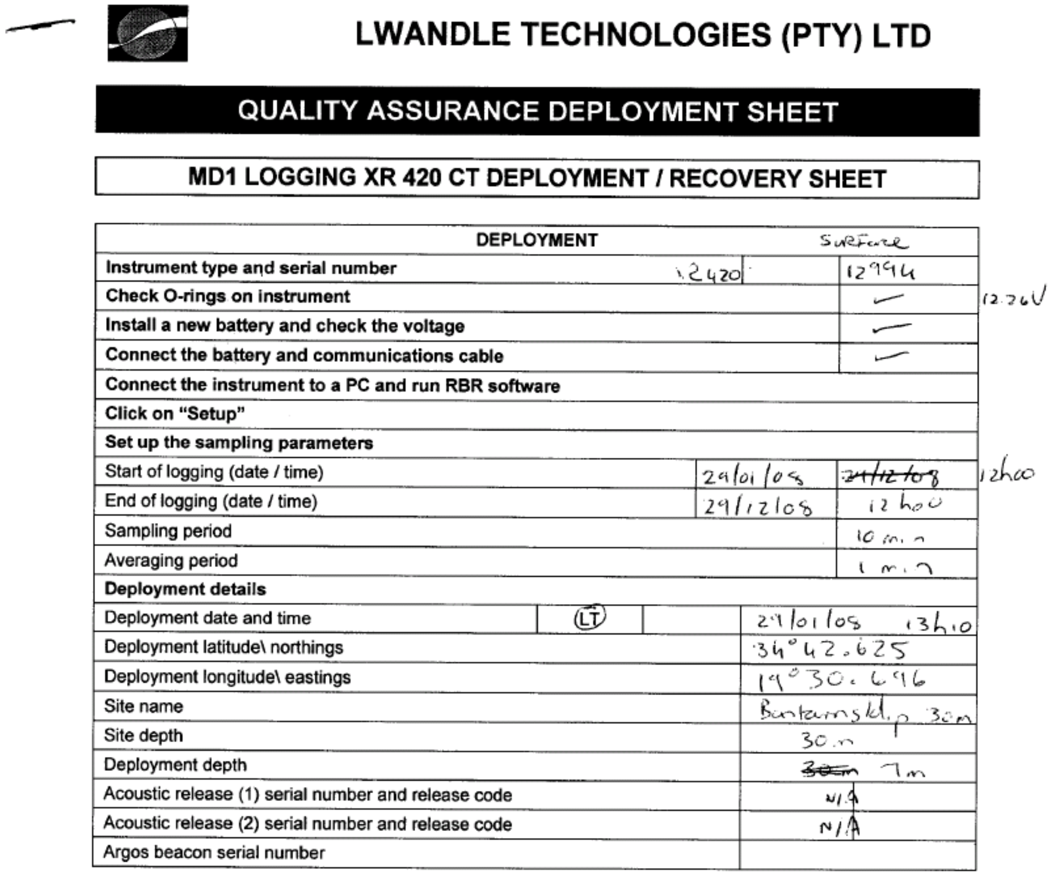
LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number	RDI	600kHz	10119
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.4 V
Connect the battery and communications cable			
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600kHz		
Depth range	30 m		
Number of bins (calculated automatically)	69		
Bin Size (calculated automatically)	0.5 m		
Wave burst duration	34 min		
Time between wave bursts	60 min		
Pings per ensemble	250		
Ensemble interval	10 min		
Deployment duration	45 days		
Transducer depth	30 m		
Any other commands	RIO		
Magnetic variation	✓		
Temperature	5°C		
Recorder size	1GIG		
Consequences of the sampling parameters			
First and last bin range	1.6 m	35.6 m	
Battery usage			3 Packs
Standard deviation			0.86 cm/s
Storage space required			340 meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment	BTK02		
Deployment details			
Switch on date and time	[✓ LT]	GMT	27/03/08 07h00
Deployment date and time	[✓ LT]	GMT	27/03/08 13h00
Deployment latitude\ northings			34° 42.603
Deployment longitude\ eastings			19° 30 .696
Site name			Batanskip 30m
Site depth			30 m
Deployment depth			30 m

1 ADCP deployment sheet

7.2 RBR-CT LOGGERS MOBILISATION AND RE-DEPLOYMENT SHEETS.

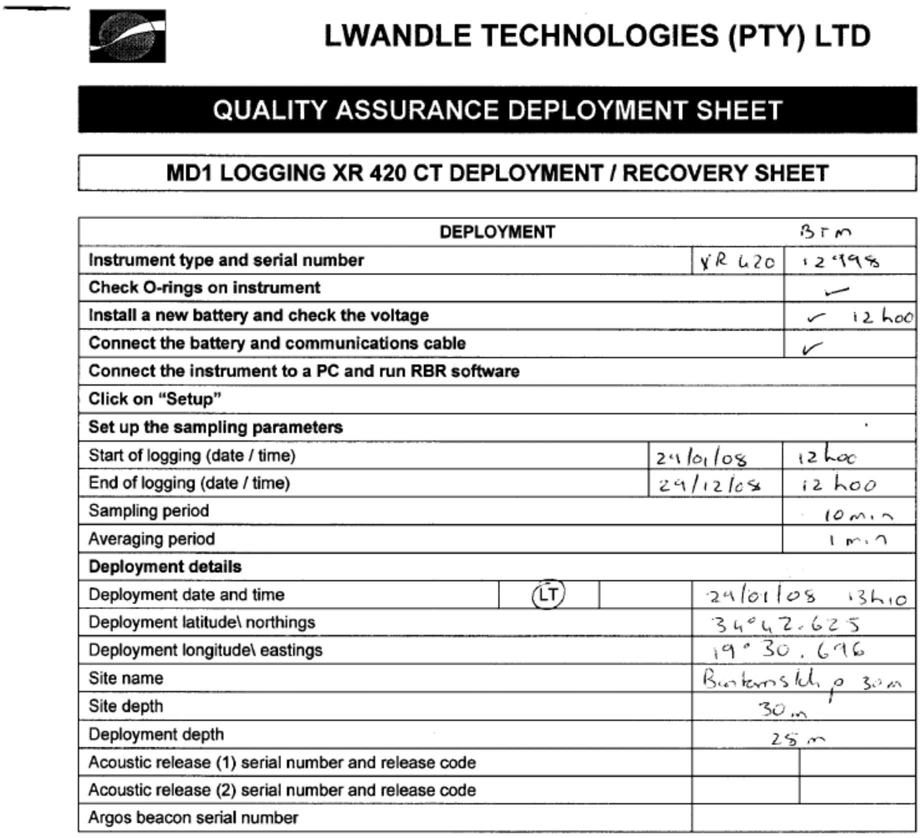


LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			Surface	
Instrument type and serial number	2420		12994	
Check O-rings on instrument			✓	12.76V
Install a new battery and check the voltage			✓	
Connect the battery and communications cable			✓	
Connect the instrument to a PC and run RBR software				
Click on "Setup"				
Set up the sampling parameters				
Start of logging (date / time)	29/01/08		~~24/12/08~~	12h00
End of logging (date / time)	29/12/08		12h00	
Sampling period			10 min	
Averaging period			1 min	
Deployment details				
Deployment date and time	(LT)		29/01/08 13h10	
Deployment latitude\ northings			34°42.625	
Deployment longitude\ eastings			19°30.696	
Site name			Bantamsklip 30m	
Site depth			30m	
Deployment depth			~~30m~~ 7m	
Acoustic release (1) serial number and release code			N/A	
Acoustic release (2) serial number and release code			N/A	
Argos beacon serial number				

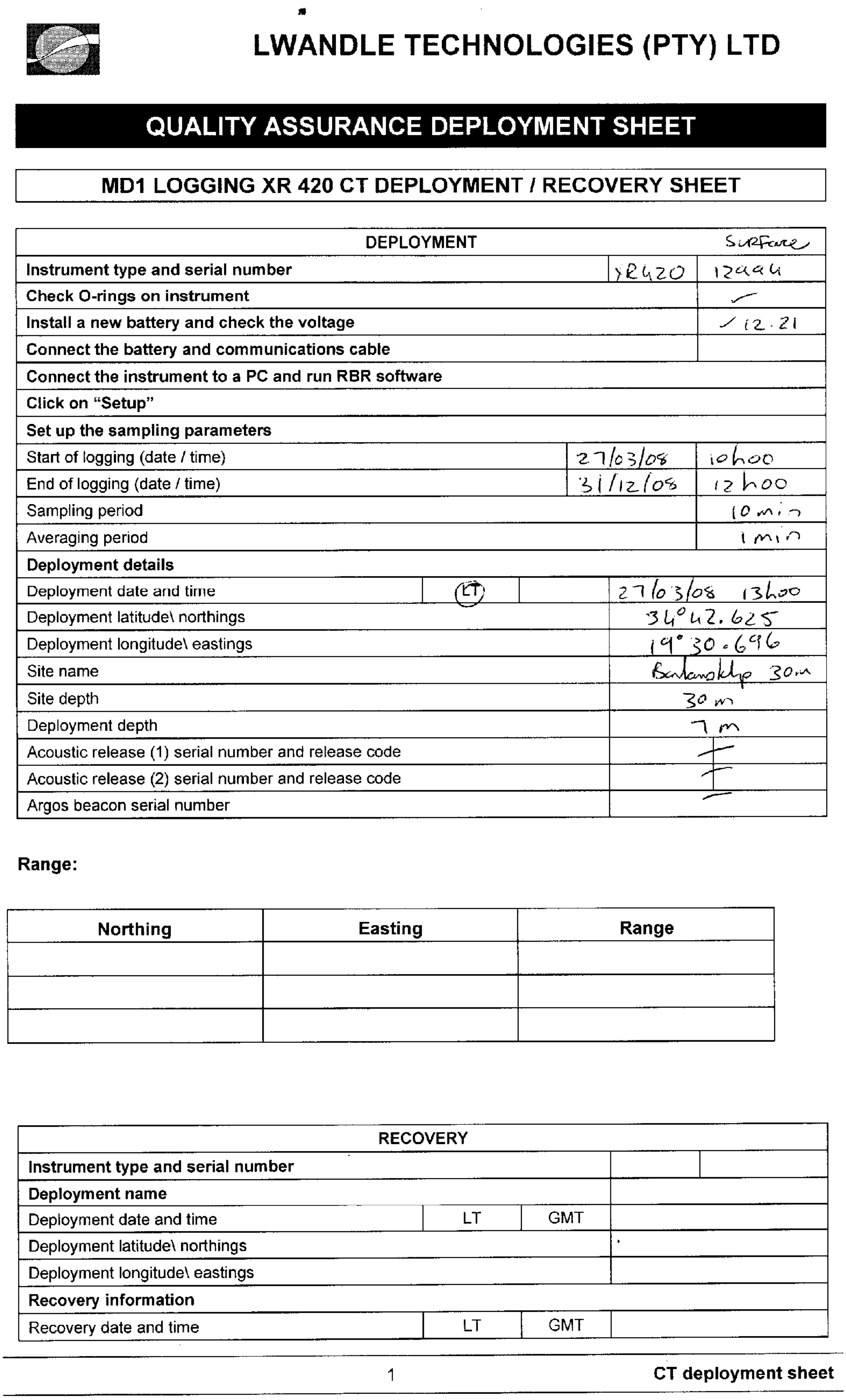


LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			BTM
Instrument type and serial number		XR 420	12998
Check O-rings on instrument			✓
Install a new battery and check the voltage			✓ 12h00
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		29/01/08	12h00
End of logging (date / time)		29/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	(LT)		29/01/08 13h10
Deployment latitude\ northings			34°42.625
Deployment longitude\ eastings			19°30.696
Site name			Bantamsklip 30m
Site depth			30m
Deployment depth			25m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

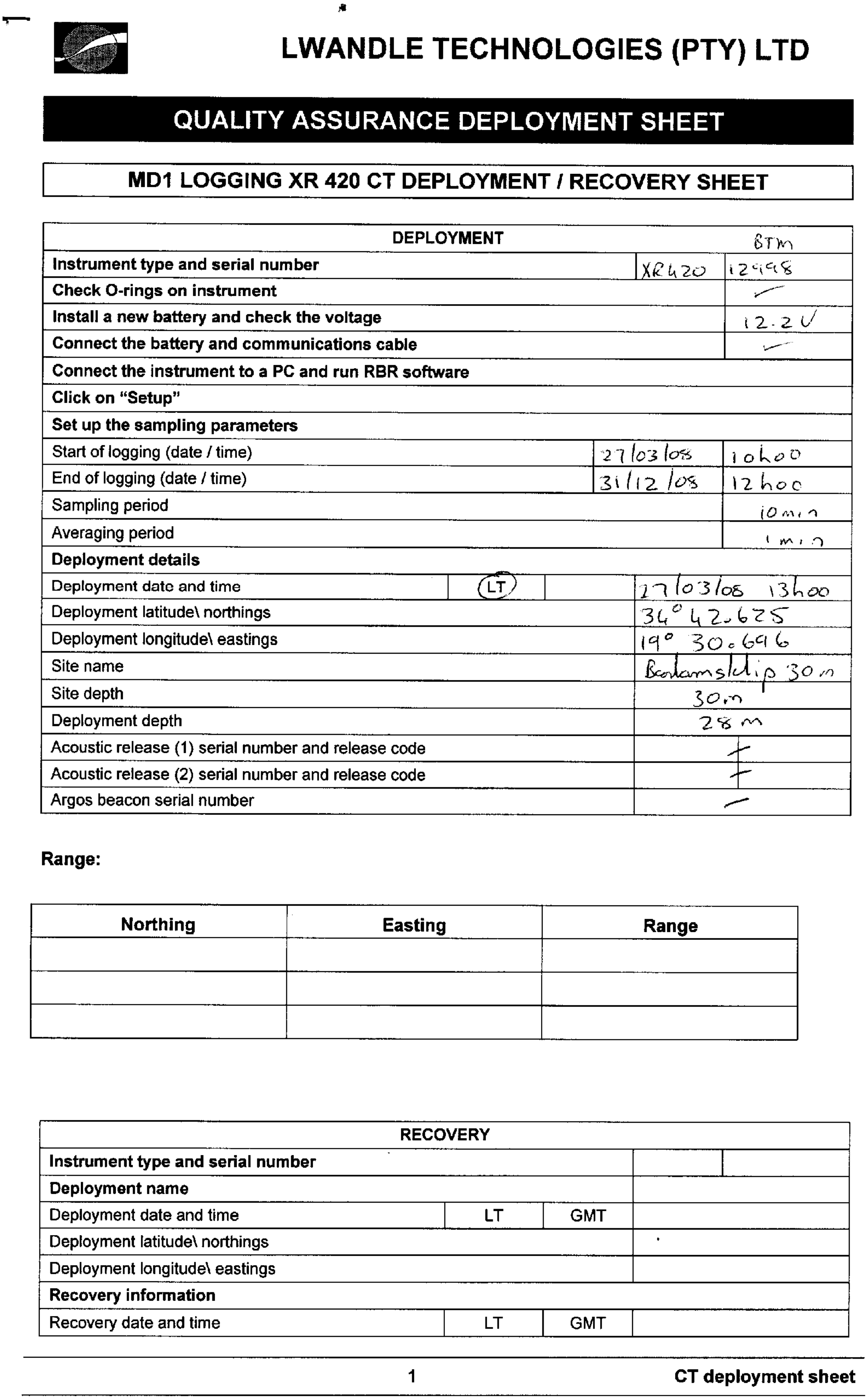
MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			Surface
Instrument type and serial number		XR420	12994
Check O-rings on instrument			✓
Install a new battery and check the voltage			✓ 12.21
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		27/03/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10min
Averaging period			1min
Deployment details			
Deployment date and time	[✓ LT]		27/03/08 13h00
Deployment latitude\ northings			34°42.625
Deployment longitude\ eastings			19°30.696
Site name			Bantamsklip 30m
Site depth			30 m
Deployment depth			7 m
Acoustic release (1) serial number and release code			-
Acoustic release (2) serial number and release code			-
Argos beacon serial number			-

Range:

Northing	Easting	Range

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			BTM
Instrument type and serial number		XR420	12998
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.2V
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		27/03/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10min
Averaging period			1min
Deployment details			
Deployment date and time	[✓ LT]		27/03/08 13h00
Deployment latitude\ northings			34° 42.625
Deployment longitude\ eastings			19° 30.696
Site name			Baalamsklip 30m
Site depth			30m
Deployment depth			28m
Acoustic release (1) serial number and release code			–
Acoustic release (2) serial number and release code			–
Argos beacon serial number			–

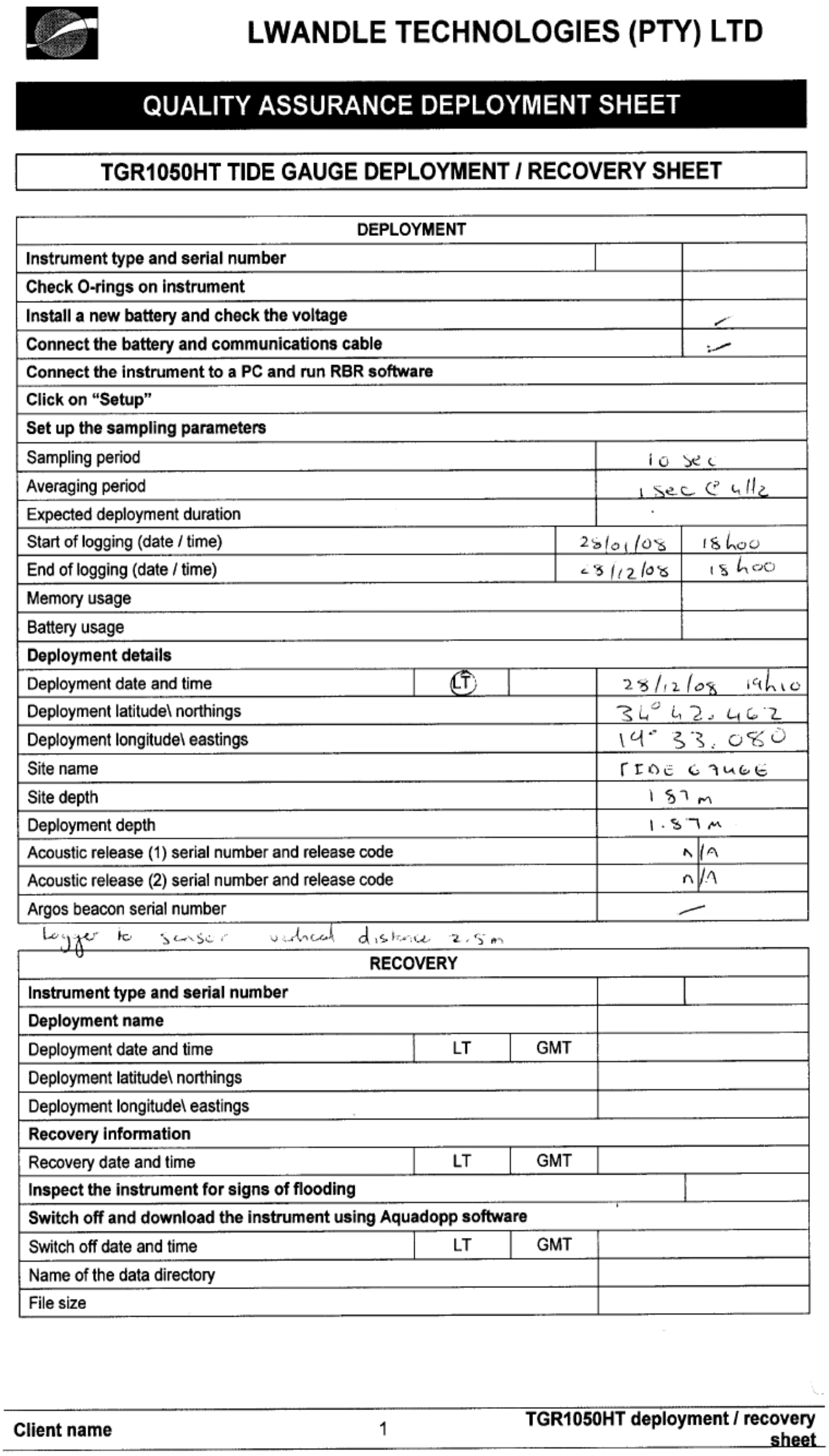
Range:

Northing	Easting	Range

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	

1 **CT deployment sheet**

7.3 TIDE GAUGE



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

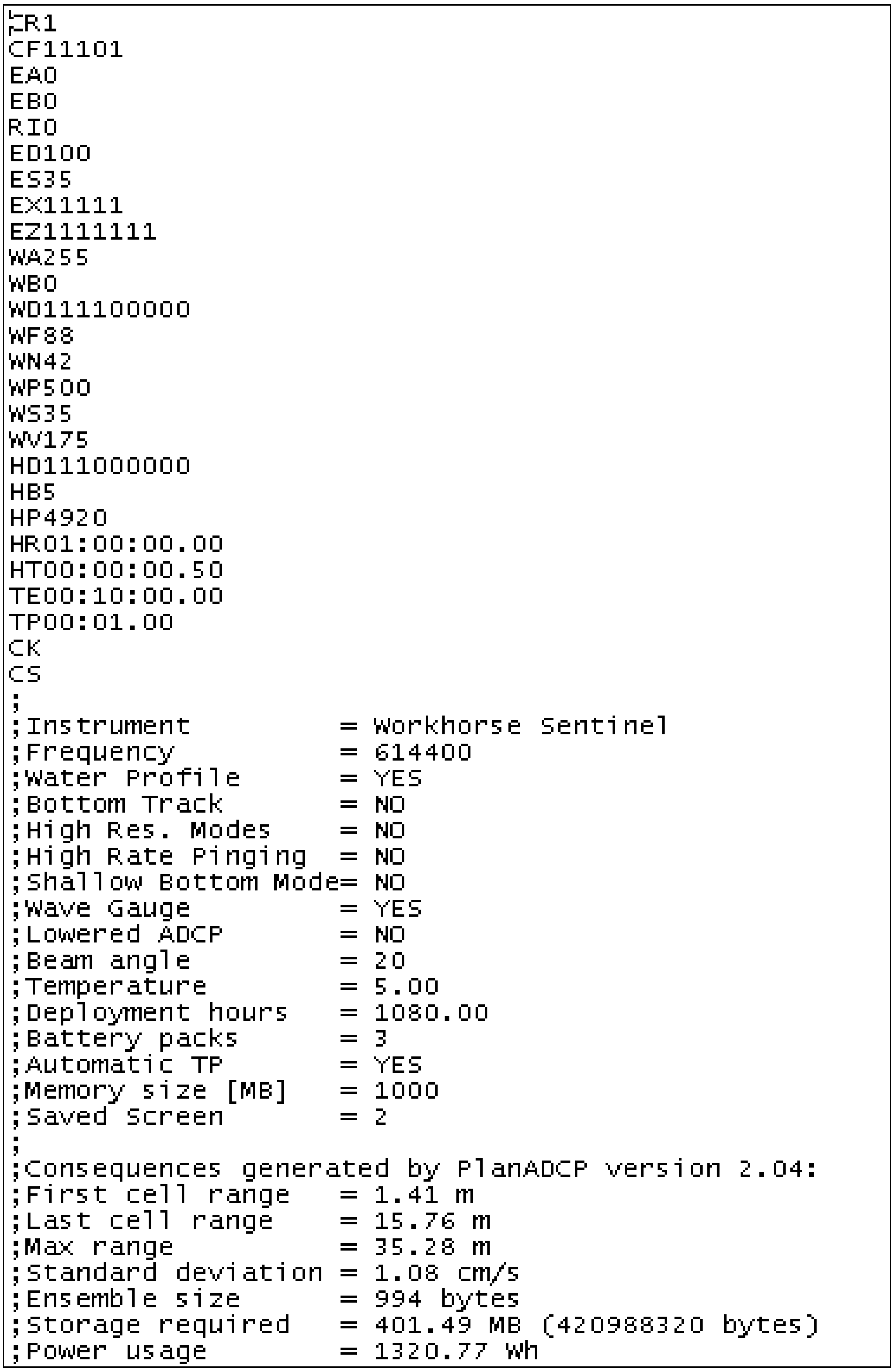
DEPLOYMENT			
Instrument type and serial number			
Check O-rings on instrument			
Install a new battery and check the voltage			✓
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period			10 sec
Averaging period			1sec @ 4Hz
Expected deployment duration			
Start of logging (date / time)		28/01/08	18h00
End of logging (date / time)		28/12/08	18h00
Memory usage			
Battery usage			
Deployment details			
Deployment date and time	[✓ LT]		28/12/08 19h10
Deployment latitude\ northings			34° 42.462
Deployment longitude\ eastings			19° 33.080
Site name			TIDE GAUGE
Site depth			1.87 m
Deployment depth			1.87 m
Acoustic release (1) serial number and release code			n/A
Acoustic release (2) serial number and release code			n/A
Argos beacon serial number			—

logger to sensor vertical distance 2.5m

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	
Inspect the instrument for signs of flooding			
Switch off and download the instrument using Aquadopp software			
Switch off date and time	LT	GMT	
Name of the data directory			
File size			

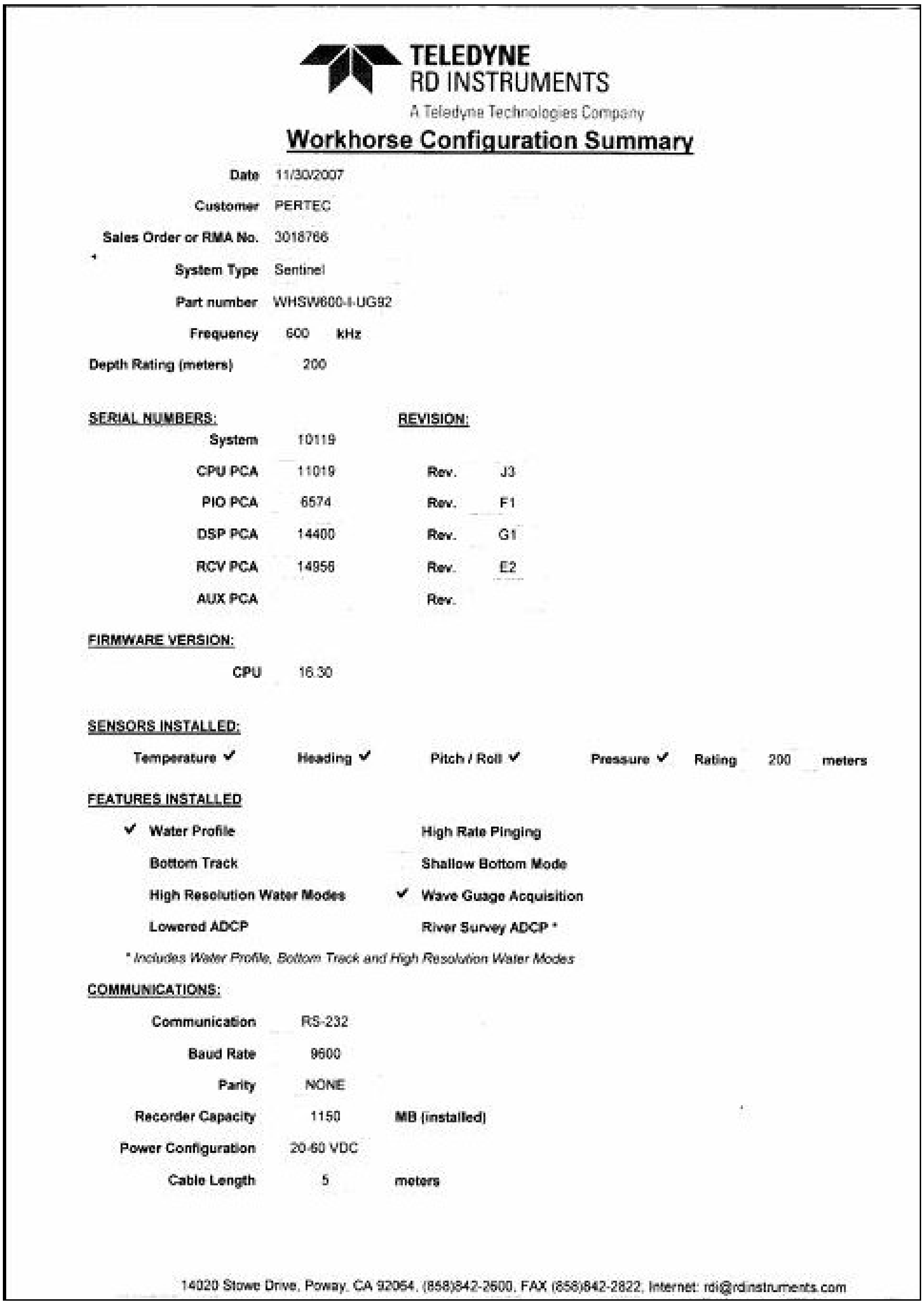
Client name 1 **TGR1050HT deployment / recovery sheet**

7.4 ADCPS CONFIGURATION FILES



```
CR1
CF11101
EA0
EB0
RI0
ED100
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:01.00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 1080.00
;Battery packs       = 3
;Automatic TP        = YES
;Memory size [MB]    = 1000
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 401.49 MB (420988320 bytes)
;Power usage         = 1320.77 Wh
```

7.5 TRDI ADCPS CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS:		REVISION:	
System	10119		
CPU PCA	11019	Rev.	J3
PIO PCA	6574	Rev.	F1
DSP PCA	14400	Rev.	G1
RCV PCA	14956	Rev.	E2
AUX PCA		Rev.	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

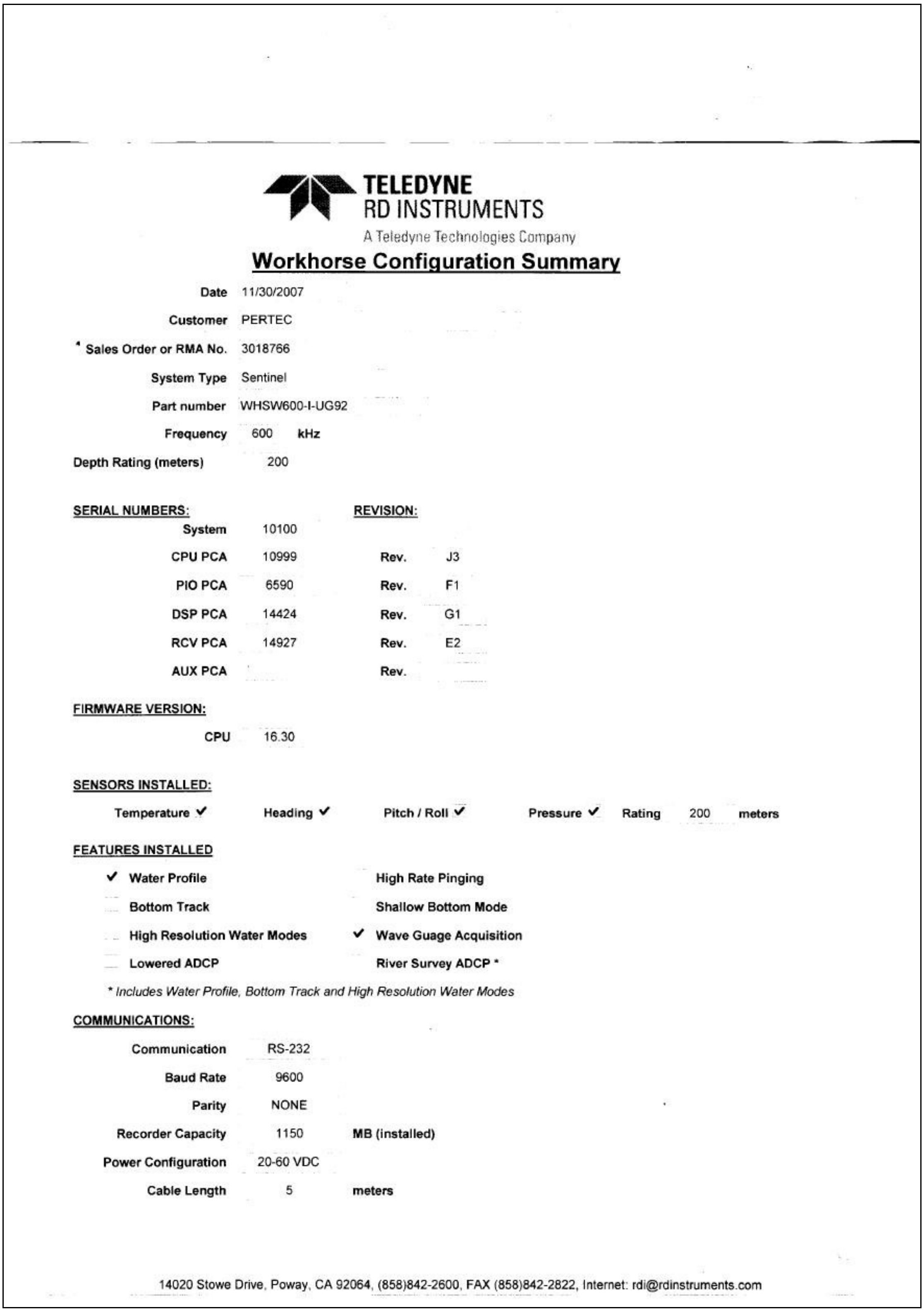
✓ Water Profile	High Rate Pinging
Bottom Track	Shallow Bottom Mode
High Resolution Water Modes	✓ Wave Guage Acquisition
Lowered ADCP	River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007

Customer PERTEC

*** Sales Order or RMA No.** 3018766

System Type Sentinel

Part number WHSW600-I-UG92

Frequency 600 **kHz**

Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10100		
CPU PCA	10999	**Rev.**	J3
PIO PCA	6590	**Rev.**	F1
DSP PCA	14424	**Rev.**	G1
RCV PCA	14927	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232

Baud Rate 9600

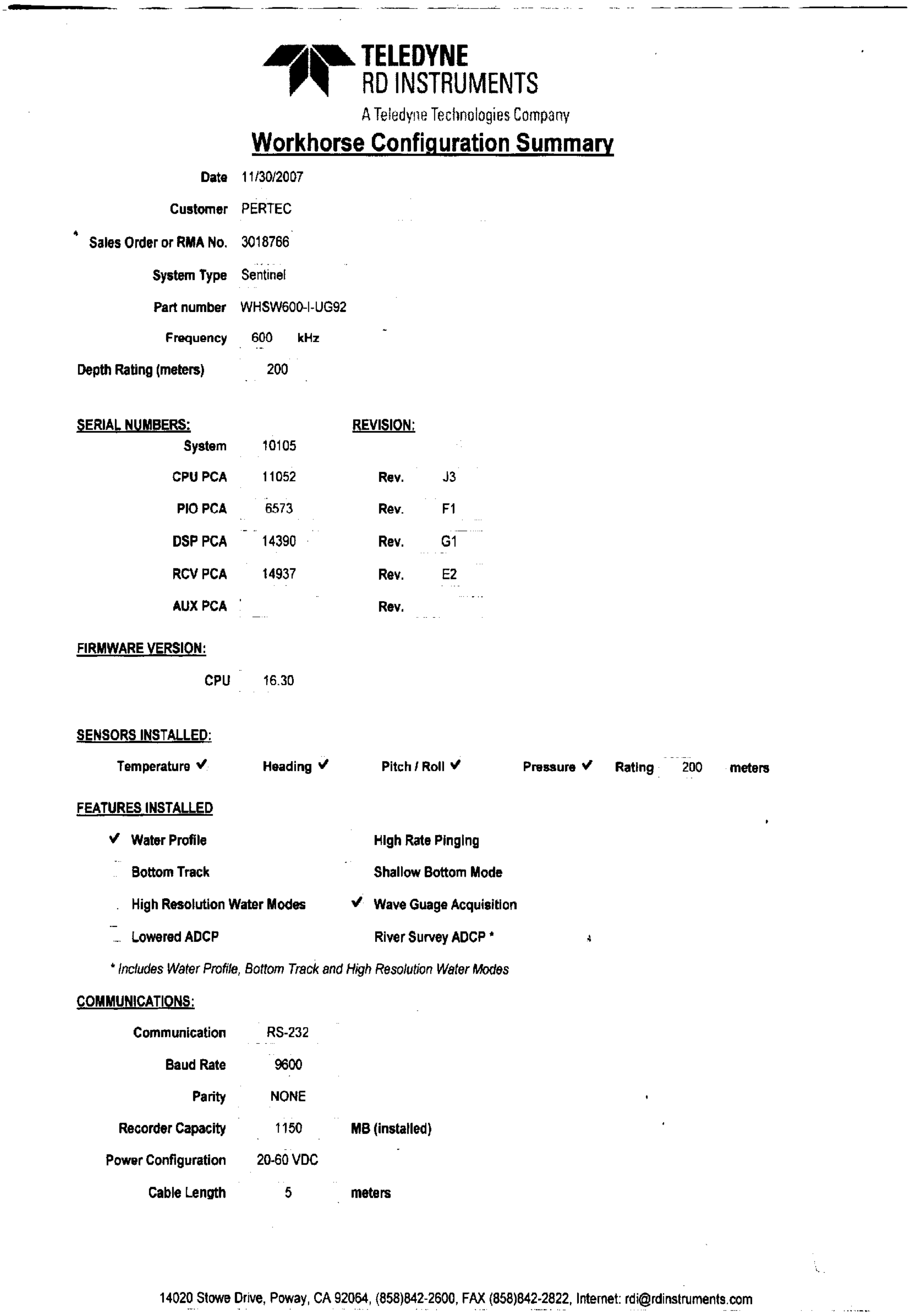
Parity NONE

Recorder Capacity 1150 **MB (installed)**

Power Configuration 20-60 VDC

Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date	11/30/2007
Customer	PERTEC
Sales Order or RMA No.	3018766
System Type	Sentinel
Part number	WHSW600-I-UG92
Frequency	600 kHz
Depth Rating (meters)	200

SERIAL NUMBERS:		**REVISION:**	
System	10105		
CPU PCA	11052	Rev.	J3
PIO PCA	6573	Rev.	F1
DSP PCA	14390	Rev.	G1
RCV PCA	14937	Rev.	E2
AUX PCA		Rev.	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ Heading ✓ Pitch / Roll ✓ Pressure ✓ Rating 200 meters

FEATURES INSTALLED

✓ Water Profile	High Rate Pinging
Bottom Track	Shallow Bottom Mode
High Resolution Water Modes	✓ Wave Guage Acquisition
Lowered ADCP	River Survey ADCP *

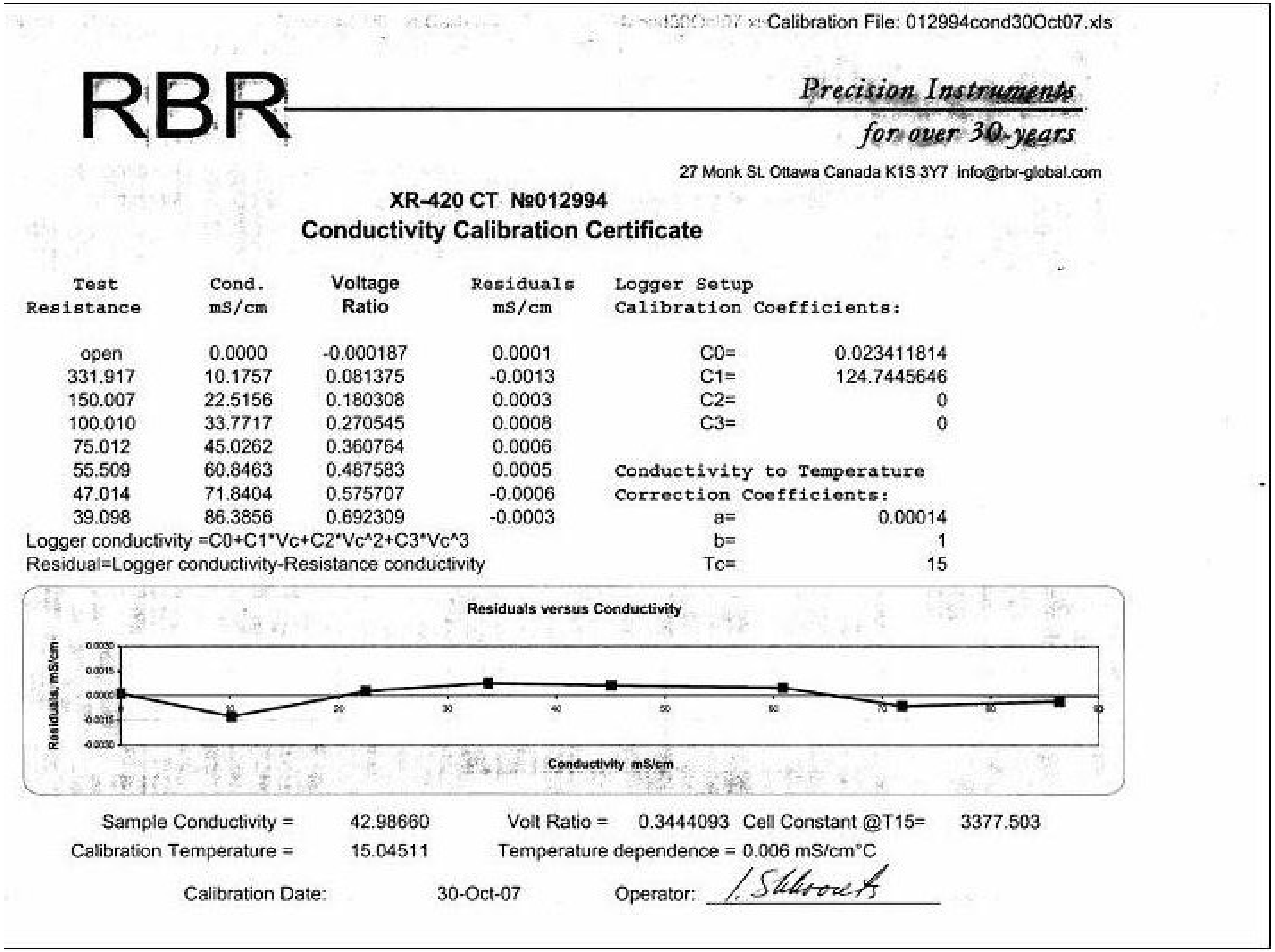
** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication	RS-232
Baud Rate	9600
Parity	NONE
Recorder Capacity	1150 MB (installed)
Power Configuration	20-60 VDC
Cable Length	5 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com

RBR-CT CALIBRATION CERTIFICATES



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments
for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

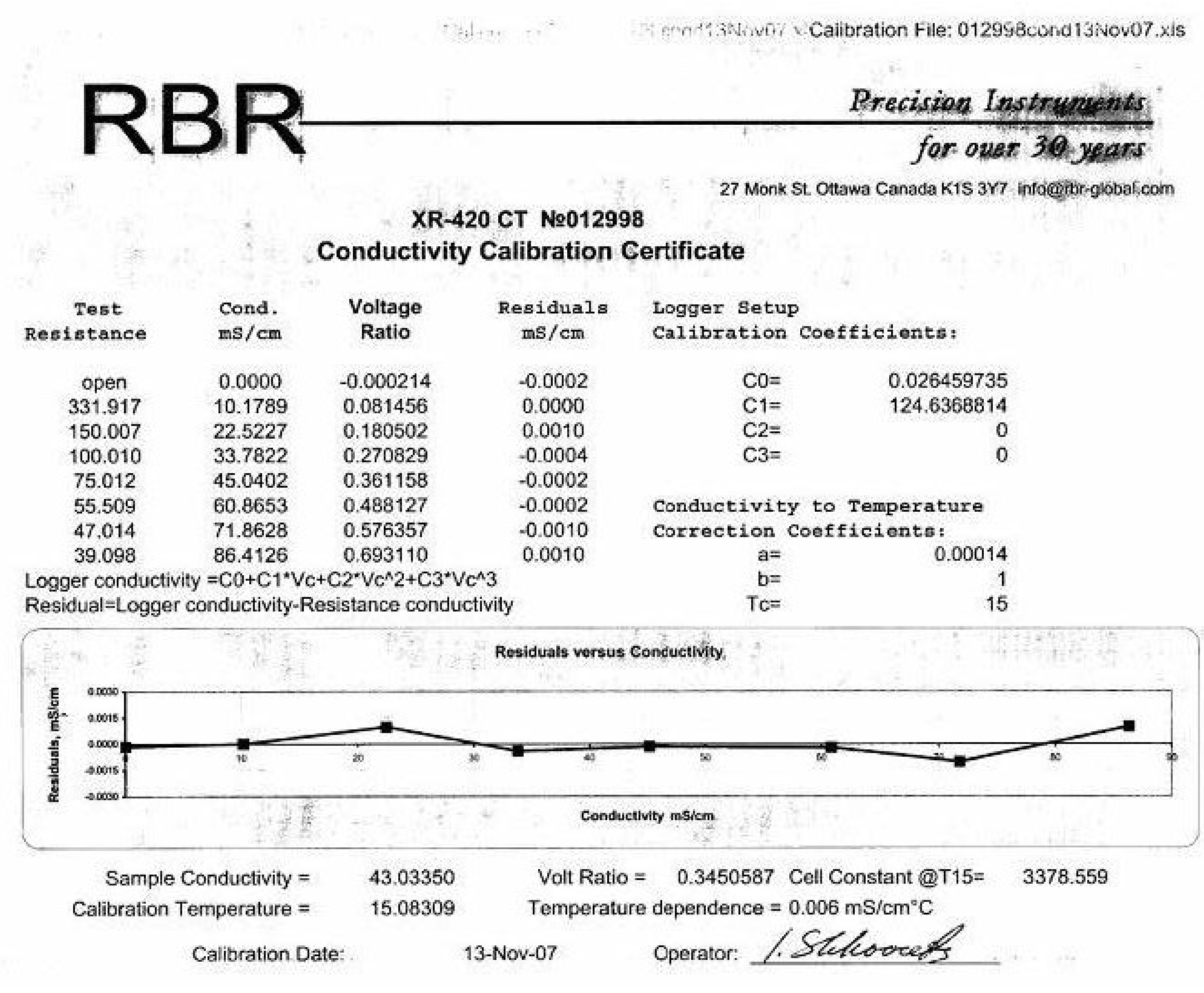
C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 42.98660
Volt Ratio = 0.3444093
Cell Constant @T15= 3377.503
Calibration Temperature = 15.04511
Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07
Operator: I. Shkvorets



Calibration File: 012998cond13Nov07.xls

RBR

Precision Instruments
for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012998
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000214	-0.0002
331.917	10.1789	0.081456	0.0000
150.007	22.5227	0.180502	0.0010
100.010	33.7822	0.270829	-0.0004
75.012	45.0402	0.361158	-0.0002
55.509	60.8653	0.488127	-0.0002
47.014	71.8628	0.576357	-0.0010
39.098	86.4126	0.693110	0.0010

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.026459735
C1= 124.6368814
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

Sample Conductivity = 43.03350
Volt Ratio = 0.3450587
Cell Constant @T15= 3378.559
Calibration Temperature = 15.08309
Temperature dependence = 0.006 mS/cm°C

Calibration Date: 13-Nov-07
Operator: I. Stikhoverts

8. PHOTOS TAKEN.

(a)

(b)

(c)

Figure 8: Recovered instruments: (a) RBR string (b) and (c) the ADCPs.

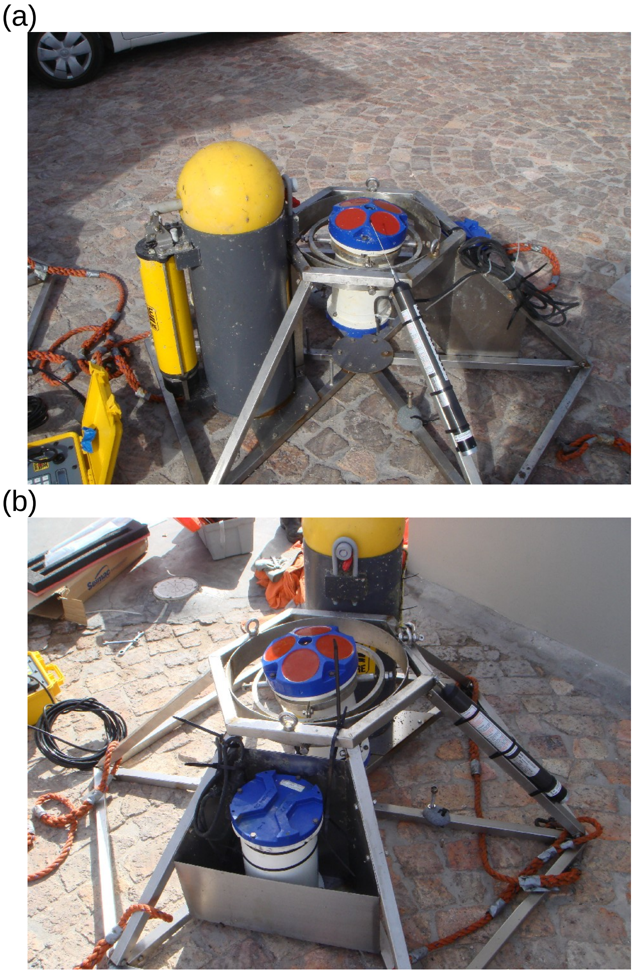


Figure 9: Instruments ready for redeployment.

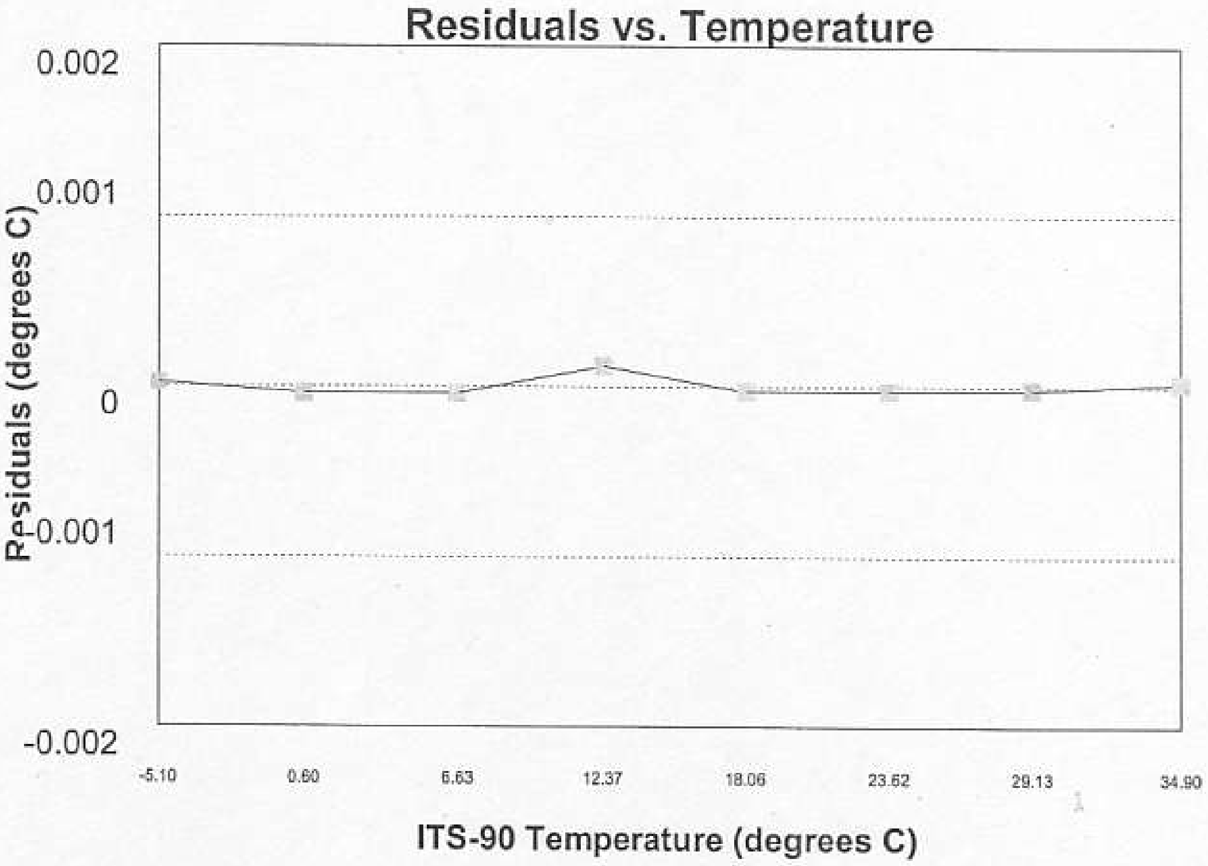
9. REPORTS FROM THE CSIR

The reports from the CSIR are attached as an appendage.

RBR Temperature Calibration Certificate

Logger ID: TGR-2050 Serial No: 13070

ITS-90 Temp	Voltage Ratio	Residuals	Coefficients
-5.09674	0.728090	0.00002	**0.003476451095491**
0.59564	0.665181	-0.00004	**-0.000255412457248**
6.63301	0.594167	-0.00004	**0.000002584810438**
12.36797	0.525356	0.00012	**-0.000000076888248**
18.05689	0.458460	-0.00003	
23.62267	0.396474	-0.00003	
29.13254	0.340010	-0.00002	
34.90487	0.287054	0.00002	



Operator: ____________________

Calibration Date: 8/Dec/2006

RBR Ltd. 27 Monk St., Ottawa, Canada K1S 3Y7 | (613) 233-1621 | www.rbr-global.com

Logger Serial Number: 013070pres.xls

RBR
Precision Instruments
for over 25 years
27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

Pressure (dBar)	Logger reading	Residuals
11.3963	0.068930	0.0001
18.2899	0.110775	-0.0002
25.1835	0.152387	0.0000
32.0771	0.193733	-0.0002
38.9707	0.234801	0.0007
45.8643	0.275554	-0.0001
52.7579	0.315983	-0.0005
59.6515	0.356076	0.0003

Logger Calibration Coefficients

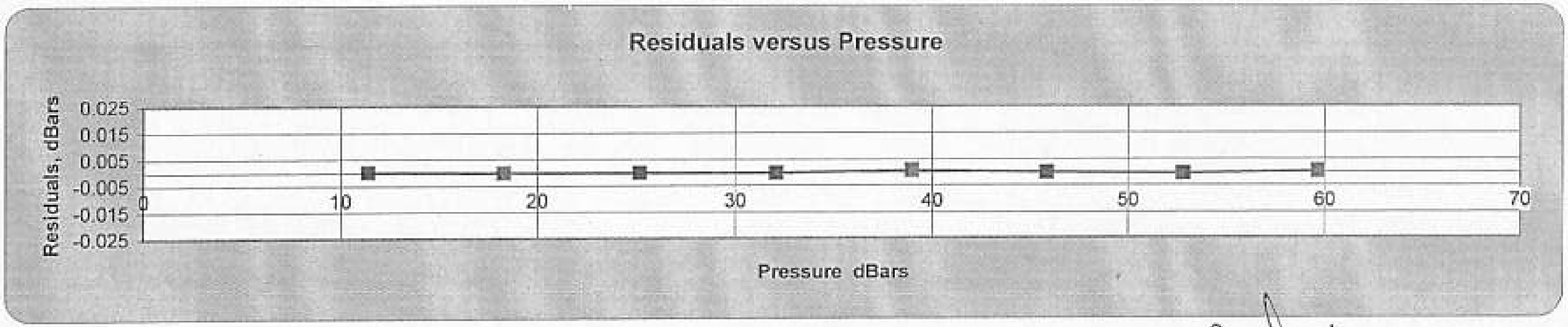
a	0.114824378683
b	163.091749203944
c	7.597060860367
d	11.087876505218

Logger pressure=a+b*VR+c*VR^2+d*VR^3

Residual = logger pressure - Pressure

Atmos. P 10.098

Ht (cm) 8



Calibration Date: 18-Dec-06

Operator:

Barometer reading in mm: 759.8 Temp: 19.5

RBR Calibration Shipping Certificate

Calibration values for all channels when shipped.

Logger ID: TGR-2050   Serial No: 13070

```
2006/Dec/18 14:21:08
  1: 0.003476451095491 -0.000255412457248 0.000002584810438 -0.000000076888248
  2: 0.114824378683000 163.091749203944000 7.597060860367000 11.087876505218000
```

Operator: ____________________

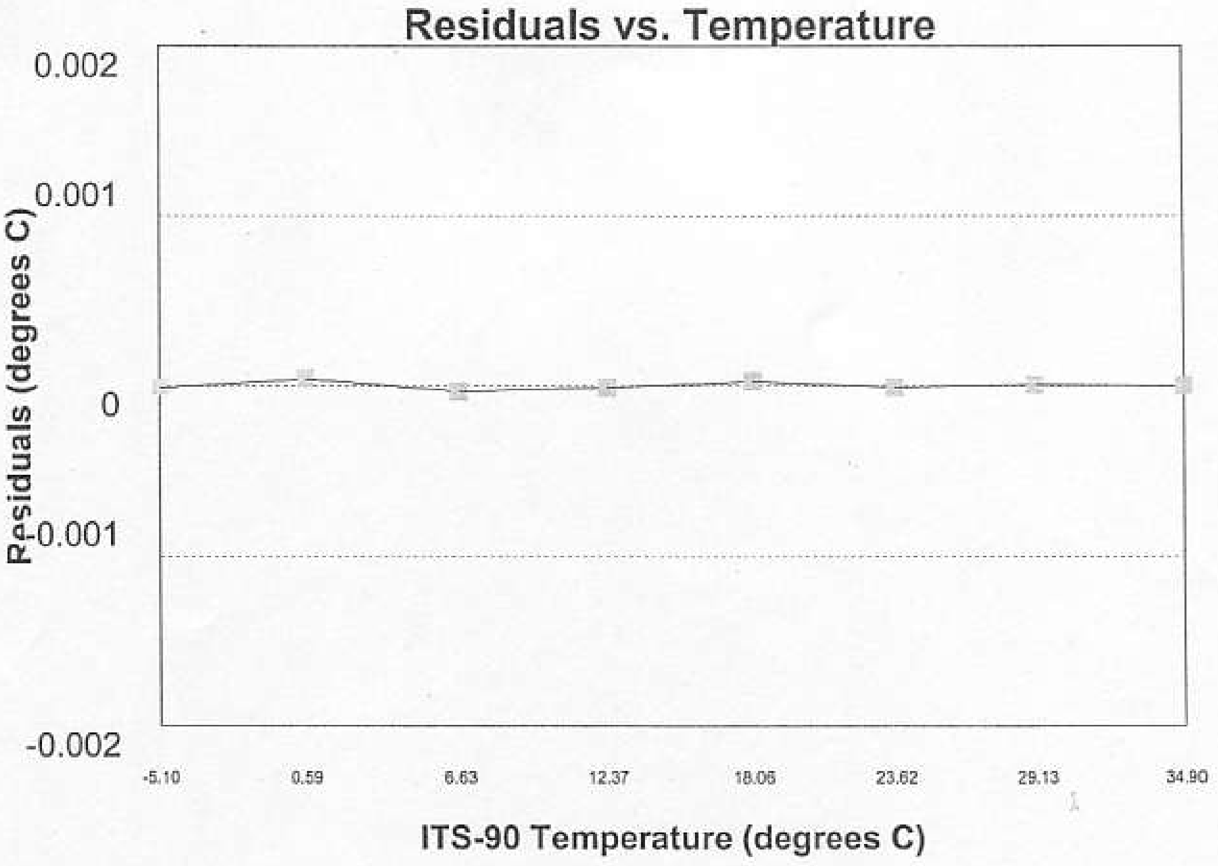
20/Dec/2006

Richard Brancker Research Ltd.   27 Monk St., Ottawa, Canada K1S 3Y7 (613) 233-1621

RBR Temperature Calibration Certificate

Logger ID: TGR-2050 Serial No: 13084

ITS-90 Temp	Voltage Ratio	Residuals	Coefficients
-5.09890	0.735395	-0.00001	**0.003467203073564**
0.59351	0.673355	0.00004	**-0.000255022957844**
6.63105	0.602975	-0.00003	**0.000002564034233**
12.36636	0.534427	-0.00001	**-0.000000068680142**
18.05621	0.467447	0.00002	
23.62145	0.405113	-0.00001	
29.13260	0.348072	0.00001	
34.90448	0.294384	-0.00000	



Operator: ____________________

Calibration Date: 15/Dec/2006

RBR Ltd. 27 Monk St., Ottawa, Canada K1S 3Y7 | (613) 233-1621 | www.rbr-global.com

Logger Serial Number: 013084pres.xls

RBR
Precision Instruments for over 25 years
27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

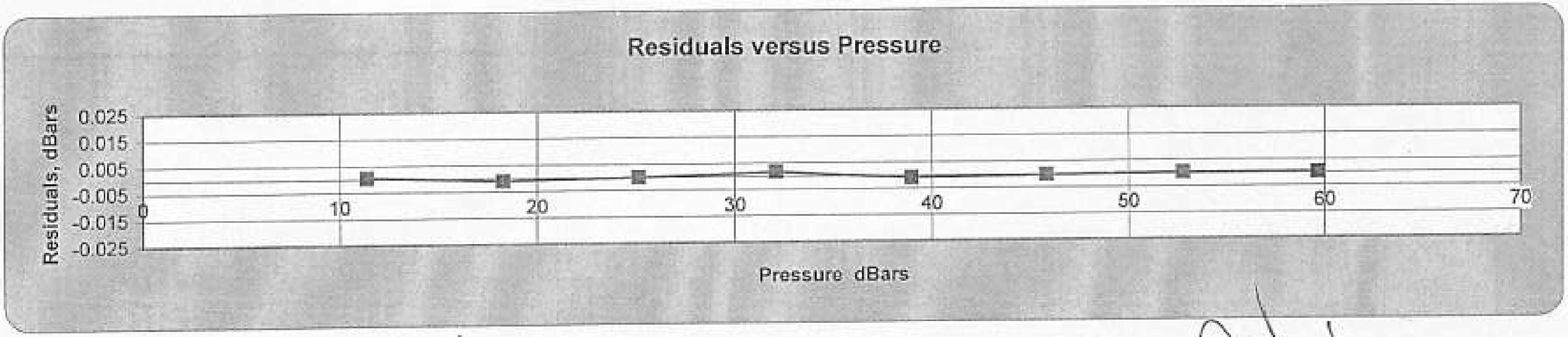
Pressure (dBar)	Logger reading	Residuals
11.3838	0.068665	0.0005
18.2774	0.110444	-0.0011
25.1710	0.152017	0.0000
32.0646	0.193350	0.0016
38.9582	0.234397	-0.0009
45.8518	0.275183	-0.0003
52.7454	0.315672	0.0002
59.6390	0.355847	0.0000

Logger Calibration Coefficients

a	0.126651796065
b	163.391117159044
c	7.500539942877
d	9.330928458832

Logger pressure=a+b*VR+c*VR^2+d*VR^3
Residual = logger pressure - Pressure

Atmos. P 10.085
Ht (cm) 8



Calibration Date: 18-Dec-06
Barometer reading in mm: 758.8
Temp: 19
Operator:

RBR Calibration Shipping Certificate

Calibration values for all channels when shipped.

Logger ID: TGR-2050 Serial No: 13084

2006/Dec/18 09:45:12
1: 0.003467203073564 -0.000255022957844 0.000002564034233 -0.000000068680142
2: 0.126651796065000 163.391117159044000 7.500539942877000 9.330928458832000

Operator: ______________________

20/Dec/2006

Richard Brancker Research Ltd. 27 Monk St., Ottawa, Canada K1S 3Y7 (613) 233-1621

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT TWO

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

16 July 2008

Job No: LT-JOB-50

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1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 2 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-11.0	100	0.1675	0.0317	0.0217	0.0200	64.29
-10.7	100	0.1660	0.0349	0.0232	0.0231	57.53
-10.3	100	0.1690	0.0374	0.0240	0.0245	48.93
-10.0	100	0.1506	0.0376	0.0235	0.0226	43.02
-9.6	100	0.1575	0.0366	0.0226	0.0226	43.09
-9.3	100	0.1664	0.0363	0.0223	0.0219	45.64
-8.9	100	0.1615	0.0354	0.0217	0.0203	46.89
-8.6	100	0.1469	0.0348	0.0209	0.0181	46.28
-8.2	100	0.1516	0.0343	0.0207	0.0161	46.76
-7.9	100	0.1641	0.0340	0.0205	0.0147	48.62
-7.5	100	0.1588	0.0338	0.0208	0.0121	49.57
-7.2	100	0.1371	0.0339	0.0210	0.0091	53.81
-6.8	100	0.1532	0.0346	0.0218	0.0068	53.80
-6.5	100	0.1854	0.0363	0.0232	0.0038	60.65
-6.1	100	0.1903	0.0378	0.0248	0.0009	99.05
-5.8	100	0.1953	0.0392	0.0268	0.0025	211.90
-5.4	100	0.2356	0.0417	0.0295	0.0060	221.32
-5.1	100	0.2560	0.0446	0.0327	0.0093	227.24
-4.7	100	0.2666	0.0475	0.0352	0.0133	229.04
-4.4	99.97	0.2868	0.0508	0.0380	0.0178	231.23
-4.0	100	0.3062	0.0552	0.0420	0.0236	235.62
-3.7	100	0.3130	0.0604	0.0472	0.0297	238.33
-3.3	100	0.3436	0.0647	0.0497	0.0341	243.03
-3.0	100	0.3736	0.0653	0.0481	0.0293	248.69
-2.6	100	0.3878	0.0834	0.0597	0.0325	287.15
-2.3	100	0.4162	0.1167	0.0829	0.0535	319.22
-1.9	100	0.4387	0.1405	0.0930	0.0609	328.31
-1.6	97.86	0.4810	0.1410	0.0898	0.0420	330.63
-1.2	87.06	0.4741	0.1366	0.0820	0.0295	322.67

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	98.98	5.17	0.89	1.68	0.65
Tp (s)	98.98	17.00	2.20	12.25	2.17

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-30.8	100	0.2112	0.0271	0.0186	0.0072	48.87
-30.3	100	0.2256	0.0282	0.0200	0.0056	48.96
-29.8	99.98	0.2438	0.0295	0.0215	0.0045	50.53
-29.3	100	0.2562	0.0313	0.0226	0.0035	53.50
-28.8	100	0.2612	0.0329	0.0240	0.0028	59.19
-28.3	100	0.2647	0.0347	0.0256	0.0018	70.43
-27.8	100	0.2926	0.0365	0.0272	0.0012	102.08
-27.3	100	0.2936	0.0385	0.0285	0.0010	144.45
-26.8	100	0.3066	0.0402	0.0298	0.0017	169.56
-26.3	100	0.3021	0.0422	0.0312	0.0019	171.52
-25.8	100	0.2818	0.0438	0.0320	0.0024	175.69
-25.3	100	0.2854	0.0459	0.0330	0.0030	164.91
-24.8	99.98	0.2837	0.0480	0.0342	0.0038	160.90
-24.3	100	0.2761	0.0494	0.0348	0.0046	154.66
-23.8	100	0.2618	0.0510	0.0351	0.0051	150.97
-23.3	99.98	0.2663	0.0523	0.0352	0.0057	142.26
-22.8	100	0.2517	0.0535	0.0352	0.0064	139.49
-22.3	100	0.2569	0.0547	0.0352	0.0068	132.06
-21.8	100	0.2696	0.0555	0.0352	0.0073	127.94
-21.3	100	0.2634	0.0560	0.0356	0.0082	120.74
-20.8	100	0.2610	0.0561	0.0356	0.0086	116.42
-20.3	100	0.2554	0.0565	0.0360	0.0087	111.69
-19.8	100	0.2661	0.0566	0.0360	0.0092	109.55
-19.3	100	0.2612	0.0566	0.0364	0.0094	103.99
-18.8	100	0.2518	0.0567	0.0362	0.0097	99.73
-18.3	100	0.2581	0.0571	0.0366	0.0102	98.09
-17.8	100	0.2603	0.0572	0.0371	0.0104	96.00
-17.3	100	0.2617	0.0572	0.0376	0.0106	93.19
-16.8	100	0.2608	0.0574	0.0380	0.0103	90.67
-16.3	100	0.2570	0.0576	0.0384	0.0098	88.10
-15.8	100	0.2499	0.0576	0.0380	0.0093	87.90
-15.3	100	0.2581	0.0579	0.0380	0.0087	85.64
-14.8	100	0.2593	0.0587	0.0380	0.0079	84.27
-14.3	99.98	0.2559	0.0591	0.0381	0.0067	84.32
-13.8	100	0.2555	0.0599	0.0383	0.0059	83.17
-13.3	100	0.2658	0.0605	0.0384	0.0046	89.53
-12.8	100	0.2491	0.0614	0.0385	0.0033	110.58
-12.3	99.98	0.2493	0.0618	0.0387	0.0024	154.98
-11.8	100	0.2539	0.0632	0.0390	0.0030	186.91
-11.3	100	0.2549	0.0636	0.0391	0.0047	206.46
-10.8	100	0.2619	0.0646	0.0400	0.0066	216.23
-10.3	100	0.2560	0.0661	0.0405	0.0087	221.16
-9.8	100	0.2501	0.0672	0.0409	0.0116	223.78

-9.3	100	0.2682	0.0685	0.0418	0.0144	225.51
-8.8	100	0.2586	0.0695	0.0423	0.0166	227.18
-8.3	100	0.2683	0.0708	0.0428	0.0186	228.42
-7.8	100	0.2671	0.0724	0.0438	0.0206	230.69
-7.3	100	0.2814	0.0751	0.0449	0.0217	232.35
-6.8	100	0.3034	0.0777	0.0460	0.0221	235.26
-6.3	100	0.3174	0.0801	0.0459	0.0104	244.56
-5.8	100	0.3054	0.0856	0.0474	0.0104	356.14
-5.3	100	0.3482	0.0932	0.0541	0.0288	340.72
-4.8	100	0.4039	0.1189	0.0680	0.0509	310.07
-4.3	100	0.5765	0.1583	0.1016	0.0879	281.85
-3.8	99.98	0.6236	0.1973	0.1217	0.1220	267.02
-3.3	99.95	0.5388	0.2159	0.1259	0.1297	247.58
-2.8	99.21	0.5393	0.2122	0.1185	0.1243	235.93
-2.3	73.35	0.5559	0.2106	0.1202	0.1187	247.35

Table 4 – Waves summary for 30m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	98.53	5.98	0.92	2.14	0.86
Tp (s)	98.53	19.50	2.70	12.32	1.87

Table 5 – Water temperature and salinity summary (surface)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	11.44	15.22	9.53
Conductivity	100	39.13	43.00	37.21
Salinity (psu)	100	34.66	34.94	34.34

Table 6 – Water temperature and salinity summary (bottom)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	10.20	11.75	9.39
Conductivity	100	38.03	39.46	36.65
Salinity (psu)	99.78	34.75	34.84	34.50

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents currents, waves, temperature and salinity data collected at Bantamsklip station for the period March 27th 2008 - April 24th 2008 (Period 2) collected during Service Visit 2 (April 24th – 25th 2008). Re-deployment of the instruments was undertaken in two parts as outlined in the Operations section.

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 7 for the Bantamsklip site.

Table 7 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 1050 HT Tide Gauge	1	0
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The initial deployment location of the mooring is given in Table 8 and shown in Figure 1.

Figure 1 - Map of the project area.

Table 8 – Measurement locations

Instrument	Latitude (^oS)	Longitude (^oE)
Tide Gauge	34° 42.462’	19° 33.080’
10m ADCP	34° 43.186’	19° 33.637’
Biofouling	34° 43.190’	19° 33.686’
30m ADCP	34° 42.625’	19° 30.690’
T&C mooring	34° 42.605’	19° 30.659’

3. OPERATIONS

3.1 SUMMARY OF EVENTS

Service visits 2a and 2b were undertaken on April 24th – 25th 2008 and May 23rd 2008 respectively.

Table 9 – Summary of events for Service Visit 2a

Date	Description
24 April 2008 07h00	Lwandle's engineers departed from Cape Town.
09h00	The engineers arrived at Kleinbaai Harbour.
10h00	The vessel was launched and it reached the 30m ADCP deployment location in approximately 50 minutes.
11h00	The CART Pop-Up buoy was successfully released on the 30m mooring.
11h10	The divers released the T&C line and detached the weights from the mooring. The 30m ADCP mooring was successfully retrieved.
12h00	The 10m ADCP mooring was successfully retrieved
13h00	The vessel arrived back at Kleinbaai harbour.
14h00	The vessel was offloaded and the instruments taken back for servicing.
15h30	The engineers arrived at the tide gauge site to download data. The logger box was removed and only the Druck sensor cable was at the position. The logger box was found inshore and was stripped of its batteries and wires and filled with water.
16h30	The instruments were cleaned, serviced and setup for deployment.
25 April 2008 09h30	The vessel was launched and it reached the 30m ADCP deployment location in approximately 50 minutes.
10h30	The 30m ADCP mooring was redeployed.
11h30	The 10m ADCP mooring was redeployed.
13h00	The vessel arrived back at Kleinbaai harbour.
13h30	The vessel was offloaded and washed down
14h30	The engineers depart for Cape Town.

Owing to bad weather, the T&C mooring was not re-deployed on April 25th.

Table 10 – Summary of events for Service Visit 2b

Date	Description
23 May 2008 10h30	The Lwandle engineer met up with the skipper at Kleinbaai harbour.
11h00	The engineer and skipper loaded up the vessel with the T & C mooring string.
11h15	The vessel departed from Kleinbaai harbour and headed towards the mooring position.
11h35	The vessel arrived at the deployement position
11h45	The T&C mooring line was lowered down to the seabed (position 34’42.605 / 19’30.659) at a distance of about 6m away from the 30m ADCP frame.
12h20	The vessel returned to Kleinbaai harbour
13h30	A TGR 2050 tide gauge was installed at the original tide gauge position.
15h00	The Lwandle engineer returned to Cape Town.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 55).

3.2.1 600kHz ADCP

Table 11 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10105
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Table 12 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

3.2.2 RBR XR420 CT LOGGER

Table 13 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (7m) and s/n 12998 (28m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

3.2.3 RBR TGR1050 HT TIDE GAUGE

Table 14 – Instrument configuration for the Tide Gauge

Parameter	**Configuration**
TGR 1050 HT	s/n 14005
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.4 RBR TGR2050 HT TIDE GAUGE

Table 15 – Instrument configuration for the Tide Gauge

Parameter	**Configuration**
TGR 2050 HT	s/n 013070
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.5 Biofouling Mooring

Table 16 – Instrument configuration for Biofouling Mooring Line.

Parameter	**Configuration**
Biofouling Plates	3 plates (50cmx50cm) at 3m and 3 plates (50cmx50cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed inside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water. The sensor cable was covered with garden hosing and laid out to the tide logger box which was cemented onto a nearby rocky outcrop.

The TGR 2050 tide gauge was installed on the steel frame at the same location where the TGR 1050 was previously installed. No external logger box is necessary for this instrument.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods. Recovery of the biofouling mooring was not scheduled for the second service visit.

3.4 MALFUNCTIONS AND LESSONS LEARNT

A list of malfunctions experienced and consequent measures to be taken in future are provided in Table 17.

Table 17 – Lessons learnt and future mitigation measures

Problem	Mitigation measure(s)
Poachers dive in vicinity of tide gauge – they tamper with the instrument.	The RBR 1050 has been replaced with the RBR 2050.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

4.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 22' W and 25° 21' W for the 10m and 30m ADCPs respectively.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP's pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2 and Figure 3).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 22' W and 25° 21' W for the 10m and 30m ADCPs respectively.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Salinity values less than 34.5psu were flagged for the bottom instrument.

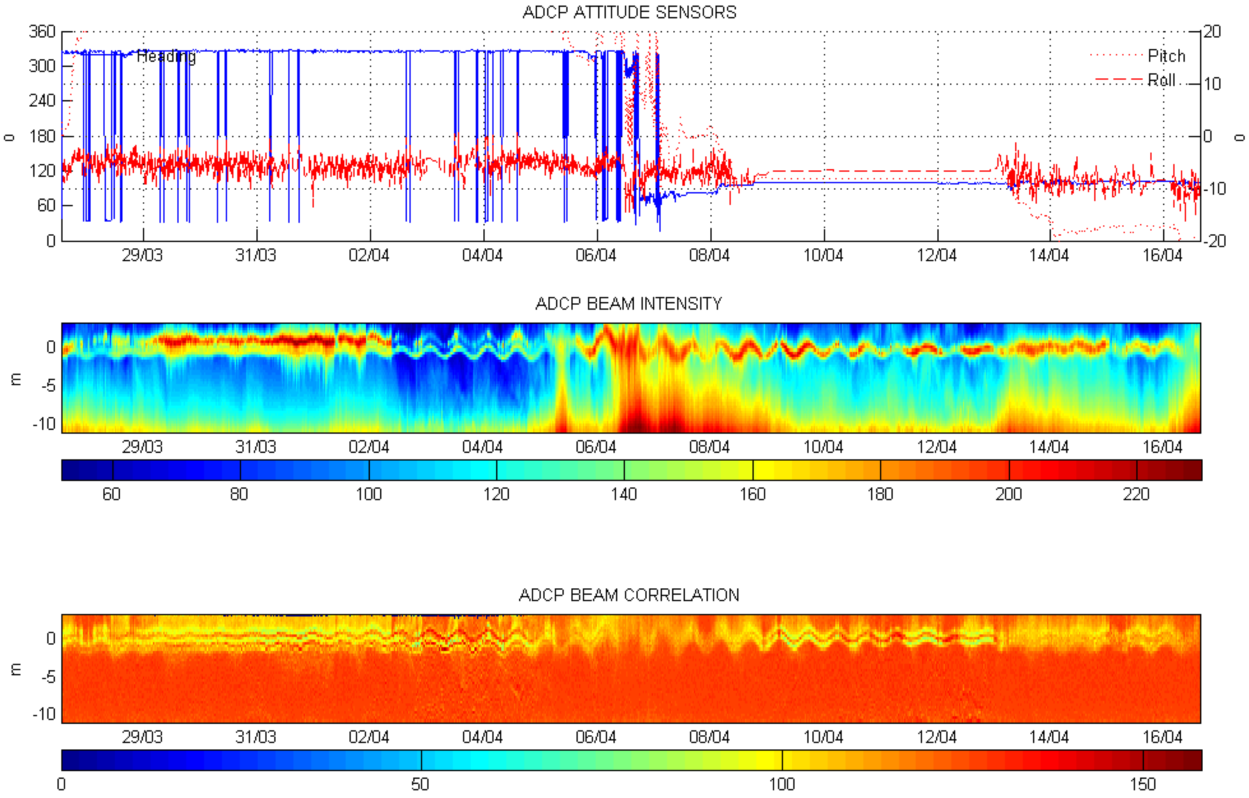


Figure 2: Attitude data for 10m ADCP.

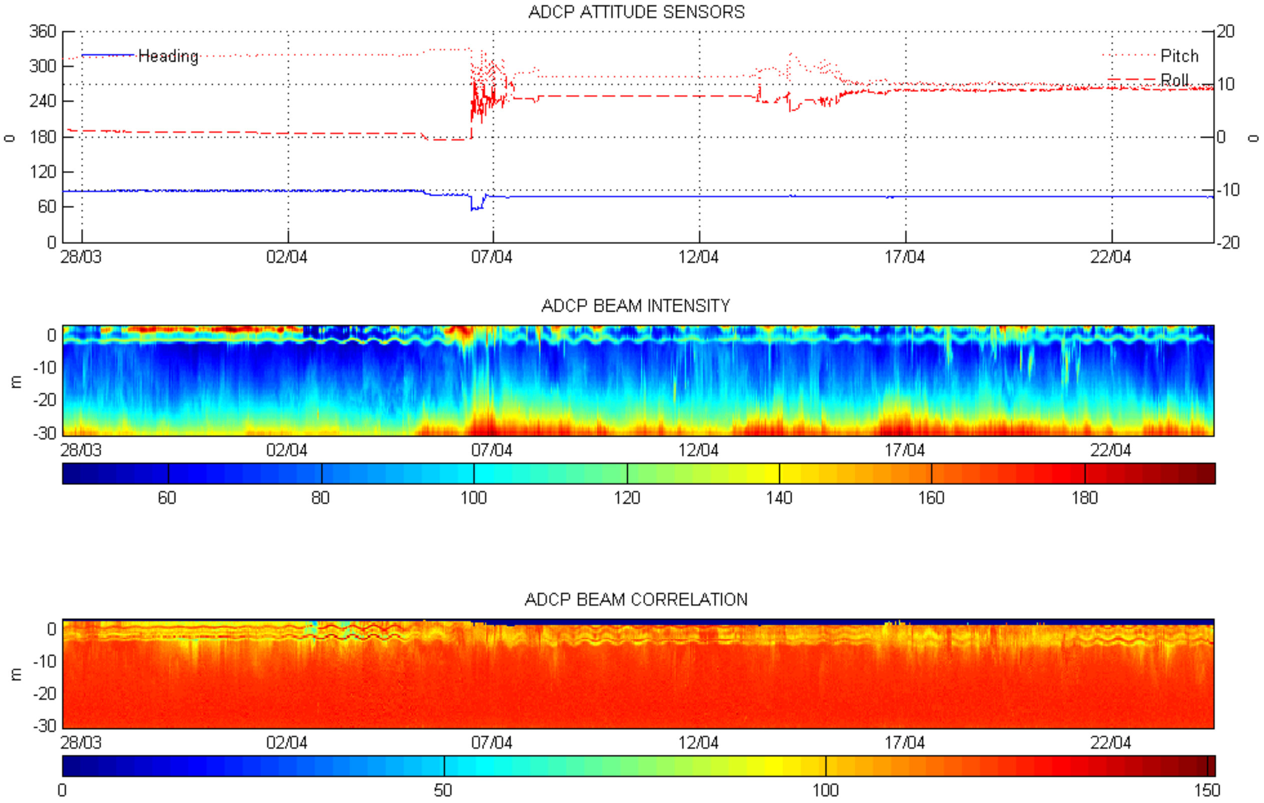


Figure 3: Attitude data for 30m ADCP.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

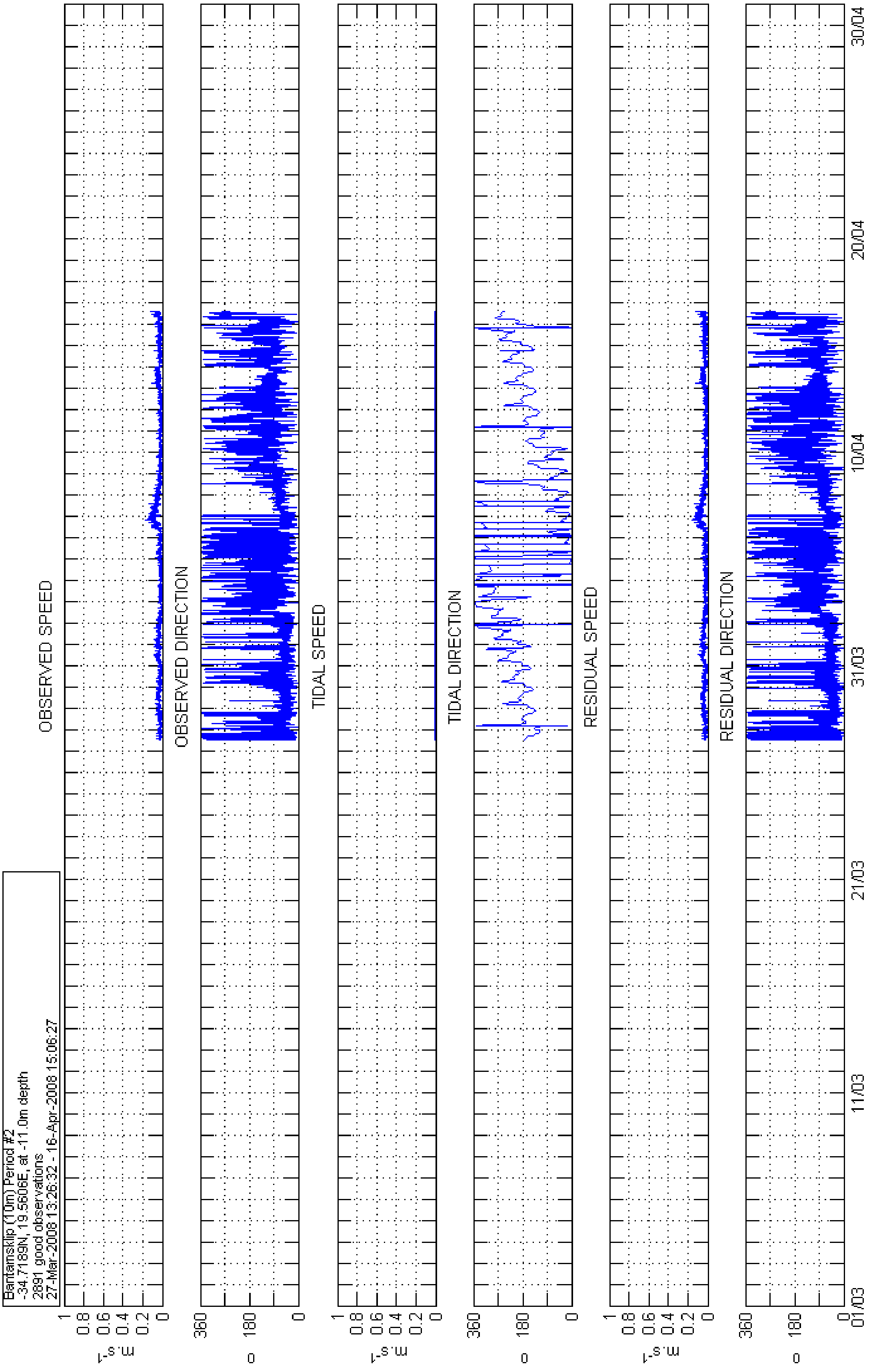


Figure 4: Time series plot for 10m ADCP current data at 11.0m

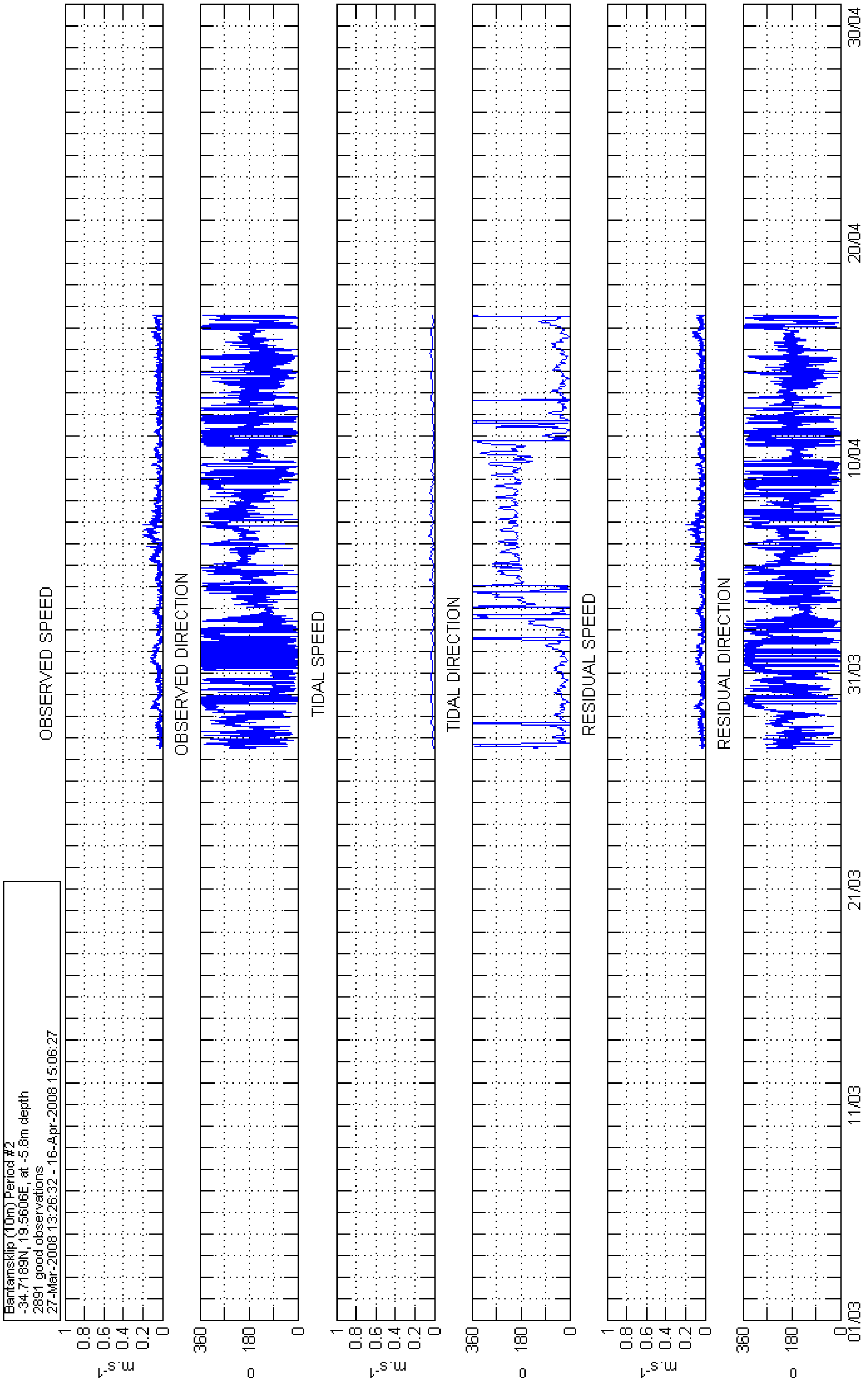


Figure 5: Time series plot for 10m ADCP current data at 5.8m

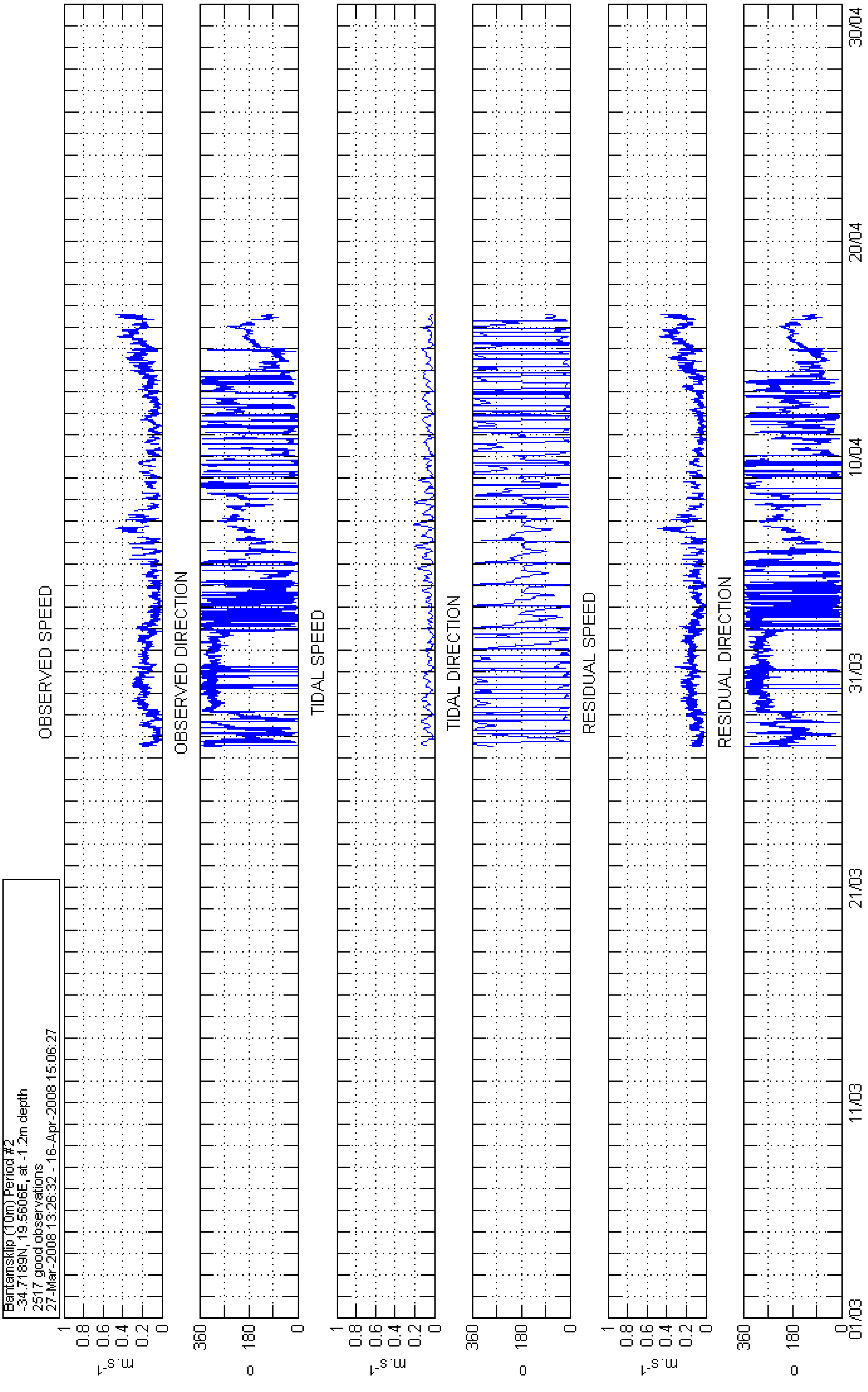


Figure 6: Time series plot for 10m ADCP current data at 1.2m

5.1.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

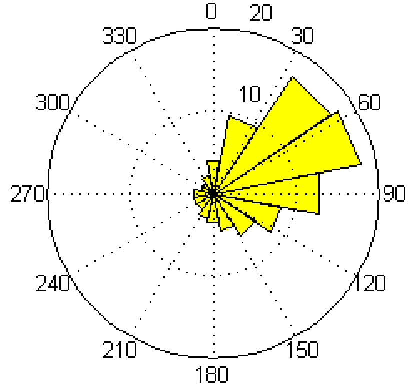
- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at -11.0m depth
2891 good observations
27-Mar-2008 13:26:32 - 16-Apr-2008 15:06:27

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	3.74	8.99	16.50	17.92	12.97	8.37	6.09	4.67	3.60	3.11	2.35	2.35	2.35	1.45	1.66	2.14	98.27
0.1-0.2	0.21	0.52	0.66	0.21									0.10			0.03	1.73
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	3.94	9.51	17.16	18.13	12.97	8.37	6.09	4.67	3.60	3.11	2.35	2.35	2.46	1.45	1.66	2.18	100.00

CURRENT DIRECTION ROSE



CURRENT SPEED HISTOGRAM

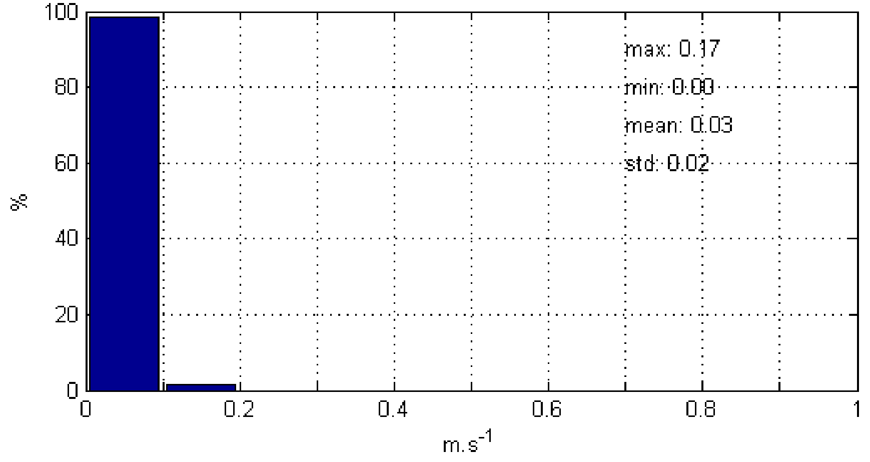
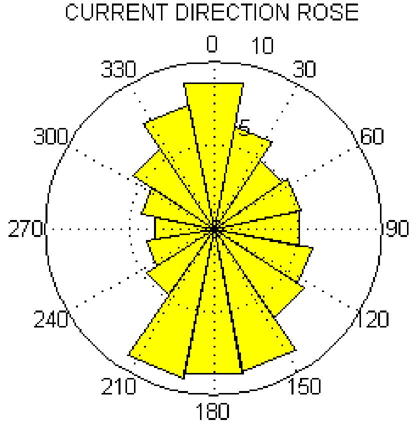


Figure 7: Summary plot for 10m ADCP current data at 11.0m

Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at -5.8m depth
2891 good observations
27-Mar-2008 13:26:32 - 16-Apr-2008 15:06:27

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	8.47	6.23	4.91	5.33	5.19	5.98	6.43	8.54	8.23	8.13	4.53	4.01	3.32	4.29	5.57	7.54	96.71
0.1-0.2	0.38						0.03	0.24	0.62	1.04	0.31	0.07	0.24	0.10	0.21	0.03	3.29
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	8.86	6.23	4.91	5.33	5.19	5.98	6.47	8.79	8.86	9.17	4.84	4.08	3.56	4.39	5.78	7.58	100.00



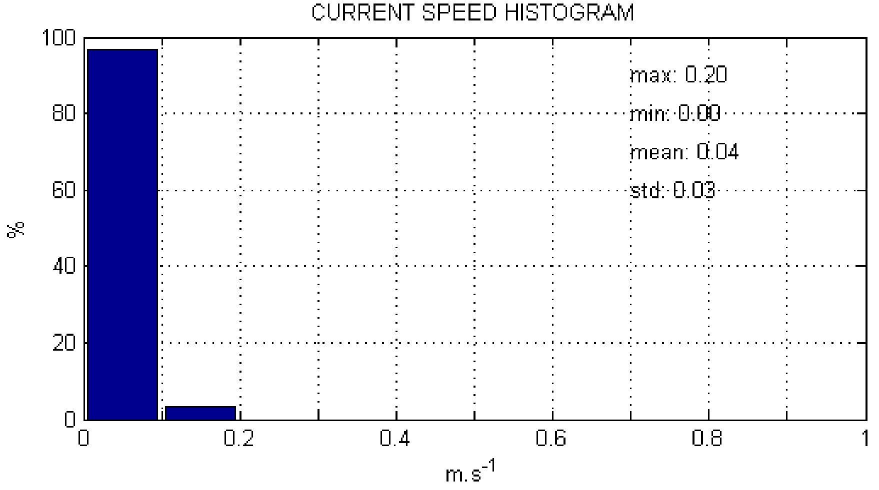


Figure 8: Summary plot for 10m ADCP current data at 5.8m

Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at -1.2m depth
2517 good observations
27-Mar-2008 13:26:32 - 16-Apr-2008 15:06:27

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	5.05	4.49	3.38	1.51	1.15	1.31	0.95	1.39	1.19	1.75	2.70	2.86	2.74	2.42	2.34	3.73	38.97
0.1-0.2	3.85	5.05	2.30	1.19	0.60	1.27	0.99	1.47	0.83	0.95	2.15	2.26	2.11	5.72	5.88	4.93	41.56
0.2-0.3	1.15	0.20	0.72	1.31	0.75	0.52	0.08	0.91	1.51	1.11	0.68	0.24	0.20	1.83	1.95	1.95	15.10
0.3-0.4			0.20	0.36	0.28	0.28	0.04	0.32	1.51	0.56	0.08	0.04	0.04		0.04	0.04	3.77
0.4-0.5					0.16			0.04	0.08	0.32							0.60
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	10.05	9.73	6.60	4.37	2.94	3.38	2.07	4.13	5.13	4.69	5.60	5.40	5.09	9.97	10.21	10.65	100.00

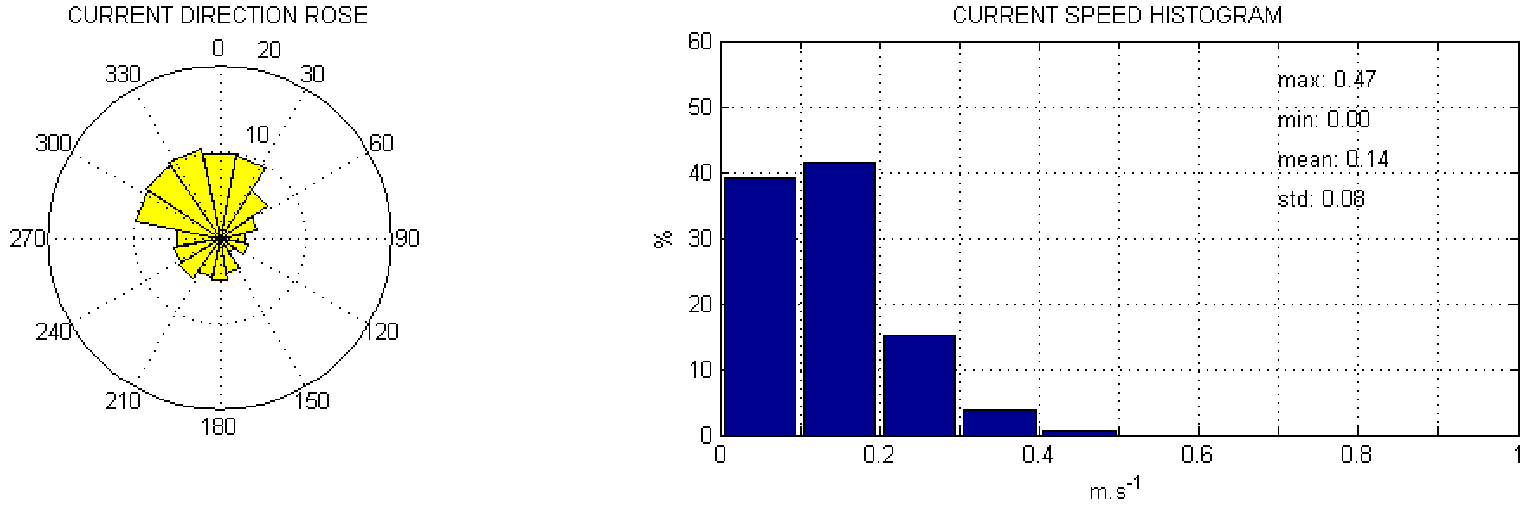


Figure 9: Summary plot for 10m ADCP current data at 1.2m

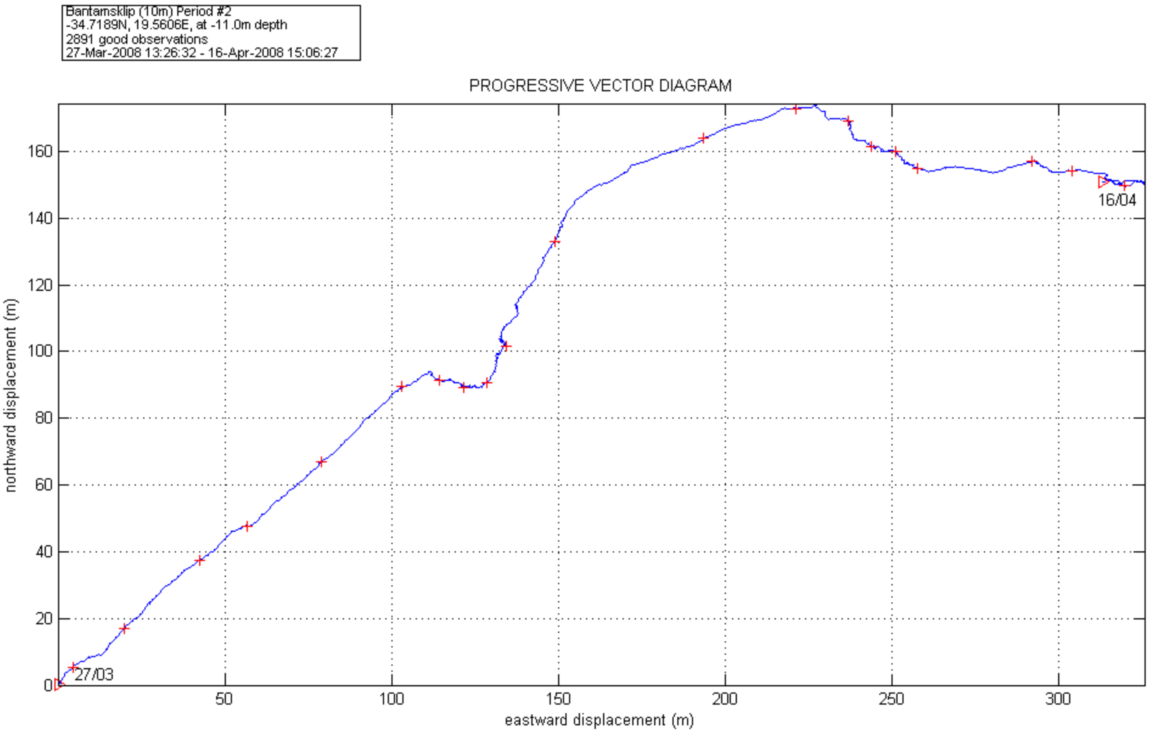


Figure 10: Progressive vector plot for 10m ADCP current data at 11.0m

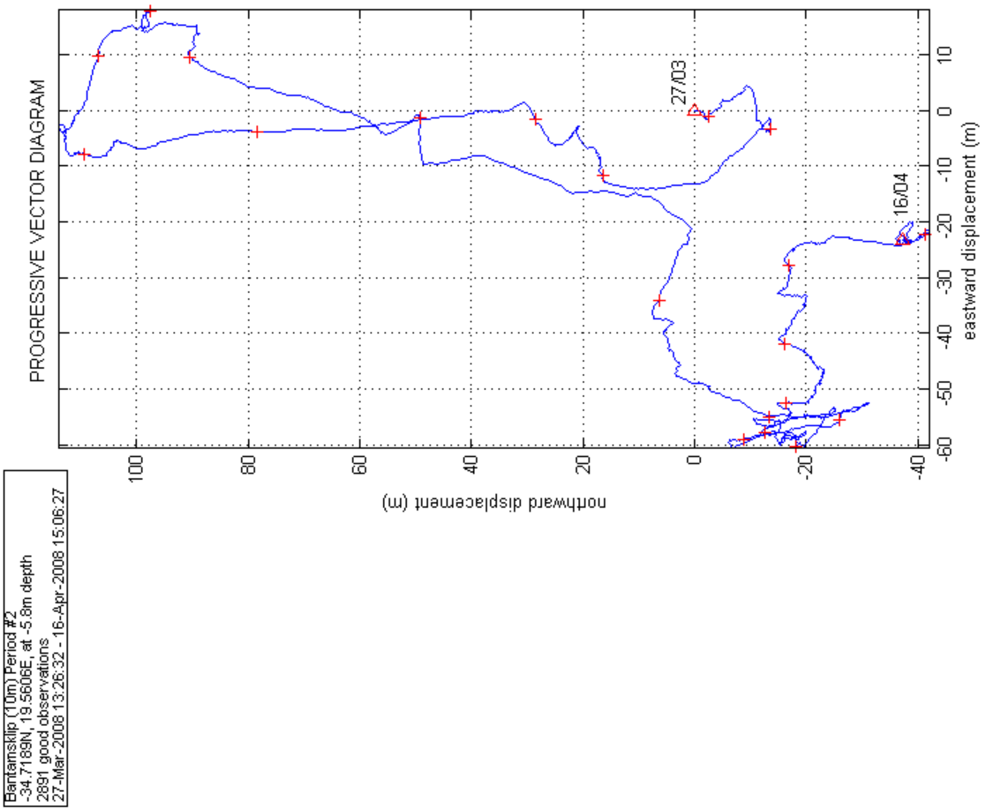


Figure 11: Progressive vector plot for 10m ADCP current data at 5.8m

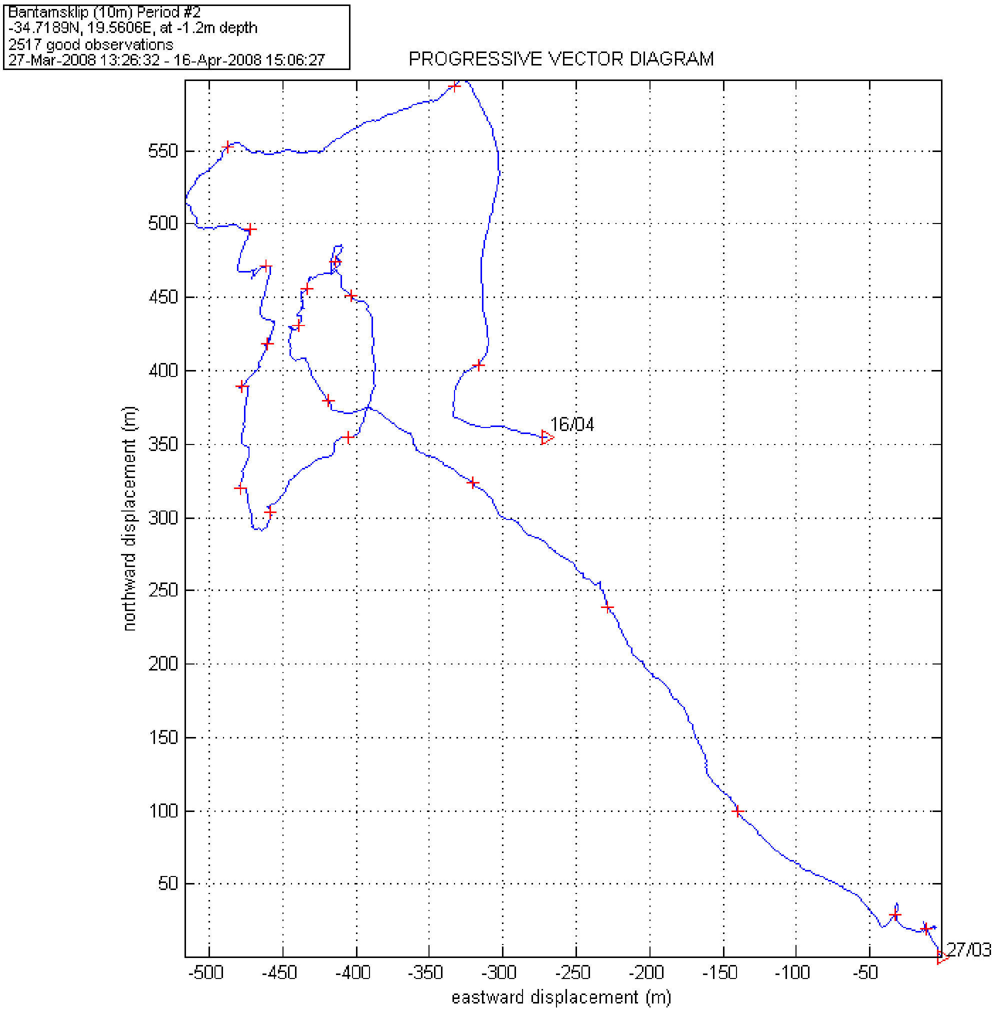


Figure 12: Progressive vector plot for 10m ADCP current data at 1.2m

5.1.2 Wave Data.

5.1.2.1 Hs and Tp summary plot

Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.2 Hs and Dp summary plot

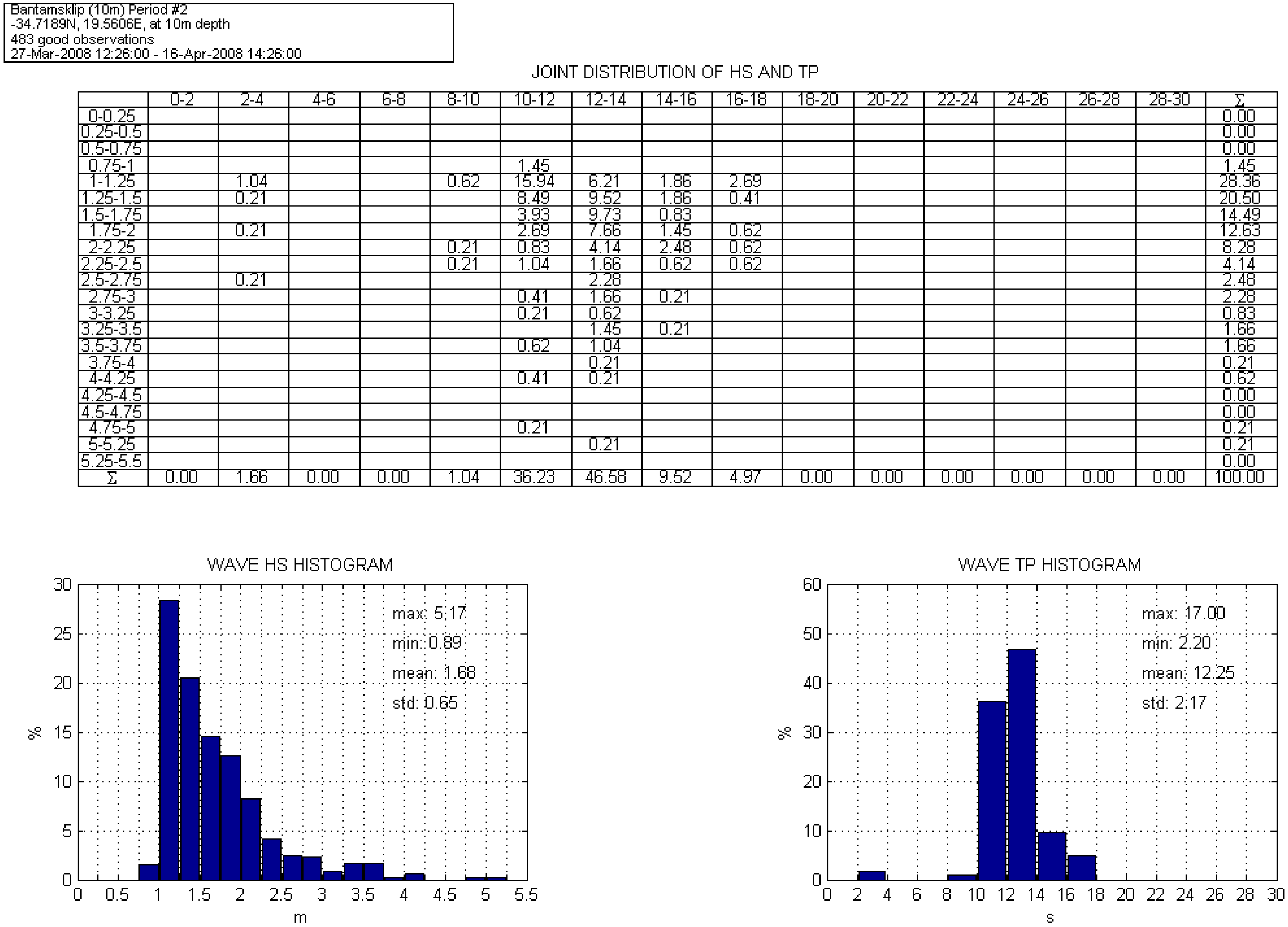
Figure 14 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.3 Tp and Dp summary plot

Figure 15 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.



Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at 10m depth
483 good observations
27-Mar-2008 12:26:00 - 16-Apr-2008 14:26:00

JOINT DISTRIBUTION OF HS AND TP

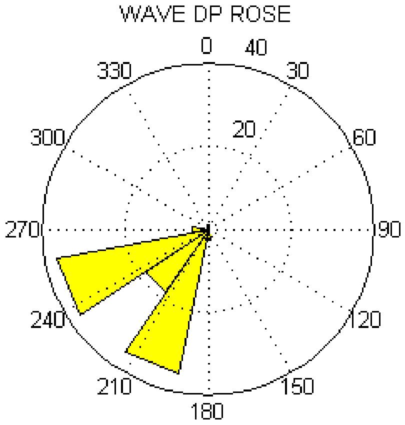
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1						1.45										1.45
1-1.25		1.04			0.62	15.94	6.21	1.86	2.69							28.36
1.25-1.5		0.21				8.49	9.52	1.86	0.41							20.50
1.5-1.75						3.93	9.73	0.83								14.49
1.75-2		0.21				2.69	7.66	1.45	0.62							12.63
2-2.25					0.21	0.83	4.14	2.48	0.62							8.28
2.25-2.5					0.21	1.04	1.66	0.62	0.62							4.14
2.5-2.75		0.21					2.28									2.48
2.75-3						0.41	1.66	0.21								2.28
3-3.25						0.21	0.62									0.83
3.25-3.5							1.45	0.21								1.66
3.5-3.75						0.62	1.04									1.66
3.75-4							0.21									0.21
4-4.25						0.41	0.21									0.62
4.25-4.5																0.00
4.5-4.75																0.00
4.75-5						0.21										0.21
5-5.25							0.21									0.21
5.25-5.5																0.00
Σ	0.00	1.66	0.00	0.00	1.04	36.23	46.58	9.52	4.97	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Figure 13: Summary plot of H_s and T_p.

Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at 10m depth
483 good observations
27-Mar-2008 12:26:00 - 16-Apr-2008 14:26:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1										1.24	0.21						1.45
1-1.25	0.21									10.56	3.93	12.01	1.66				28.36
1.25-1.5										9.94	4.76	5.59	0.21				20.50
1.5-1.75	0.21							0.21	0.41	4.97	2.69	5.80	0.21				14.49
1.75-2								0.21	1.24	5.18	1.86	3.31	0.21	0.21		0.41	12.63
2-2.25									0.41	1.24	2.28	3.93	0.41				8.28
2.25-2.5									0.21	0.41	0.83	2.28	0.41				4.14
2.5-2.75										0.62		1.66	0.21				2.48
2.75-3	0.21						0.21			0.41	0.41	1.04					2.28
3-3.25							0.21				0.21	0.41					0.83
3.25-3.5										0.21	0.41	0.62	0.21			0.21	1.66
3.5-3.75	0.21									0.41	0.62	0.21	0.21				1.66
3.75-4												0.21					0.21
4-4.25										0.41	0.21						0.62
4.25-4.5																	0.00
4.5-4.75																	0.00
4.75-5									0.21								0.21
5-5.25									0.21								0.21
5.25-5.5																	0.00
Σ	0.83	0.00	0.00	0.00	0.00	0.00	0.41	0.41	2.69	35.61	18.43	37.06	3.73	0.21	0.00	0.62	100.00



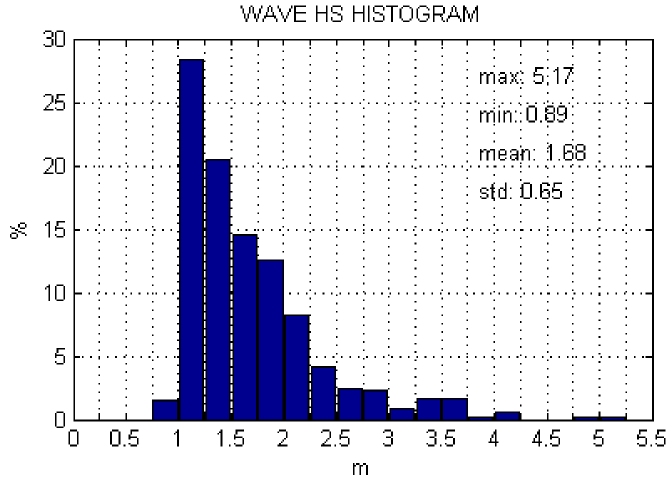


Figure 14: Summary plot of H_s and D_p.

Bantamsklip (10m) Period #2
-34.7189N, 19.5606E, at 10m depth
483 good observations
27-Mar-2008 12:26:00 - 16-Apr-2008 14:26:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4	0.21									1.24	0.21						1.66
4-6																	0.00
6-8																	0.00
8-10											0.41	0.62					1.04
10-12							0.41		0.21	14.70	5.80	14.49	0.62				36.23
12-14	0.62							0.41	1.86	18.22	9.73	14.08	1.45	0.21			46.58
14-16									0.62	1.24	1.24	4.76	1.04			0.62	9.52
16-18										0.21	1.04	3.11	0.62				4.97
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.83	0.00	0.00	0.00	0.00	0.00	0.41	0.41	2.69	35.61	18.43	37.06	3.73	0.21	0.00	0.62	100.00

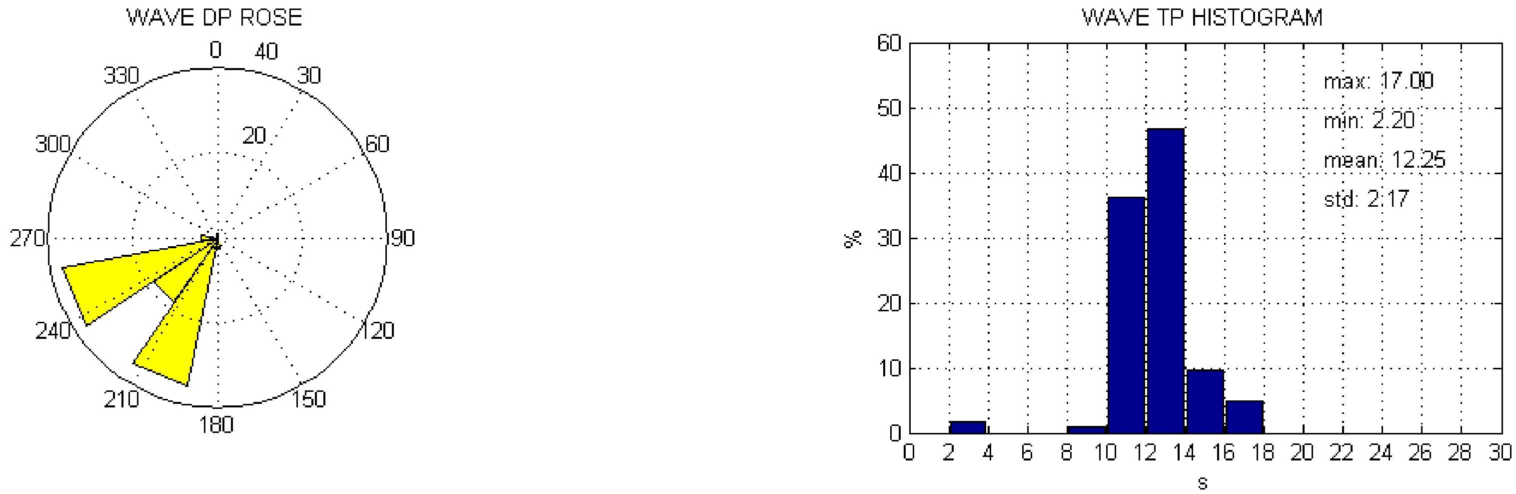
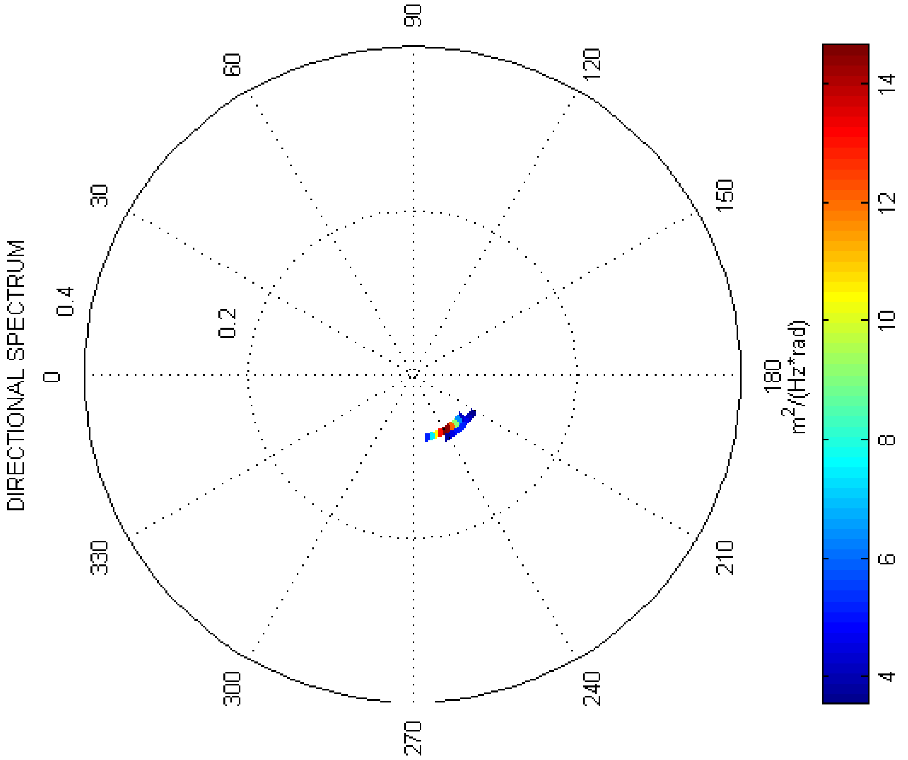


Figure 15: Summary plot of T_p and D_p.

5.1.2.4 Wave spectral plot

Figure 16 and Figure 17 display wave spectral plots for significant waves events. The time of each spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.



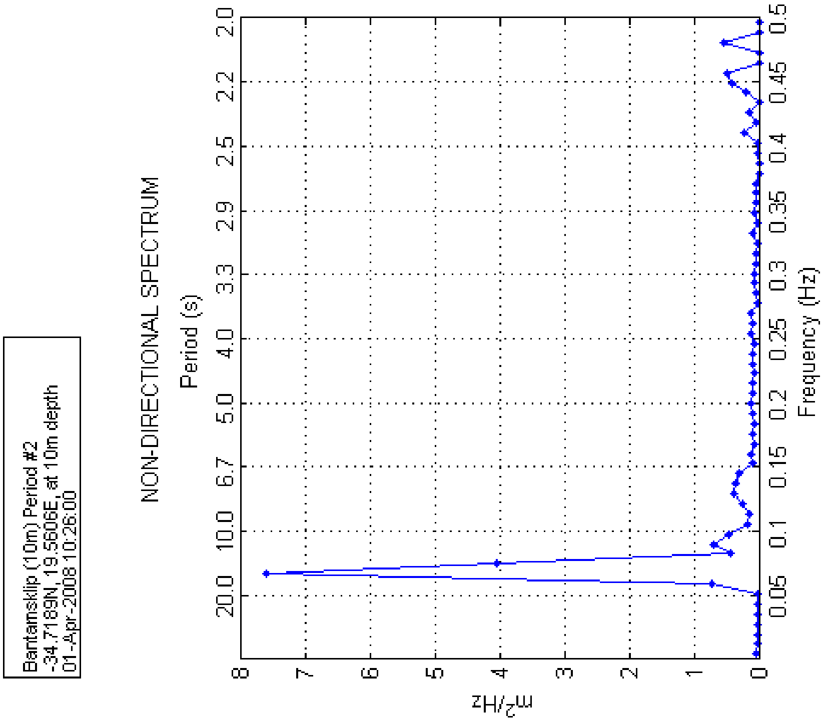


Figure 16: Wave spectra for 1st of April 2008 at 10:26:00.

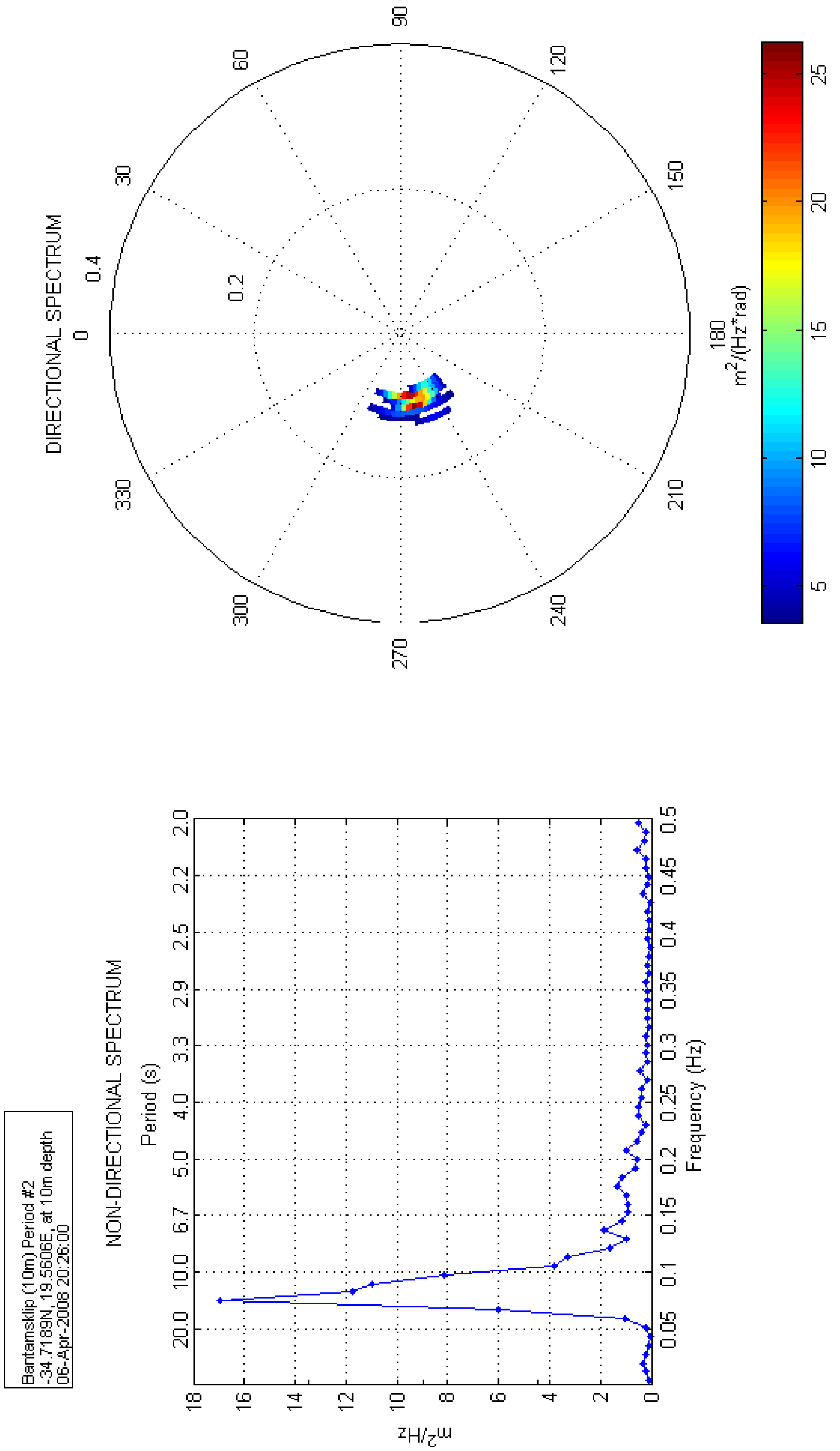


Figure 17: Wave spectra for 6th of April 2008 at 20:26:00.

5.2 30M ADCP

5.2.1 Current Data

5.2.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

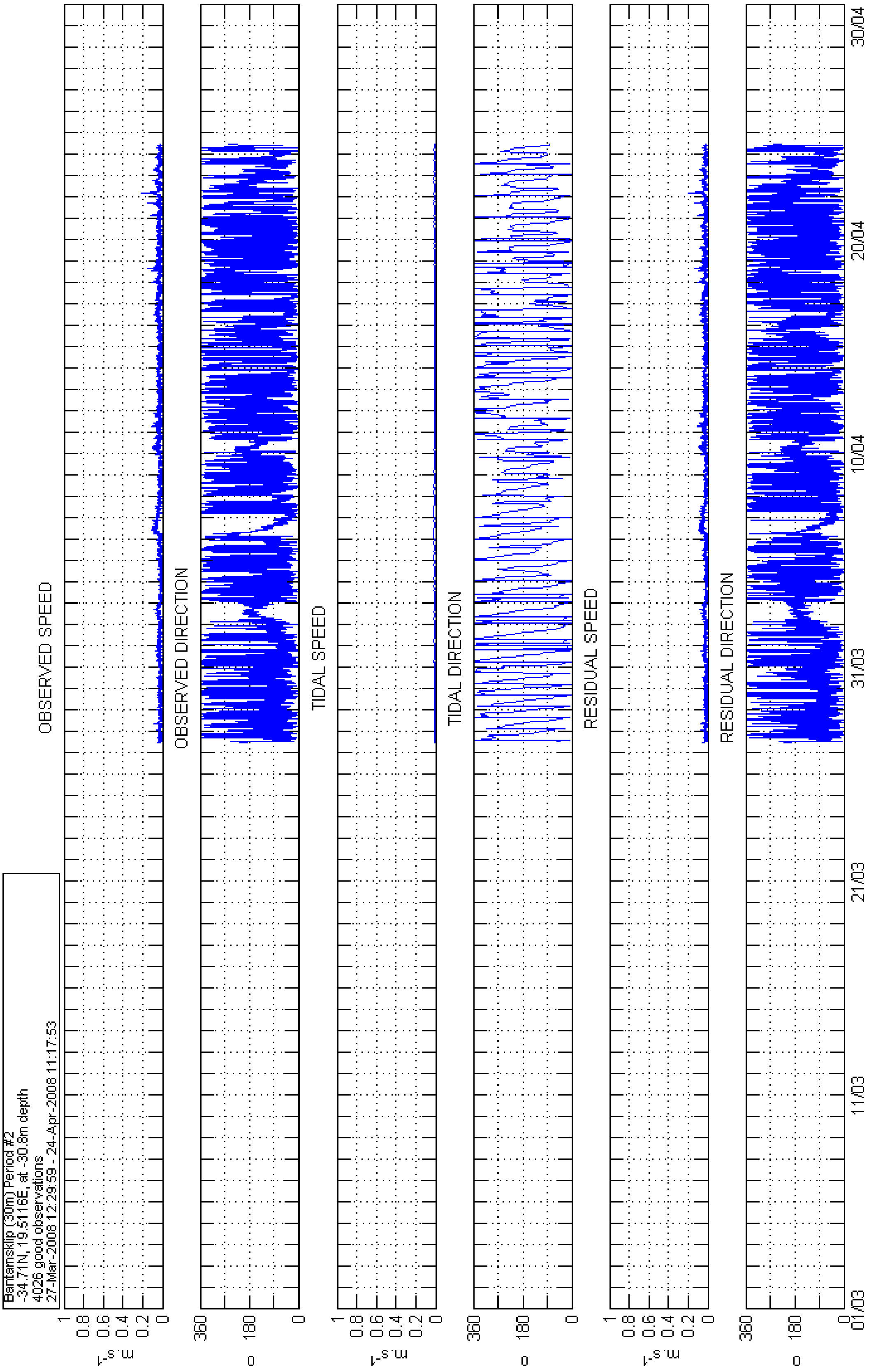


Figure 18: Time series plot for 30m ADCP current data at 30.8m

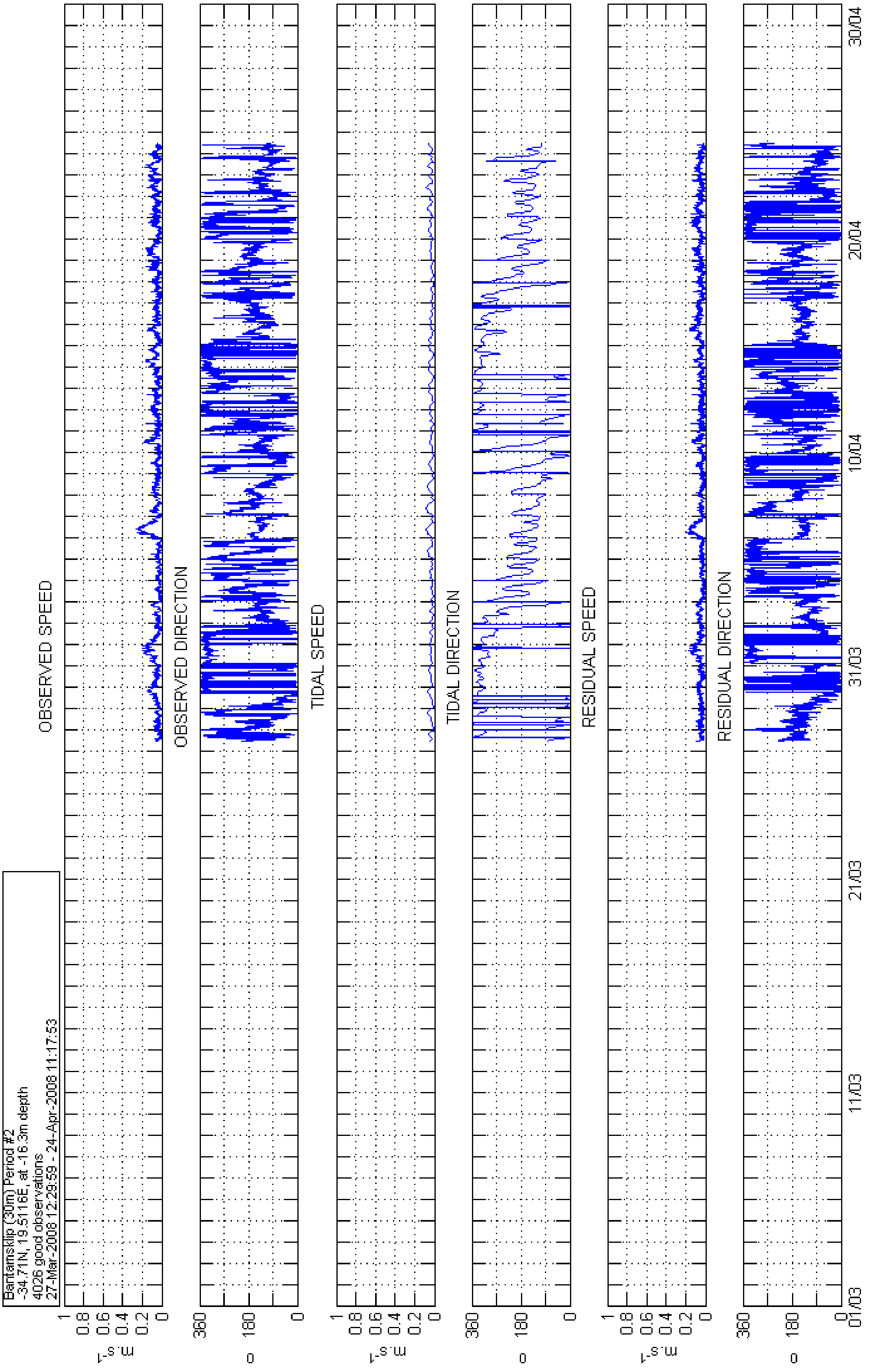


Figure 19: Time series plot for 30m ADCP current data at 16.3m

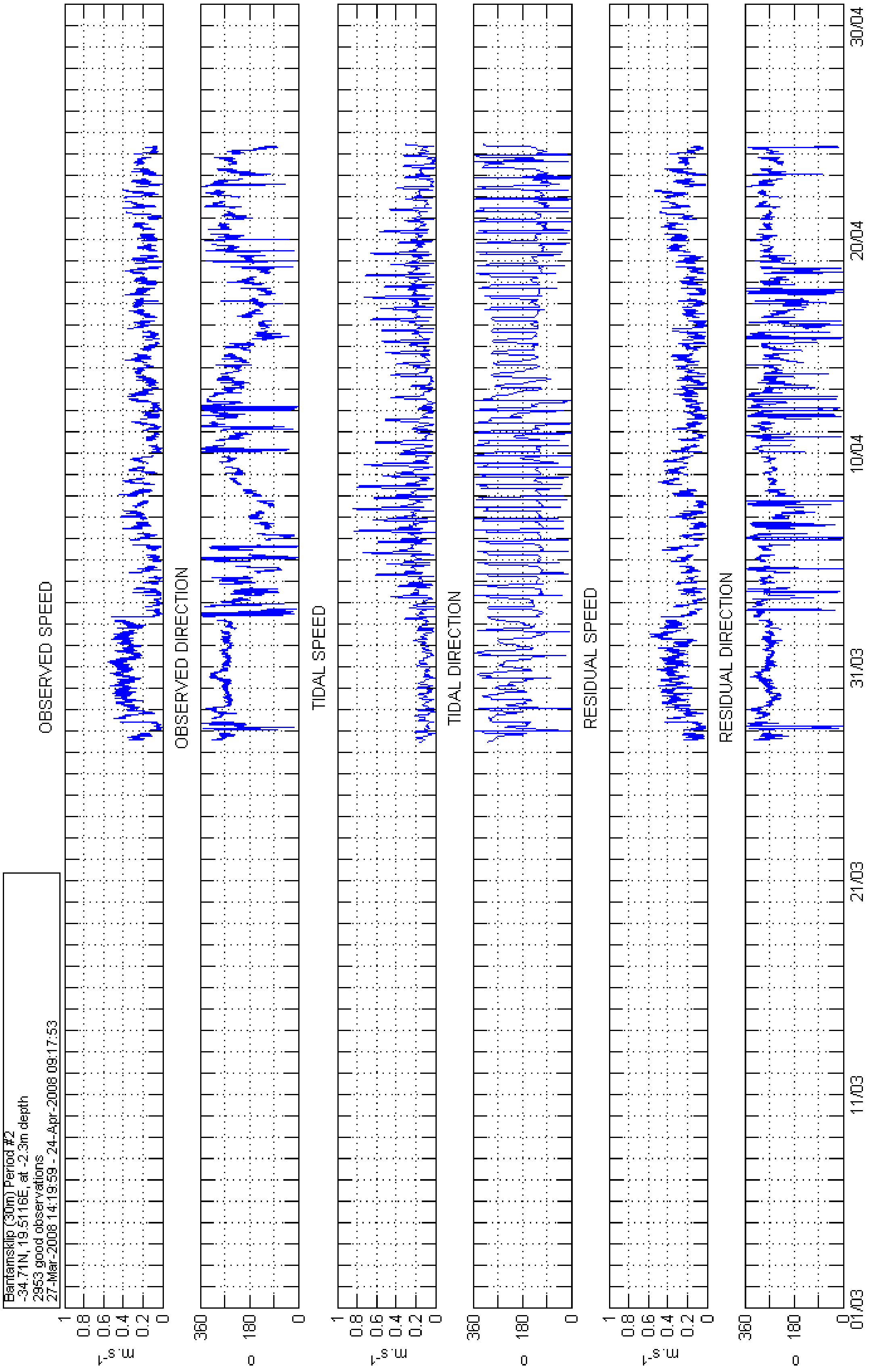


Figure 20: Time series plot for 30m ADCP current data at 2.3m

5.2.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.2.1.3 Progressive vector plots

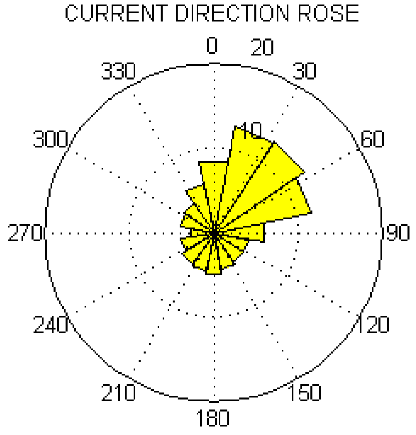
The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at -30.8m depth
4026 good observations
27-Mar-2008 12:29:59 - 24-Apr-2008 11:17:53

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	8.45	12.84	12.87	11.77	5.99	4.20	4.22	4.40	5.02	4.60	4.17	3.97	2.73	4.02	4.25	5.96	99.45
0.1-0.2			0.02				0.02	0.02		0.07	0.32				0.02		0.50
0.2-0.3											0.05						0.05
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	8.45	12.84	12.89	11.77	5.99	4.20	4.25	4.42	5.02	4.67	4.55	3.97	2.73	4.02	4.27	5.96	100.00



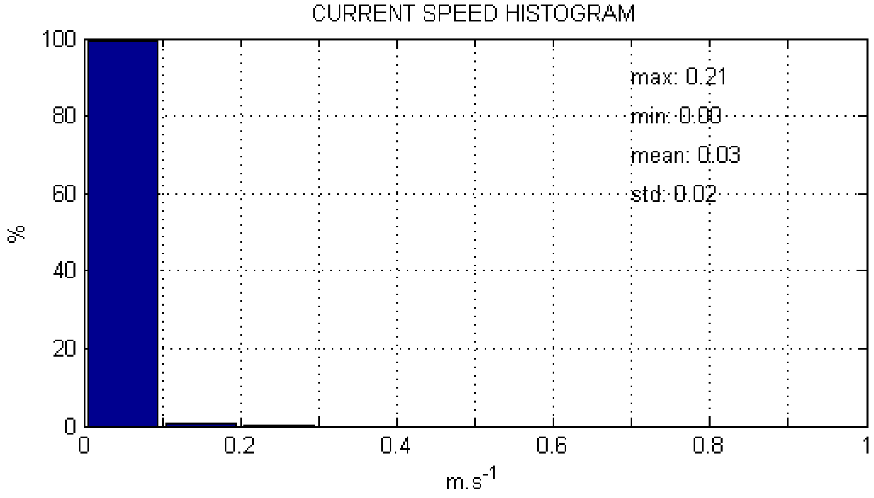
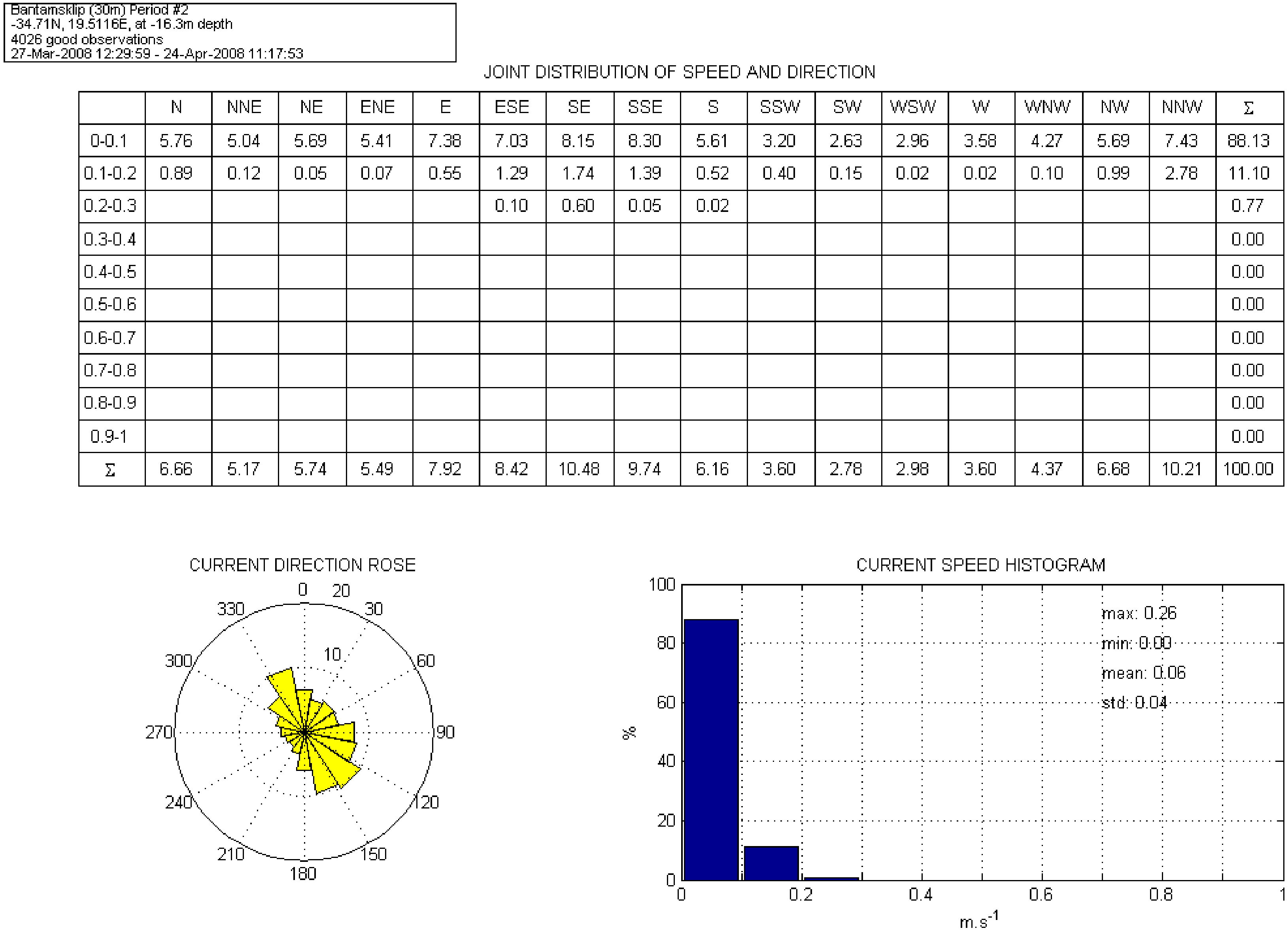


Figure 21: Summary plot for 30m ADCP current data at 30.8m



Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at -16.3m depth
4026 good observations
27-Mar-2008 12:29:59 - 24-Apr-2008 11:17:53

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	5.76	5.04	5.69	5.41	7.38	7.03	8.15	8.30	5.61	3.20	2.63	2.96	3.58	4.27	5.69	7.43	88.13
0.1-0.2	0.89	0.12	0.05	0.07	0.55	1.29	1.74	1.39	0.52	0.40	0.15	0.02	0.02	0.10	0.99	2.78	11.10
0.2-0.3						0.10	0.60	0.05	0.02								0.77
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	6.66	5.17	5.74	5.49	7.92	8.42	10.48	9.74	6.16	3.60	2.78	2.98	3.60	4.37	6.68	10.21	100.00

Figure 22: Summary plot for 30m ADCP current data at 16.3m

Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at -2.3m depth
2953 good observations
27-Mar-2008 14:19:59 - 24-Apr-2008 09:17:53

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.08	0.47	0.58	0.51	0.78	1.12	0.98	1.15	1.49	2.44	3.83	2.27	1.66	1.66	1.39	1.05	22.45
0.1-0.2	0.17	0.14	0.34	0.68	0.54	1.79	2.27	1.46	2.17	2.44	3.59	4.00	3.22	2.68	1.39	0.41	27.26
0.2-0.3			0.07	0.17	0.54	2.34	2.54	2.54	1.29	1.25	2.95	4.44	3.32	3.05	1.35	0.61	26.45
0.3-0.4					0.07	0.58	0.64	0.54	0.30	0.24	0.95	4.13	5.38	1.46	1.25	0.20	15.75
0.4-0.5								0.14			0.07	2.61	3.12	0.37	1.08		7.38
0.5-0.6												0.27	0.27	0.07	0.10		0.71
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	1.25	0.61	0.98	1.35	1.93	5.82	6.43	5.82	5.25	6.37	11.38	17.71	16.97	9.28	6.57	2.27	100.00

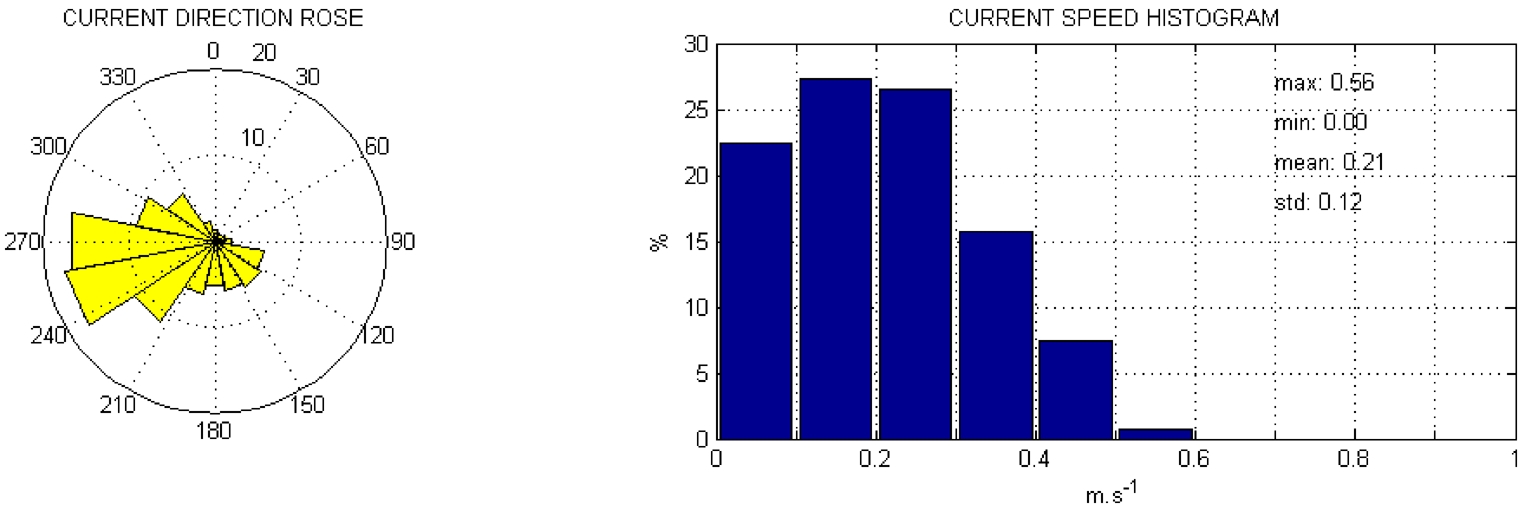


Figure 23: Summary plot for 30m ADCP current data at 2.3m

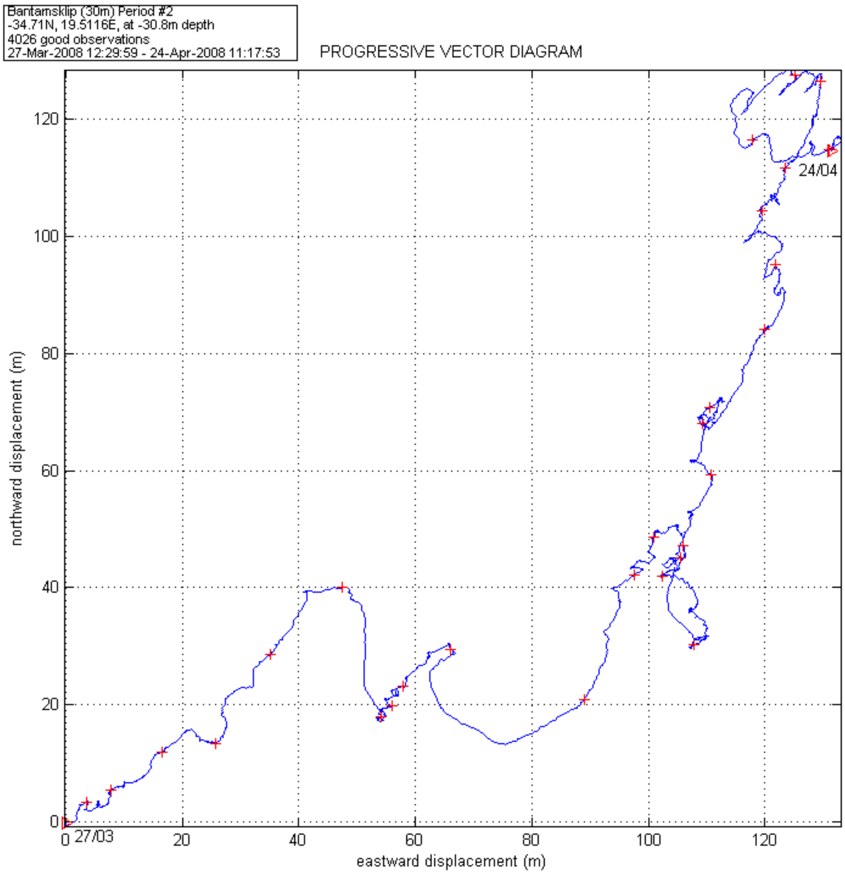


Figure 24: Progressive vector plot for 30m ADCP current data at 30.8m

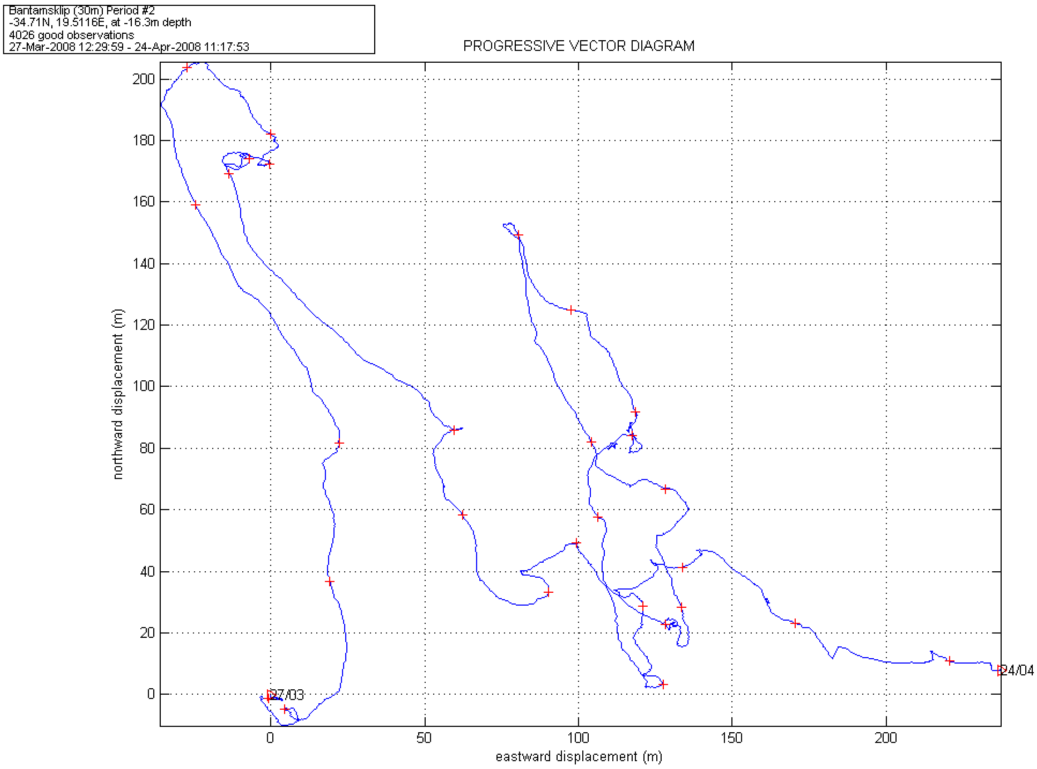


Figure 25: Progressive vector plot for 30m ADCP current data at 16.3m

Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at -2.3m depth
2953 good observations
27-Mar-2008 14:19:59 - 24-Apr-2008 09:17:53

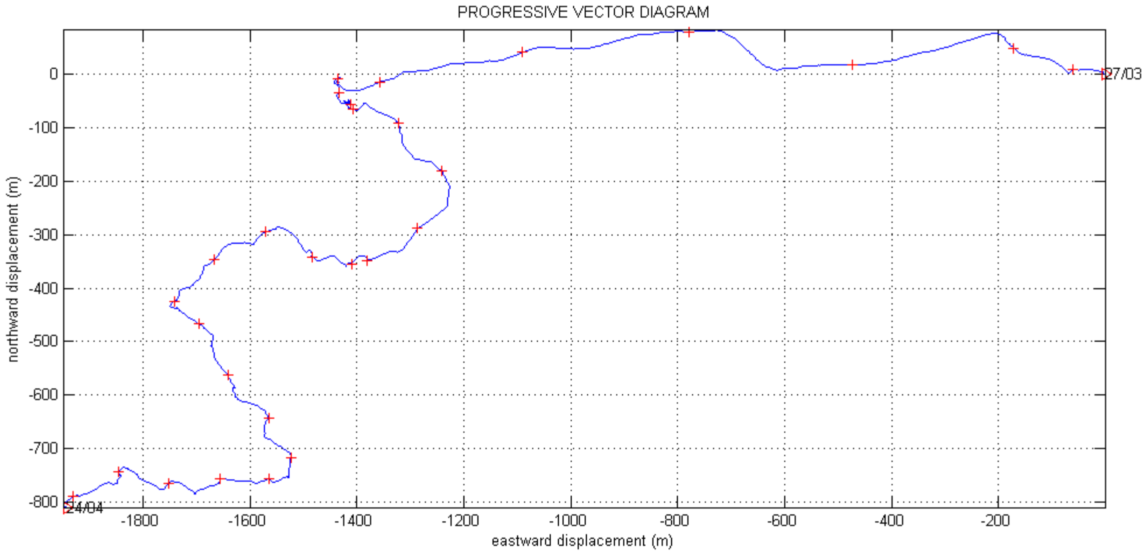


Figure 26: Progressive vector plot for 30m ADCP current data at 2.3m

5.2.2 Wave Data.

5.2.2.1 Hs and Tp summary plot

Figure 27 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.2.2.2 Hs and Dp summary plot

Figure 28 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.2.2.3 Tp and Dp summary plot

Figure 29 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at 30m depth
672 good observations
27-Mar-2008 12:00:00 - 24-Apr-2008 11:00:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1						0.30	0.15									0.45
1-1.25		0.15				4.32	3.42	0.15								8.04
1.25-1.5			0.15		0.89	9.23	5.95	1.34	0.89	0.45						18.90
1.5-1.75					0.89	5.80	7.44	1.04	0.89							16.07
1.75-2					0.30	2.83	6.40	1.49								11.01
2-2.25				0.30	0.30	1.49	4.61	0.89	0.15							7.74
2.25-2.5					0.30	2.53	4.32	1.04	0.74							8.93
2.5-2.75				0.15	0.15	1.19	3.57	1.34	0.30							6.70
2.75-3						1.49	2.98	0.89	0.15							5.51
3-3.25					0.60	0.89	1.93	0.89	0.30							4.61
3.25-3.5						0.74	2.08	0.45								3.27
3.5-3.75					0.15	0.89	1.49		0.30							2.83
3.75-4						0.15	0.89	0.15	0.30							1.49
4-4.25						0.15	0.89	0.30								1.34
4.25-4.5						0.30	0.89	0.30								1.49
4.5-4.75						0.30	0.89									1.19
4.75-5							0.15									0.15
5-5.25							0.15									0.15
5.25-5.5																0.00
5.5-5.75																0.00
5.75-6								0.15								0.15
Σ	0.00	0.15	0.15	0.45	3.57	32.59	48.21	10.42	4.02	0.45	0.00	0.00	0.00	0.00	0.00	100.00

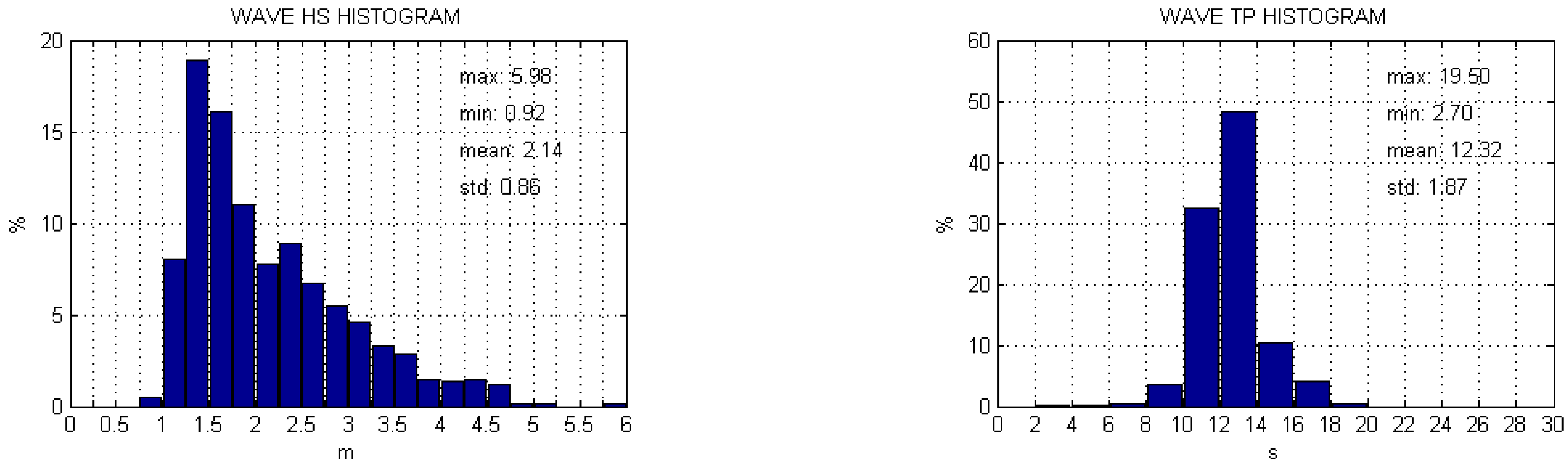
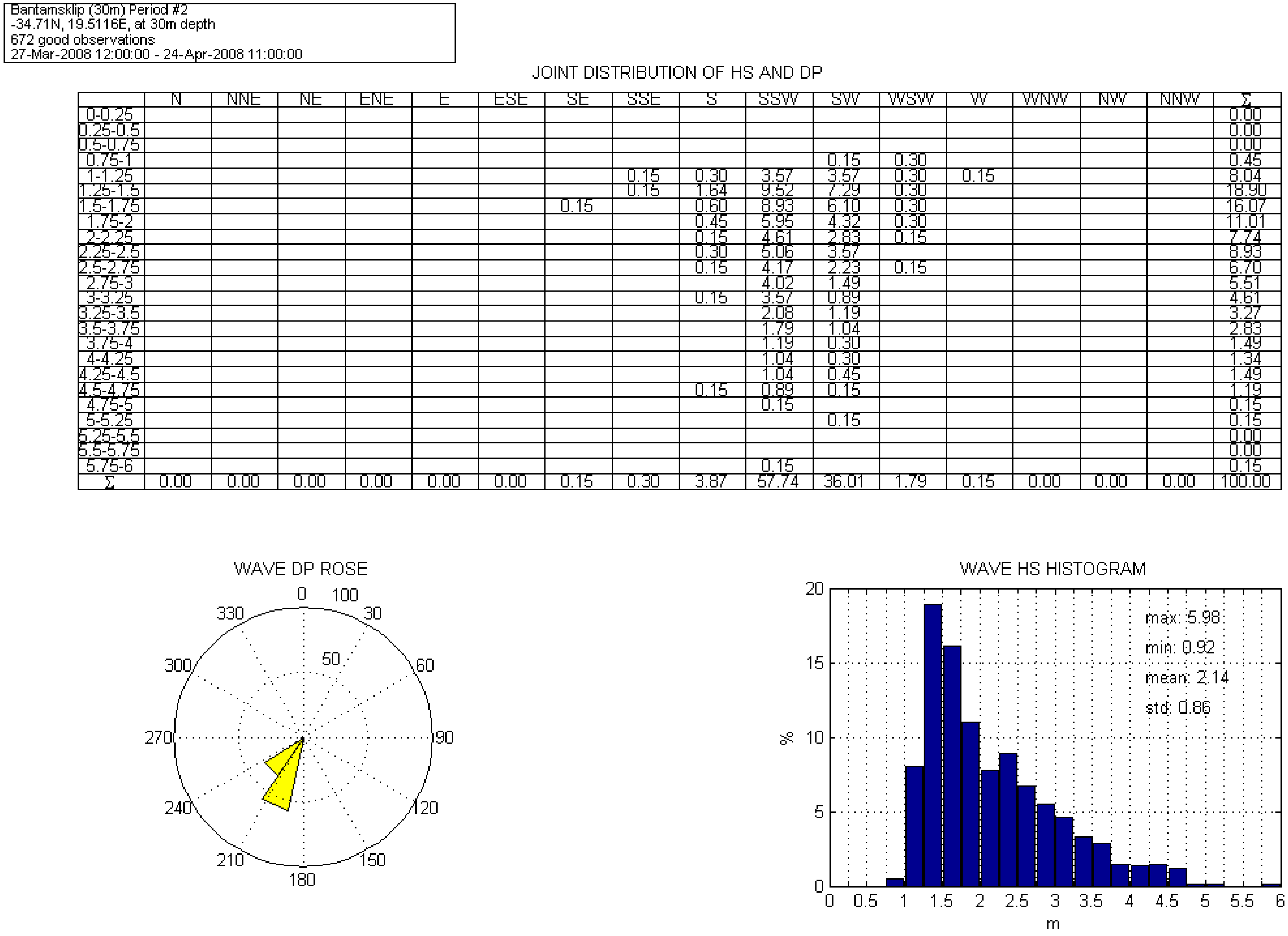


Figure 27: Summary plot of H_s and T_p.



Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at 30m depth
672 good observations
27-Mar-2008 12:00:00 - 24-Apr-2008 11:00:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1											0.15	0.30					0.45
1-1.25								0.15	0.30	3.57	3.57	0.30	0.15				8.04
1.25-1.5								0.15	1.64	9.52	7.29	0.30					18.90
1.5-1.75							0.15		0.60	8.93	6.10	0.30					16.07
1.75-2									0.45	5.95	4.32	0.30					11.01
2-2.25									0.15	4.61	2.83	0.15					7.74
2.25-2.5									0.30	5.06	3.57						8.93
2.5-2.75									0.15	4.17	2.23	0.15					6.70
2.75-3										4.02	1.49						5.51
3-3.25									0.15	3.57	0.89						4.61
3.25-3.5										2.08	1.19						3.27
3.5-3.75										1.79	1.04						2.83
3.75-4										1.19	0.30						1.49
4-4.25										1.04	0.30						1.34
4.25-4.5										1.04	0.45						1.49
4.5-4.75									0.15	0.89	0.15						1.19
4.75-5										0.15							0.15
5-5.25											0.15						0.15
5.25-5.5																	0.00
5.5-5.75																	0.00
5.75-6										0.15							0.15
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.30	3.87	57.74	36.01	1.79	0.15	0.00	0.00	0.00	100.00

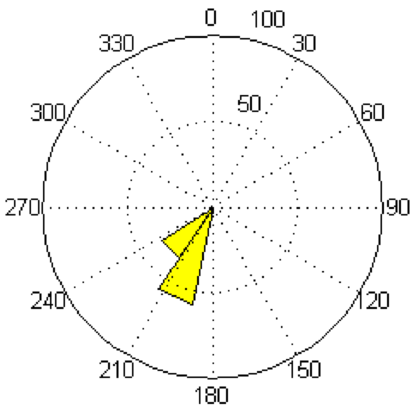
Figure 28: Summary plot of H_s and D_p.

Bantamsklip (30m) Period #2
-34.71N, 19.5116E, at 30m depth
672 good observations
27-Mar-2008 12:00:00 - 24-Apr-2008 11:00:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4											0.15						0.15
4-6										0.15							0.15
6-8										0.15	0.15	0.15					0.45
8-10									0.60	2.23	0.74						3.57
10-12							0.15	0.15	1.93	19.05	10.71	0.45	0.15				32.59
12-14								0.15	1.34	26.93	18.60	1.19					48.21
14-16										6.99	3.42						10.42
16-18										2.08	1.93						4.02
18-20										0.15	0.30						0.45
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.30	3.87	57.74	36.01	1.79	0.15	0.00	0.00	0.00	100.00

WAVE DP ROSE



WAVE TP HISTOGRAM

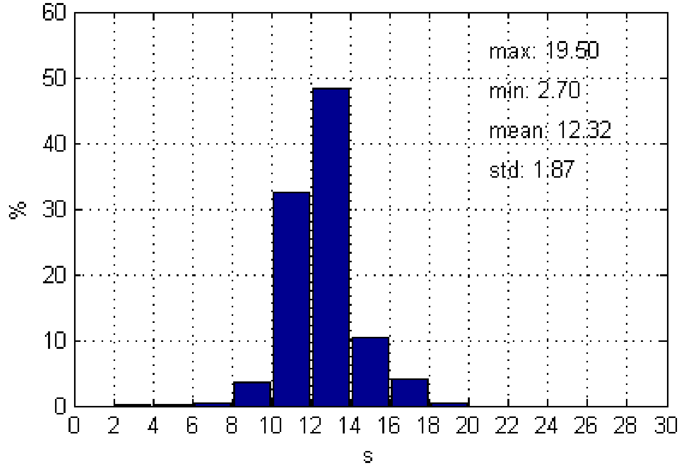


Figure 29: Summary plot of T_p and D_p.

5.2.2.4 Wave spectral plot

Figure 30 and Figure 31 display wave spectral plots for significant waves events. The time of each spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

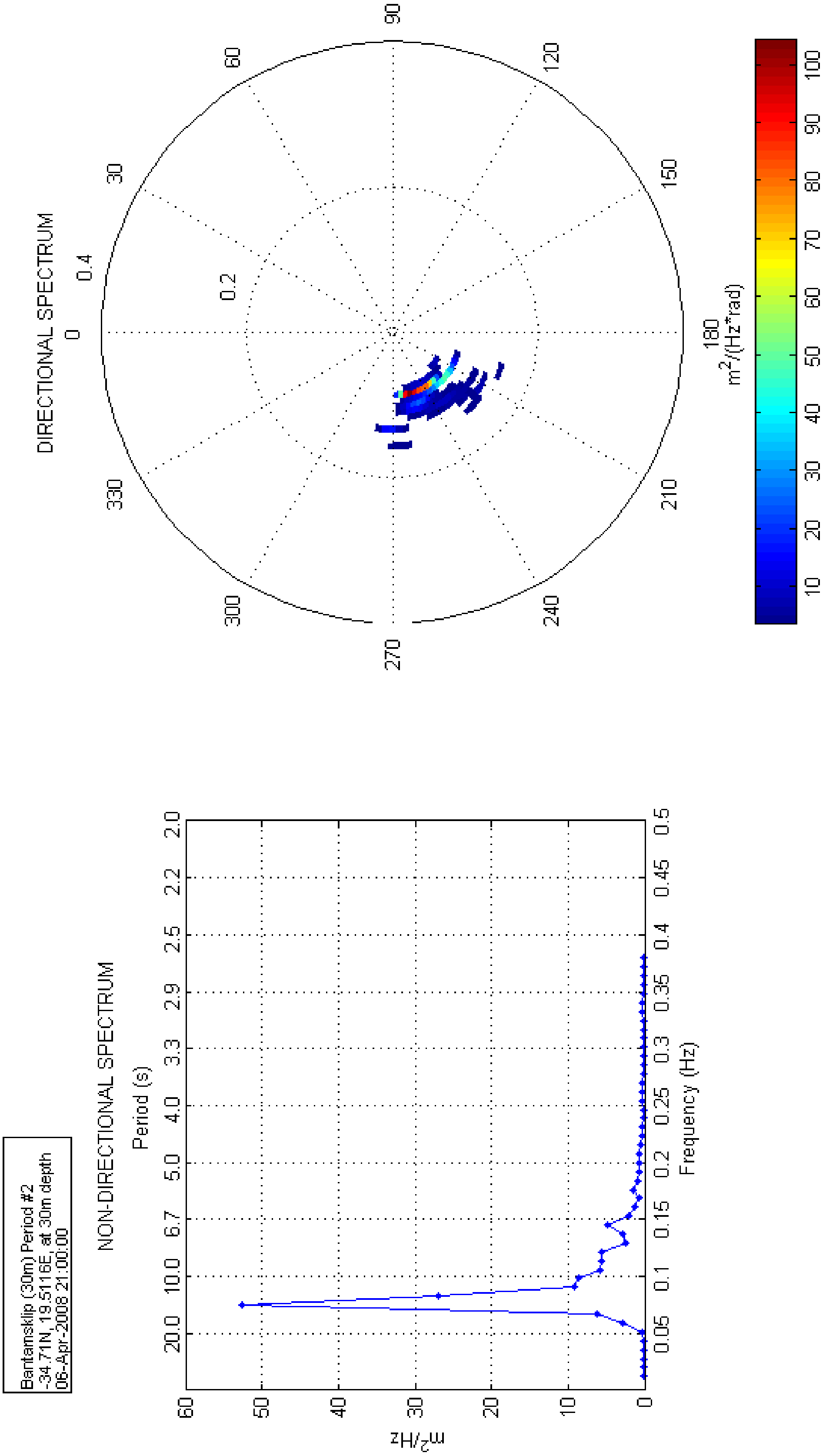


Figure 30: Wave spectra for 6th of April 2008 at 21:00:00.

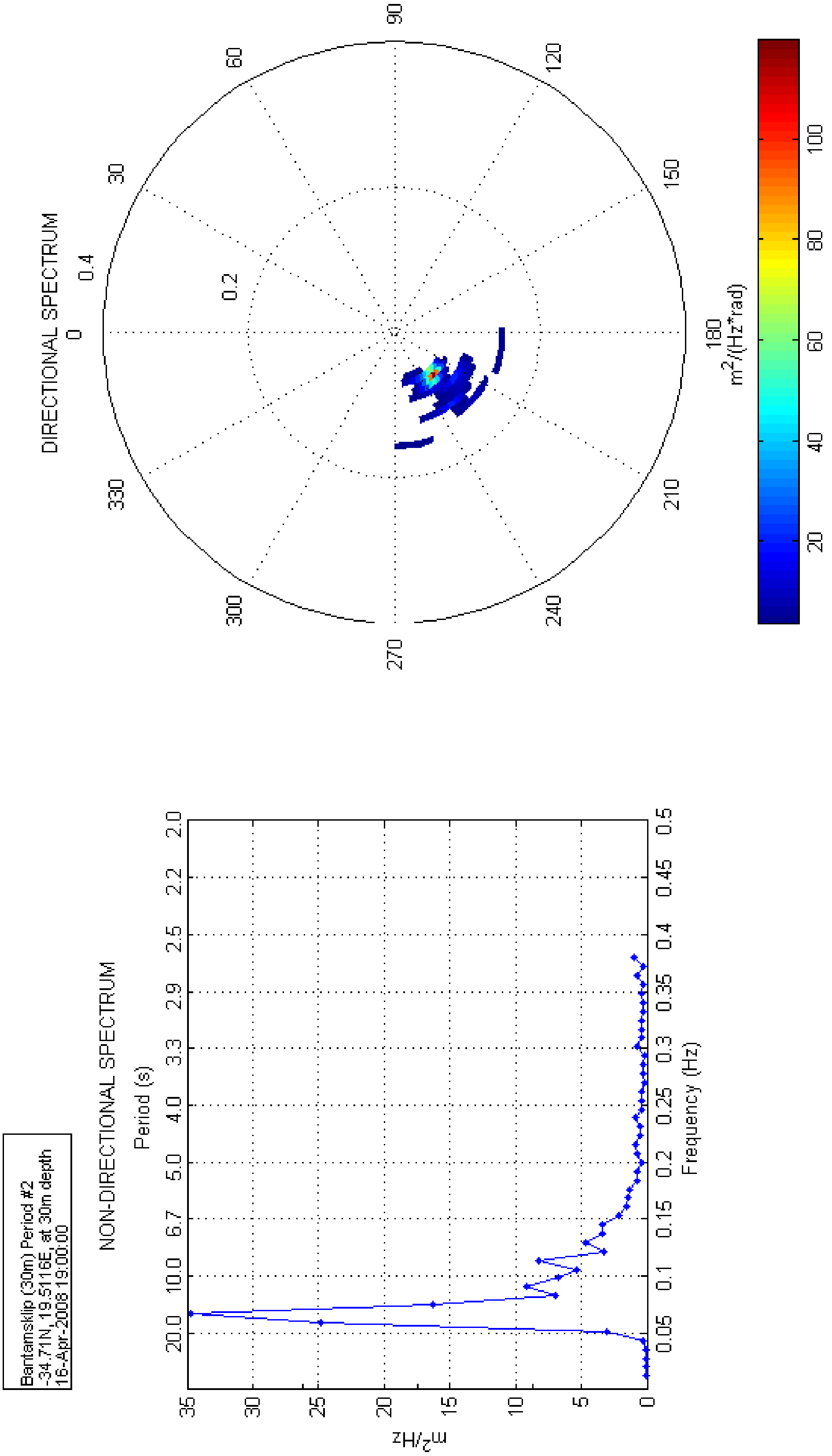


Figure 31: Wave spectra for 16th of April 2008 at 19:00:00.

5.3 COMPARISON PLOTS

5.3.1 Hs, Tp and Dp time series plots for 10m and 30m ADCPs.

Figure 32 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

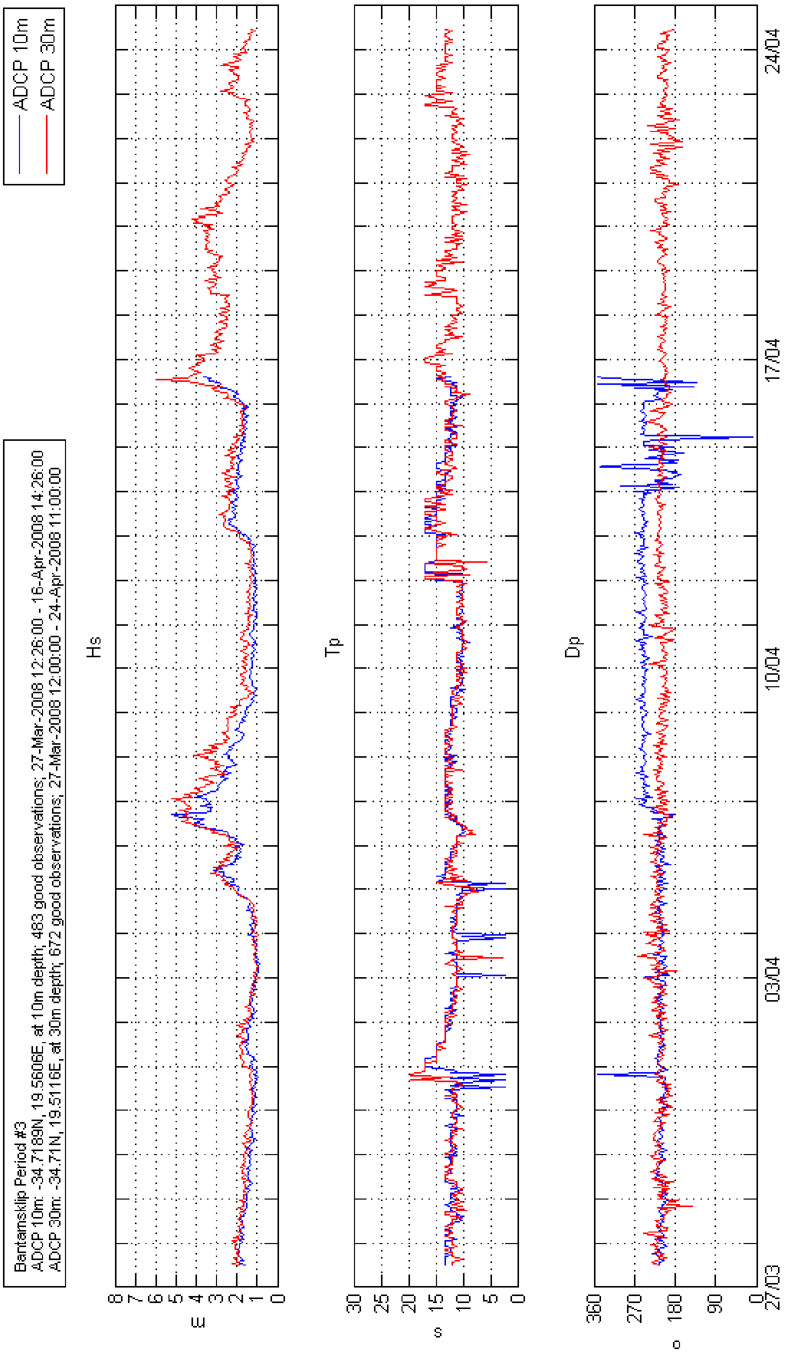


Figure 32: Wave Hs, Tp, and Dp for 10m and 30m ADCP.

5.3.2 Water properties: RBR-CT loggers and ADCPs temperature sensors.

Figure 33 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCP temperature sensor against time.
- The second panel is of the derived salinity from the two RBR loggers against time.

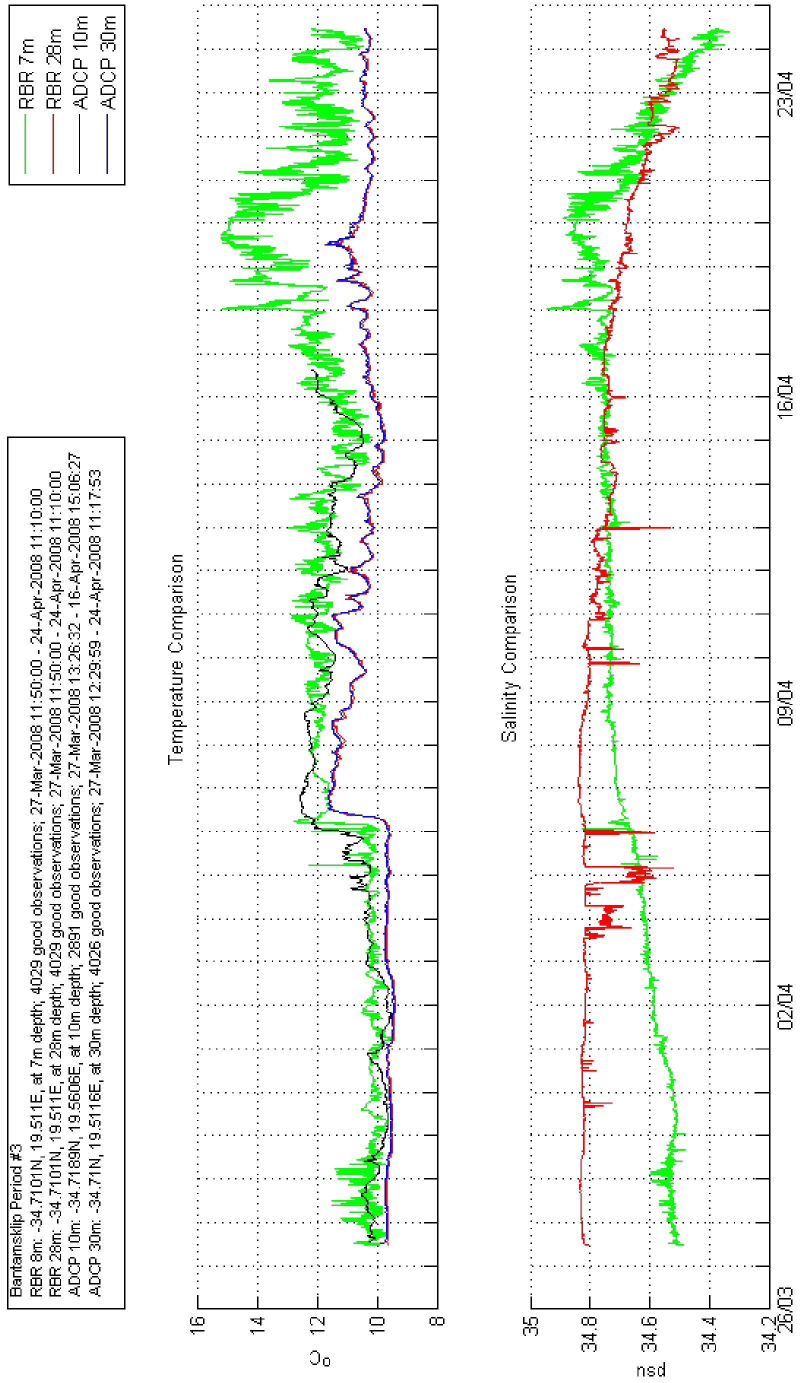


Figure 33: Time series of temperature and salinity from the RBR loggers and ADCPs.

6. DISCUSSION

The second set of oceanographic data collected off the coast of Bantamsklip for the period between March 27th and April 24th 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

At the Bantamsklip site, 2 600 kHz ADCP, 2 RBR-CT loggers and 1 RBR tide gauge have been deployed to measure currents, waves, water temperature and salinity and tidal record. The ADCP is fixed on a frame at ~10m and ~30m and the RBR loggers are moored at ~7m and ~28m below the surface. During recovery of the data, undertaken during April 24th – 25th 2008, it was found that the tide gauge was tampered with. This report presents data obtained from 2 ADCPs and 2 RBR-CT loggers. During the service visit, only the ADCPs were re-deployed on account of bad weather. The engineers went on site again on May 23rd 2008 to deploy the 2 RBR-CT loggers. A new tide gauge (RBR 2050 HT) was also installed.

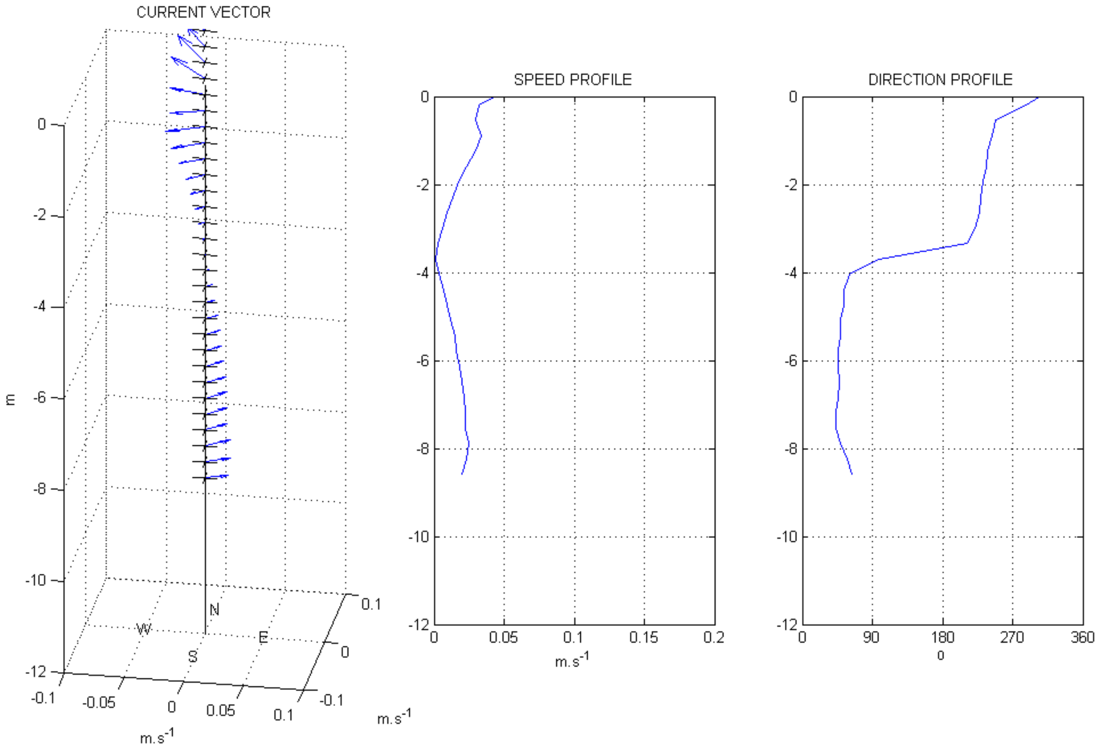


Figure 34: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.14ms^{-1}, decreasing to ~0.03ms^{-1} at 11m depth. The flow direction at the surface was predominantly towards the SW, while at depths below 4m, it was mainly towards the NE.

At the 30m site, the average flow at 2.3m was 0.21ms^{-1}, decreasing to 0.02ms^{-1} at 30.8m depth. The flow direction was variable throughout the water column.

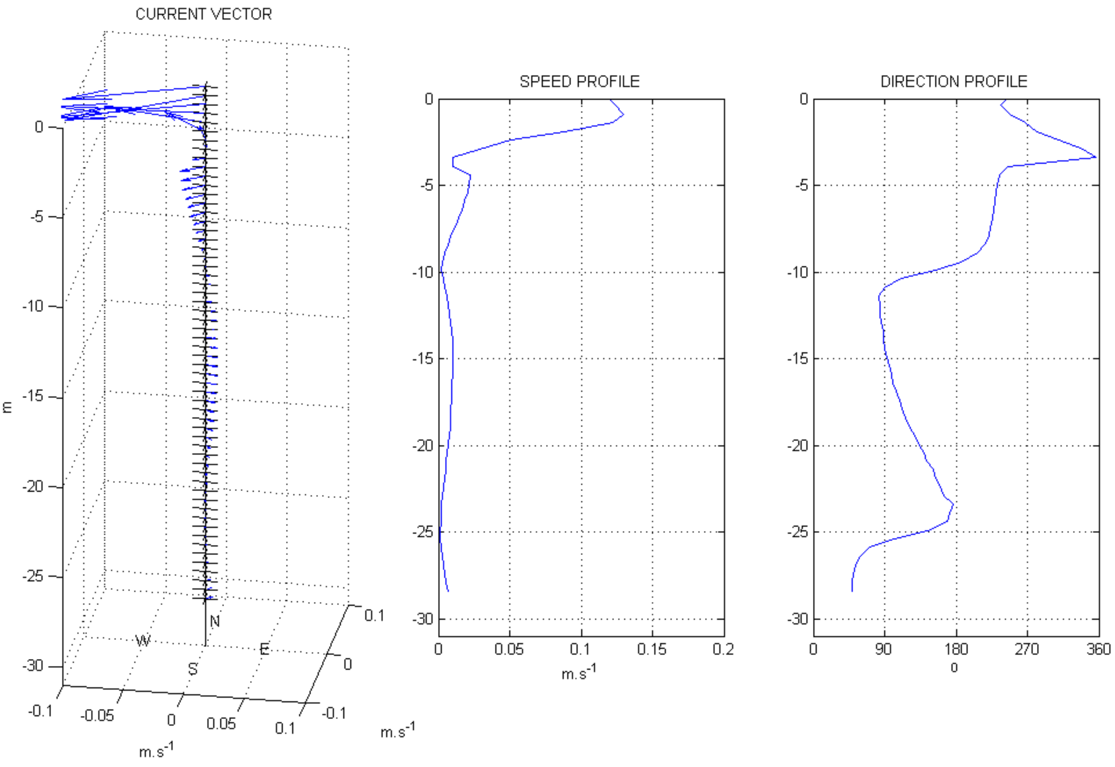


Figure 35: Mean profile plot for 30m ADCP.

Table 18: Mean wave parameters.

	Hs (m)	Tp (s)	Dp
10m ADCP	1.68	12.25	SW*
30m ADCP	2.14	12.32	SW

*The 10m ADCP attitude sensors showed a significant shift in the pitch after April 7th 2008 which may account for the sudden jump in the wave direction observed in Figure 32. Table 18 summarises the wave parameters for both ADCPs.

The temperature measured by the RBR-loggers and the corresponding ADCPs sensors were in good agreement.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT TWO

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code	NA
Acoustic release (2) serial number and release code	N/A
Argos beacon serial number	Platform ID ~~80804~~ 80801

2. RECOVERY

Instrument type and serial number		ROI	600kHz	10105*
Deployment name			BTK02	
Deployment date and time	[✓ LT]	GMT	27/03/08 07h24	
Deployment latitude\ northings			34° 43.187	
Deployment longitude\ eastings			19° 33.635	
Recovery information				
Recovery date and time	[✓ LT]	GMT	24/04/08 11h20	
Inspect the transducer faces for cuts or scratches			—	
Inspect the instrument for signs of flooding			Flooding on CART	
Switch off and download the instrument using WinSC				
Switch off date and time	[✓ LT]	GMT	24/04/08 ± 17h00	
Name of the data directory				
File size				

LWANDLE TECHNOLOGIES (PTY) LTD

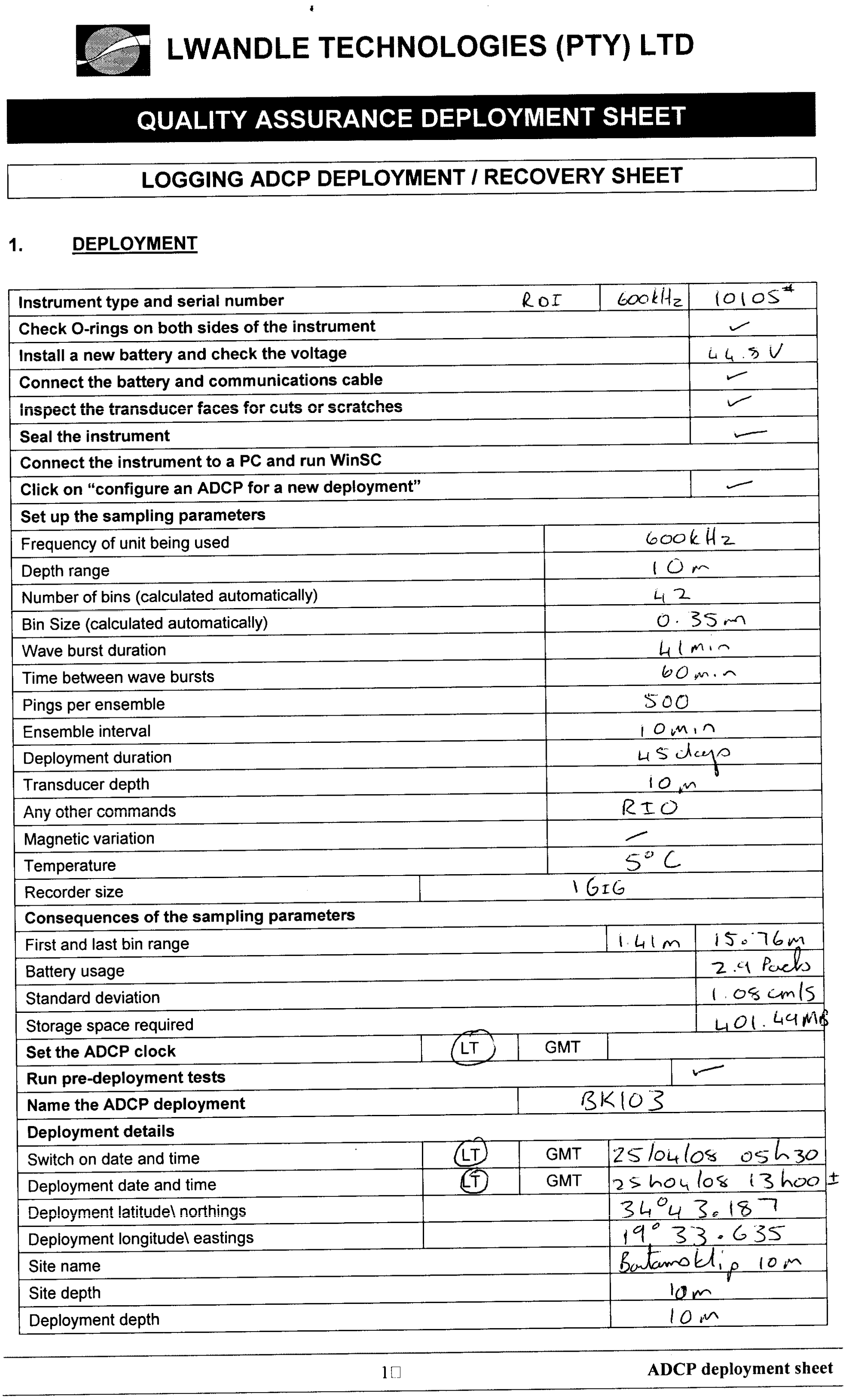
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code	—
Acoustic release (2) serial number and release code	—
Argos beacon serial number	ID 80803

2. RECOVERY

Instrument type and serial number		ROI	600kHz	10119
Deployment name				
Deployment date and time	[✓ LT]	GMT	27/03/08 07h00	
Deployment latitude\ northings			34°42.603	
Deployment longitude\ eastings			19° 30.696	
Recovery information				
Recovery date and time	[✓ LT]	GMT	24/04/08 17h20	
Inspect the transducer faces for cuts or scratches			✓ Fine	
Inspect the instrument for signs of flooding			Fine	
Switch off and download the instrument using WinSC				
Switch off date and time	[✓ LT]	GMT	24/04/08 17h00±	
Name of the data directory				
File size				



LWANDLE TECHNOLOGIES (PTY) LTD

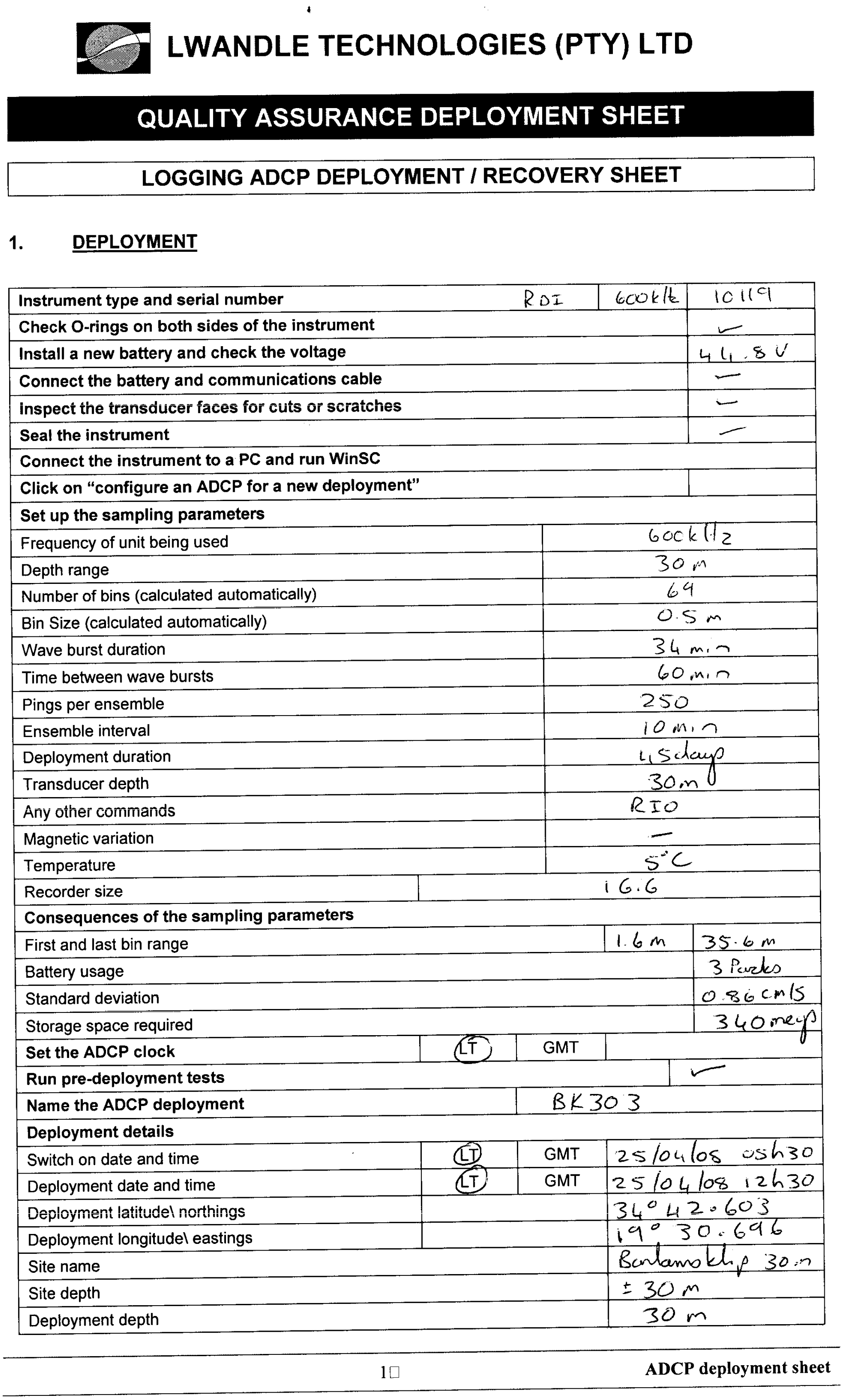
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number	ROI	600kHz	10105#
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.5V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			✓
Set up the sampling parameters			
Frequency of unit being used			600kHz
Depth range			10m
Number of bins (calculated automatically)			42
Bin Size (calculated automatically)			0.35m
Wave burst duration			41min
Time between wave bursts			60min
Pings per ensemble			500
Ensemble interval			10min
Deployment duration			45days
Transducer depth			10m
Any other commands			RIO
Magnetic variation			✓
Temperature			5° C
Recorder size			1GIG
Consequences of the sampling parameters			
First and last bin range		1.41m	15.76m
Battery usage			2.9 Packs
Standard deviation			1.08cm/s
Storage space required			401.49MB
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			BK103
Deployment details			
Switch on date and time	[✓ LT]	GMT	25/04/08 05h30
Deployment date and time	[✓ LT]	GMT	25/04/08 13h00 ±
Deployment latitude\ northings			34°43.187
Deployment longitude\ eastings			19° 33.635
Site name			Bantamsklip 10m
Site depth			10m
Deployment depth			10m

1□ **ADCP deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

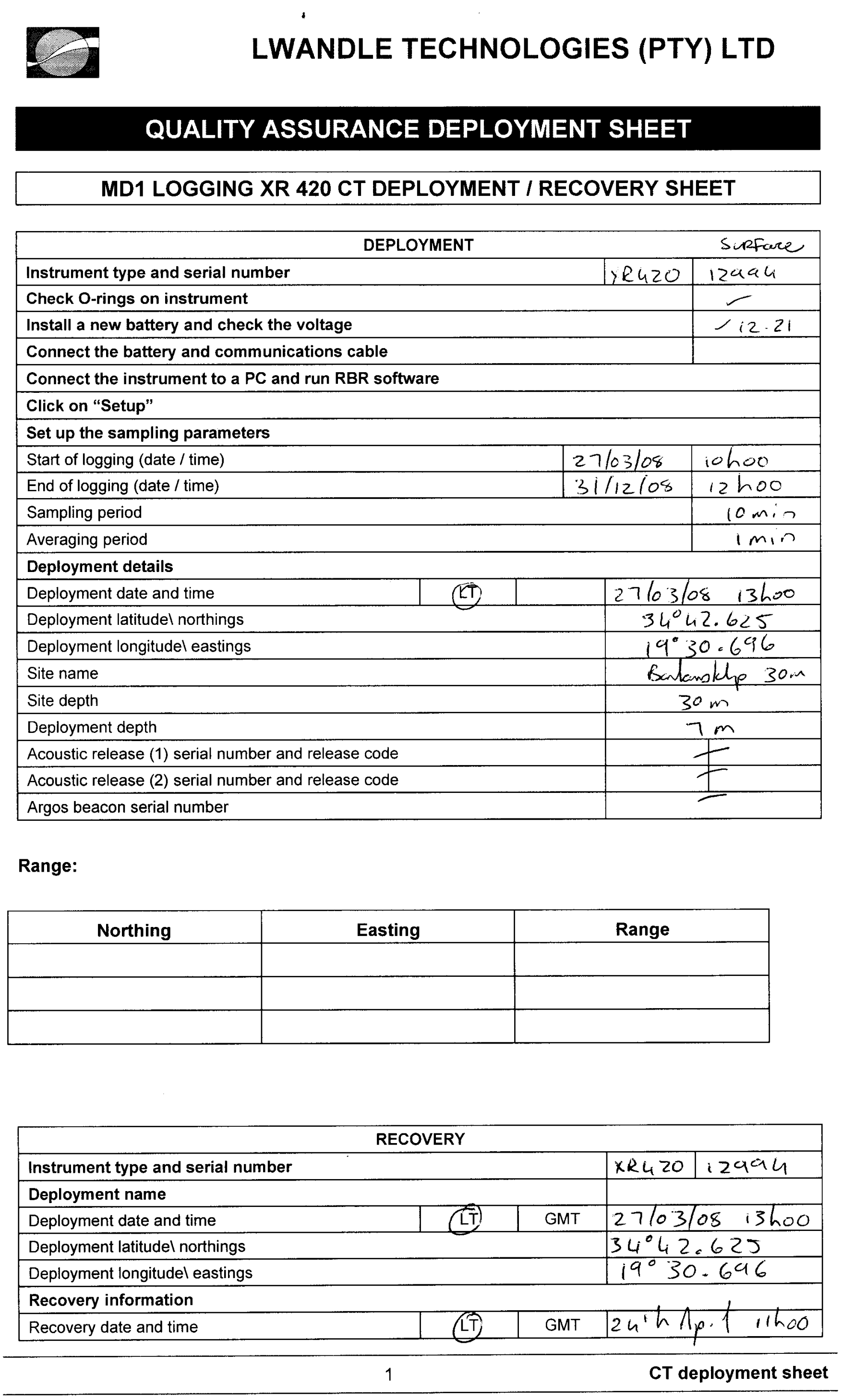
LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number	RDI	600kHz	10119
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.8 V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600kHz		
Depth range	30 m		
Number of bins (calculated automatically)	64		
Bin Size (calculated automatically)	0.5 m		
Wave burst duration	34 min		
Time between wave bursts	60 min		
Pings per ensemble	250		
Ensemble interval	10 min		
Deployment duration	45 days		
Transducer depth	30 m		
Any other commands	RIO		
Magnetic variation	–		
Temperature	5°C		
Recorder size	16.6		
Consequences of the sampling parameters			
First and last bin range		1.6 m	35.6 m
Battery usage			3 Packs
Standard deviation			0.86 cm/s
Storage space required			340 megs
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment	BK303		
Deployment details			
Switch on date and time	[✓ LT]	GMT	25/04/08 05h30
Deployment date and time	[✓ LT]	GMT	25/04/08 12h30
Deployment latitude\ northings			34° 42.603
Deployment longitude\ eastings			19° 30.696
Site name			Bantamsklip 30 m
Site depth			± 30 m
Deployment depth			30 m

1□ **ADCP deployment sheet**

7.2 RBR-CT LOGGERS RECOVERY SHEETS



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

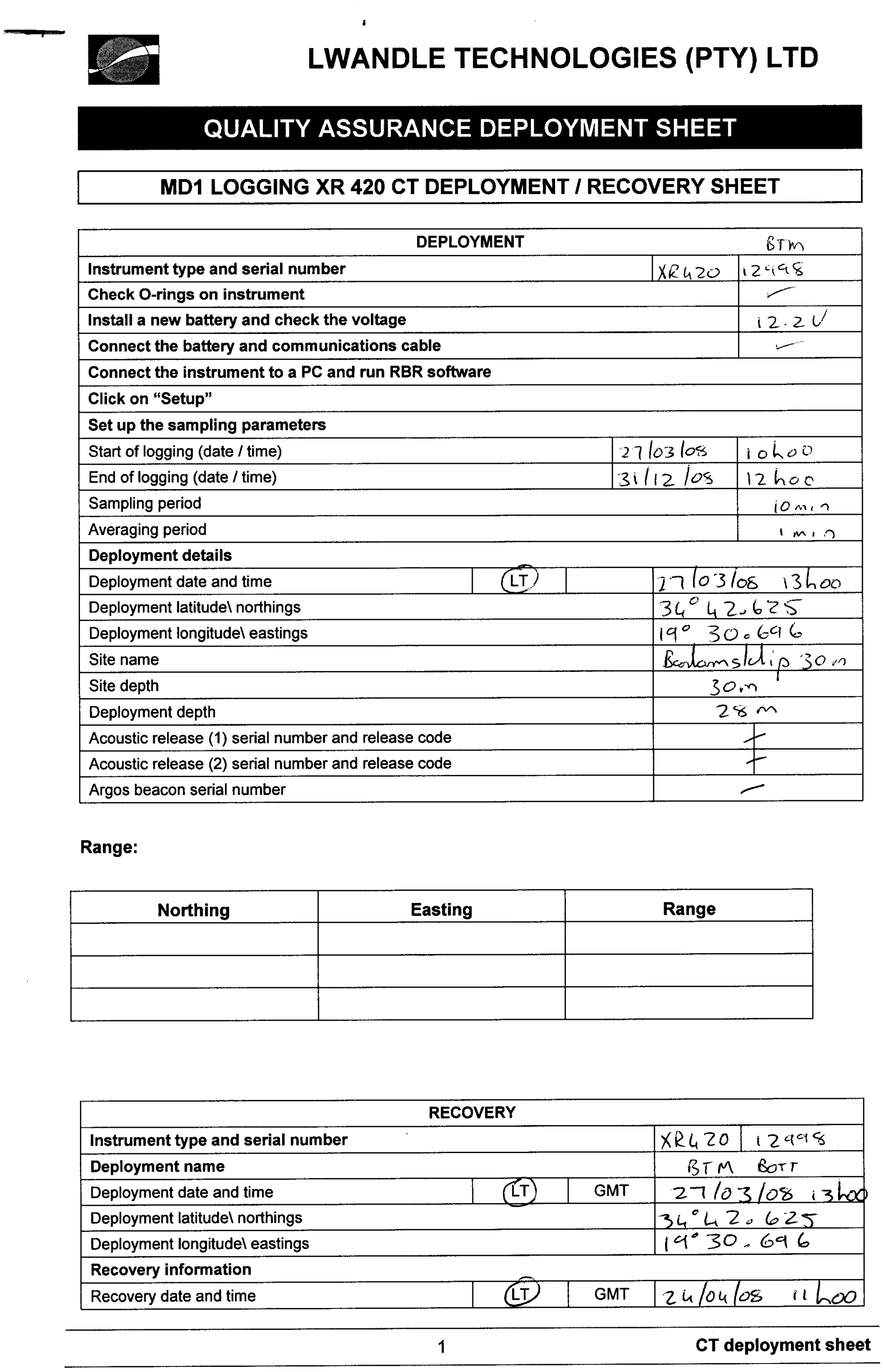
DEPLOYMENT			Surface
Instrument type and serial number		XR420	12994
Check O-rings on instrument			✓
Install a new battery and check the voltage			✓ 12.21
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		27/03/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10min
Averaging period			1min
Deployment details			
Deployment date and time	[✓ LT]		27/03/08 13h00
Deployment latitude\ northings			34°42.625
Deployment longitude\ eastings			19°30.696
Site name			Bantamsklip 30m
Site depth			30m
Deployment depth			7m
Acoustic release (1) serial number and release code			-
Acoustic release (2) serial number and release code			-
Argos beacon serial number			-

Range:

Northing	Easting	Range

RECOVERY				
Instrument type and serial number			XR420	12994
Deployment name				
Deployment date and time	[✓ LT]	GMT	27/03/08 13h00	
Deployment latitude\ northings			34°42.625	
Deployment longitude\ eastings			19°30.696	
Recovery information				
Recovery date and time	[✓ LT]	GMT	24th April 11h00	

1 **CT deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

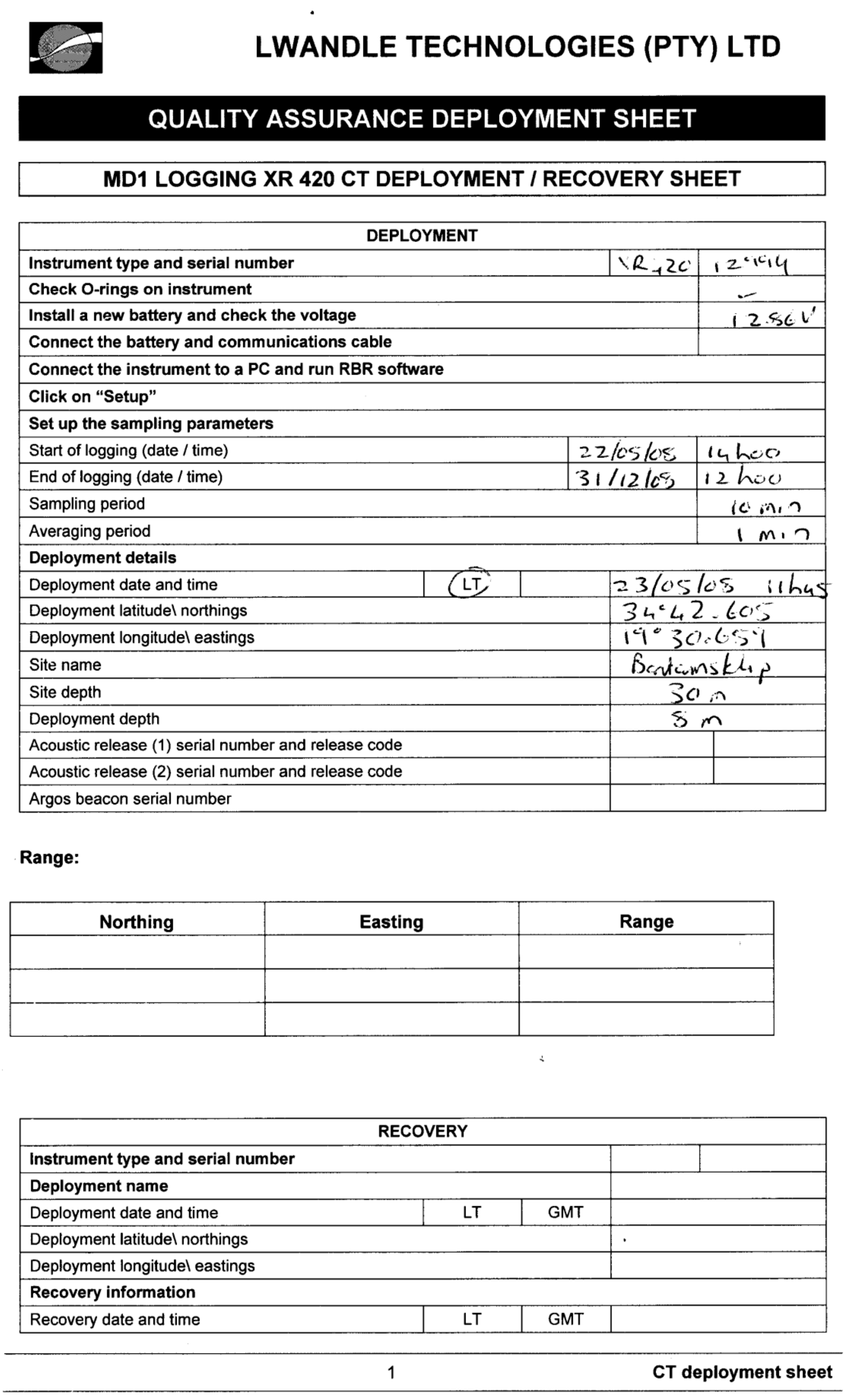
DEPLOYMENT			BTM
Instrument type and serial number		XR420	12998
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.2V
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		27/03/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10min
Averaging period			1min
Deployment details			
Deployment date and time	[✓ LT]		27/03/08 13h00
Deployment latitude\ northings			34° 42.625
Deployment longitude\ eastings			19° 30.696
Site name			Baalamsklip 30m
Site depth			30m
Deployment depth			28m
Acoustic release (1) serial number and release code			–
Acoustic release (2) serial number and release code			–
Argos beacon serial number			–

Range:

Northing	Easting	Range

RECOVERY			
Instrument type and serial number		XR420	12998
Deployment name			BTM BOTT
Deployment date and time	[✓ LT]	GMT	27/03/08 13h00
Deployment latitude\ northings			34°42.625
Deployment longitude\ eastings			19°30.696
Recovery information			
Recovery date and time	[✓ LT]	GMT	24/04/08 11h00

1 **CT deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

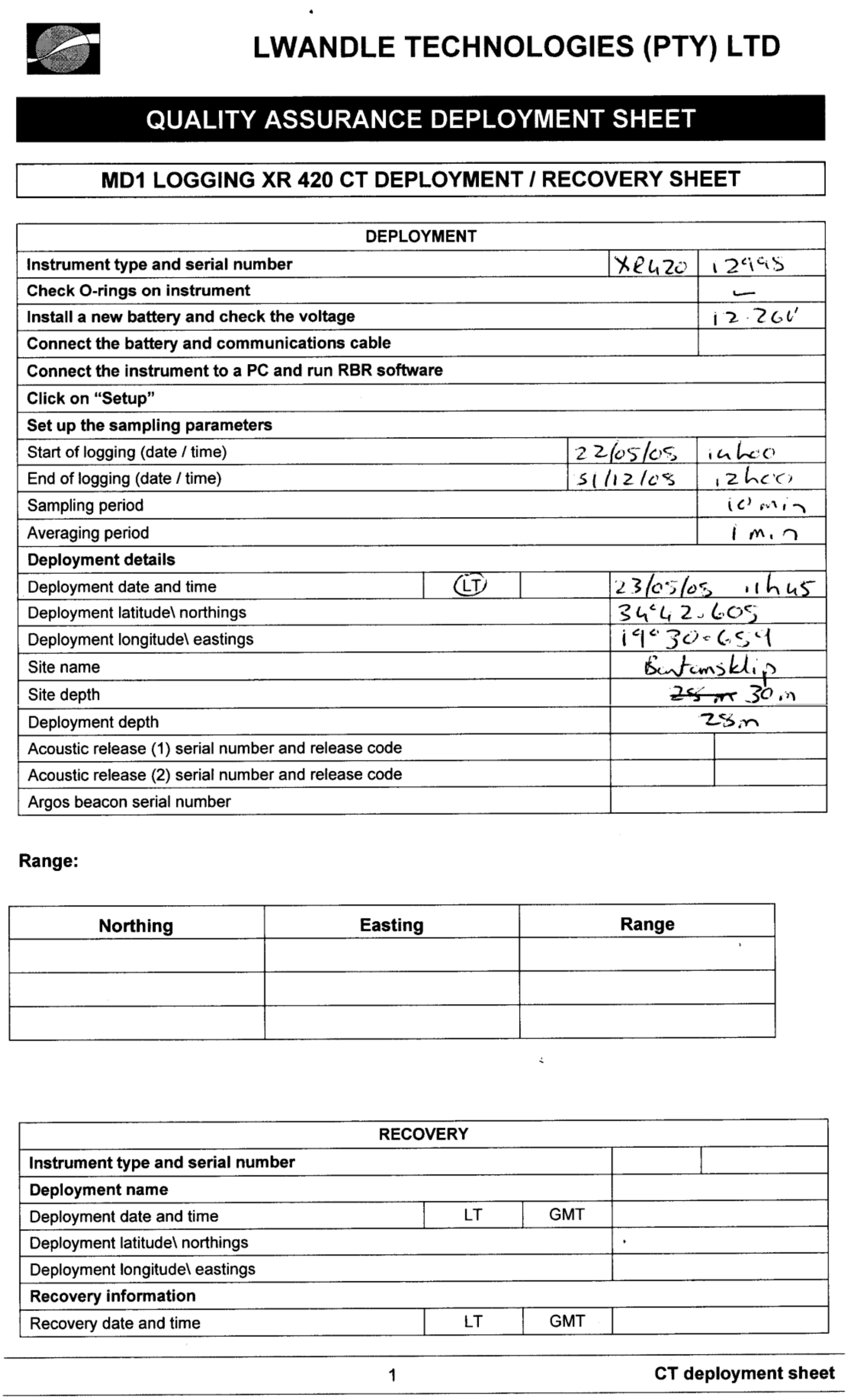
DEPLOYMENT			
Instrument type and serial number		XR420	12994
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.86V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		22/05/08	14h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	[✓ LT]		23/05/08 11h45
Deployment latitude\ northings			34°42.605
Deployment longitude\ eastings			19°30.659
Site name			Bantamsklip
Site depth			30 m
Deployment depth			8 m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

Range:

Northing	Easting	Range

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	

1 **CT deployment sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		XR420	12995
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.26V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		22/05/05	14h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	[✓ LT]		23/05/05 11h45
Deployment latitude\ northings			34°42.605
Deployment longitude\ eastings			19°30.654
Site name			Bantamsklip
Site depth			~~25 m~~ 30 m
Deployment depth			28 m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

Range:

Northing	Easting	Range

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	

1 **CT deployment sheet**

7.3 TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS

LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

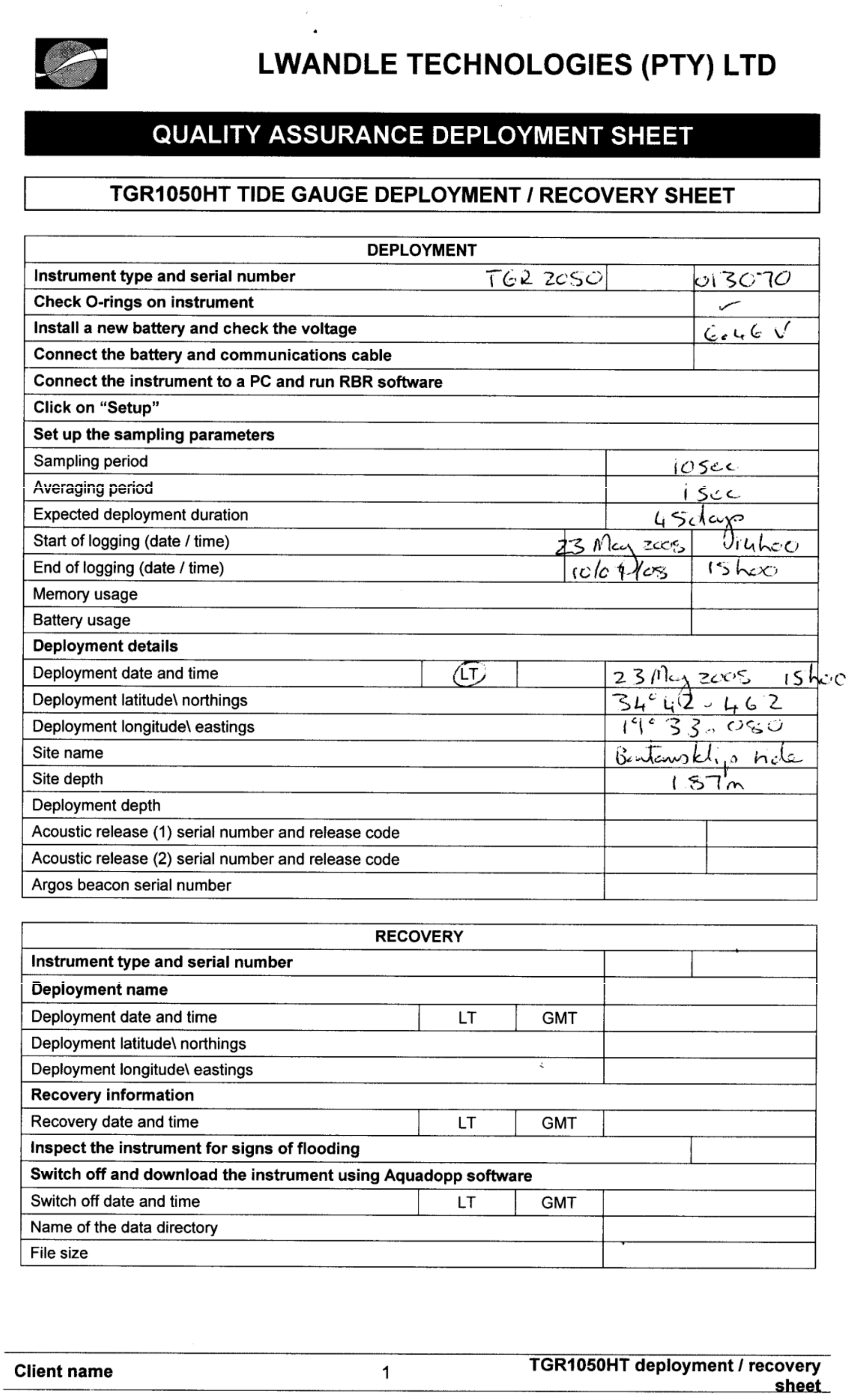
TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number	TGR1050	14002	
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.5V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period			10secs
Averaging period			1secs
Expected deployment duration			3 years
Start of logging (date / time)		27/03/08	15h40
End of logging (date / time)		31/12/08	06h00
Memory usage			86.2%
Battery usage			3771mAH
Deployment details			
Deployment date and time	[✓ LT]		27/03/08 16h20
Deployment latitude\ northings			34°42.462
Deployment longitude\ eastings			19°33.080
Site name			Bantamsklip
Site depth			1.87m
Deployment depth			1.87m
Acoustic release (1) serial number and release code			–
Acoustic release (2) serial number and release code			–
Argos beacon serial number			–

RECOVERY			
Instrument type and serial number		TGR 1050	14002
Deployment name			
Deployment date and time	[✓ LT]	GMT	27/03/08 16h20
Deployment latitude\ northings			34°42.462
Deployment longitude\ eastings			19°33.080
Recovery information			
Recovery date and time	LT	GMT	
Inspect the instrument for signs of flooding			
Switch off and download the instrument using Aquadopp software			
Switch off date and time	LT	GMT	
Name of the data directory			
File size			

Instrument was taken and stripped of batteries, cables exposed to water

Client name 1 **TGR1050HT deployment / recovery sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

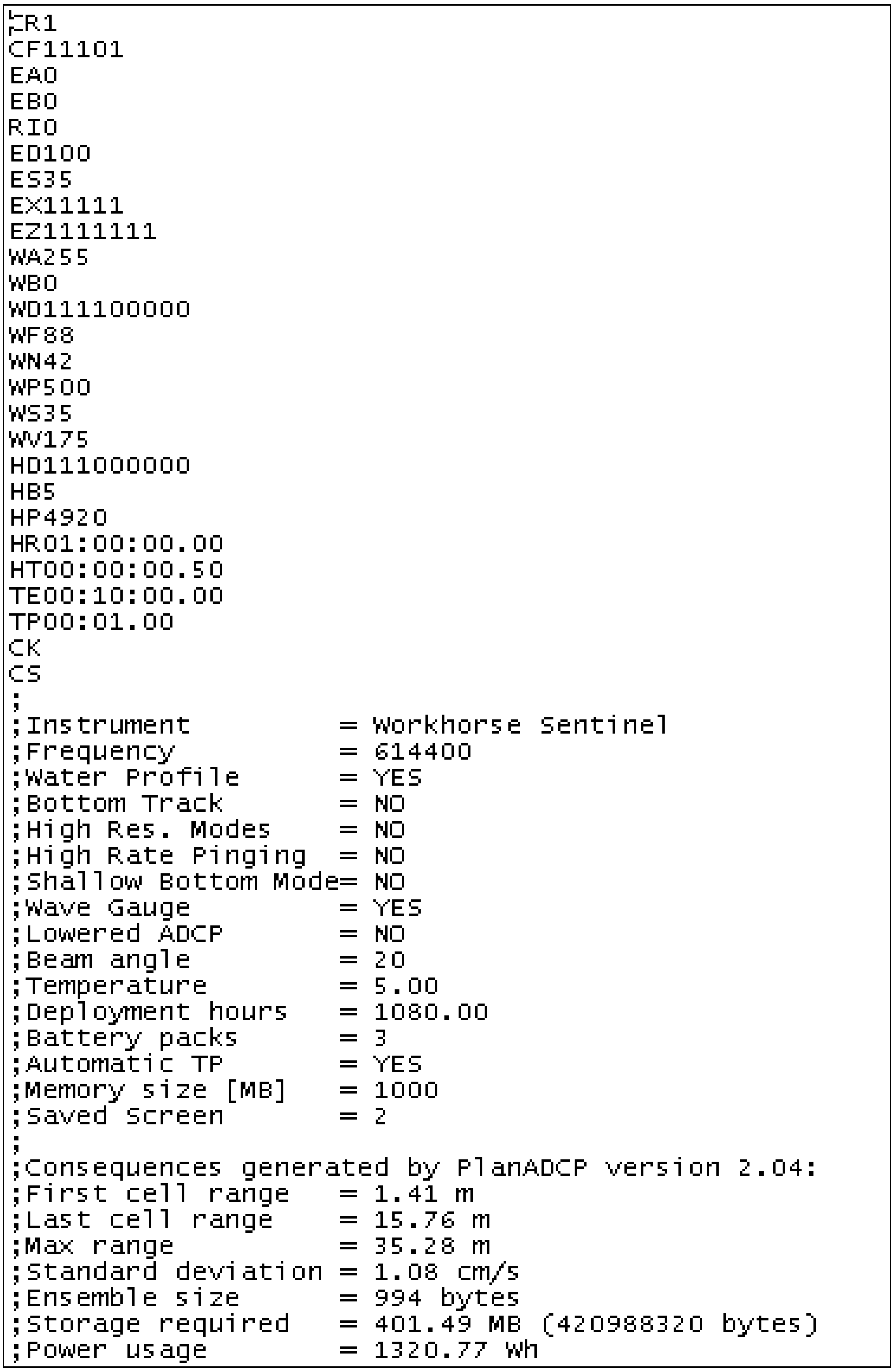
TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number	TGR 2050		013070
Check O-rings on instrument			✓
Install a new battery and check the voltage			6.46 V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period			10sec
Averaging period			1sec
Expected deployment duration			45days
Start of logging (date / time)		23 May 2005	@14h00
End of logging (date / time)		10/07/05	15h00
Memory usage			
Battery usage			
Deployment details			
Deployment date and time	[✓ LT]		23 May 2005 15h00
Deployment latitude\ northings			34° 42.462
Deployment longitude\ eastings			19° 33.080
Site name			Bantamsklip hole
Site depth			1.87m
Deployment depth			
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

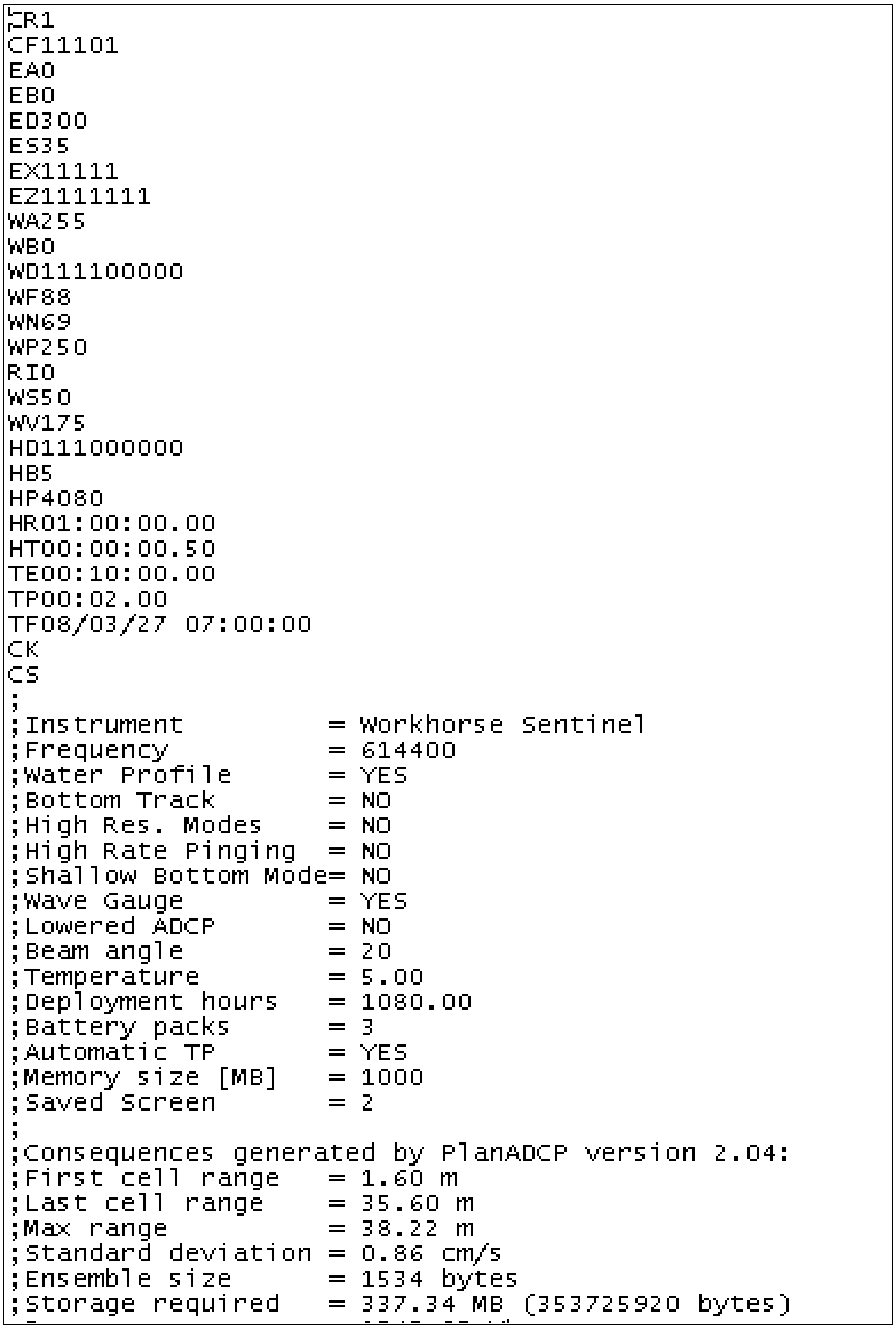
RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	
Inspect the instrument for signs of flooding			
Switch off and download the instrument using Aquadopp software			
Switch off date and time	LT	GMT	
Name of the data directory			
File size			

Client name 1 **TGR1050HT deployment / recovery sheet**

7.4 ADCPS CONFIGURATION FILES

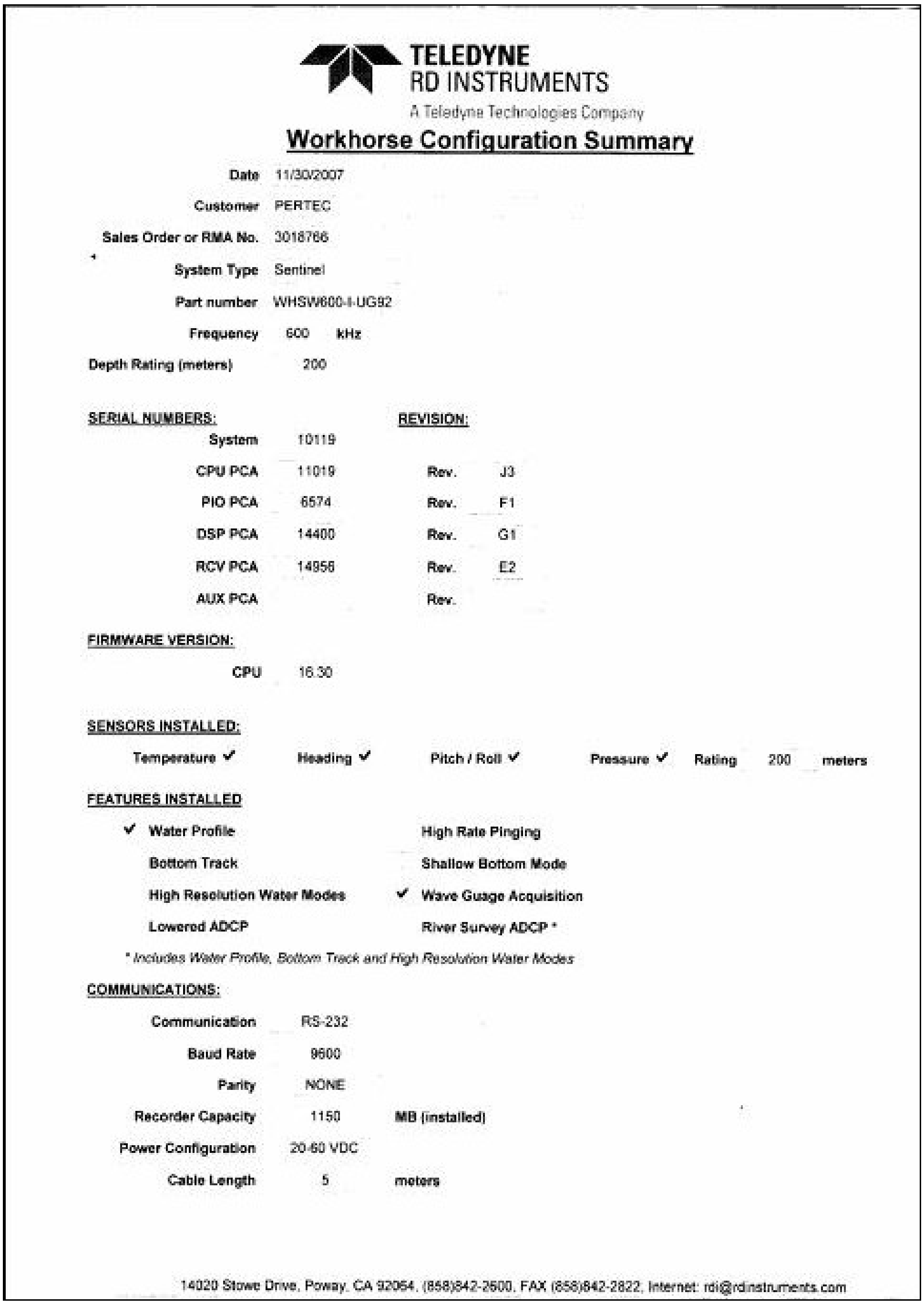


```
CR1
CF11101
EA0
EB0
RI0
ED100
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:01.00
CK
CS
;
;Instrument           = Workhorse Sentinel
;Frequency            = 614400
;Water Profile        = YES
;Bottom Track         = NO
;High Res. Modes      = NO
;High Rate Pinging    = NO
;Shallow Bottom Mode= NO
;Wave Gauge           = YES
;Lowered ADCP         = NO
;Beam angle           = 20
;Temperature          = 5.00
;Deployment hours     = 1080.00
;Battery packs        = 3
;Automatic TP         = YES
;Memory size [MB]     = 1000
;Saved Screen         = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range     = 1.41 m
;Last cell range      = 15.76 m
;Max range            = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size        = 994 bytes
;Storage required     = 401.49 MB (420988320 bytes)
;Power usage          = 1320.77 Wh
```



```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN69
WP250
RI0
WS50
WV175
HD111000000
HB5
HP4080
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:02.00
TF08/03/27 07:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 1080.00
;Battery packs       = 3
;Automatic TP        = YES
;Memory size [MB]    = 1000
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.60 m
;Last cell range     = 35.60 m
;Max range           = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size       = 1534 bytes
;Storage required    = 337.34 MB (353725920 bytes)
```

7.5 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS: **REVISION:**
System 10119
CPU PCA 11019 **Rev.** J3
PIO PCA 6574 **Rev.** F1
DSP PCA 14400 **Rev.** G1
RCV PCA 14956 **Rev.** E2
AUX PCA **Rev.**

FIRMWARE VERSION:
CPU 16.30

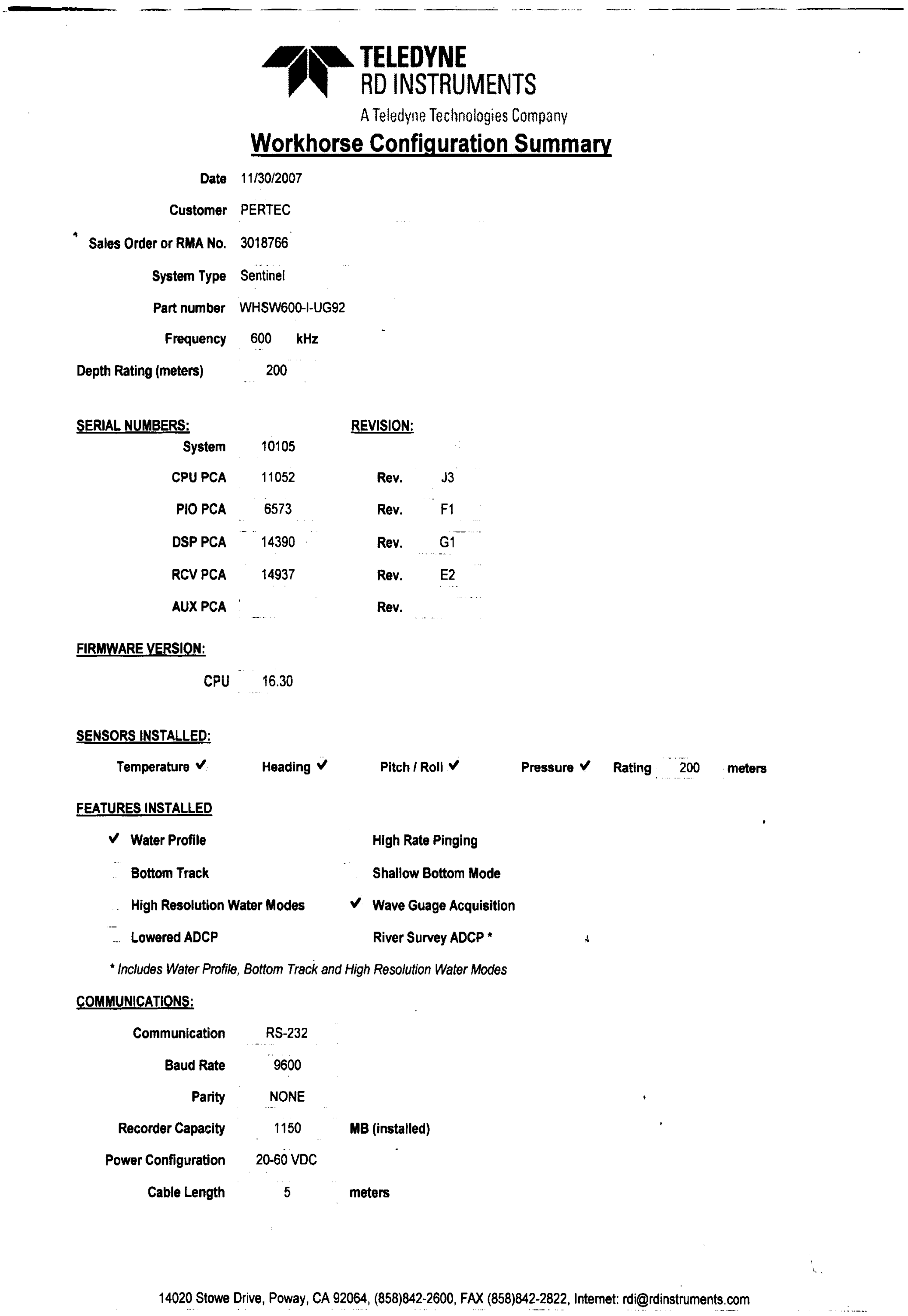
SENSORS INSTALLED:
Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED
✓ **Water Profile**
Bottom Track
High Resolution Water Modes
Lowered ADCP
High Rate Pinging
Shallow Bottom Mode
✓ **Wave Guage Acquisition**
River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:
Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10105		
CPU PCA	11052	**Rev.**	J3
PIO PCA	6573	**Rev.**	F1
DSP PCA	14390	**Rev.**	G1
RCV PCA	14937	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

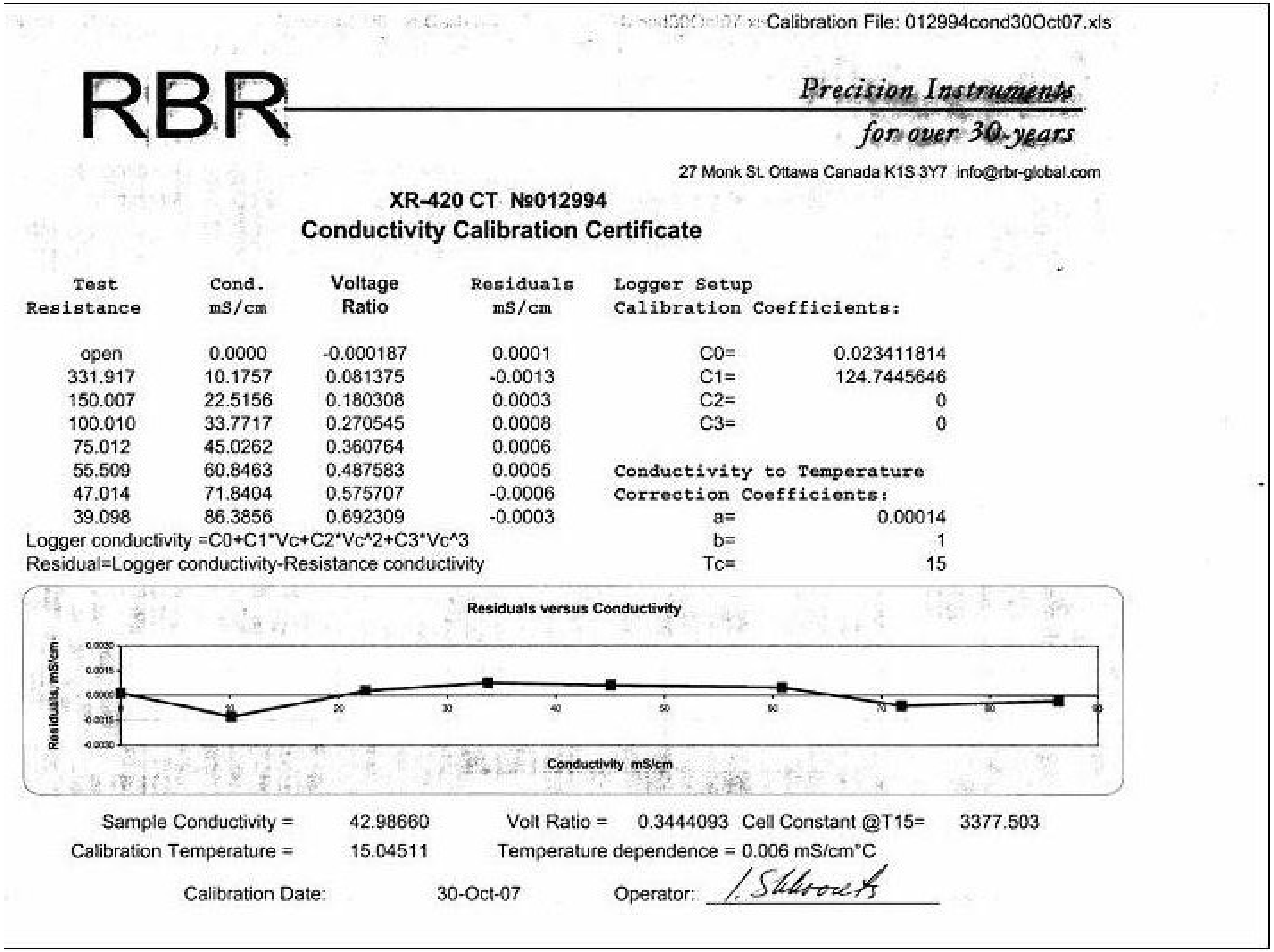
✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0=	0.023411814
C1=	124.7445646
C2=	0
C3=	0

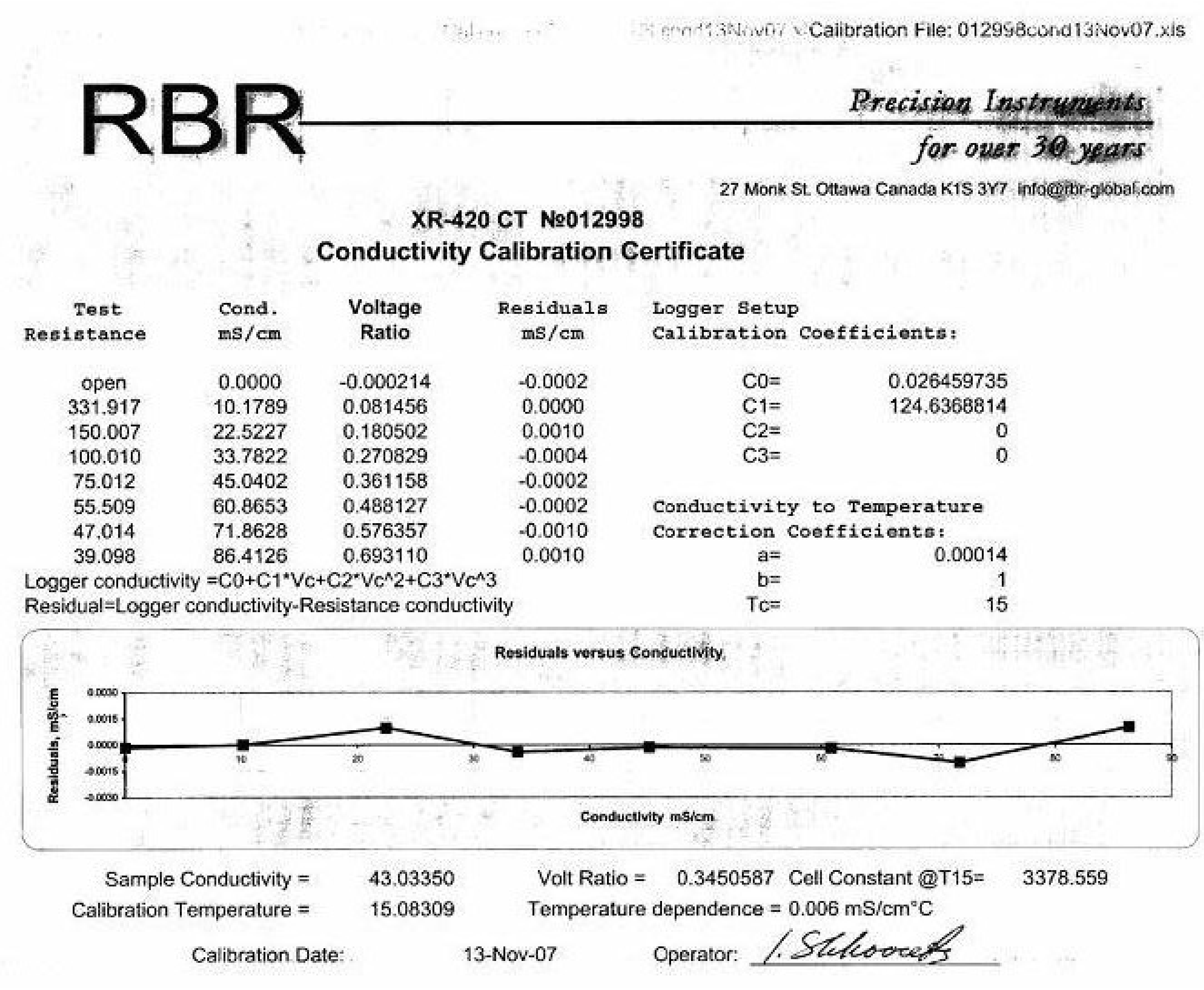
Conductivity to Temperature
Correction Coefficients:

a=	0.00014
b=	1
Tc=	15

Sample Conductivity = 42.98660 Volt Ratio = 0.3444093 Cell Constant @T15= 3377.503

Calibration Temperature = 15.04511 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07 Operator:



Calibration File: 012998cond13Nov07.xls

RBR *Precision Instruments for over 30 years*

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012998
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000214	-0.0002
331.917	10.1789	0.081456	0.0000
150.007	22.5227	0.180502	0.0010
100.010	33.7822	0.270829	-0.0004
75.012	45.0402	0.361158	-0.0002
55.509	60.8653	0.488127	-0.0002
47.014	71.8628	0.576357	-0.0010
39.098	86.4126	0.693110	0.0010

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

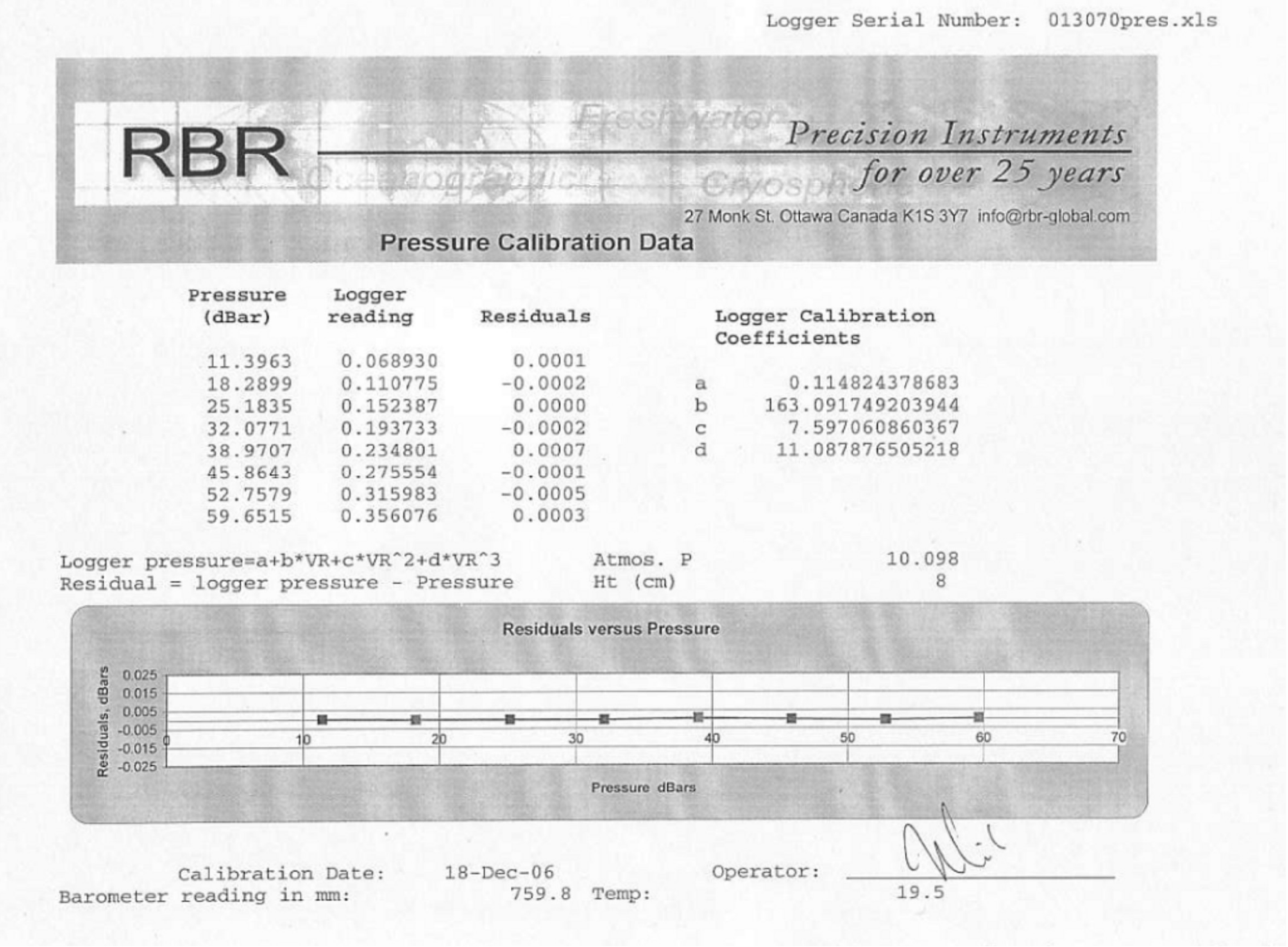
C0= 0.026459735
C1= 124.6368814
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 43.03350 Volt Ratio = 0.3450587 Cell Constant @T15= 3378.559
Calibration Temperature = 15.08309 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 13-Nov-07 Operator: I. Stkhoorek



Logger Serial Number: 013070pres.xls

RBR Precision Instruments for over 25 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

Pressure (dBar)	Logger reading	Residuals
11.3963	0.068930	0.0001
18.2899	0.110775	-0.0002
25.1835	0.152387	0.0000
32.0771	0.193733	-0.0002
38.9707	0.234801	0.0007
45.8643	0.275554	-0.0001
52.7579	0.315983	-0.0005
59.6515	0.356076	0.0003

Logger Calibration Coefficients

a	0.114824378683
b	163.091749203944
c	7.597060860367
d	11.087876505218

Logger pressure=a+b*VR+c*VR^2+d*VR^3

Residual = logger pressure - Pressure

Atmos. P 10.098

Ht (cm) 8

Calibration Date: 18-Dec-06

Operator:

Barometer reading in mm: 759.8

Temp: 19.5

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT THREE

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

28 July 2008

Job No: LT-JOB-50

LWANDLE TECHNOLOGIES (PTY) LTD

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

1st floor Gabriel Place, 1 Gabriel Road, Plumstead, 7800, South Africa

Co Reg. No. 2003/015524/07

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 3 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-11.5	100	0.3814	0.0306	0.0184	0.0187	68.62
-11.1	100	0.1951	0.0338	0.0190	0.0223	65.48
-10.8	100	0.1346	0.0357	0.0199	0.0238	62.25
-10.4	100	0.2051	0.0361	0.0206	0.0224	63.04
-10.1	100	0.2481	0.0360	0.0207	0.0206	65.34
-9.7	100	0.1532	0.0351	0.0197	0.0181	73.28
-9.4	100	0.1736	0.0350	0.0200	0.0163	81.59
-9.0	100	0.2297	0.0350	0.0208	0.0148	92.48
-8.7	100	0.1854	0.0347	0.0212	0.0129	103.26
-8.3	100	0.1817	0.0356	0.0220	0.0125	117.16
-8.0	100	0.1835	0.0363	0.0226	0.0124	129.05
-7.6	100	0.1755	0.0372	0.0236	0.0126	142.25
-7.3	100	0.1815	0.0383	0.0246	0.0136	154.26
-6.9	100	0.1771	0.0400	0.0256	0.0148	164.36
-6.6	100	0.1721	0.0420	0.0262	0.0161	173.67
-6.2	100	0.1748	0.0441	0.0272	0.0181	181.67
-5.9	100	0.1849	0.0467	0.0282	0.0204	187.31
-5.5	100	0.1781	0.0490	0.0293	0.0227	191.99
-5.2	100	0.1994	0.0524	0.0308	0.0250	196.82
-4.8	100	0.1910	0.0557	0.0315	0.0275	200.28
-4.5	100	0.2344	0.0591	0.0326	0.0298	203.14
-4.1	100	0.2280	0.0626	0.0335	0.0323	205.51
-3.8	100	0.2249	0.0660	0.0347	0.0342	207.66
-3.4	100	0.2543	0.0692	0.0357	0.0364	209.32
-3.1	100	0.2698	0.0725	0.0362	0.0378	210.63
-2.7	100	0.2968	0.0756	0.0368	0.0380	210.39
-2.4	100	0.3312	0.0800	0.0385	0.0324	206.39
-2.0	100	0.3461	0.0923	0.0442	0.0209	192.30
-1.7	100	0.4449	0.1198	0.0608	0.0176	200.98
-1.3	92.75	0.6213	0.1625	0.0906	0.0370	230.10

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	88.32	5.42	0.88	1.91	0.66
Tp (s)	88.32	23.10	2.00	12.25	2.24

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-30.8	98.89	0.1772	0.0305	0.0228	0.0081	123.70
-30.3	98.83	0.1887	0.0328	0.0253	0.0084	134.42
-29.8	98.89	0.1971	0.0351	0.0275	0.0088	148.92
-29.3	98.86	0.2135	0.0374	0.0290	0.0099	158.48
-28.8	98.89	0.2060	0.0402	0.0305	0.0108	163.30
-28.3	98.89	0.2079	0.0430	0.0318	0.0118	168.66
-27.8	98.86	0.2321	0.0459	0.0339	0.0135	169.56
-27.3	98.89	0.2366	0.0487	0.0356	0.0148	169.69
-26.8	98.89	0.2373	0.0520	0.0368	0.0159	170.98
-26.3	98.89	0.2461	0.0552	0.0385	0.0170	169.38
-25.8	98.89	0.2476	0.0580	0.0396	0.0178	167.73
-25.3	98.89	0.2487	0.0608	0.0402	0.0185	165.44
-24.8	98.89	0.2556	0.0629	0.0409	0.0188	162.63
-24.3	98.89	0.2582	0.0650	0.0407	0.0186	159.90
-23.8	98.89	0.2541	0.0662	0.0407	0.0187	157.49
-23.3	98.89	0.2491	0.0678	0.0403	0.0184	154.52
-22.8	98.89	0.2360	0.0685	0.0397	0.0178	151.71
-22.3	98.89	0.2482	0.0693	0.0394	0.0175	147.87
-21.8	98.89	0.2447	0.0699	0.0388	0.0167	145.27
-21.3	98.89	0.2511	0.0703	0.0386	0.0167	141.35
-20.8	98.89	0.2552	0.0703	0.0382	0.0164	137.71
-20.3	98.86	0.2451	0.0706	0.0380	0.0161	134.24
-19.8	98.86	0.2623	0.0704	0.0377	0.0151	132.11
-19.3	98.86	0.2594	0.0708	0.0383	0.0150	129.66
-18.8	98.86	0.2438	0.0711	0.0383	0.0150	126.97
-18.3	98.86	0.2437	0.0712	0.0387	0.0146	126.12
-17.8	98.86	0.2527	0.0714	0.0386	0.0146	125.08
-17.3	98.86	0.2510	0.0718	0.0386	0.0148	123.74
-16.8	98.86	0.2524	0.0719	0.0386	0.0144	120.98
-16.3	98.86	0.2627	0.0719	0.0391	0.0142	118.71
-15.8	98.86	0.2553	0.0718	0.0391	0.0138	116.28
-15.3	98.86	0.2596	0.0714	0.0395	0.0136	113.29
-14.8	98.86	0.2680	0.0717	0.0398	0.0130	110.19
-14.3	98.89	0.2921	0.0720	0.0407	0.0130	107.36
-13.8	98.86	0.3090	0.0721	0.0411	0.0126	105.83
-13.3	98.86	0.3396	0.0728	0.0416	0.0119	101.11
-12.8	98.86	0.3573	0.0734	0.0421	0.0115	102.22
-12.3	98.89	0.3764	0.0745	0.0425	0.0111	97.80
-11.8	98.89	0.3547	0.0752	0.0429	0.0107	96.32
-11.3	98.86	0.3456	0.0762	0.0436	0.0101	95.14
-10.8	98.86	0.4005	0.0772	0.0449	0.0094	92.61
-10.3	98.86	0.3872	0.0789	0.0461	0.0092	94.59
-9.8	98.83	0.3592	0.0796	0.0469	0.0086	93.45

-9.3	98.78	0.3862	0.0811	0.0479	0.0079	94.69
-8.8	98.69	0.3926	0.0831	0.0491	0.0069	94.77
-8.3	98.67	0.4064	0.0850	0.0513	0.0062	96.21
-7.8	98.55	0.4175	0.0868	0.0528	0.0058	99.47
-7.3	98.61	0.4244	0.0890	0.0544	0.0047	102.13
-6.8	98.55	0.4441	0.0912	0.0558	0.0046	101.00
-6.3	98.44	0.4529	0.0939	0.0575	0.0033	104.44
-5.8	98.55	0.4307	0.0973	0.0593	0.0029	102.28
-5.3	98.53	0.4453	0.1000	0.0607	0.003	107.97
-4.8	98.42	0.4578	0.1027	0.0616	0.0026	110.36
-4.3	98.39	0.4604	0.1053	0.0635	0.0022	74.36
-3.8	98.14	0.4516	0.1073	0.0649	0.0053	0.16
-3.3	97.66	0.4771	0.1121	0.0651	0.0155	3.36
-2.8	96.78	0.4708	0.1275	0.0658	0.0258	22.40
-2.3	76.12	0.4797	0.1498	0.0730	0.0250	25.32

Table 4 – Waves summary for 30m ADCP

	Data Return (%)	**Max**	**Min**	**Mean**	**Std**
Hs (m)	96.80	4.59	1.07	2.18	0.68
Tp (s)	96.80	19.50	5.20	11.80	1.86

Table 5 – Water temperature and salinity summary (surface)

Parameter	**Data Return (%)**	**Mean**	**Max**	**Min**
Temperature (^{o}C)	100	16.37	17.24	14.49
Conductivity	100	44.38	45.27	42.39
Salinity (psu)	100	35.09	35.18	34.95

Table 6 – Water temperature and salinity summary (bottom)

Parameter	**Data Return (%)**	**Mean**	**Max**	**Min**
Temperature (^{o}C)	100	15.73	16.92	12.47
Conductivity	100	5.06	8.34	2.09
Salinity (psu)	0	-	-	-

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents currents, waves, temperature and salinity and tidal data collected at Bantamsklip station for the period April 25th 2008 - June 19th 2008 (Period 3) as well as water samples collected during Service Visit 3 (June 18th – 20th and 27th 2008).

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 7 for the Bantamsklip site.

Table 7 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The initial deployment location of the mooring is given in Table 8 and shown in Figure 1. Table 9 shows the locations where water samples were taken respectively.

Figure 1 - Map of the project area.

Table 8 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34° 42.462'	19° 33.080'
10m ADCP	34° 43.186'	19° 33.637'
Biofouling	34° 43.190'	19° 33.686'
30m ADCP	34° 42.625'	19° 30.690'
T&C mooring	34° 42.605'	19° 30.659'

Table 9 – Locations where water samples were taken

Station 26 Mar 2008		Latitude (°S)	Longitude (°E)
S1	30m ADCP 4m	34° 42.603'	19° 30.696'
S2	30m ADCP 12m	34° 42.603'	19° 30.696'
S3	30m ADCP 20m	34° 42.603'	19° 30.696'
S4	30m ADCP 28m	34° 42.603'	19° 30.696'
S5	10m ADCP 4m	34° 43.187'	19° 33.635'
S6	10m ADCP 8m	34° 43.187'	19° 33.635'
S7		34° 43.141'	19° 33.710'
S8		34° 43.055'	19° 33.616'
S9		34° 42.938'	19° 33.445'
S10		34° 42.901'	19° 33.287'
S11		34° 42.860'	19° 33.149'

3. OPERATIONS

3.1 SUMMARY OF EVENTS

Service visit 3 was undertaken on June 18th – 20th 2008 and June 27th 2008.

Table 10 – Summary of events for Service Visit 3

Date	Description
18 June 2008 10h00	Lwandle's engineers departed from Cape Town to Kleinbaai Harbour.
12h30	The engineers stored the Lwandle vessel at the White Shark dive centre.
14h47	The Lwandle engineers retrieved the tide gauge unit and installed a new unit.
19 June 2008 08h00	The engineers started prepping the boat for the frame recoveries and water samples to be taken.
09h30	The vessel departed from Kleinbaai harbour to the 30m site.
10h50	The engineer proceeded to collect the four water samples at the 30m site. The Pop-up buoy was released and the diver descended to release the RBR mooring string, and to disconnect the chain sections from the ADCP frame. The frame was successfully lifted onboard the vessel.
11h30	The engineer proceeded to the 10m site.
12h00	When the vessel arrived at the 10 site the Pop-up canister float was already at the surface. The diver descended to undo the chain sections. The frame was successfully lifted onboard the vessel. The engineer collected the 2 water samples.
13h00	The engineers deployed a shotline on the biofouling position. The diver proceeded with several searches in the area, but could not locate the mooring string. After several search attempts, it was decided to release the mooring line via the acoustic release. There was no response from the acoustic release to the deck unit and the operation was aborted.
16h30	The vessel started back to Kleinbaai harbour, stopping to finish off the last five water samples.
17h30	The vessel arrived back at Kleinbaai harbour and was taken to the base camp where frames are to be dismantled.
20 June 2008 08h00	The engineers started prepping the boat.
10h00	The vessel left Kleinbaai harbour and headed to the 10m site.
11h00	The 10m instrument frame was dropped on site.
12h00	The 30m instrument was dropped on site and the diver descended to attach the chain weights. The RBR T&C string could not be deployed due to adverse weather conditions.
13h00	The diver descended to attach the chain weights to the 10m frame.
27 June 2008	Redeployment of RBR T&C loggers.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 58).

3.2.1 600kHz ADCP

Table 11 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10105
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Some tests needed to be carried out with the ADCP s/n 10105. This was replaced with the space instrument s/n 10120.

Table 12 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

3.2.2 RBR XR420 CT LOGGER

Table 13 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (7m) and s/n 12998 (28m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

3.2.3 RBR TGR2050 HT TIDE GAUGE

Table 14 – Instrument configuration for the Tide Gauge

Parameter	Configuration
TGR 2050 HT	s/n 013070
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

The TGR 2050 s/n 013070 was withdrawn and replaced with the s/n 014695.

3.2.4 Biofouling Mooring

Table 15 – Instrument configuration for Biofouling Mooring Line.

Parameter	Configuration
Biofouling Plates	3 plates (50cmx50cm) at 3m and 3 plates (50cmx50cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed at depth of about 1.5m outside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods.

3.4 MALFUNCTIONS AND LESSONS LEARNT

A list of malfunctions experienced and consequent measures to be taken in future are provided in Table 16.

Table 16 – Lessons learnt and future mitigation measures

Problem	Mitigation measure(s)
The Pop-up float on the 10m frame broke loose and surfaced.	The pop-up systems have been made redundant. All frames are only to be fitted with the CART units (for triangulation purposes)
10m ADCP frame seems to have moved	The unit was taken out of gulley and put back to its original position.
The biofouling mooring is lost	Use smaller (20cm x 20cm) plates, which will offer less resistance and strengthen them with a plastic backing.
One of the Y cable pins corroded off in the 30m external battery canister bulkhead connecter.	Cable was sent to TRDI factory.
The 10m external battery canister only gives a 42V output.	Canister to be sent to TRDI factory. Only the 30m frame to have a spare external battery canister. It was reported from the TDRI factory that the external canister was indeed faulty.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

4.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 23' W and 25° 21' W for the 10m and 30m ADCPs respectively.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP's pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2 and Figure 3).
- A cap of 1ms^{-1} was implemented for the 30m ADCP data.
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 23' W and 25° 21' W for the 10m and 30m ADCPs respectively.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Salinity values less than 34.5psu were flagged for the bottom instrument.

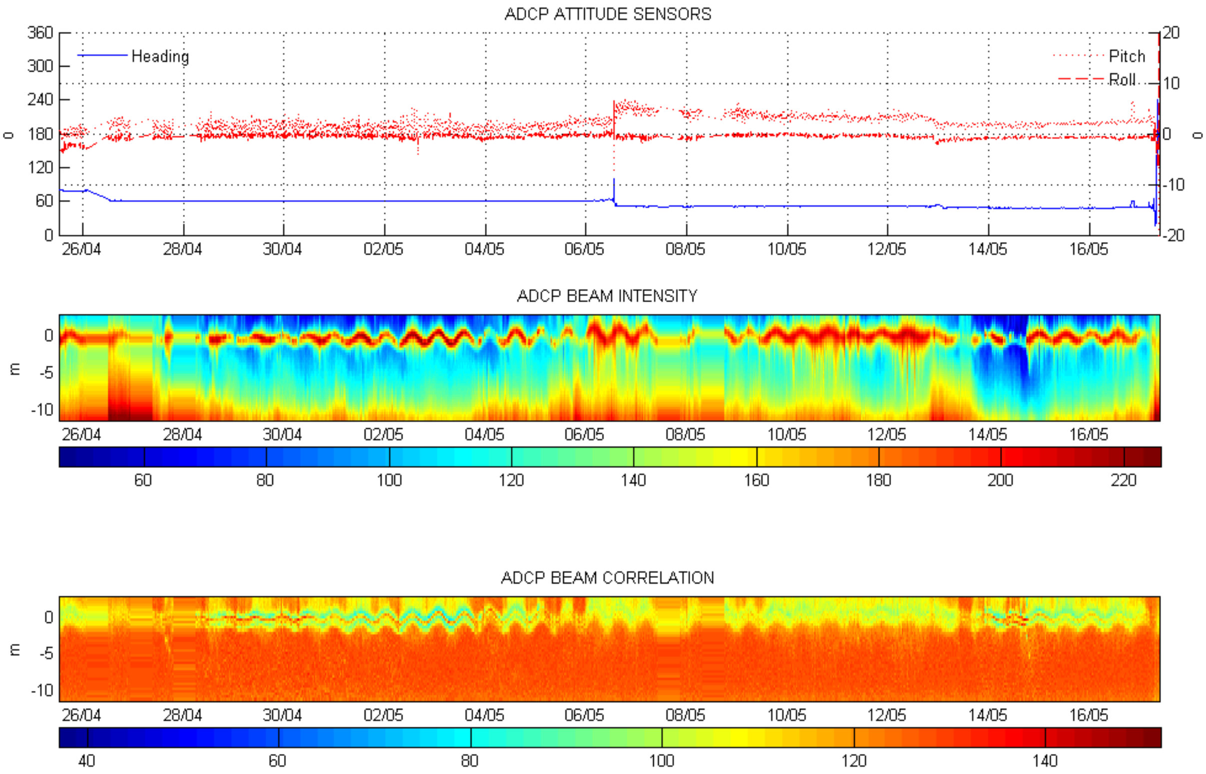


Figure 2: Attitude data for 10m ADCP.

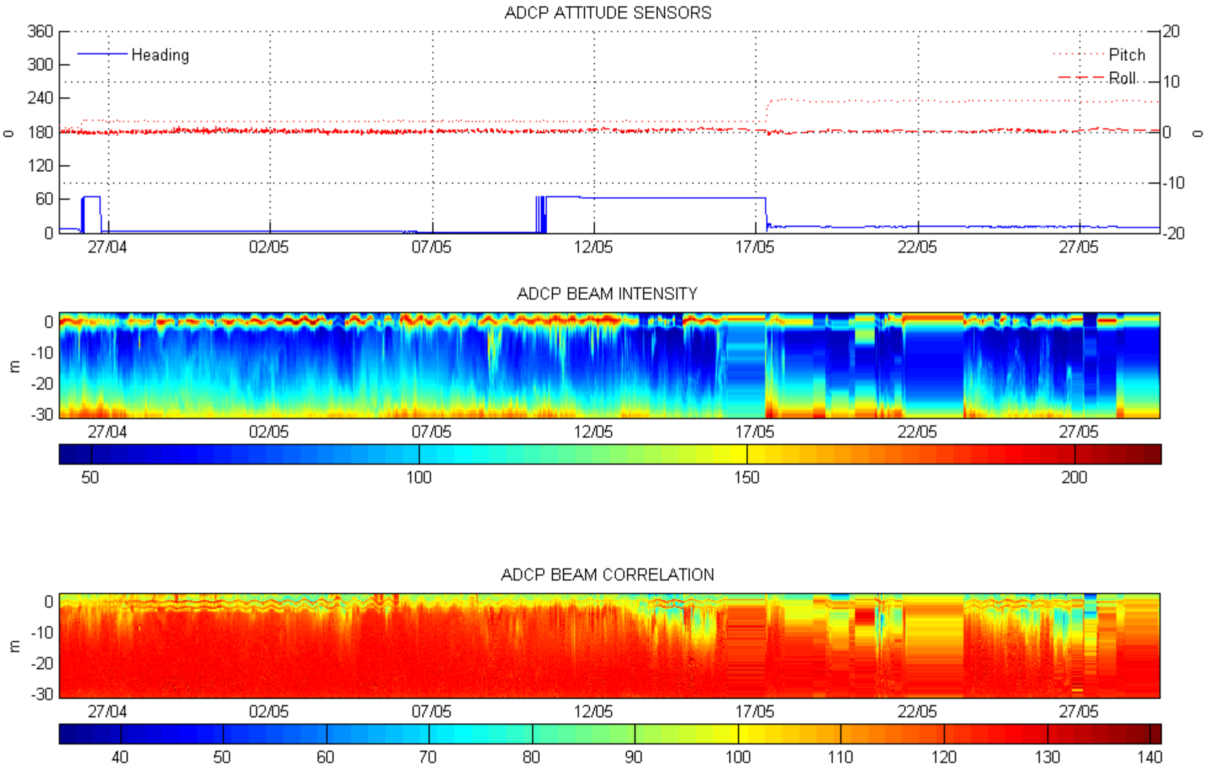


Figure 3: Attitude data for 30m ADCP.

4.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

4.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was scheduled for service visit 3. However, the plates were lost. Recovery of the new plates is now scheduled in three months, where two plates (surface (3m) and bottom (8m)) will be collected.

4.5 WATER SAMPLE.

Water sample were collected and sent to the Council for Scientific and Industrial Research (CSIR) for analysis.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

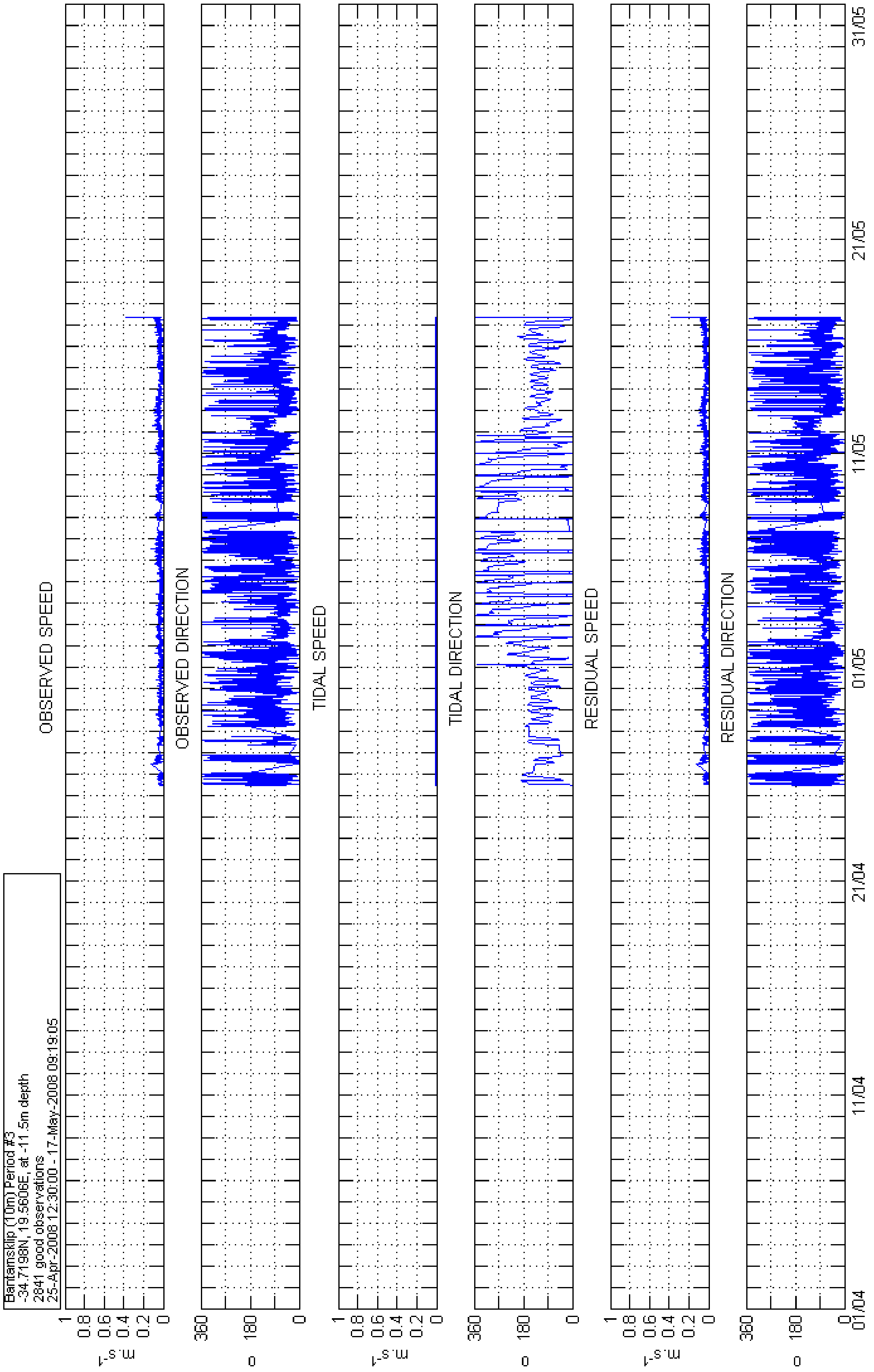


Figure 4: Time series plot for 10m ADCP current data at 11.5m

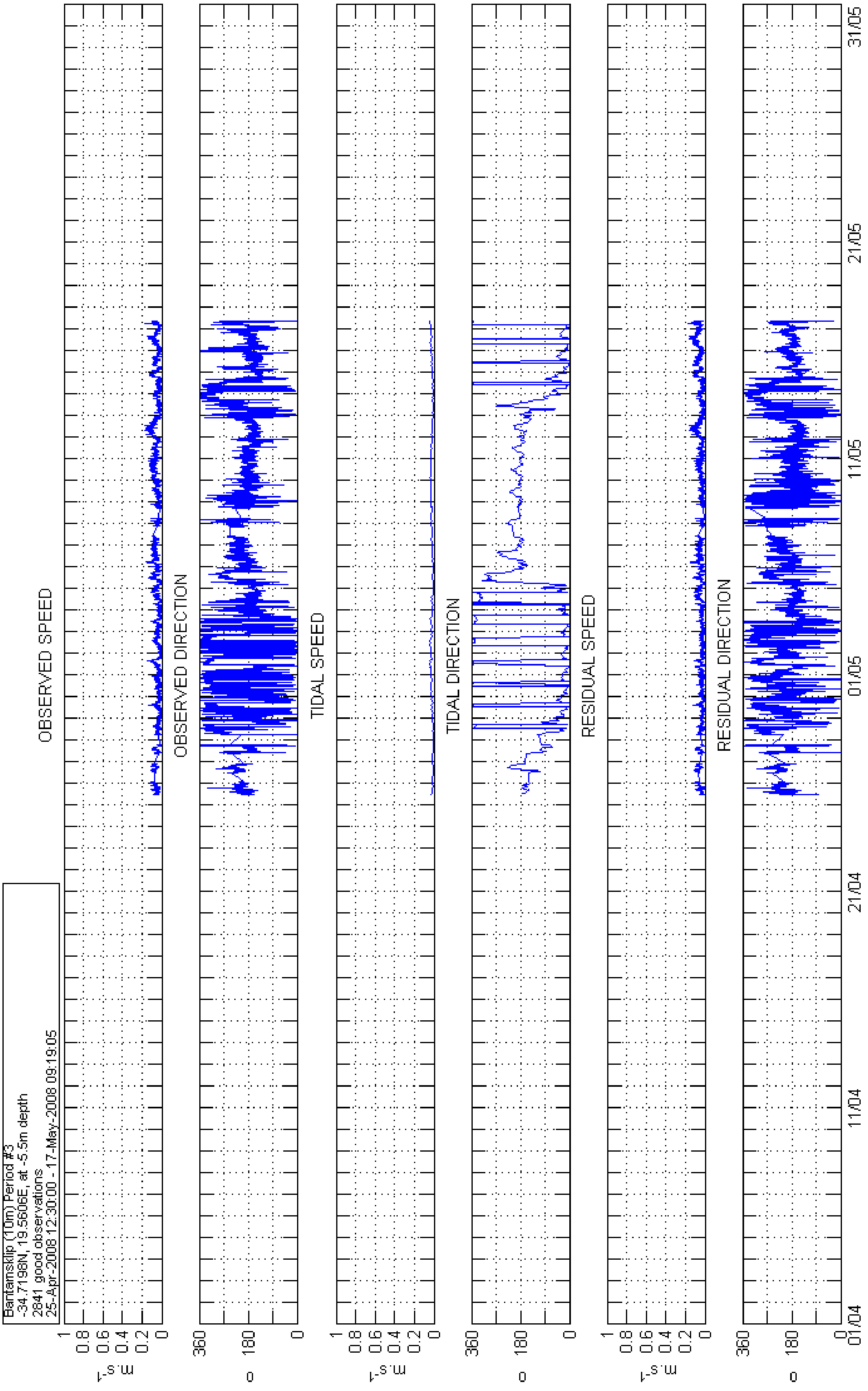


Figure 5: Time series plot for 10m ADCP current data at 5.5m

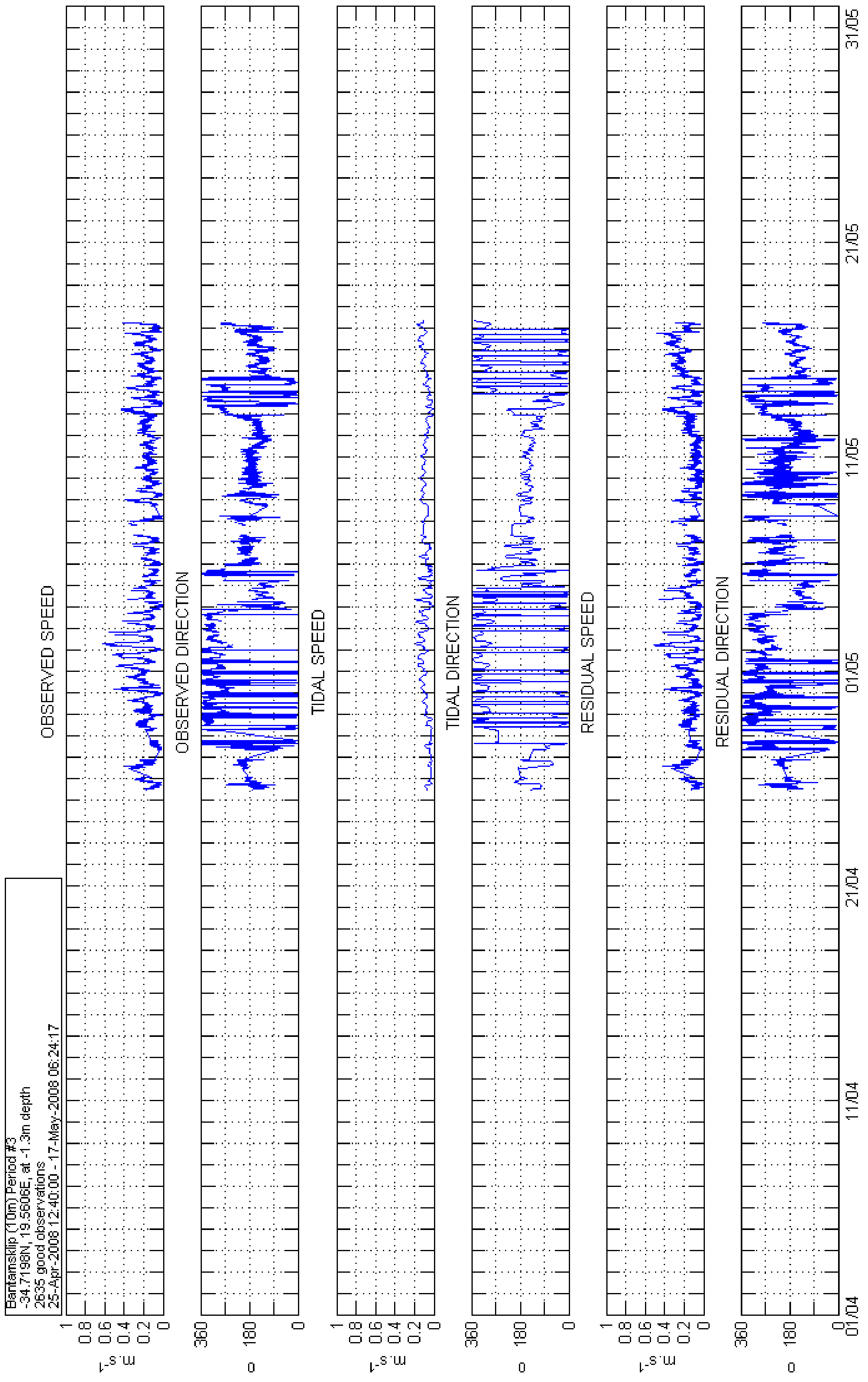


Figure 6: Time series plot for 10m ADCP current data at 1.3m

5.1.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at -11.5m depth
2841 good observations
25-Apr-2008 12:30:00 - 17-May-2008 09:19:05

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	3.94	9.08	15.52	19.85	12.11	9.43	6.16	4.47	3.66	2.64	1.90	2.04	1.76	1.80	2.92	2.46	99.75
0.1-0.2	0.07	0.04				0.04		0.04								0.04	0.21
0.2-0.3																	0.00
0.3-0.4									0.04								0.04
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	4.01	9.12	15.52	19.85	12.11	9.47	6.16	4.51	3.70	2.64	1.90	2.04	1.76	1.80	2.92	2.50	100.00

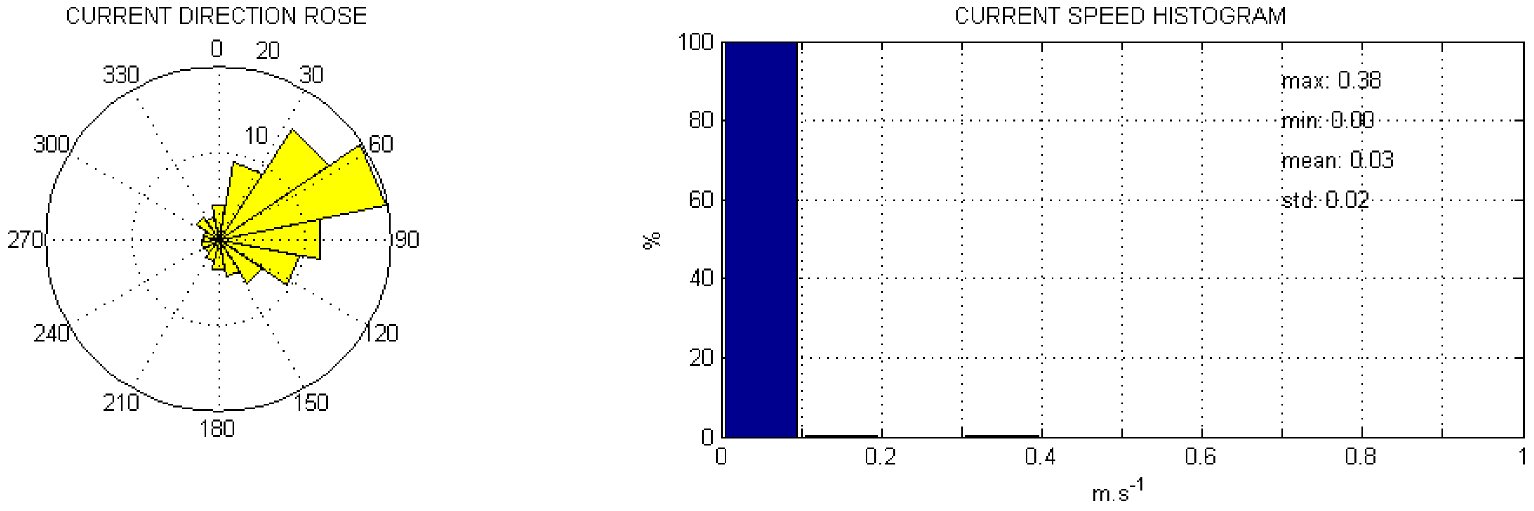


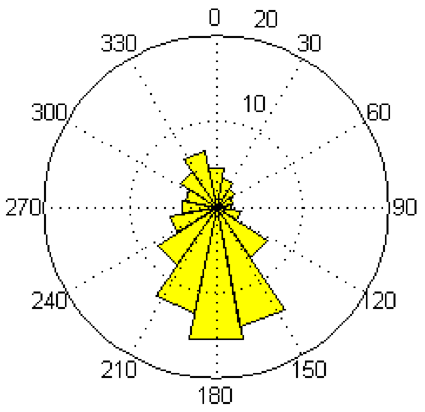
Figure 7: Summary plot for 10m ADCP current data at 11.5m

Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at -5.5m depth
2841 good observations
25-Apr-2008 12:30:00 - 17-May-2008 09:19:05

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	4.47	3.31	2.57	2.04	1.76	2.89	6.23	12.78	14.54	12.04	7.81	5.28	3.84	3.63	4.72	6.62	94.51
0.1-0.2	0.07		0.04				0.92	1.62	1.23	0.53	0.25	0.14	0.25	0.07	0.28	0.11	5.49
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	4.54	3.31	2.60	2.04	1.76	2.89	7.15	14.40	15.77	12.57	8.06	5.42	4.08	3.70	5.00	6.72	100.00

CURRENT DIRECTION ROSE



CURRENT SPEED HISTOGRAM

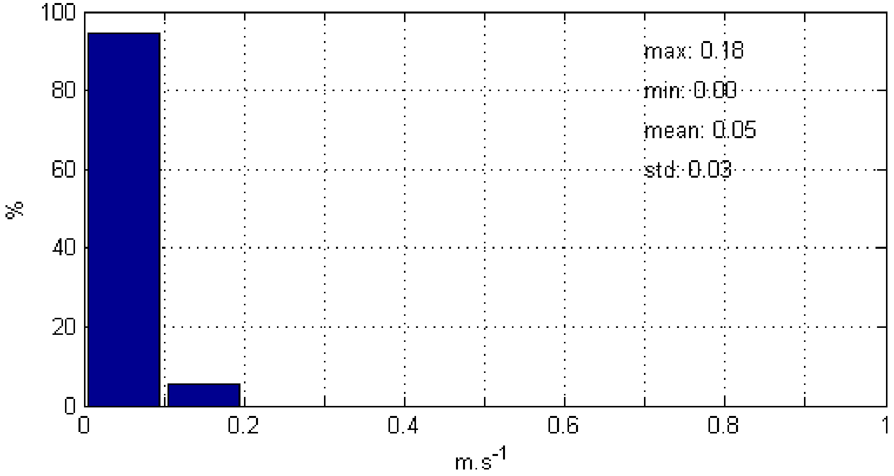


Figure 8: Summary plot for 10m ADCP current data at 5.5m

Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at -1.3m depth
2635 good observations
25-Apr-2008 12:40:00 - 17-May-2008 06:24:17

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.71	1.37	0.99	0.87	1.06	2.09	2.88	3.00	2.28	2.05	1.21	0.72	0.68	0.49	1.33	2.01	24.74
0.1-0.2	4.48	1.75	0.76	0.34	0.68	3.26	7.55	6.72	6.87	3.53	1.21	0.57	1.52	0.91	3.45	5.12	48.73
0.2-0.3	0.99	0.08			0.19	0.61	1.29	2.35	2.69	2.16	0.11	0.23	1.63	1.63	2.39	2.01	18.37
0.3-0.4						0.08		0.23	0.15	1.02	0.27	0.19	1.59	1.25	0.76	0.27	5.81
0.4-0.5												0.19	0.76	0.76	0.08		1.78
0.5-0.6												0.19	0.11	0.19			0.49
0.6-0.7													0.04	0.04			0.08
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	7.17	3.19	1.75	1.21	1.94	6.03	11.73	12.30	11.99	8.77	2.81	2.09	6.34	5.28	8.01	9.41	100.00

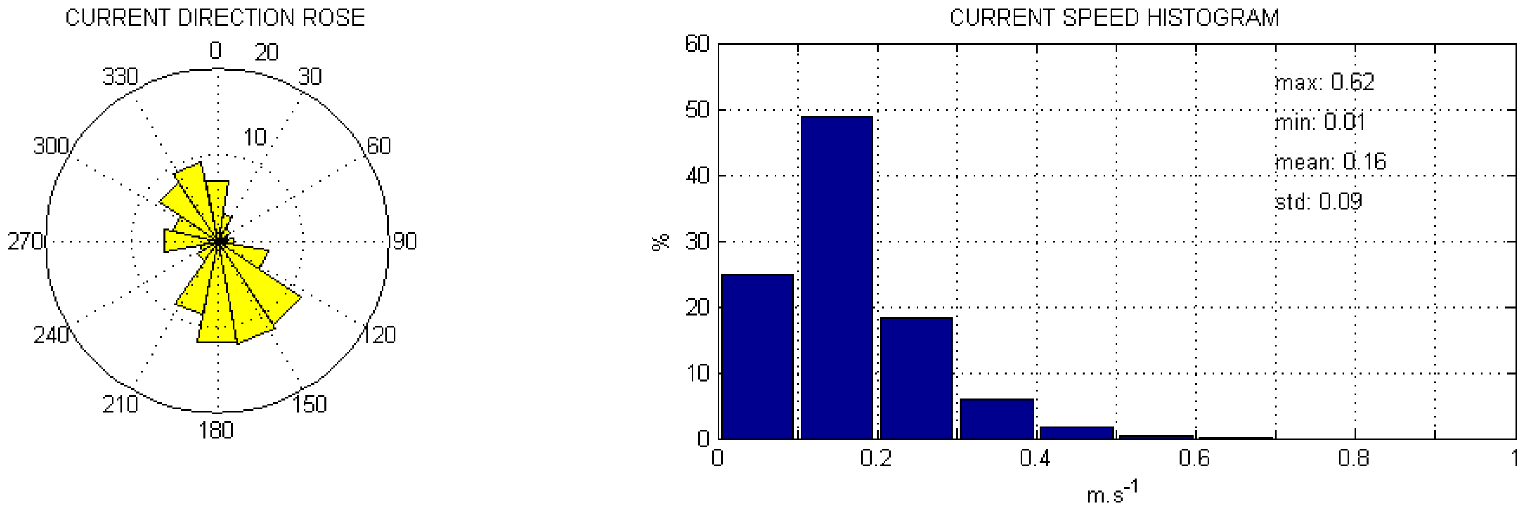
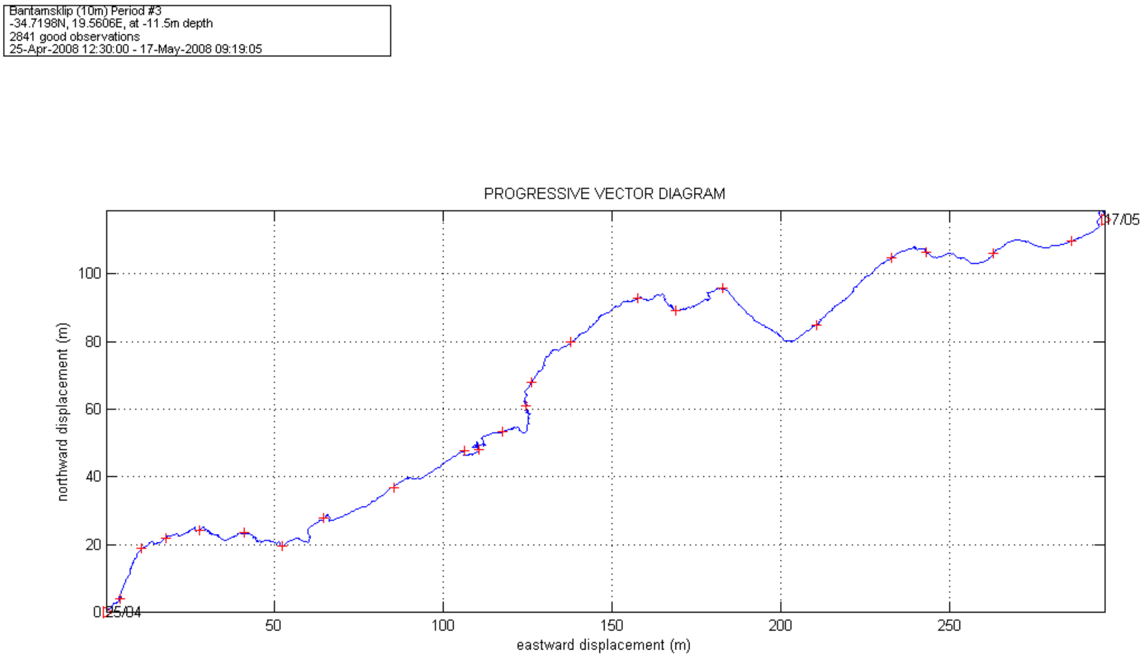
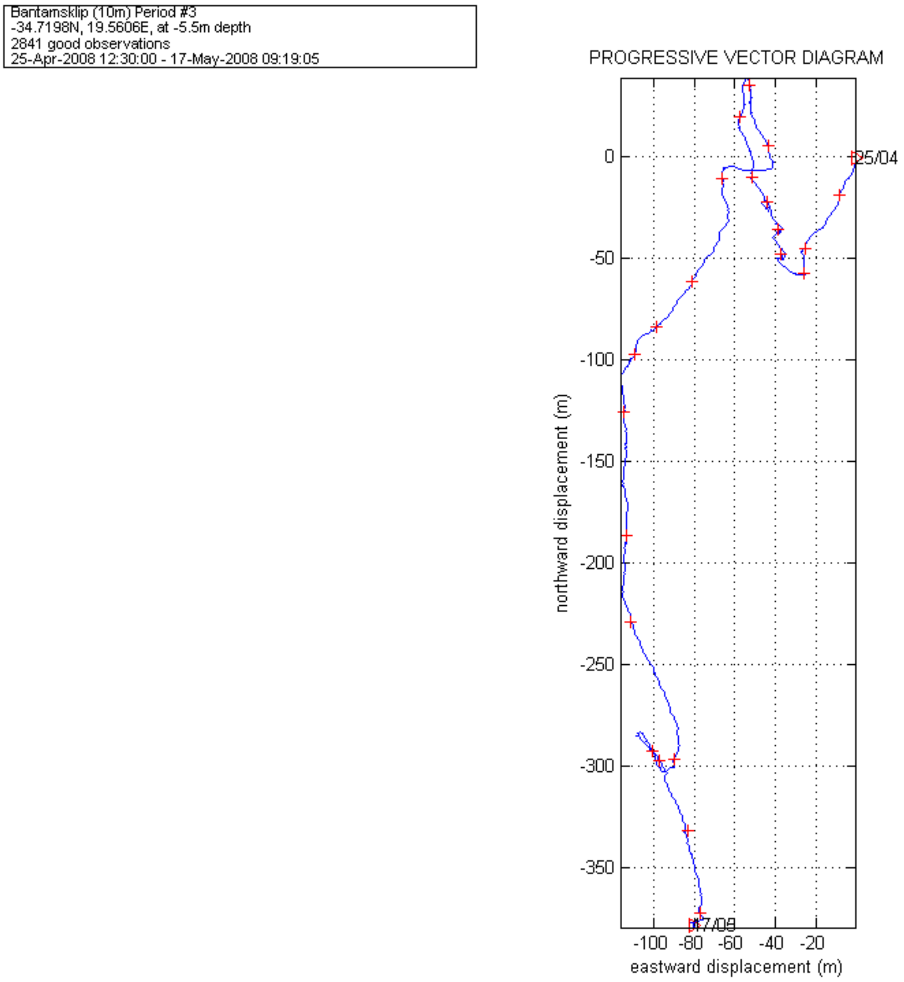


Figure 9: Summary plot for 10m ADCP current data at 1.3m



Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at -11.5m depth
2841 good observations
25-Apr-2008 12:30:00 - 17-May-2008 09:19:05

Figure 10: Progressive vector plot for 10m ADCP current data at 11.5m



Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at -5.5m depth
2841 good observations
25-Apr-2008 12:30:00 - 17-May-2008 09:19:05

Figure 11: Progressive vector plot for 10m ADCP current data at 5.5m

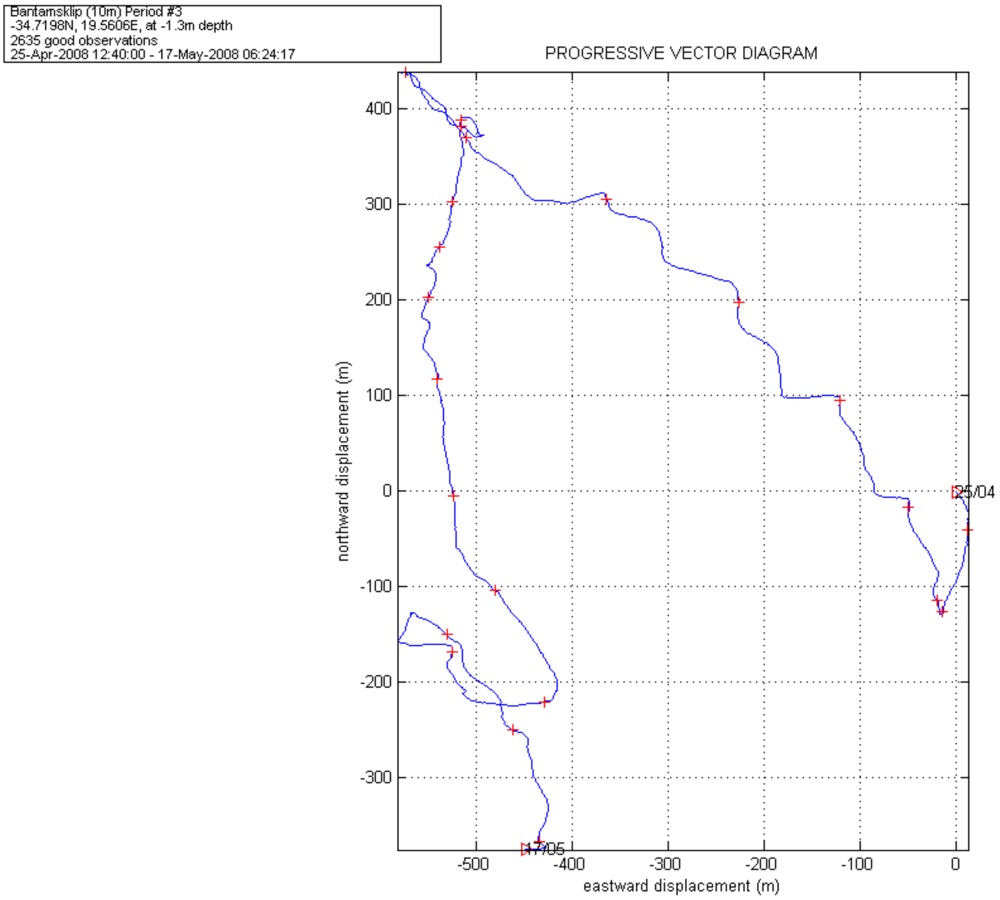


Figure 12: Progressive vector plot for 10m ADCP current data at 1.3m

5.1.2 Wave Data.

5.1.2.1 Hs and Tp summary plot

Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.2 Hs and Dp summary plot

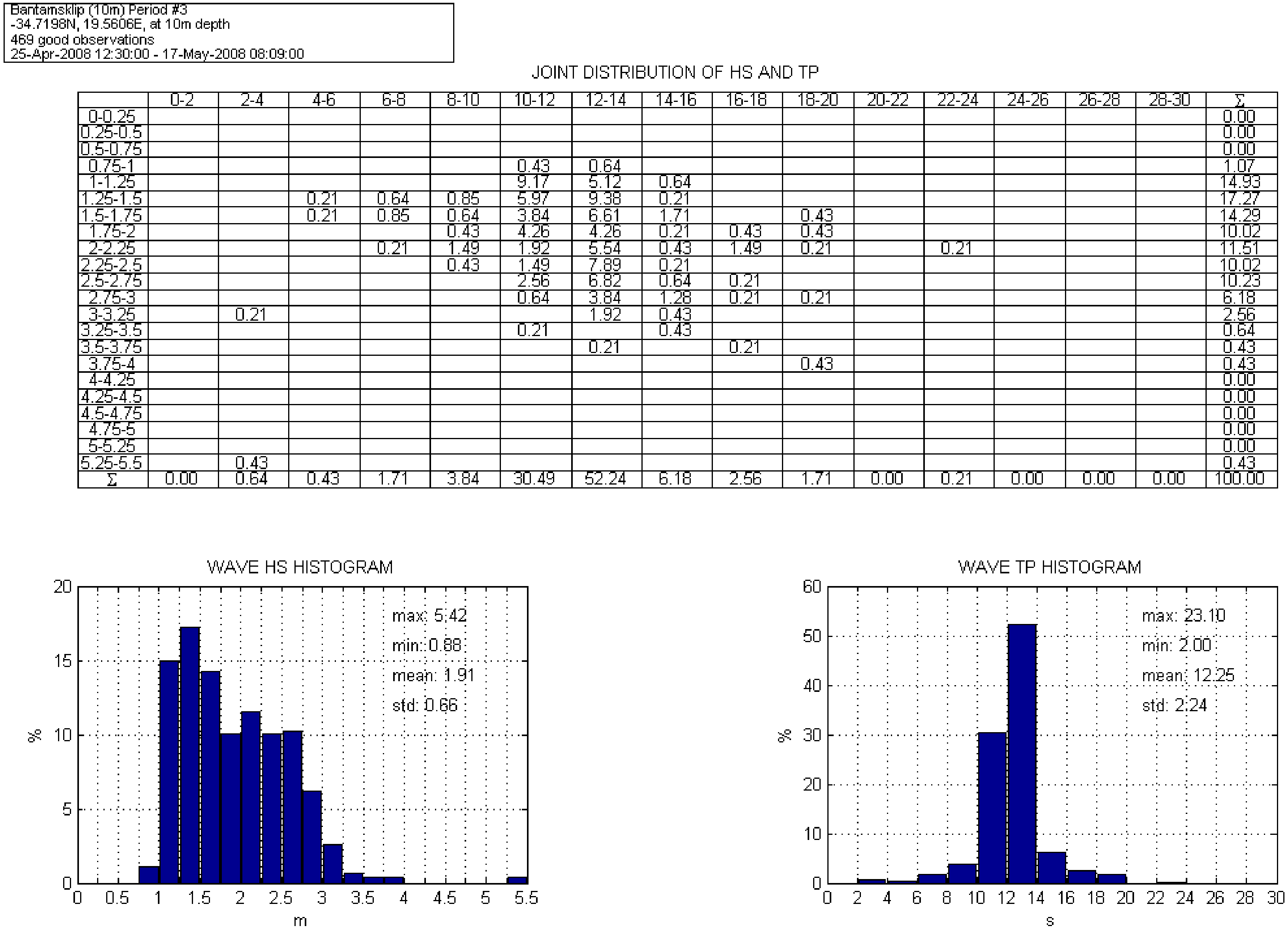
Figure 14 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.3 Tp and Dp summary plot

Figure 15 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.



Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at 10m depth
469 good observations
25-Apr-2008 12:30:00 - 17-May-2008 08:09:00

JOINT DISTRIBUTION OF HS AND TP

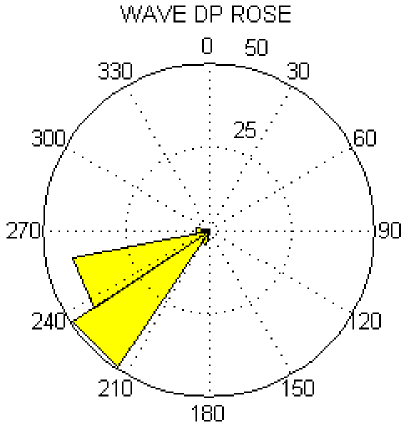
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1						0.43	0.64									1.07
1-1.25						9.17	5.12	0.64								14.93
1.25-1.5			0.21	0.64	0.85	5.97	9.38	0.21								17.27
1.5-1.75			0.21	0.85	0.64	3.84	6.61	1.71		0.43						14.29
1.75-2					0.43	4.26	4.26	0.21	0.43	0.43						10.02
2-2.25				0.21	1.49	1.92	5.54	0.43	1.49	0.21		0.21				11.51
2.25-2.5					0.43	1.49	7.89	0.21								10.02
2.5-2.75						2.56	6.82	0.64	0.21							10.23
2.75-3						0.64	3.84	1.28	0.21	0.21						6.18
3-3.25		0.21					1.92	0.43								2.56
3.25-3.5						0.21		0.43								0.64
3.5-3.75							0.21		0.21							0.43
3.75-4										0.43						0.43
4-4.25																0.00
4.25-4.5																0.00
4.5-4.75																0.00
4.75-5																0.00
5-5.25																0.00
5.25-5.5		0.43														0.43
Σ	0.00	0.64	0.43	1.71	3.84	30.49	52.24	6.18	2.56	1.71	0.00	0.21	0.00	0.00	0.00	100.00

Figure 13: Summary plot of H_s and T_p.

Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at 10m depth
469 good observations
25-Apr-2008 12:30:00 - 17-May-2008 08:09:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1											1.07						1.07
1-1.25										1.28	9.17	4.48					14.93
1.25-1.5										1.07	9.81	5.76	0.64				17.27
1.5-1.75										0.85	5.97	6.40	0.85	0.21			14.29
1.75-2											5.12	4.26	0.64				10.02
2-2.25											4.90	5.54	0.85	0.21			11.51
2.25-2.5										0.21	4.26	4.90	0.64				10.02
2.5-2.75										0.43	4.69	4.69	0.43				10.23
2.75-3											2.77	3.41					6.18
3-3.25											1.28	1.28					2.56
3.25-3.5										0.21		0.43					0.64
3.5-3.75										0.21		0.21					0.43
3.75-4		0.21									0.21						0.43
4-4.25																	0.00
4.25-4.5																	0.00
4.5-4.75																	0.00
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5												0.43					0.43
Σ	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.26	49.25	41.79	4.05	0.43	0.00	0.00	100.00



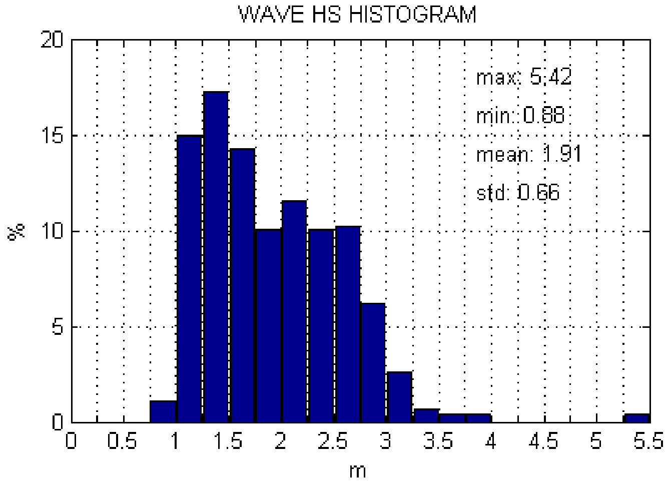
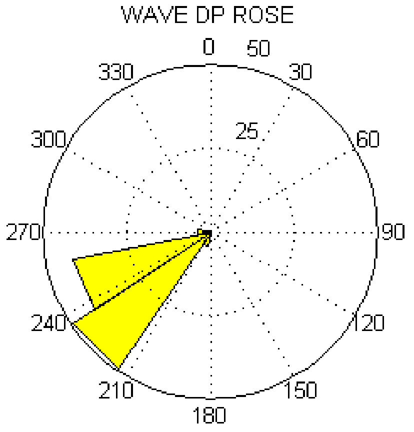


Figure 14: Summary plot of H_s and D_p.

Bantamsklip (10m) Period #3
-34.7198N, 19.5606E, at 10m depth
469 good observations
25-Apr-2008 12:30:00 - 17-May-2008 08:09:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4											0.21	0.43					0.64
4-6													0.21	0.21			0.43
6-8										0.21		0.43	1.07				1.71
8-10											2.13	0.64	0.85	0.21			3.84
10-12										2.99	18.12	8.53	0.85				30.49
12-14										0.85	23.24	27.08	1.07				52.24
14-16											2.77	3.41					6.18
16-18										0.21	1.49	0.85					2.56
18-20		0.21									1.28	0.21					1.71
20-22																	0.00
22-24												0.21					0.21
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.26	49.25	41.79	4.05	0.43	0.00	0.00	100.00



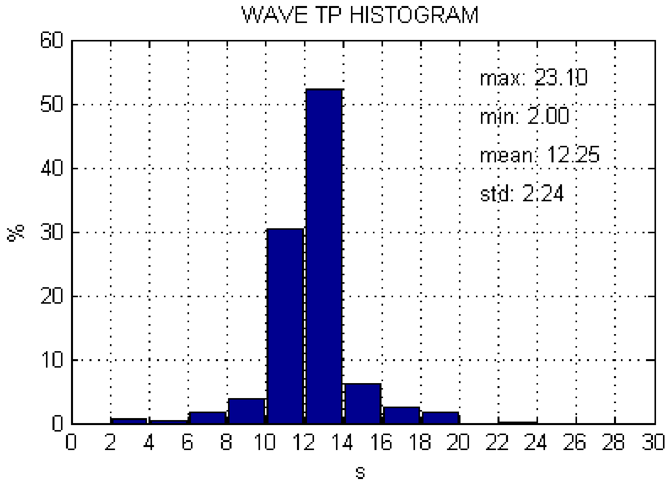


Figure 15: Summary plot of T_p and D_p.

5.1.2.4 Wave spectral plot

Figure 16 and Figure 17 display wave spectral plots for significant waves events. The time of each spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

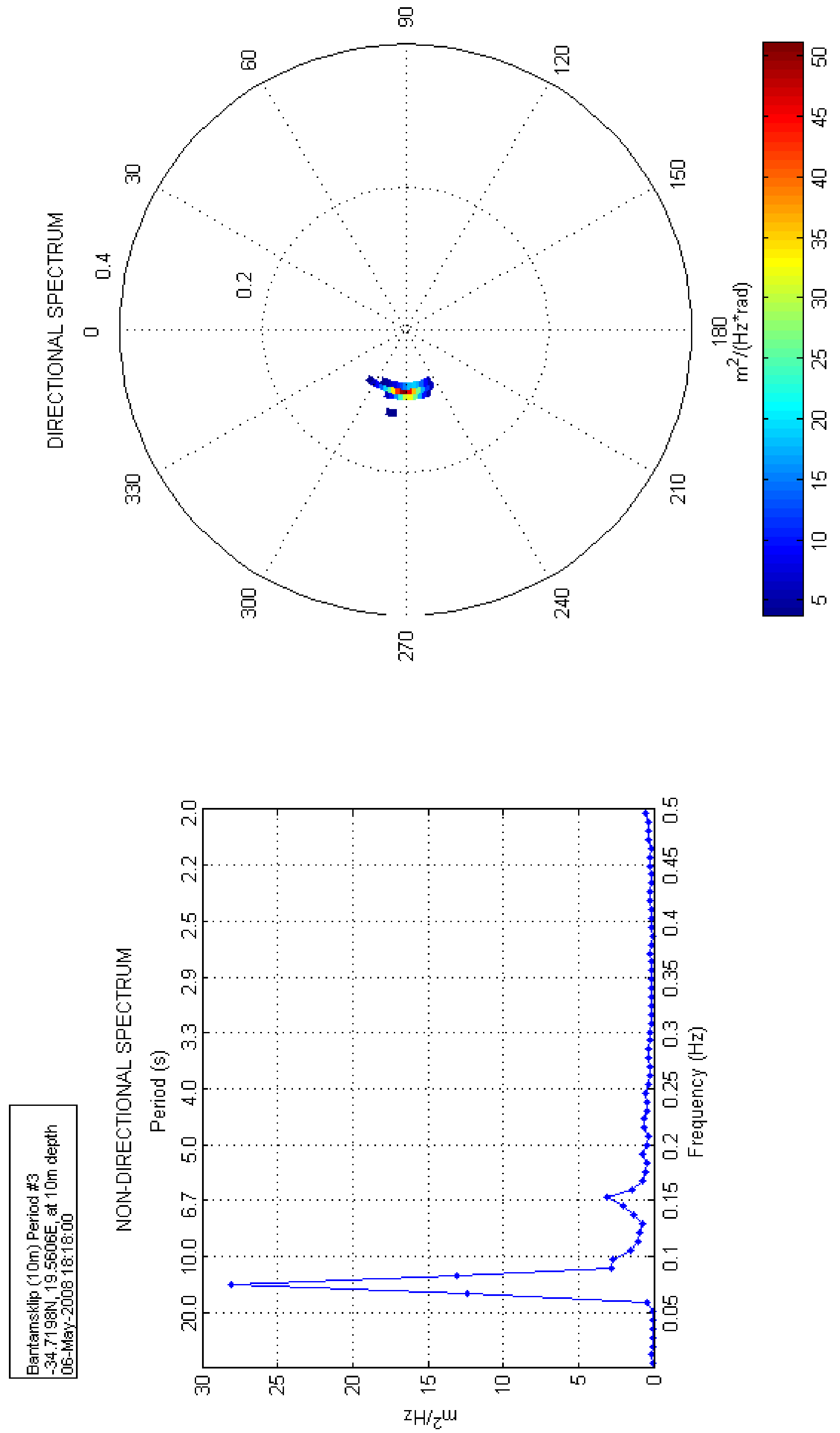


Figure 16: Wave spectra for 06th of May 2008 at 18:18:00.

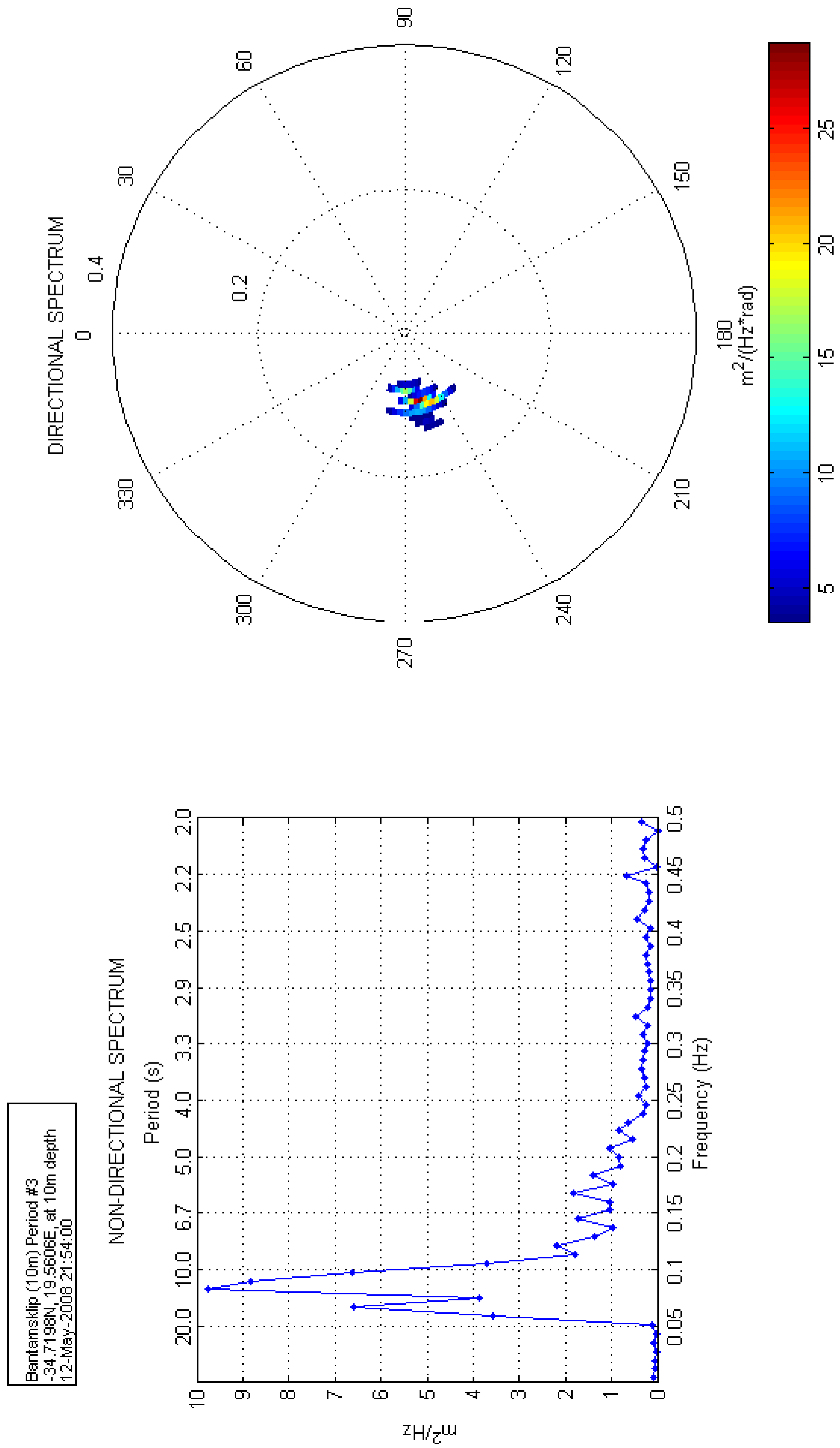


Figure 17: Wave spectra for 12th of May 2008 at 21:54:00.

5.2 30M ADCP

5.2.1 Current Data

5.2.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

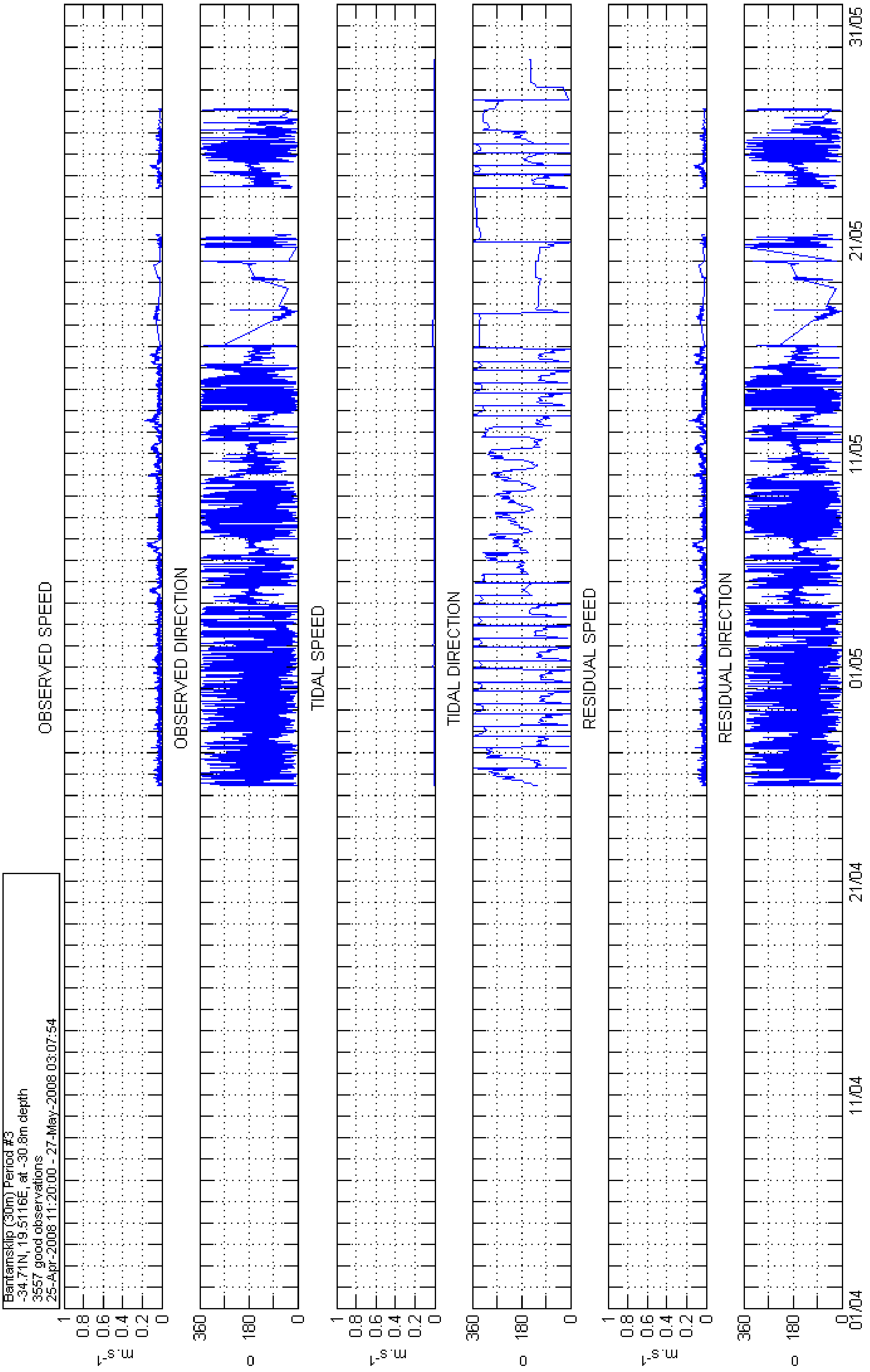


Figure 18: Time series plot for 30m ADCP current data at 30.8m

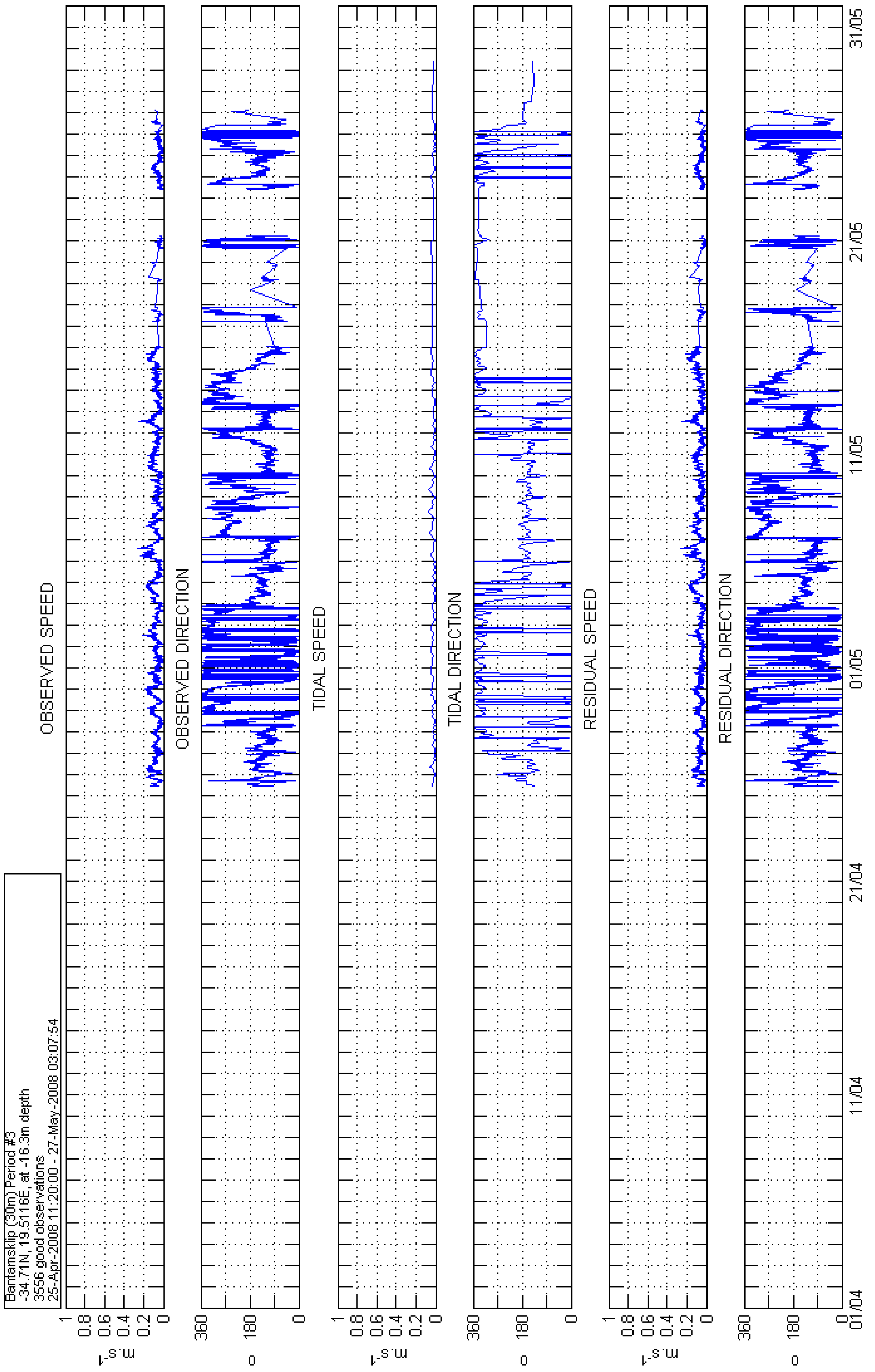


Figure 19: Time series plot for 30m ADCP current data at 16.3m

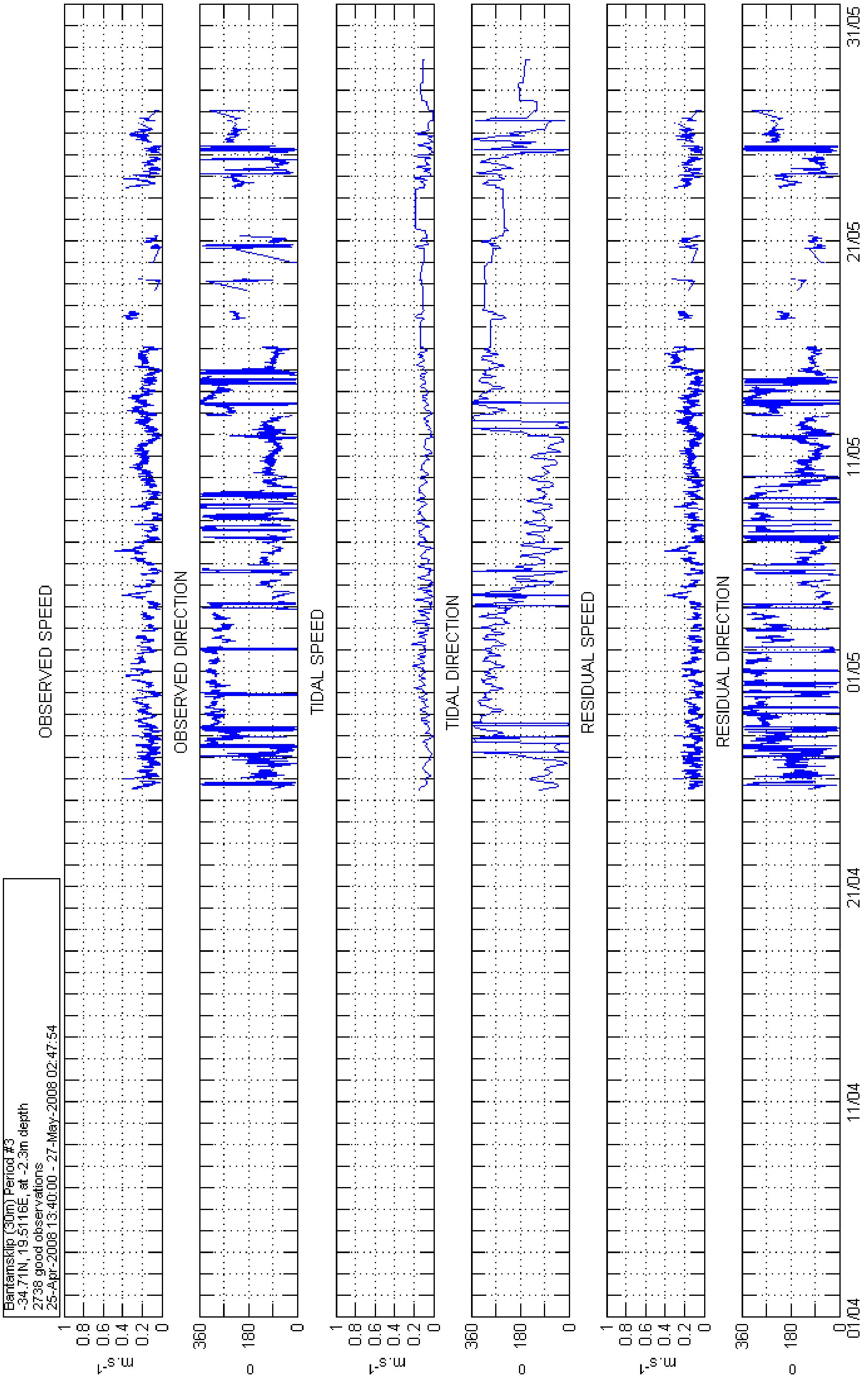


Figure 20: Time series plot for 30m ADCP current data at 2.3m

5.2.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.2.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at -30.8m depth
3557 good observations
25-Apr-2008 11:20:00 - 27-May-2008 03:07:54

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	7.11	8.21	9.28	8.21	5.51	6.16	7.14	10.26	7.82	4.58	3.40	2.95	2.84	4.16	5.17	5.29	98.09
0.1-0.2		0.03				0.17	0.22	0.73	0.53	0.06	0.17						1.91
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	7.11	8.24	9.28	8.21	5.51	6.33	7.37	10.99	8.35	4.64	3.57	2.95	2.84	4.16	5.17	5.29	100.00

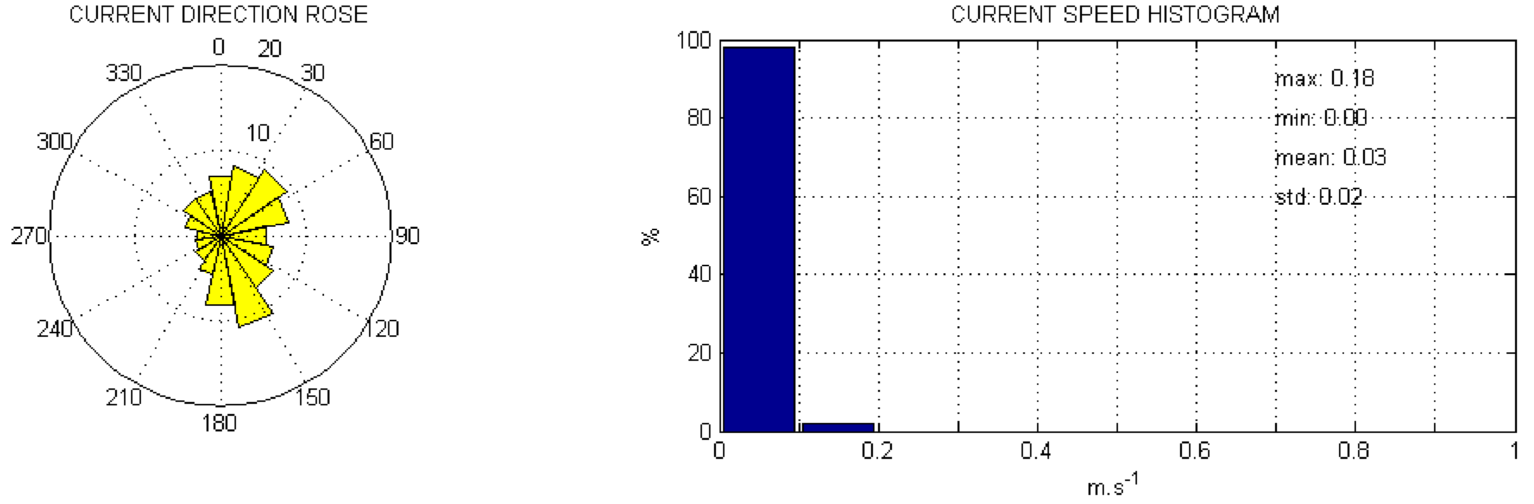
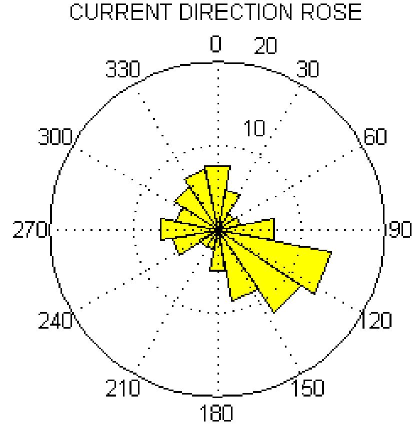


Figure 21: Summary plot for 30m ADCP current data at 30.8m

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at -16.3m depth
3556 good observations
25-Apr-2008 11:20:00 - 27-May-2008 03:07:54

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	6.13	4.75	2.39	2.81	5.79	8.58	7.23	6.19	4.27	2.39	2.25	4.50	6.16	4.75	4.81	5.12	78.12
0.1-0.2	1.52	0.17			1.10	4.95	4.72	2.53	0.67	0.06	0.25	0.98	0.67	0.31	1.27	2.14	21.34
0.2-0.3						0.39	0.11						0.03				0.53
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	7.65	4.92	2.39	2.81	6.89	13.92	12.06	8.72	4.95	2.45	2.50	5.48	6.86	5.06	6.07	7.26	100.00



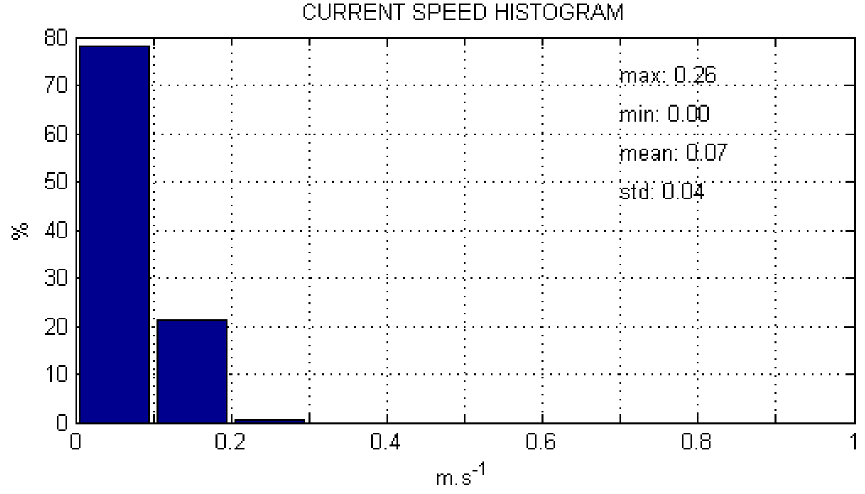


Figure 22: Summary plot for 30m ADCP current data at 16.3m

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at -2.3m depth
2738 good observations
25-Apr-2008 13:40:00 - 27-May-2008 02:47:54

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.97	2.30	1.86	2.59	2.92	2.08	1.28	0.91	1.02	0.62	0.33	1.35	1.39	2.05	2.74	2.26	27.68
0.1-0.2	3.10	1.94	2.52	4.97	8.07	5.33	2.23	0.47	0.55	0.73	1.53	2.45	2.30	3.80	5.37	2.99	48.36
0.2-0.3	0.66	0.29	0.51	2.56	2.74	2.19	0.66	0.07	0.11	0.26	2.26	1.24	0.62	3.40	2.59	0.95	21.11
0.3-0.4	0.04		0.22	0.55	0.07	0.11				0.04	1.06	0.18		0.18	0.18	0.07	2.70
0.4-0.5				0.11	0.04												0.15
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	5.77	4.53	5.11	10.77	13.84	9.72	4.16	1.46	1.68	1.64	5.19	5.22	4.31	9.42	10.88	6.28	100.00

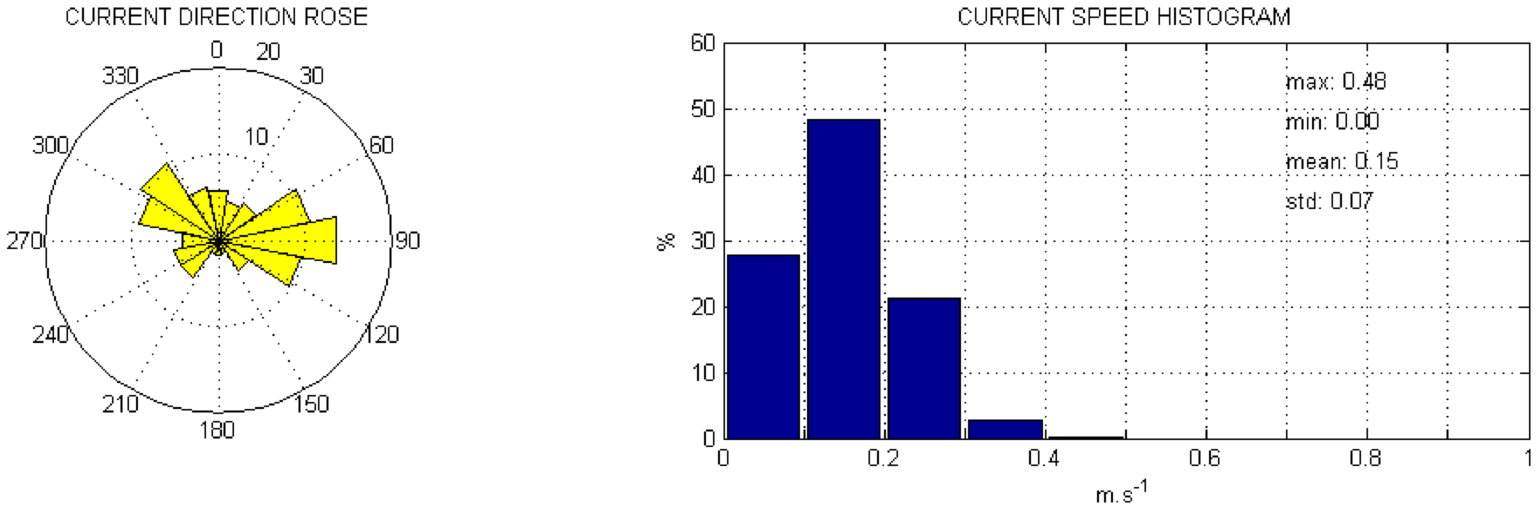


Figure 23: Summary plot for 30m ADCP current data at 2.3m

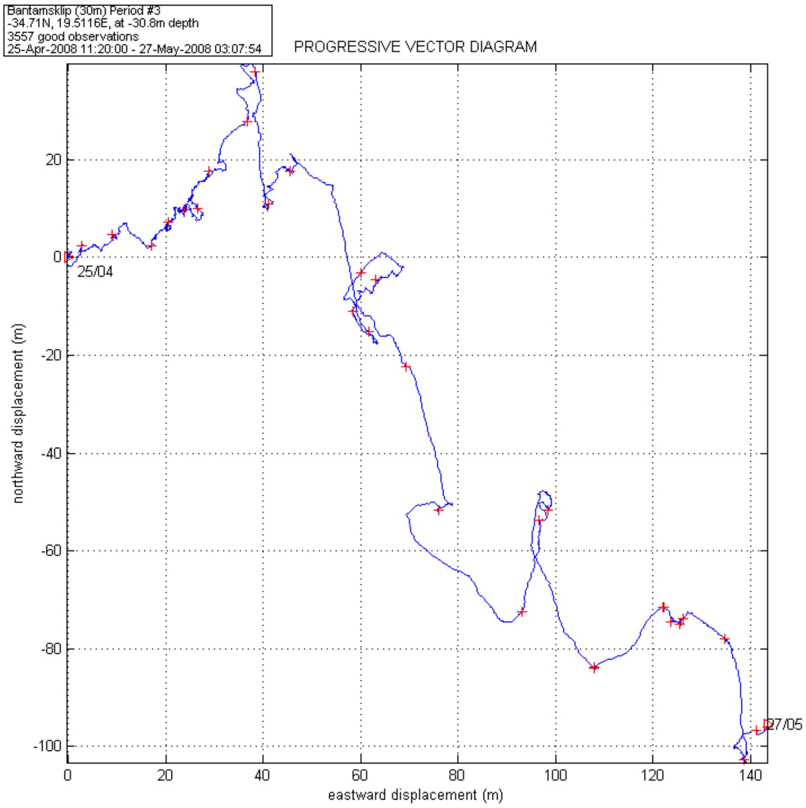


Figure 24: Progressive vector plot for 30m ADCP current data at 30.8m

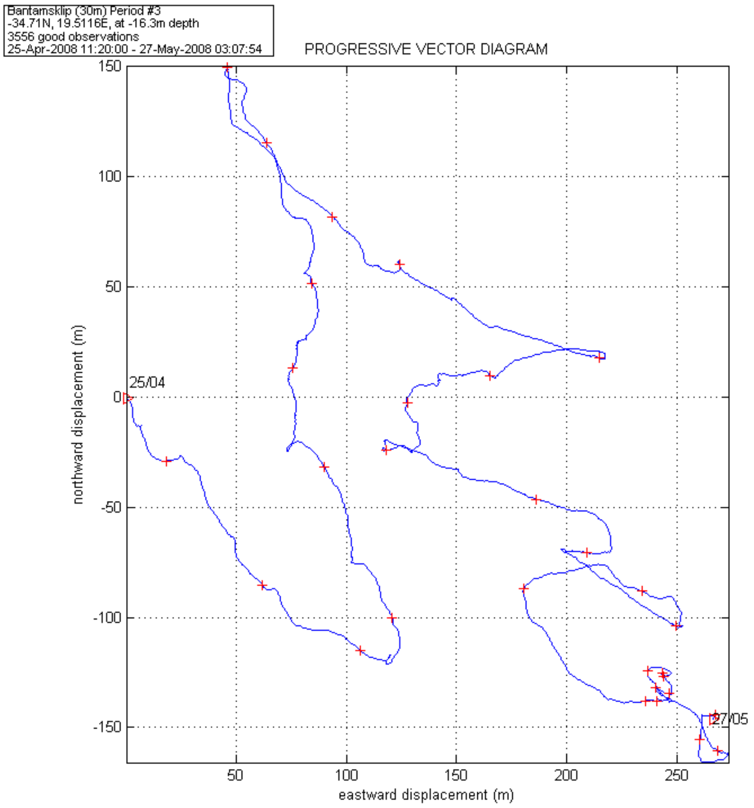


Figure 25: Progressive vector plot for 30m ADCP current data at 16.3m

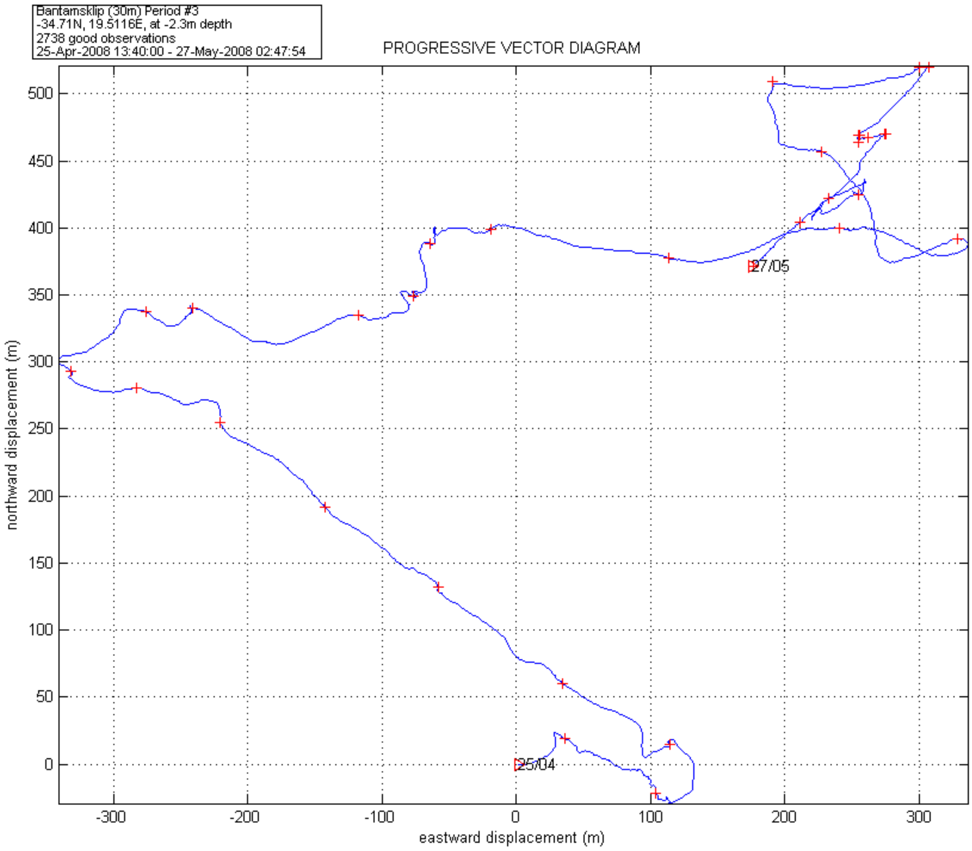


Figure 26: Progressive vector plot for 30m ADCP current data at 2.3m

5.2.2 Wave Data.

5.2.2.1 Hs and Tp summary plot

Figure 27 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.2.2.2 Hs and Dp summary plot

Figure 28 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.2.2.3 Tp and Dp summary plot

Figure 29 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at 30m depth
484 good observations
25-Apr-2008 11:30:00 - 16-May-2008 01:30:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1																0.00
1-1.25						1.86	0.83	0.21								2.89
1.25-1.5			0.21		1.03	9.30	6.61									17.15
1.5-1.75				1.03	0.83	5.37	5.99	0.21								13.43
1.75-2				1.24	0.83	6.82	2.89		0.62	0.21						12.60
2-2.25					1.45	4.13	2.69	0.62	0.83							9.71
2.25-2.5				0.21	1.86	1.86	4.55	2.07	0.41							10.95
2.5-2.75					0.83	3.10	5.79	1.24								10.95
2.75-3						2.27	6.20	1.03								9.50
3-3.25						1.86	4.96	0.21								7.02
3.25-3.5						0.41	2.07									2.48
3.5-3.75						0.21	1.24	0.21								1.65
3.75-4						0.21	0.41									0.62
4-4.25							0.62									0.62
4.25-4.5																0.00
4.5-4.75							0.41									0.41
4.75-5																0.00
5-5.25																0.00
5.25-5.5																0.00
Σ	0.00	0.00	0.21	2.48	6.82	37.40	45.25	5.79	1.86	0.21	0.00	0.00	0.00	0.00	0.00	100.00

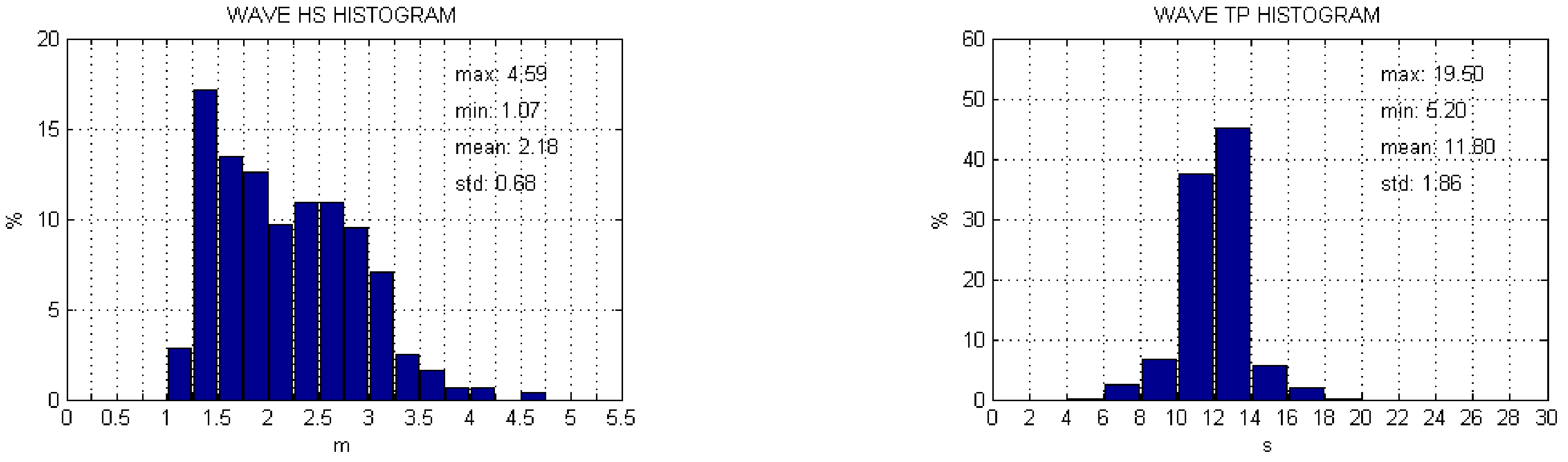
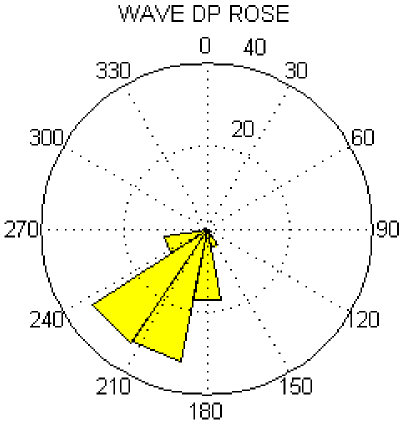


Figure 27: Summary plot of H_s and T_p.

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at 30m depth
484 good observations
25-Apr-2008 11:30:00 - 16-May-2008 01:30:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1																	0.00
1-1.25								0.21	0.83	1.03	0.83						2.89
1.25-1.5							0.21	1.24	5.37	5.58	4.34	0.41					17.15
1.5-1.75							0.41	1.03	2.48	4.75	3.31	1.24	0.21				13.43
1.75-2							0.41	0.83	2.89	3.93	4.34	0.21					12.60
2-2.25								0.21	0.83	3.93	3.72	0.83	0.21				9.71
2.25-2.5									0.21	2.89	4.55	3.31					10.95
2.5-2.75								0.62	1.65	2.69	4.34	1.65					10.95
2.75-3								0.21	1.24	4.34	2.89	0.83					9.50
3-3.25							0.21		1.24	2.27	2.27	1.03					7.02
3.25-3.5								0.21		0.62	1.24	0.41					2.48
3.5-3.75									0.21	0.62	0.83						1.65
3.75-4									0.21			0.41					0.62
4-4.25								0.21	0.21		0.21						0.62
4.25-4.5																	0.00
4.5-4.75									0.21		0.21						0.41
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	1.24	4.75	17.56	32.64	33.06	10.33	0.41	0.00	0.00	0.00	100.00



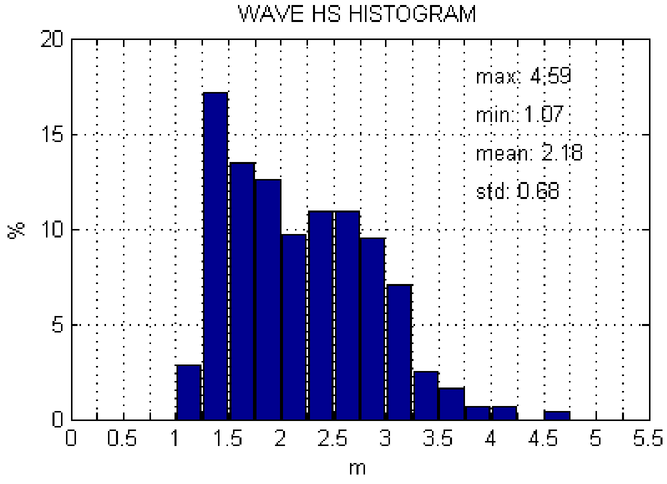
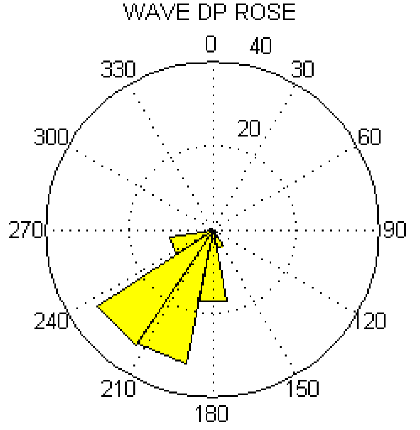


Figure 28: Summary plot of H_s and D_p.

Bantamsklip (30m) Period #3
-34.71N, 19.5116E, at 30m depth
484 good observations
25-Apr-2008 11:30:00 - 16-May-2008 01:30:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4																	0.00
4-6												0.21					0.21
6-8							0.62	0.62	0.41	0.41		0.41					2.48
8-10								0.83	0.83	1.03	1.86	2.07	0.21				6.82
10-12							0.41	2.48	10.33	13.22	8.88	1.86	0.21				37.40
12-14							0.21	0.83	5.99	16.94	17.36	3.93					45.25
14-16										1.03	3.10	1.65					5.79
16-18											1.65	0.21					1.86
18-20											0.21						0.21
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	1.24	4.75	17.56	32.64	33.06	10.33	0.41	0.00	0.00	0.00	100.00



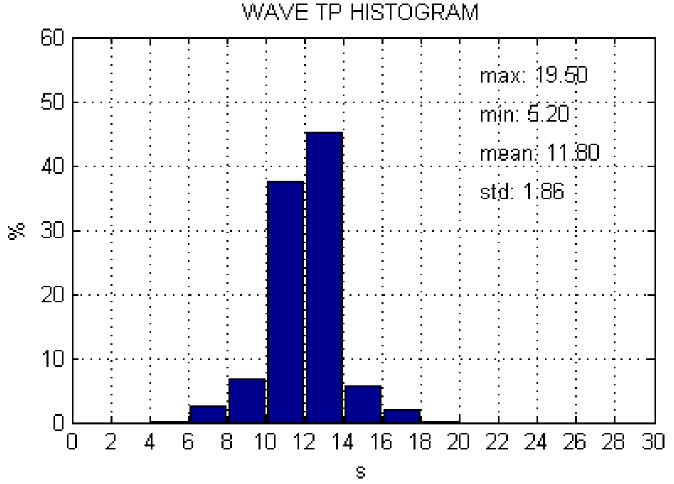


Figure 29: Summary plot of T_p and D_p.

5.2.2.4 Wave spectral plot

Figure 30 and Figure 31 display wave spectral plots for significant waves events. The time of each spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

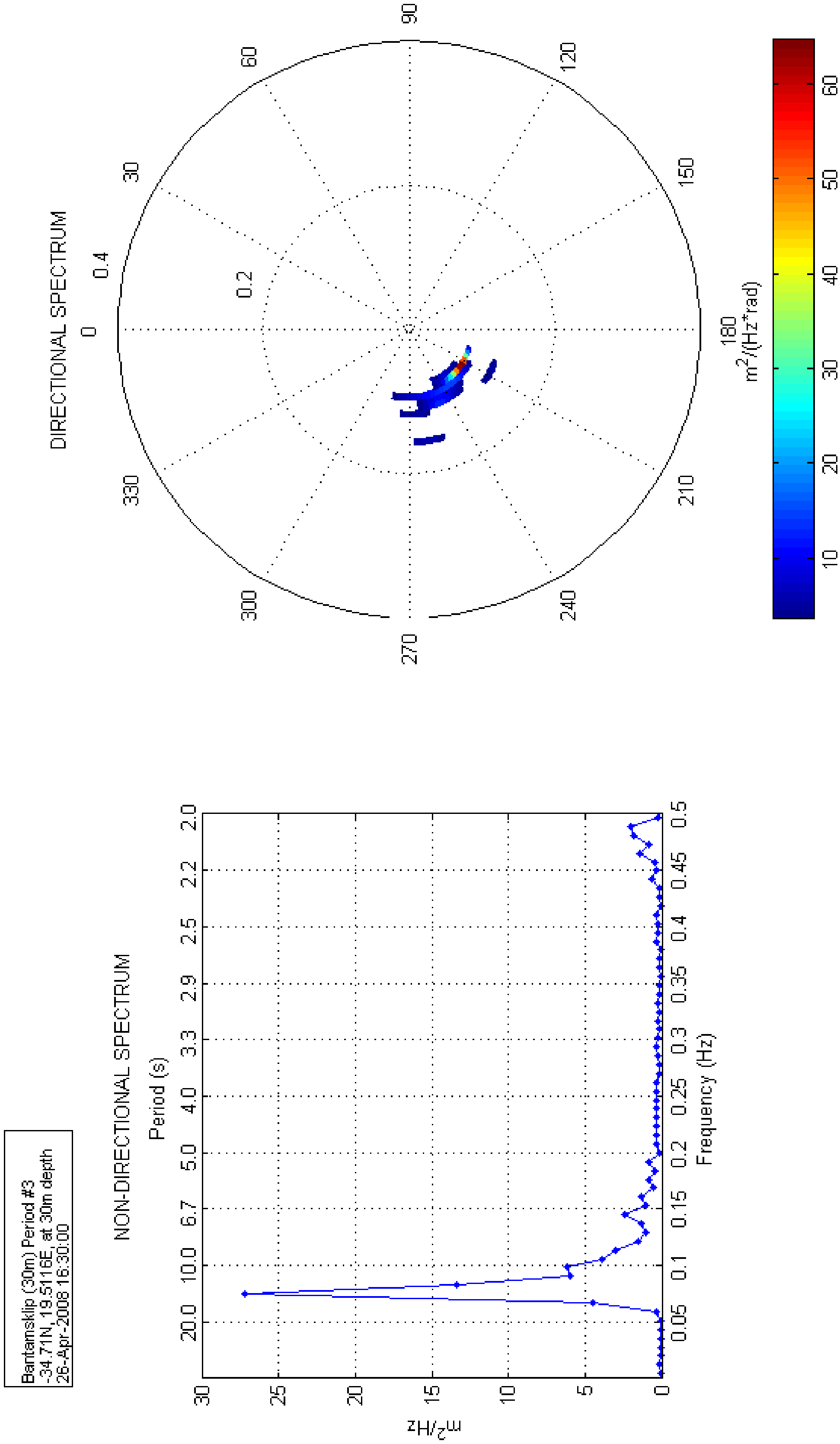
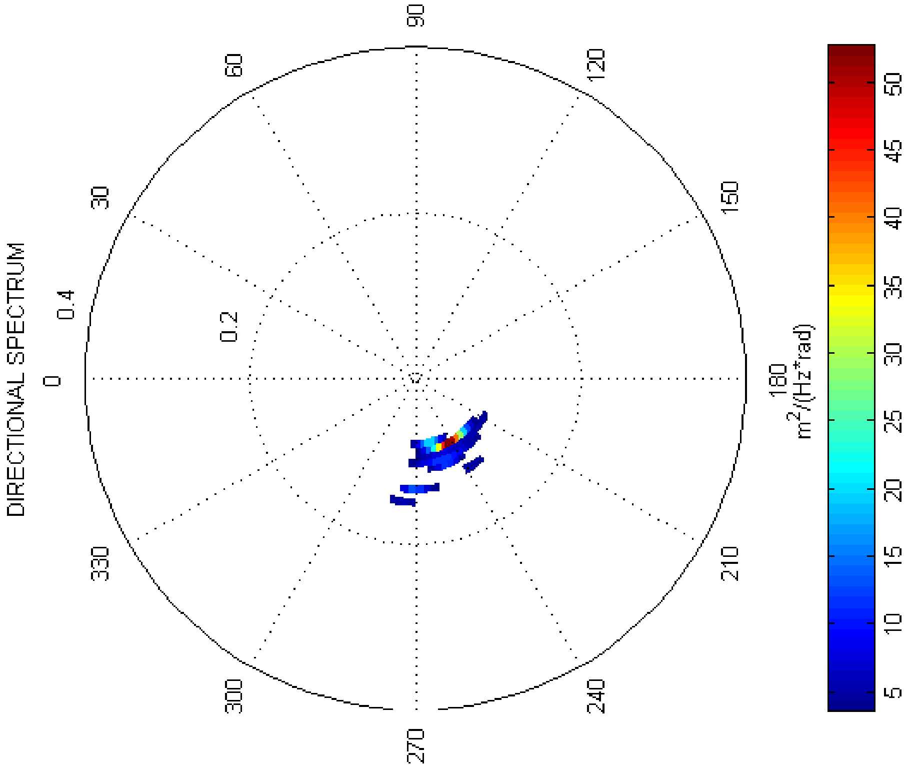


Figure 30: Wave spectra for 26th of April 2008 at 16:30:00.



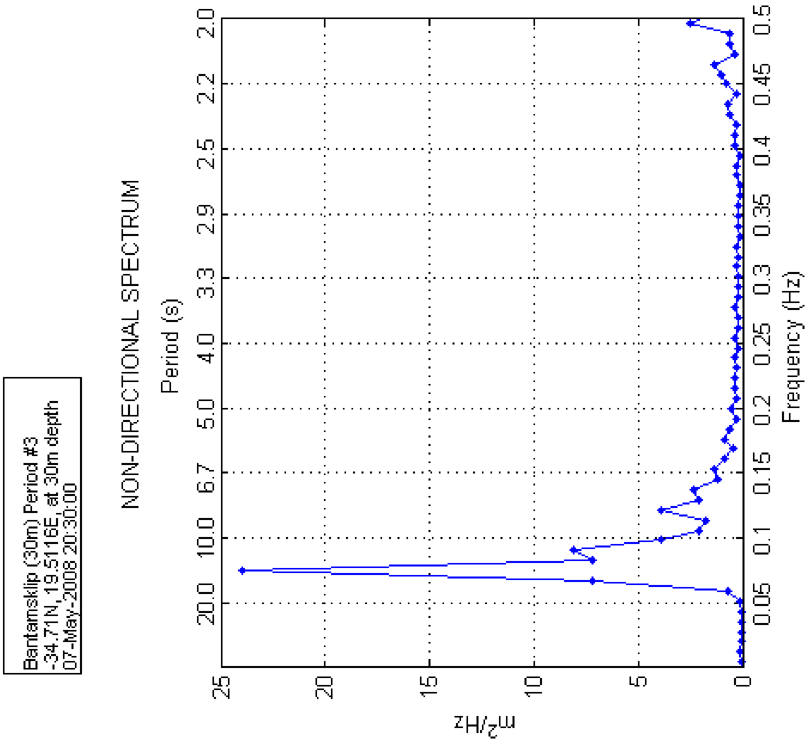


Figure 31: Wave spectra for 7th of May 2008 at 20:30:00.

5.3 COMPARISON PLOTS

5.3.1 Hs, Tp and Dp time series plots for 10m and 30m ADCPs.

Figure 32 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

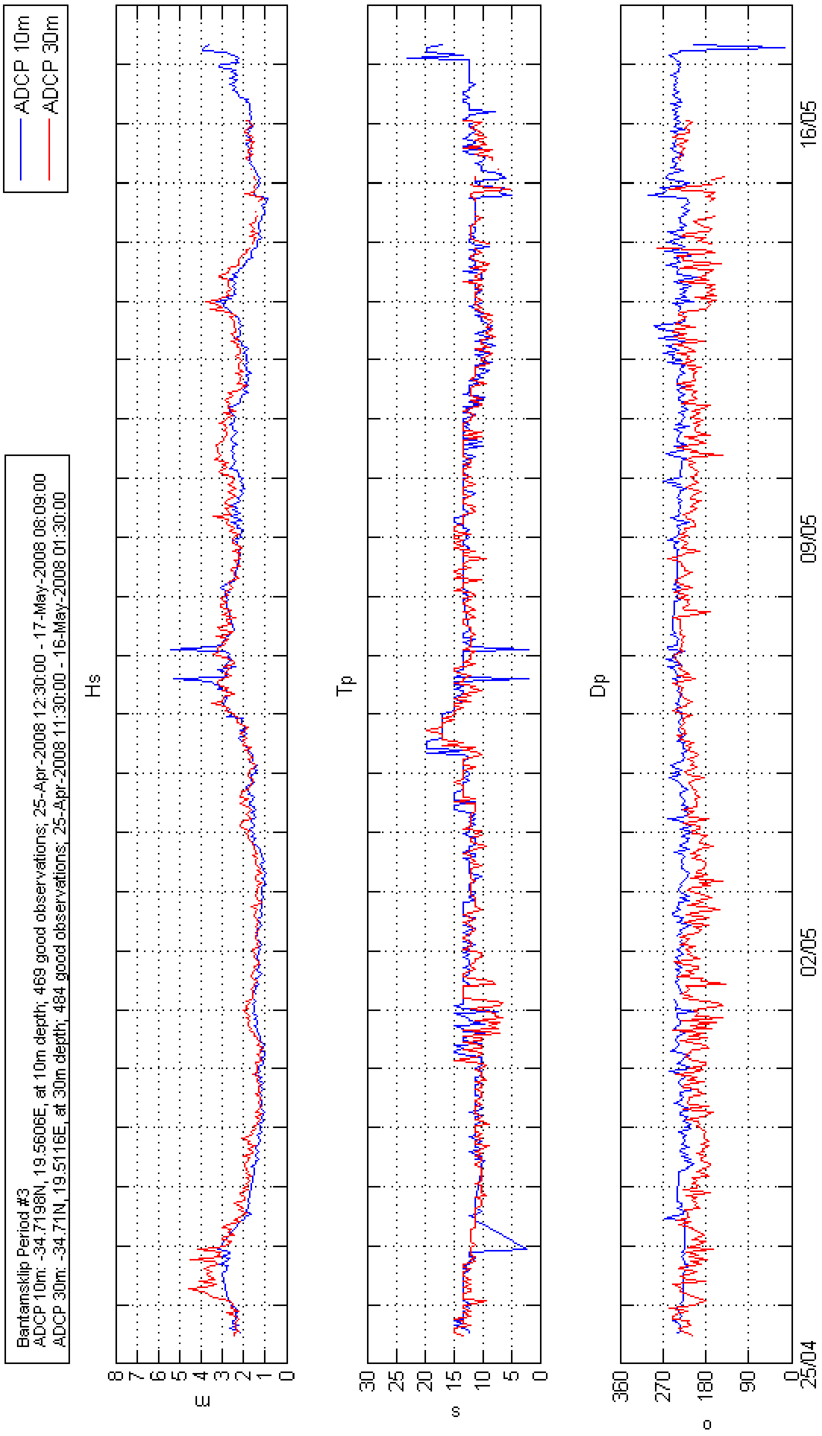


Figure 32: Wave Hs, Tp, and Dp for 10m and 30m ADCP.

5.3.2 Water properties: RBR-CT loggers and ADCPs temperature sensors.

Figure 33 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCP temperature sensor against time.
- The second panel is of the derived salinity from the two RBR loggers against time.

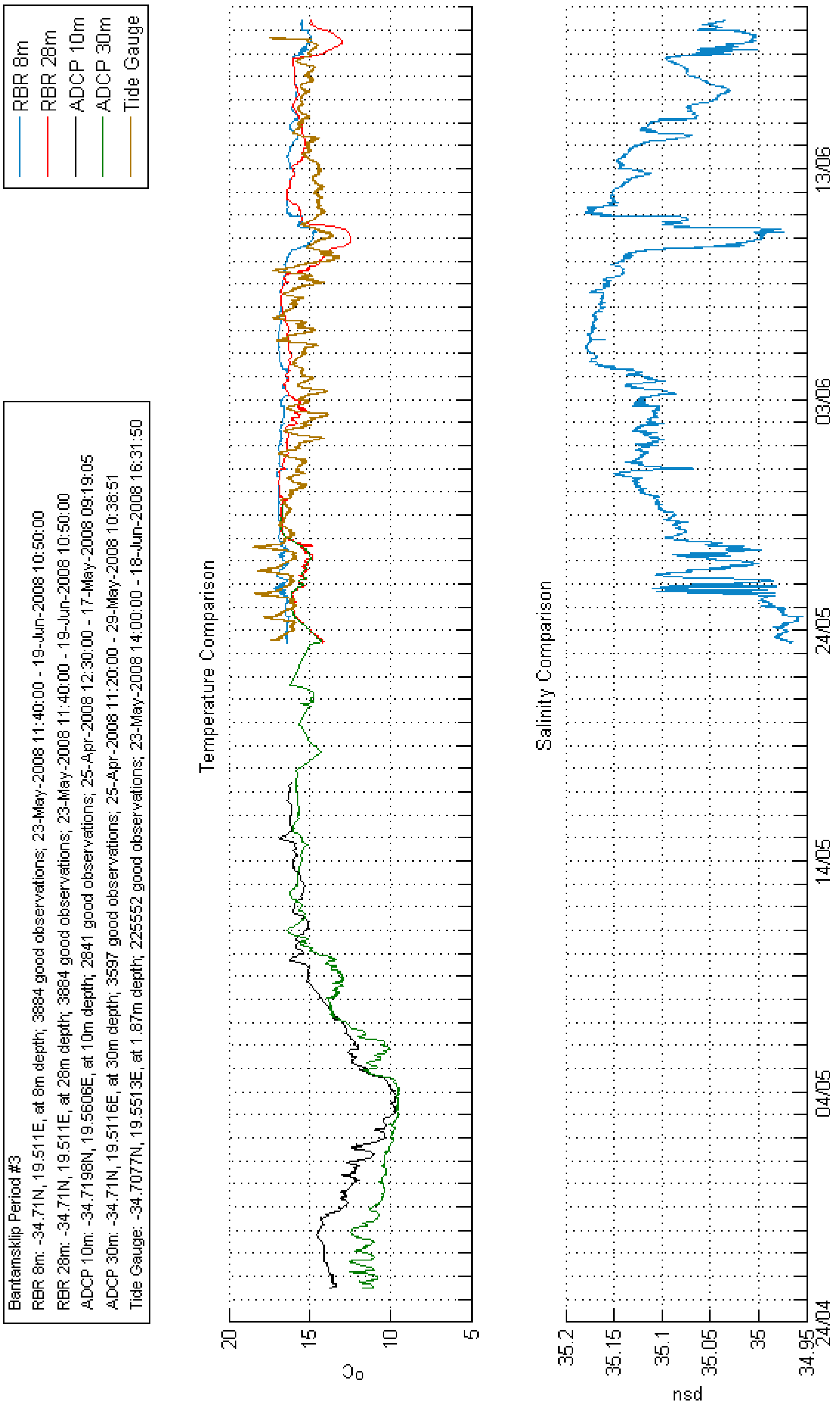


Figure 33: Time series of temperature and salinity from the RBR loggers and ADCPs.

5.4 TIDE GAUGE

Figure 34 displays a time series plot of the tidal height.

- The first (upper) panel is of the observed height against time.
- The second panel is of the tidal height, calculated from the observed height, against time. The tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The third panel is of the residual height against time. The residual has been calculated as the observed height minus the tidal height.

Table 17 shows the tidal harmonics resulting from the analysis.

5.5 WATER SAMPLES.

Analysis of water samples were undertaken by the CSIR and results are presented as an appendage (Section 8, page 75).

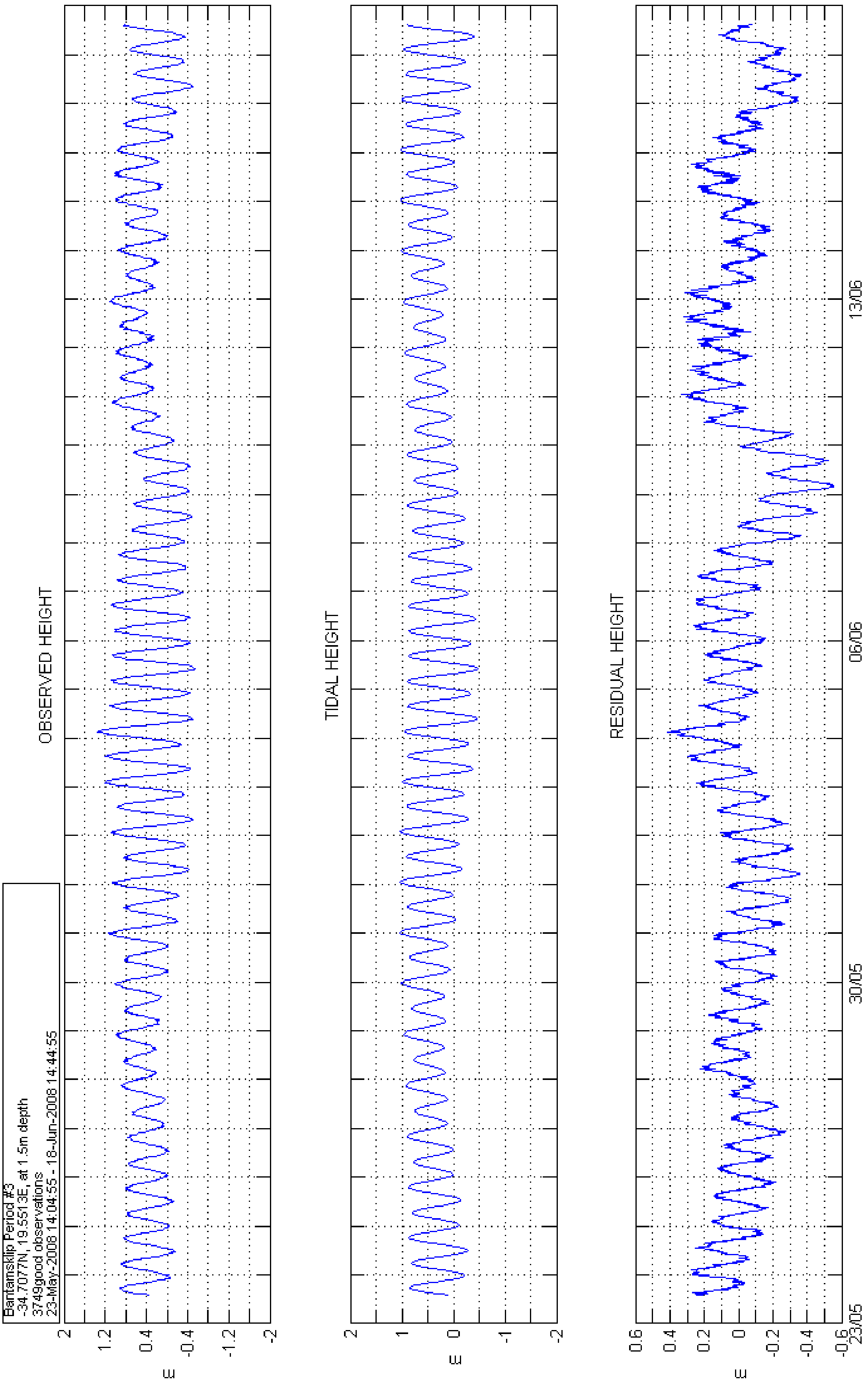
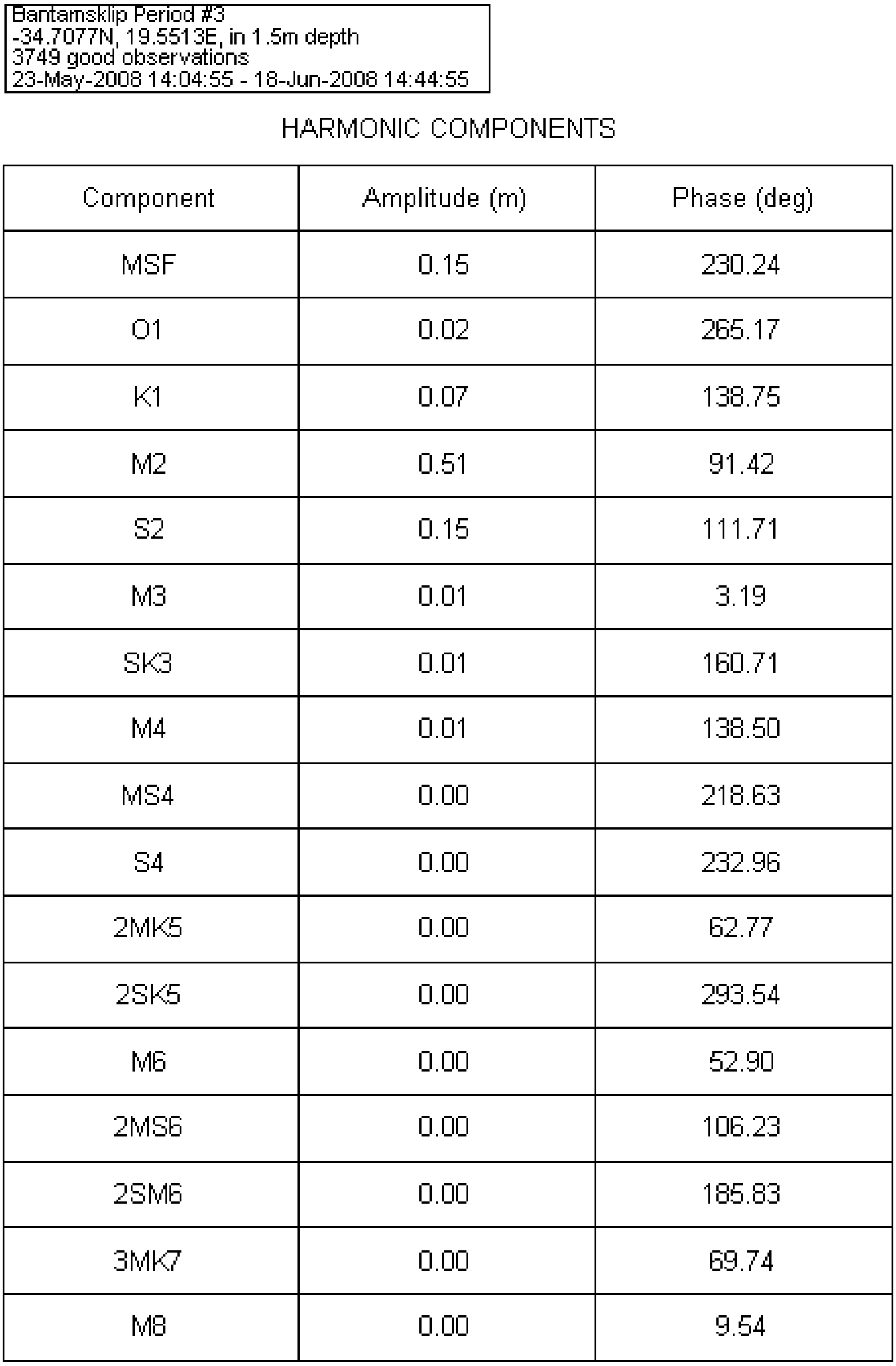


Figure 34: Tidal time series.

Table 17: Tidal harmonics.



Bantamsklip Period #3
-34.7077N, 19.5513E, in 1.5m depth
3749 good observations
23-May-2008 14:04:55 - 18-Jun-2008 14:44:55

HARMONIC COMPONENTS

Component	Amplitude (m)	Phase (deg)
MSF	0.15	230.24
O1	0.02	265.17
K1	0.07	138.75
M2	0.51	91.42
S2	0.15	111.71
M3	0.01	3.19
SK3	0.01	160.71
M4	0.01	138.50
MS4	0.00	218.63
S4	0.00	232.96
2MK5	0.00	62.77
2SK5	0.00	293.54
M6	0.00	52.90
2MS6	0.00	106.23
2SM6	0.00	185.83
3MK7	0.00	69.74
M8	0.00	9.54

6. DISCUSSION

The third set of oceanographic data collected off the coast of Bantamsklip for the period between April 25th and June 19th 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

At the Bantamsklip site, 2 600 kHz ADCP, 2 RBR-CT loggers and 1 RBR tide gauge have been deployed to measure currents, waves, water temperature and salinity and tidal record. The ADCP is fixed on a frame at ~10m and ~30m and the RBR loggers are moored at ~7m and ~28m below the surface. During the service visit, undertaken during June 18th – 20th and 27th 2008, it was found that the biofouling plates were lost. This report presents data obtained from the 2 ADCPs, the 2 RBR-CT loggers, the RBR tide gauge and water samples collected during the service visit.

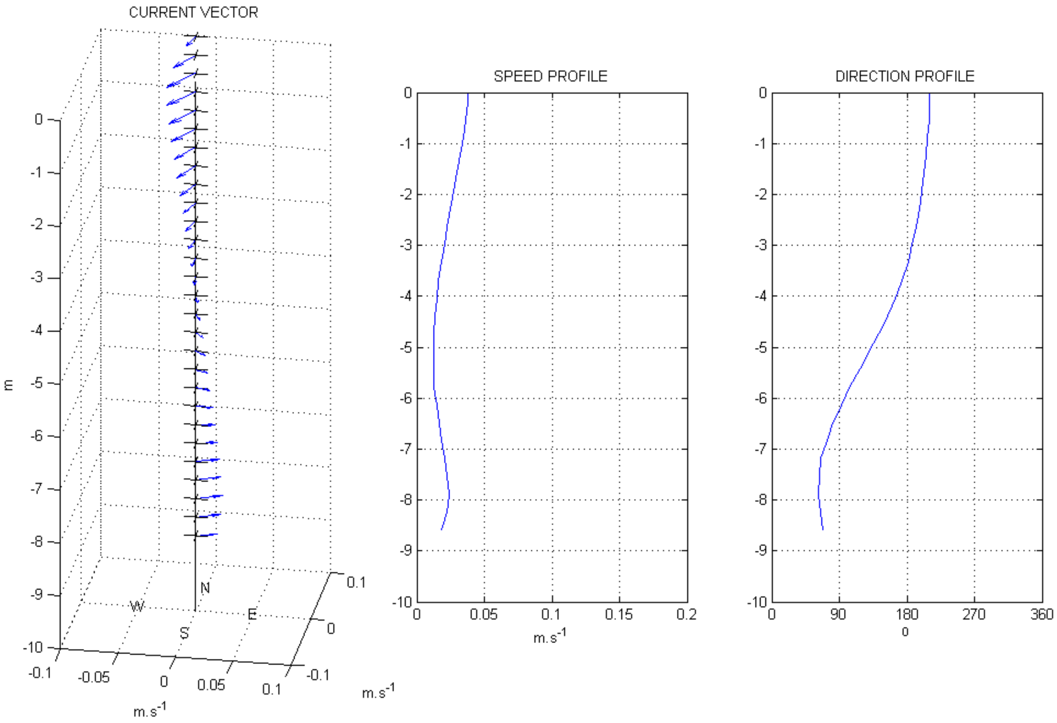


Figure 35: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.16ms^{-1}, decreasing to ~0.03ms^{-1} at 11.5m depth. The flow direction at the surface was predominantly towards the S/SE, while at depth, it was mainly towards the ENE.

At the 30m site, the average flow at 2.3m was 0.15ms^{-1}, decreasing to 0.03ms^{-1} at 30.8m depth. The flow direction was variable throughout the water column.

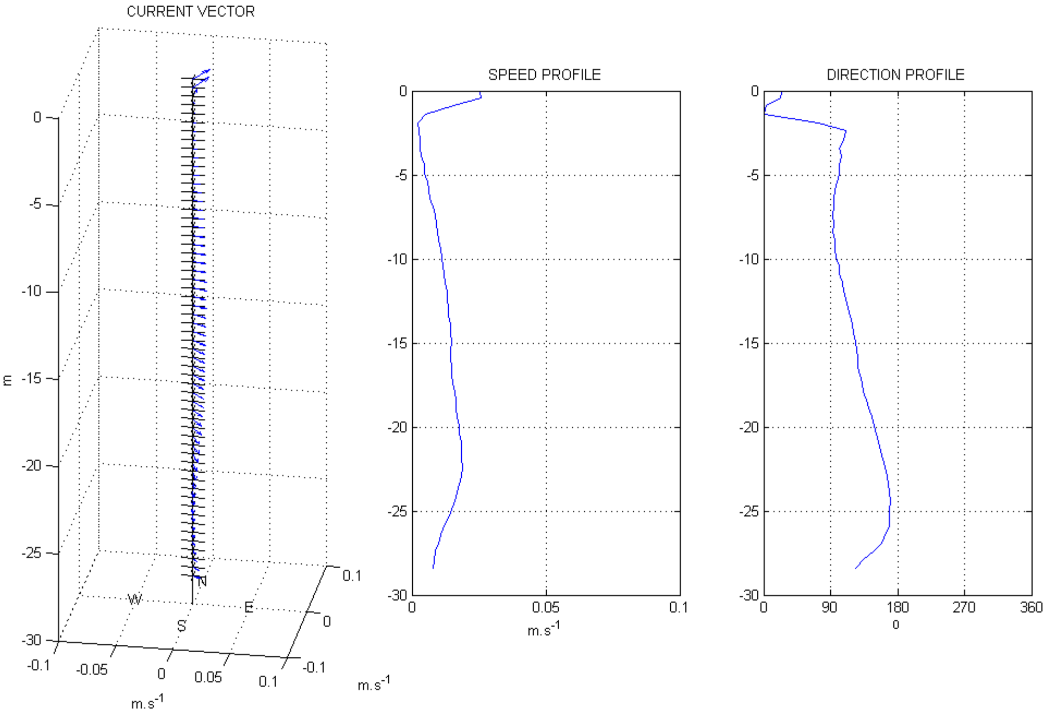


Figure 36: Mean profile plot for 30m ADCP.

Table 18: Mean wave parameters.

	Hs (m)	Tp (s)	Dp
10m ADCP	1.91	12.25	WSW-SW
30m ADCP	2.18	11.80	SSW-SW

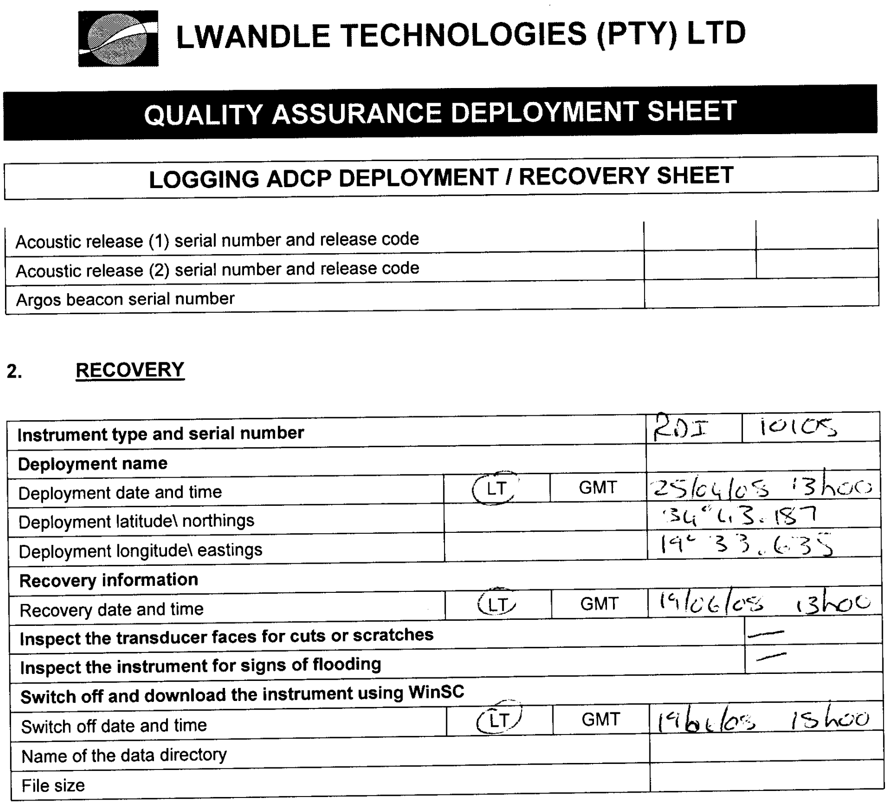
Table 18 summarises the wave parameters for both ADCPs. Figure 32 shows a fair agreement in wave parameters measured by both ADCPs.

The conductivity sensor for the bottom RBR logger failed. However, in Figure 33, the temperature sensors on board the ADCPs, tide gauge and RBR loggers recorded reasonably similar values during the deployment period.

Unfortunately, due to insufficient data, it was not possible to fully resolve the tidal constituents in the present record.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT TWO

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS



LWANDLE TECHNOLOGIES (PTY) LTD

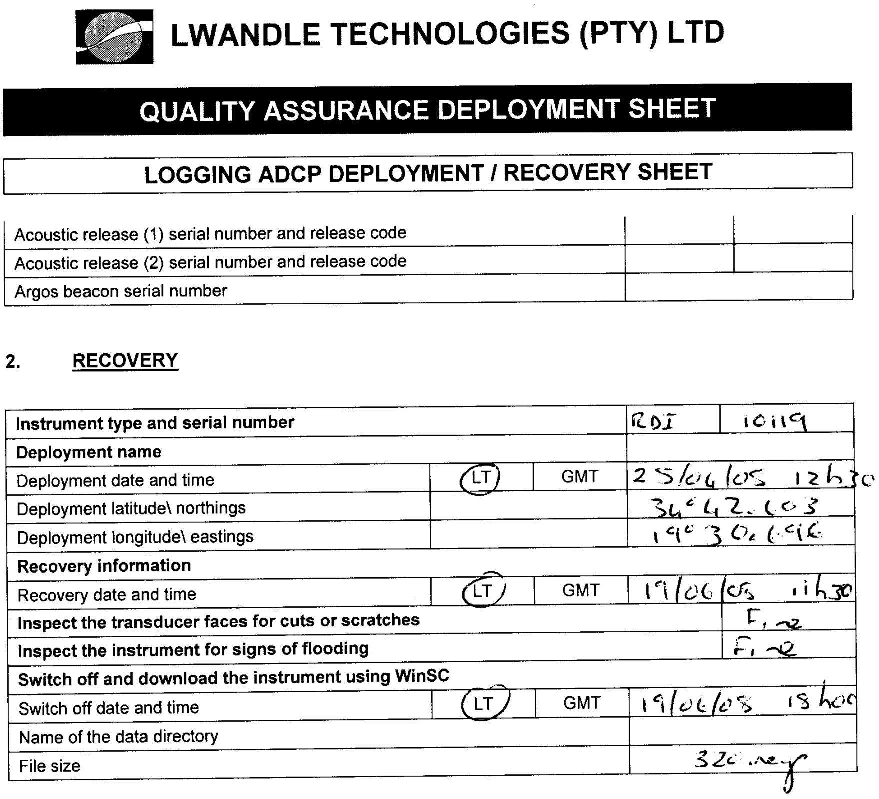
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		

2. RECOVERY

Instrument type and serial number			RDI	10105
Deployment name				
Deployment date and time	[✓ LT]	GMT	25/04/05 13h00	
Deployment latitude\ northings			34°43.187	
Deployment longitude\ eastings			19°33.635	
Recovery information				
Recovery date and time	[✓ LT]	GMT	19/06/05 13h00	
Inspect the transducer faces for cuts or scratches				—
Inspect the instrument for signs of flooding				—
Switch off and download the instrument using WinSC				
Switch off date and time	[✓ LT]	GMT	19/06/05 15h00	
Name of the data directory				
File size				



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		

2. RECOVERY

Instrument type and serial number			RDI	10119
Deployment name				
Deployment date and time	[✓ LT]	GMT	25/04/05 12h30	
Deployment latitude\ northings			34°42.103	
Deployment longitude\ eastings			19°30.196	
Recovery information				
Recovery date and time	[✓ LT]	GMT	19/06/05 11h30	
Inspect the transducer faces for cuts or scratches				Fine
Inspect the instrument for signs of flooding				Fine
Switch off and download the instrument using WinSC				
Switch off date and time	[✓ LT]	GMT	19/06/05 18h00	
Name of the data directory				
File size			320 meg	

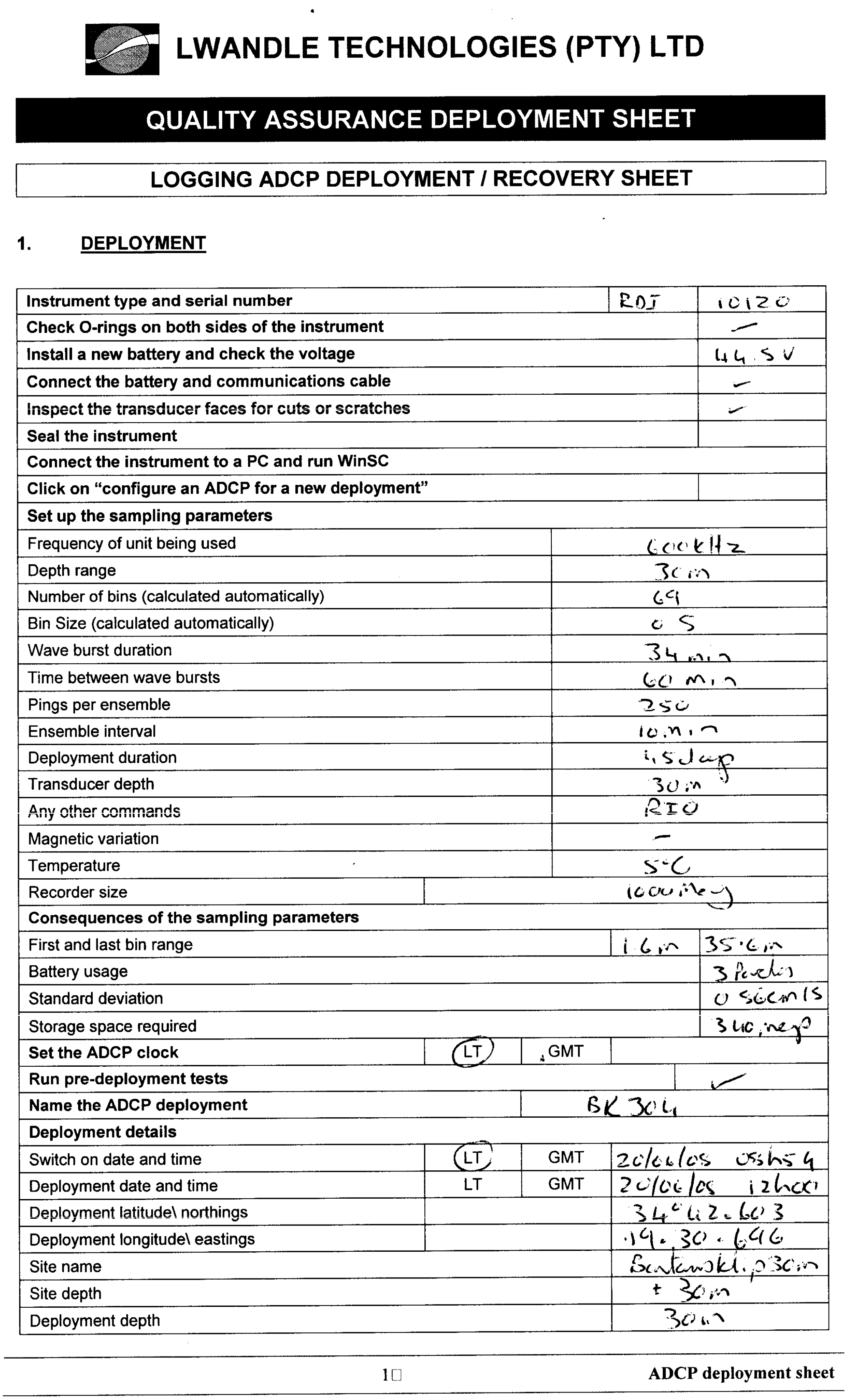
LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number	RDI		10119 ~~[illegible]~~
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.8 V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used			600kHz
Depth range			10m
Number of bins (calculated automatically)			42
Bin Size (calculated automatically)			0.35m
Wave burst duration			41min
Time between wave bursts			60min
Pings per ensemble			500
Ensemble interval			10min
Deployment duration			45days
Transducer depth			10m
Any other commands			RIO
Magnetic variation			—
Temperature			5°C
Recorder size			1000MegB
Consequences of the sampling parameters			
First and last bin range		1.41m	15.76m
Battery usage			2.9Packs
Standard deviation			1.05cm/s
Storage space required			401.44Meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			BK104
Deployment details			
Switch on date and time	[✓ LT]	GMT	07h46 20/06/05
Deployment date and time	LT	GMT	20/06/05 11h00
Deployment latitude\ northings			34°43.187
Deployment longitude\ eastings			19°33.635
Site name			Bantamsklip 10m
Site depth			10m
Deployment depth			10m



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number		RDI	10120
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44.5V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used			600kHz
Depth range			30m
Number of bins (calculated automatically)			69
Bin Size (calculated automatically)			0.5
Wave burst duration			34min
Time between wave bursts			60 min
Pings per ensemble			250
Ensemble interval			10min
Deployment duration			45days
Transducer depth			30m
Any other commands			RIO
Magnetic variation			–
Temperature			5°C
Recorder size			1000Meg
Consequences of the sampling parameters			
First and last bin range		1.6m	35.6m
Battery usage			3 Packs
Standard deviation			0.56cm/s
Storage space required			340meg
Set the ADCP clock	[✓ LT]	GMT	
Run pre-deployment tests			✓
Name the ADCP deployment			BK304
Deployment details			
Switch on date and time	[✓ LT]	GMT	20/06/05 05h54
Deployment date and time	LT	GMT	20/06/05 12h00
Deployment latitude\ northings			34°42.603
Deployment longitude\ eastings			19.30.646
Site name			Bantamsklip30m
Site depth			± 30m
Deployment depth			30m

1□ **ADCP deployment sheet**

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		XR420	12994
Check O-rings on instrument			✓
Install a new battery and check the voltage			12.86V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		22/05/08	14h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	[✓ LT]		23/05/08 11h45
Deployment latitude\ northings			34°42.605
Deployment longitude\ eastings			19°30.659
Site name			Bantamsklip
Site depth			30 m
Deployment depth			8 m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

Range:

Northing	Easting	Range

RECOVERY				
Instrument type and serial number			XR420	12994
Deployment name				
Deployment date and time	[✓ LT]	GMT	23/05/08 11h45	
Deployment latitude\ northings			34°42.605	
Deployment longitude\ eastings			19.30.659	
Recovery information				
Recovery date and time	[✓ LT]	GMT	19/06/08 10h50	

LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

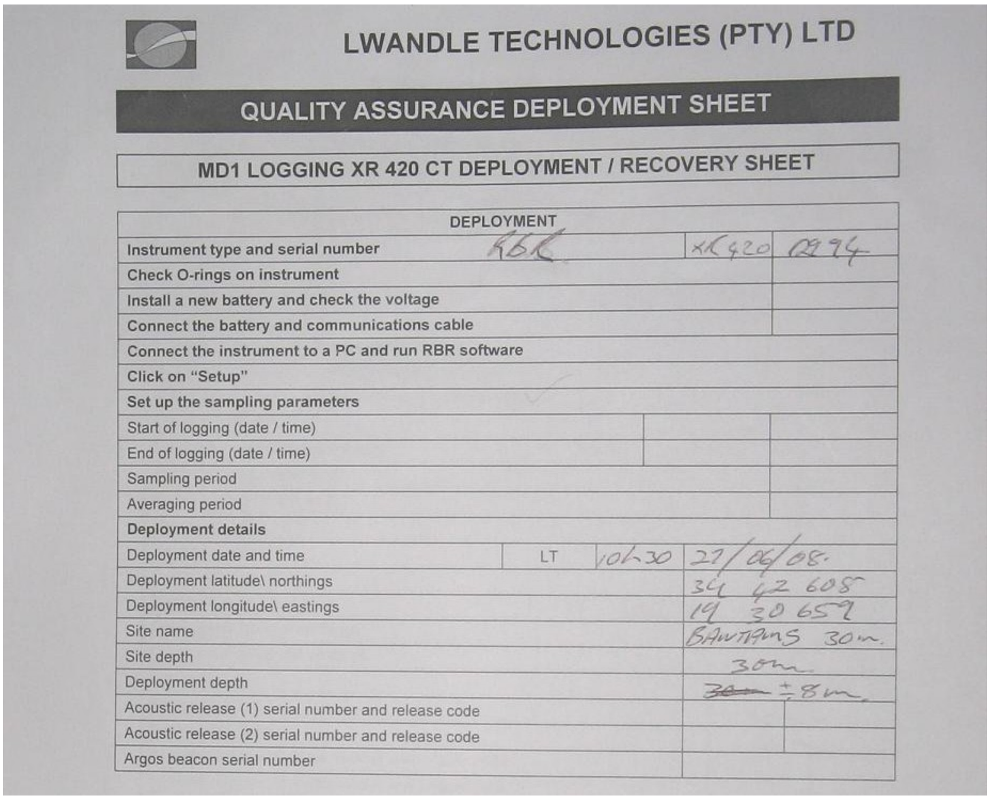
MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		XR420	12995
Check O-rings on instrument			—
Install a new battery and check the voltage			12.26V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		22/05/05	14h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 min
Averaging period			1 min
Deployment details			
Deployment date and time	[✓ LT]		23/05/05 11h45
Deployment latitude\ northings			34°42.605
Deployment longitude\ eastings			19°30.659
Site name			Bantamsklip
Site depth			~~25 m~~ 30 m
Deployment depth			25m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

Range:

Northing	Easting	Range

RECOVERY				
Instrument type and serial number			XR420	12995
Deployment name				
Deployment date and time	[✓ LT]	GMT	23/05/05 11h45	
Deployment latitude\ northings			34°42.605	
Deployment longitude\ eastings			19° 30.659	
Recovery information				
Recovery date and time	[✓ LT]	GMT	19/06/08 10h50	

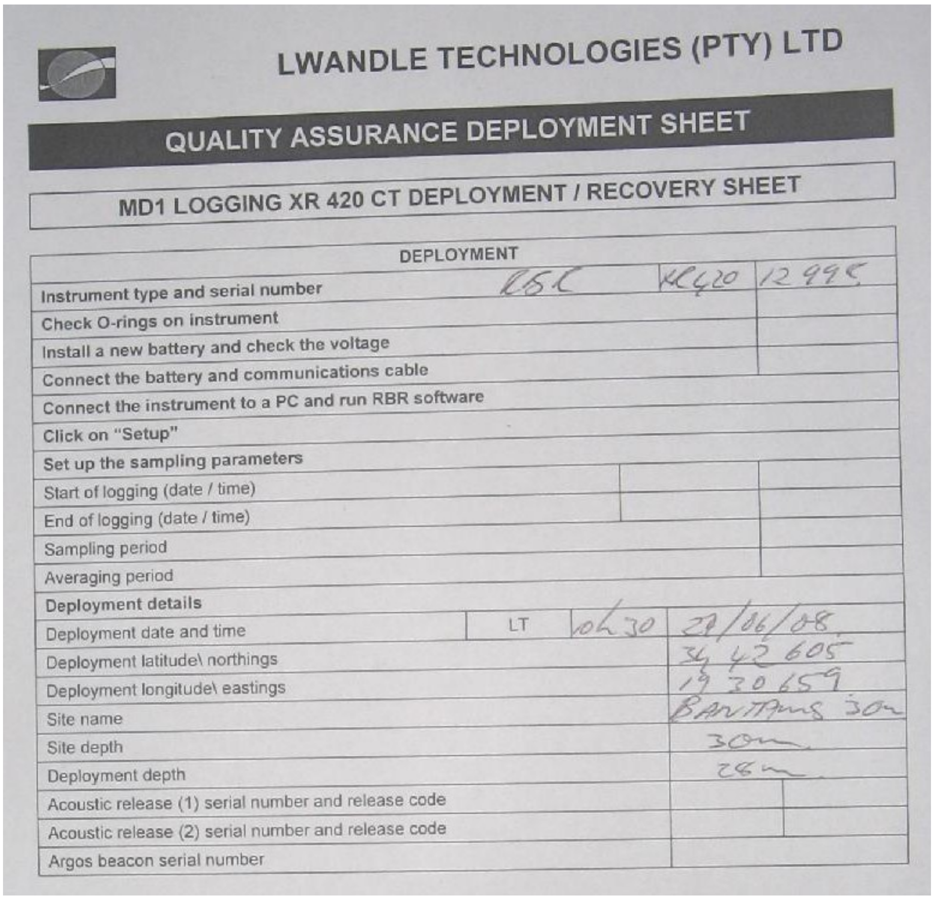


LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number	RBR	XR420	12994
Check O-rings on instrument			
Install a new battery and check the voltage			
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters	✓		
Start of logging (date / time)			
End of logging (date / time)			
Sampling period			
Averaging period			
Deployment details			
Deployment date and time	LT	10h30	27/06/08.
Deployment latitude\ northings			34 42 608
Deployment longitude\ eastings			19 30 659
Site name			BANTAMS 30m.
Site depth			30m
Deployment depth			~~30m~~ ± 8m.
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			



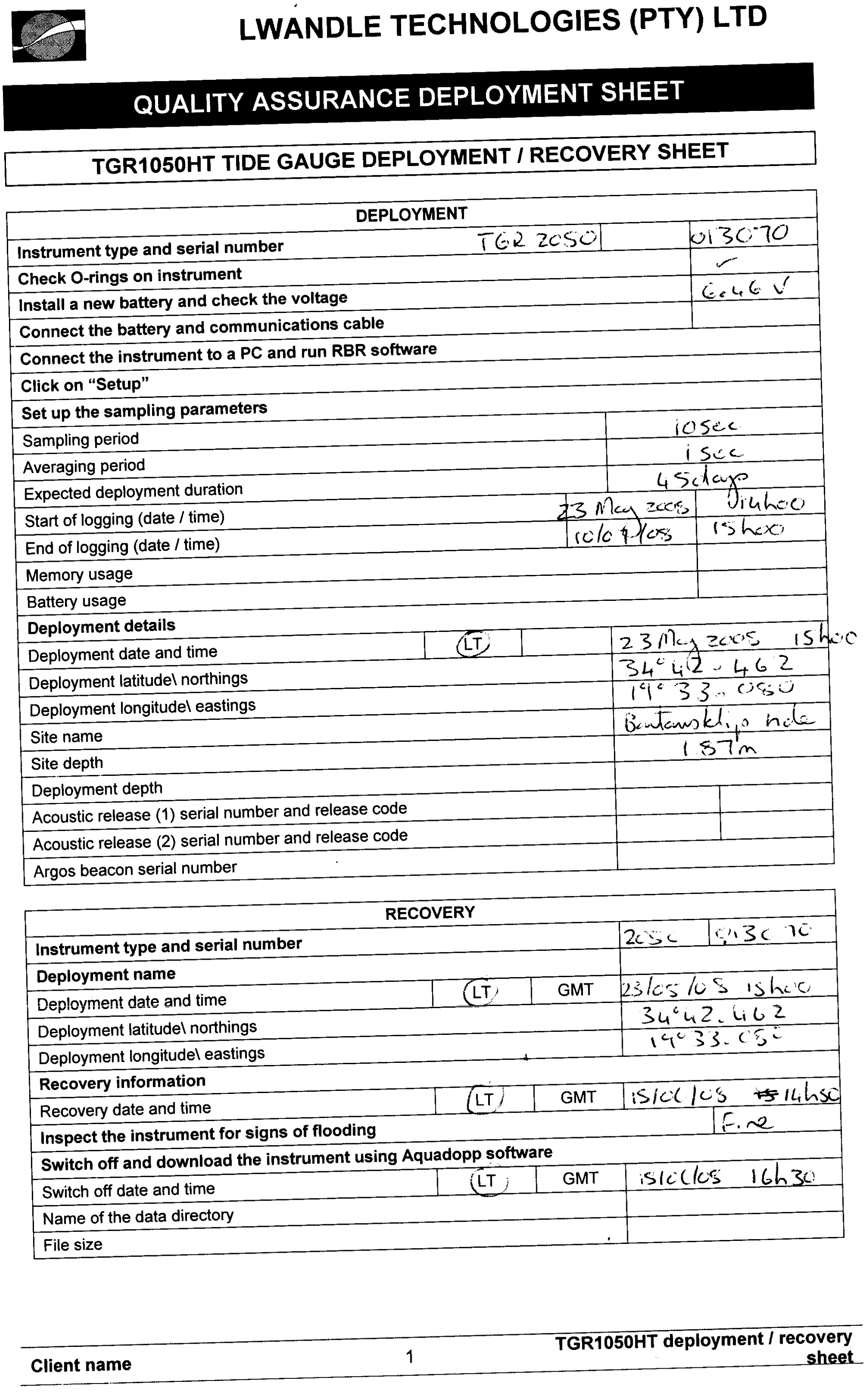
LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number	RBR	XR420	12995
Check O-rings on instrument			
Install a new battery and check the voltage			
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)			
End of logging (date / time)			
Sampling period			
Averaging period			
Deployment details			
Deployment date and time	LT	10h30	27/06/08.
Deployment latitude\ northings			34 42 605
Deployment longitude\ eastings			19 30 659
Site name			BANTAMS 30m
Site depth			30m
Deployment depth			28m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

7.3 TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS



LWANDLE TECHNOLOGIES (PTY) LTD

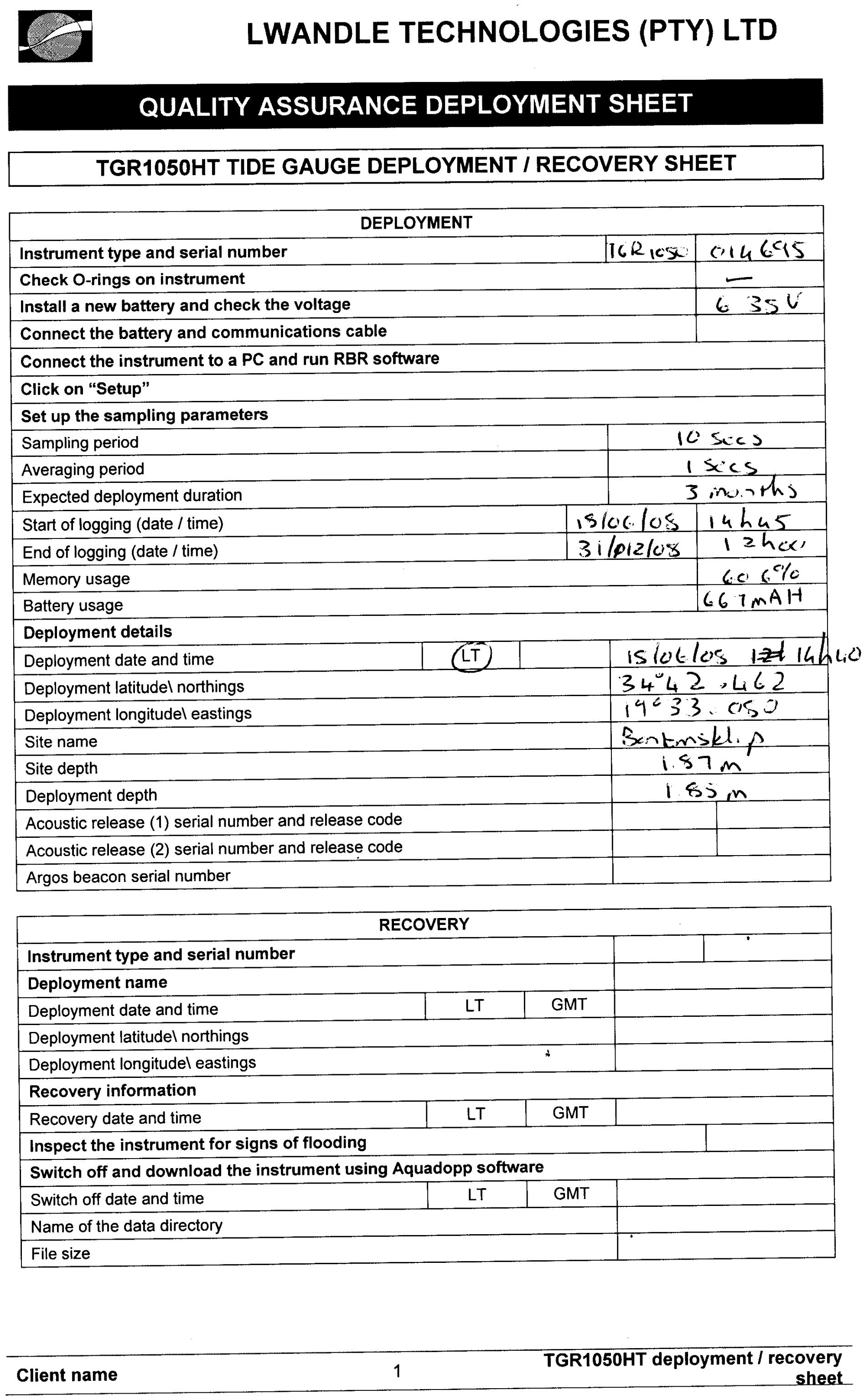
QUALITY ASSURANCE DEPLOYMENT SHEET

TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number	TGR 2050		013070
Check O-rings on instrument			✓
Install a new battery and check the voltage			6.46 V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period			10sec
Averaging period			1sec
Expected deployment duration			45days
Start of logging (date / time)		23 May 2005	14h00
End of logging (date / time)		10/07/05	15h00
Memory usage			
Battery usage			
Deployment details			
Deployment date and time	[✓ LT]		23 May 2005 15h00
Deployment latitude\ northings			34°42.462
Deployment longitude\ eastings			19°33.080
Site name			Bantamsklip hole
Site depth			1.87m
Deployment depth			
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

RECOVERY			
Instrument type and serial number		2050	013070
Deployment name			
Deployment date and time	[✓ LT]	GMT	23/05/05 15h00
Deployment latitude\ northings			34°42.462
Deployment longitude\ eastings			19°33.080
Recovery information			
Recovery date and time	[✓ LT]	GMT	15/06/05 ~~15~~ 14h50
Inspect the instrument for signs of flooding			Fine
Switch off and download the instrument using Aquadopp software			
Switch off date and time	[✓ LT]	GMT	15/06/05 16h30
Name of the data directory			
File size			

Client name 1 **TGR1050HT deployment / recovery sheet**



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		TGR1050	014695
Check O-rings on instrument			—
Install a new battery and check the voltage			6.35V
Connect the battery and communications cable			
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Sampling period		10 Secs	
Averaging period		1 Secs	
Expected deployment duration		3 months	
Start of logging (date / time)		15/06/08	14h45
End of logging (date / time)		31/012/08	12h00
Memory usage			60.6%
Battery usage			667mAH
Deployment details			
Deployment date and time	[✓ LT]		15/06/08 ~~12~~ 14h40
Deployment latitude\ northings			34°42.462
Deployment longitude\ eastings			19°33.050
Site name			Bantmsklip
Site depth			1.87m
Deployment depth			1.85m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	LT	GMT	
Inspect the instrument for signs of flooding			
Switch off and download the instrument using Aquadopp software			
Switch off date and time	LT	GMT	
Name of the data directory			
File size			

Client name 1 **TGR1050HT deployment / recovery sheet**

* Instrument type should read "TGR2050" instead of "TGR1050".

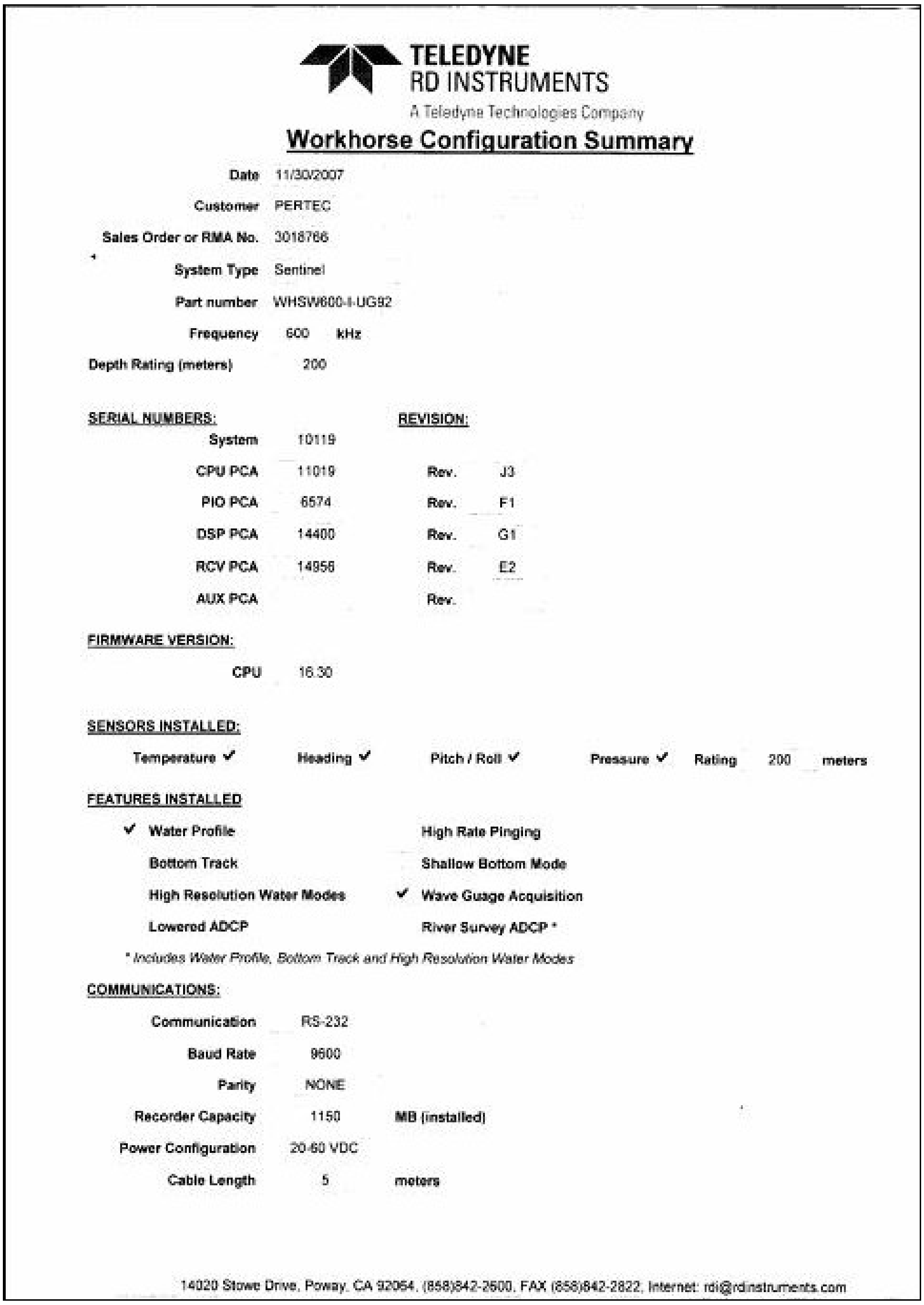
7.4 ADCPS CONFIGURATION FILES

```
                10m
CR1
CF11101
EA0
EB0
RI0
ED100
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:01.00
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 614400
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = NO
;High Rate Pinging = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = YES
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 5.00
;Deployment hours  = 360.00
;Battery packs     = 1
;Automatic TP      = YES
;Memory size [MB]  = 1000
;Saved Screen      = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range  = 1.41 m
;Last cell range   = 15.76 m
;Max range         = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size     = 994 bytes
;Storage required  = 133.83 MB (140329440 bytes)
;Power usage       = 440.26 Wh
;Battery usage     = 1.0
;Samples / Wv Burst = 4920
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 383840
```

```
30m

CR1
CF11101
EA0
EB0
RI0
ED300
ES35
EX11111
EZ1111111
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4080
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:02.00
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 614400
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = YES
;Lowered ADCP      = NO
;Beam angle        = 20
;Temperature       = 5.00
;Deployment hours   = 1080.00
;Battery packs     = 3
;Automatic TP      = YES
;Memory size [MB]   = 1000
;Saved Screen      = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range   = 1.60 m
;Last cell range    = 35.60 m
;Max range          = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size      = 1534 bytes
;Storage required   = 337.34 MB (353725920 bytes)
;Power usage        = 1343.03 Wh
;Battery usage      = 3.0
;Samples / Wv Burst = 4080
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 318320
```

7.5 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 kHz
Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10119		
CPU PCA	11019	**Rev.**	J3
PIO PCA	6574	**Rev.**	F1
DSP PCA	14400	**Rev.**	G1
RCV PCA	14956	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

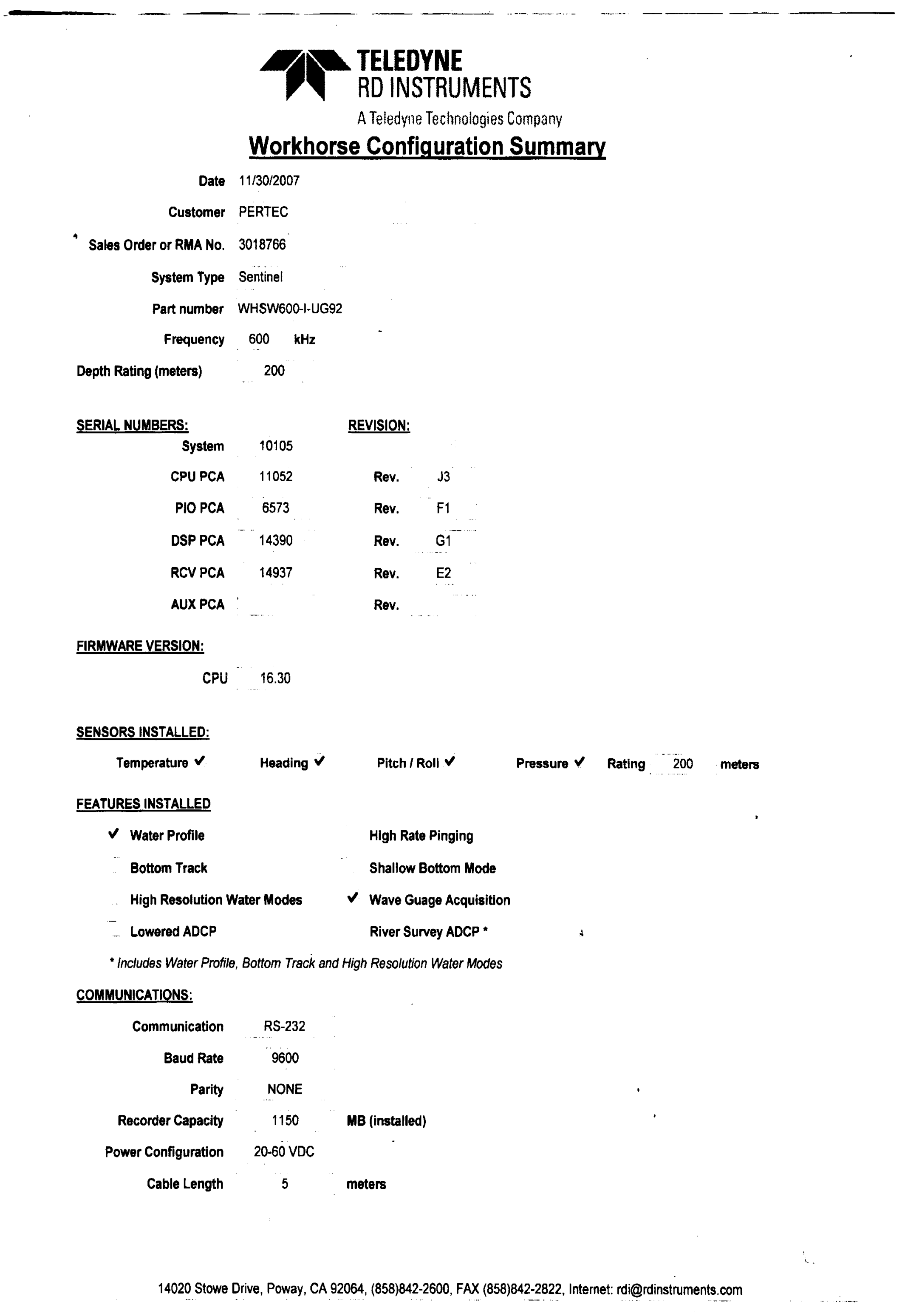
✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

* *Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10105		
CPU PCA	11052	**Rev.**	J3
PIO PCA	6573	**Rev.**	F1
DSP PCA	14390	**Rev.**	G1
RCV PCA	14937	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

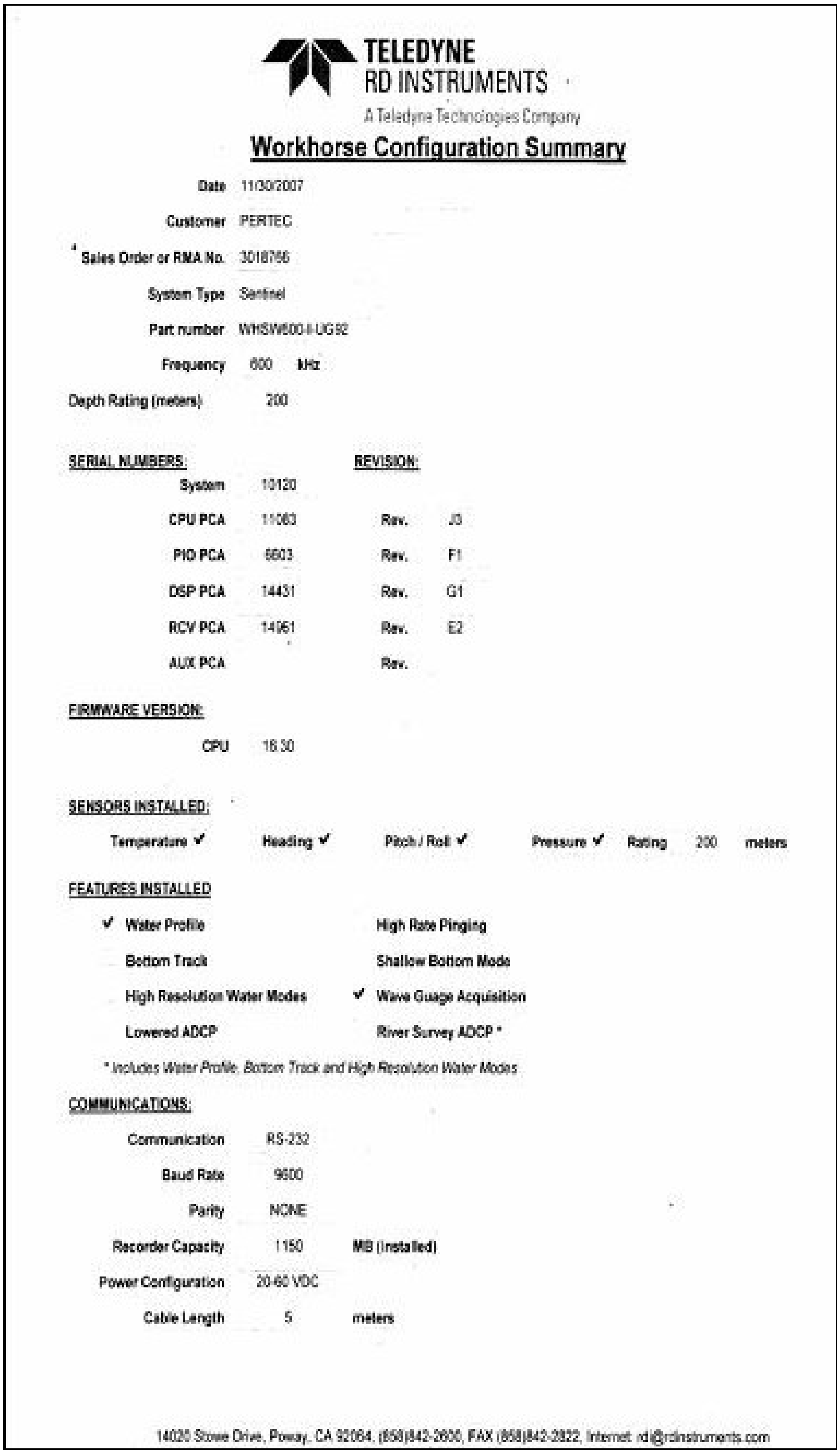
✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

* *Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007

Customer PERTEC

* Sales Order or RMA No. 3018756

System Type Sentinel

Part number WHSW600-I-UG92

Frequency 600 kHz

Depth Rating (meters) 200

SERIAL NUMBERS:		REVISION:	
System	10120		
CPU PCA	11063	Rev.	J3
PIO PCA	6603	Rev.	F1
DSP PCA	14431	Rev.	G1
RCV PCA	14961	Rev.	E2
AUX PCA		Rev.	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ Heading ✓ Pitch / Roll ✓ Pressure ✓ Rating 200 meters

FEATURES INSTALLED

✓ Water Profile	High Rate Pinging
Bottom Track	Shallow Bottom Mode
High Resolution Water Modes	✓ Wave Guage Acquisition
Lowered ADCP	River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232

Baud Rate 9600

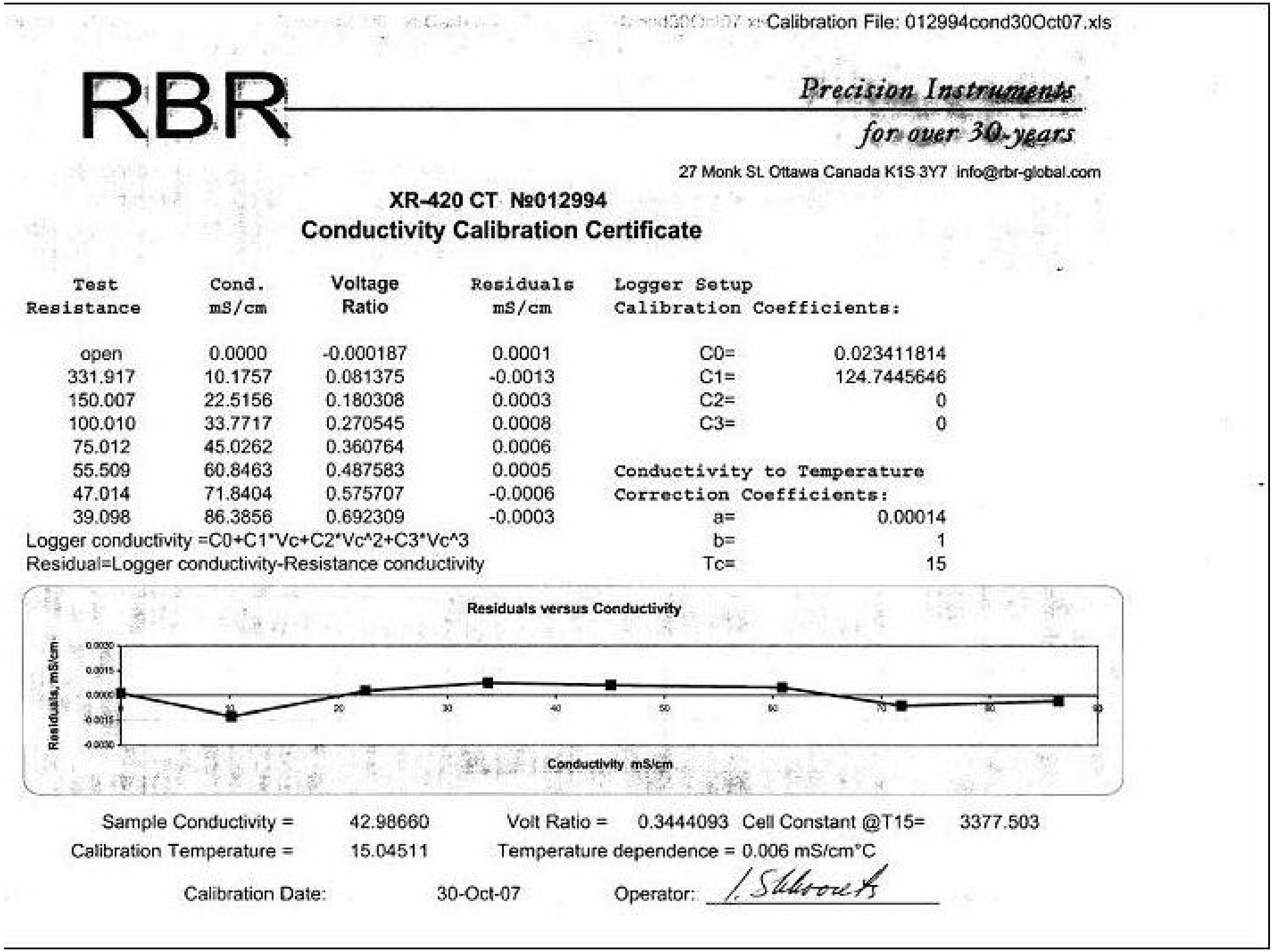
Parity NONE

Recorder Capacity 1150 MB (Installed)

Power Configuration 20-60 VDC

Cable Length 5 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

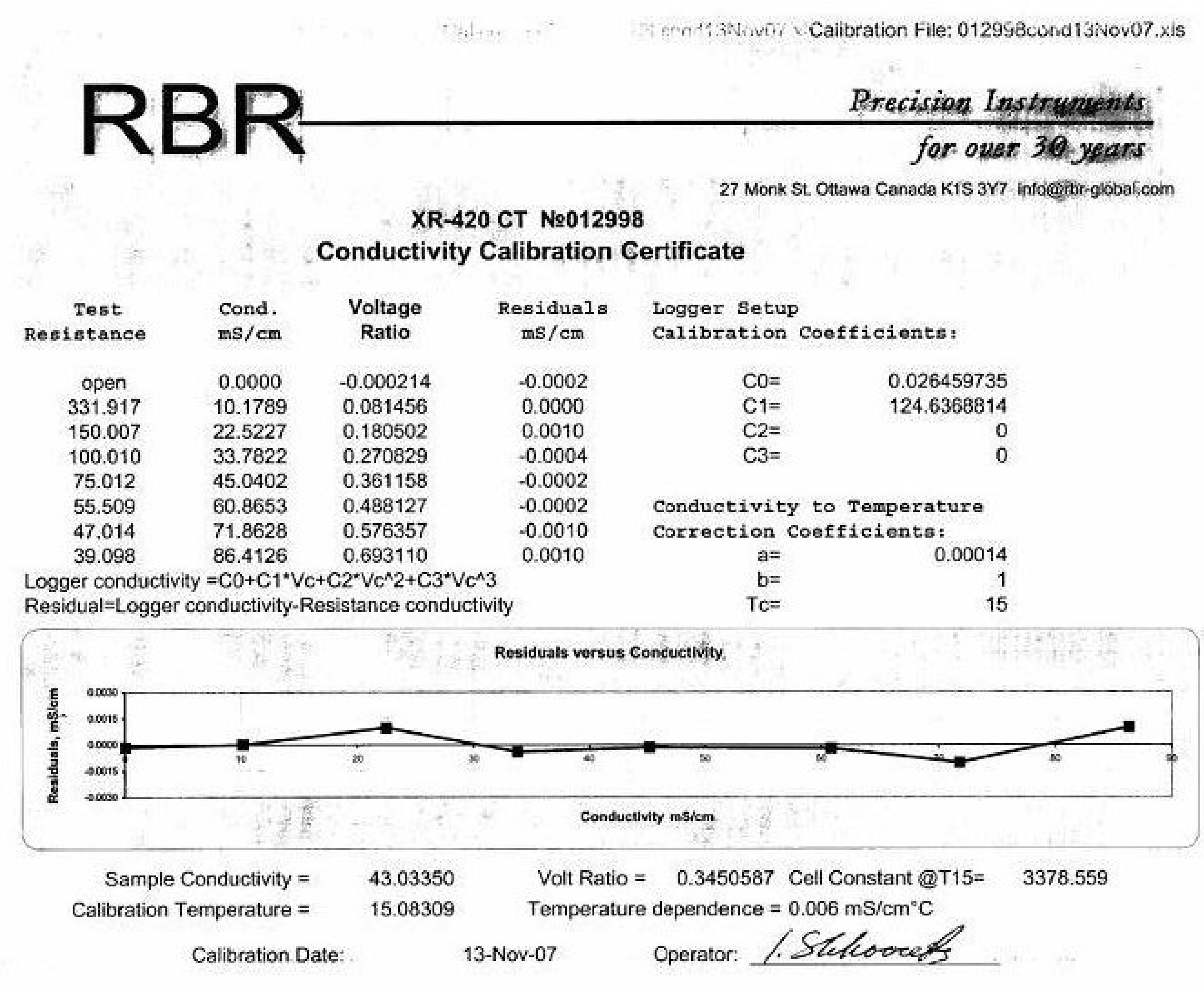
C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 42.98660
Volt Ratio = 0.3444093
Cell Constant @T15= 3377.503
Calibration Temperature = 15.04511
Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07
Operator: J. Schroeder



Calibration File: 012998cond13Nov07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012998
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000214	-0.0002
331.917	10.1789	0.081456	0.0000
150.007	22.5227	0.180502	0.0010
100.010	33.7822	0.270829	-0.0004
75.012	45.0402	0.361158	-0.0002
55.509	60.8653	0.488127	-0.0002
47.014	71.8628	0.576357	-0.0010
39.098	86.4126	0.693110	0.0010

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.026459735
C1= 124.6368814
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

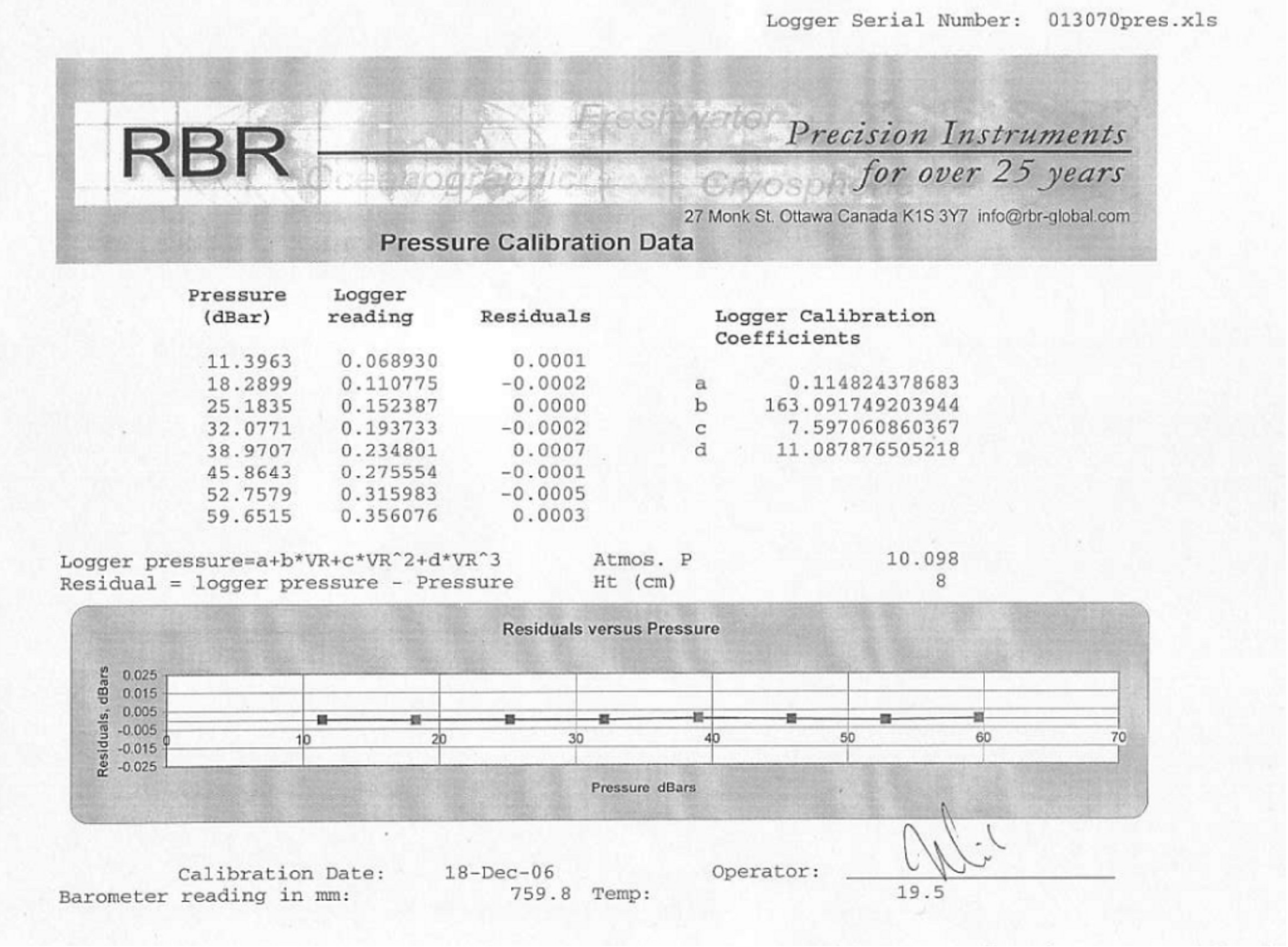
a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

Sample Conductivity = 43.03350 Volt Ratio = 0.3450587 Cell Constant @T15= 3378.559

Calibration Temperature = 15.08309 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 13-Nov-07 Operator: I. Stkhoorets



Logger Serial Number: 013070pres.xls

RBR Precision Instruments *for over 25 years*

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

Pressure (dBar)	Logger reading	Residuals
11.3963	0.068930	0.0001
18.2899	0.110775	-0.0002
25.1835	0.152387	0.0000
32.0771	0.193733	-0.0002
38.9707	0.234801	0.0007
45.8643	0.275554	-0.0001
52.7579	0.315983	-0.0005
59.6515	0.356076	0.0003

Logger Calibration Coefficients

a	0.114824378683
b	163.091749203944
c	7.597060860367
d	11.087876505218

Logger pressure=a+b*VR+c*VR^2+d*VR^3

Residual = logger pressure - Pressure

Atmos. P	10.098
Ht (cm)	8

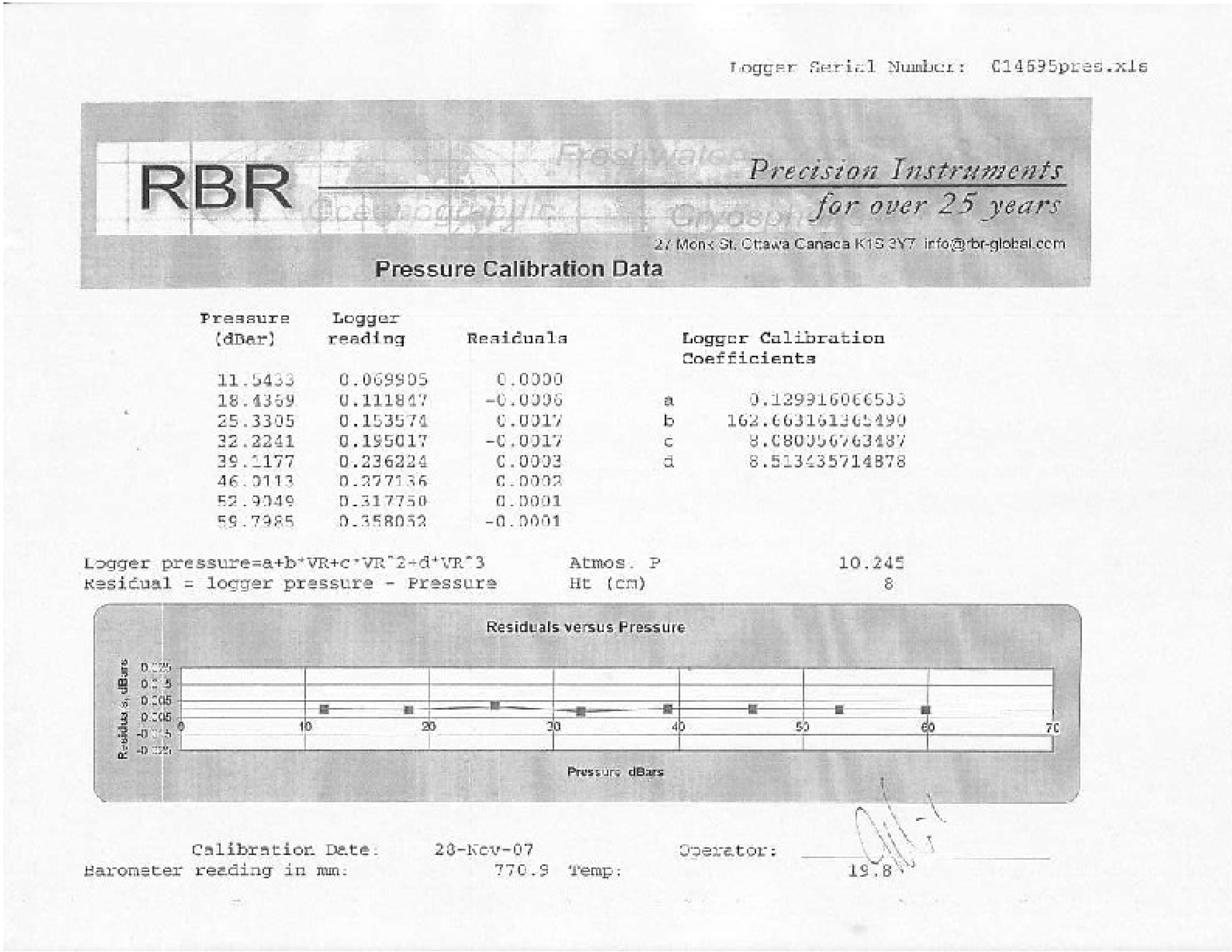
Residuals versus Pressure

Calibration Date: 18-Dec-06

Barometer reading in mm: 759.8

Operator:

Temp: 19.5



Logger Serial Number: C14695pres.xls

RBR

Precision Instruments for over 25 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

Pressure (dBar)	Logger reading	Residuals		Logger Calibration Coefficients
11.5433	0.069905	0.0000		
18.4359	0.111847	-0.0006	a	0.129916066533
25.3305	0.153574	0.0017	b	162.663161365490
32.2241	0.195017	-0.0017	c	8.080056763487
39.1177	0.236224	0.0003	d	8.513435714878
46.0113	0.277136	0.0002		
52.9049	0.317750	0.0001		
59.7985	0.358052	-0.0001		

Logger pressure=a+b*VR+c*VR^2+d*VR^3 Atmos. P 10.245
Residual = logger pressure - Pressure Ht (cm) 8

Residuals versus Pressure

Calibration Date: 28-Nov-07 Operator:
Barometer reading in mm: 770.9 Temp: 19.8

8. REPORTS FROM THE CSIR

The reports from the CSIR are attached as an appendage.

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT FOUR

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

14 October 2008

Job No: LT-JOB-50

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 4 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-11.1	99.31	0.2167	0.0572	0.0329	0.0492	59.56
-10.7	99.34	0.2008	0.0539	0.0323	0.0451	64.02
-10.4	99.35	0.2285	0.0513	0.0304	0.0416	68.54
-10.0	99.35	0.2244	0.0500	0.0295	0.0388	73.56
-9.7	99.35	0.2368	0.0489	0.0293	0.0362	78.68
-9.3	99.35	0.2641	0.0477	0.0294	0.0334	87.03
-9.0	99.35	0.2795	0.0522	0.0284	0.0398	79.68
-8.6	99.31	0.2761	0.0480	0.0301	0.0332	96.28
-8.3	99.31	0.3229	0.0478	0.0313	0.0320	108.05
-7.9	99.32	0.3223	0.0490	0.0327	0.0332	114.55
-7.6	99.32	0.3293	0.0501	0.0341	0.0347	121.26
-7.2	99.29	0.3296	0.0515	0.0355	0.0363	126.41
-6.9	99.28	0.3317	0.0533	0.0372	0.0385	130.94
-6.5	99.28	0.3917	0.0554	0.0389	0.0411	135.73
-6.2	99.29	0.3754	0.0574	0.0410	0.0431	139.13
-5.8	99.29	0.3901	0.0598	0.0433	0.0459	142.63
-5.5	99.28	0.4019	0.0625	0.0456	0.0490	145.21
-5.1	99.28	0.4247	0.0654	0.0479	0.0521	148.25
-4.8	99.28	0.3677	0.0682	0.0501	0.0549	150.22
-4.4	99.31	0.4190	0.0711	0.0526	0.0579	151.67
-4.1	99.28	0.4098	0.0740	0.0545	0.0606	152.70
-3.7	99.31	0.4442	0.0778	0.0575	0.0640	153.63
-3.4	99.29	0.4387	0.0811	0.0596	0.0671	154.29
-3.0	99.29	0.4515	0.0842	0.0618	0.0697	153.94
-2.7	99.29	0.4864	0.0870	0.0632	0.0716	152.53
-2.3	99.29	0.5014	0.0891	0.0647	0.0713	148.29
-2.0	99.29	0.4974	0.0951	0.0659	0.0695	139.41
-1.6	99.23	0.5179	0.1088	0.0694	0.0694	129.41
-1.3	92.88	0.5452	0.1313	0.0765	0.0761	130.02

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	96.24	5.13	0.78	2.07	0.74
Tp (s)	96.24	17.00	2.00	12.09	1.66
Dp (°)	96.24	284.58	171.58	219.98	11.59

Table 3 – Water temperature and salinity summary (surface)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	14.98	15.90	14.16
Conductivity	100	43.05	44.00	42.15
Salinity (psu)	100	35.13	35.21	35.00

Table 4 – Water temperature and salinity summary (bottom)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100	14.72	15.74	12.55
Conductivity	100	3.58	5.48	2.00
Salinity (psu)	0	-	-	-

1.1 DATA RETURN FOR BANTAMSKLIP SITE.

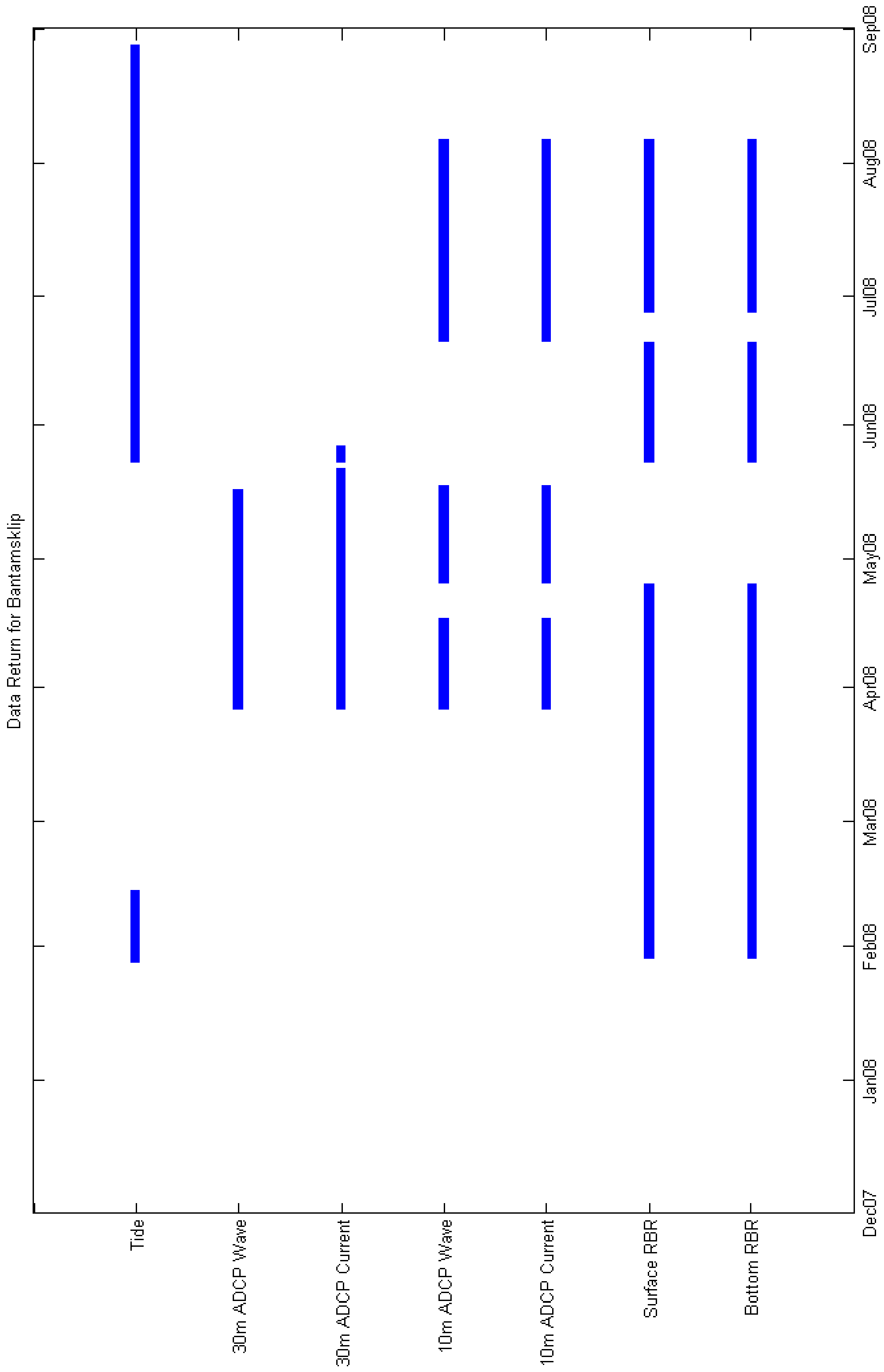


Figure 1: An indication of the data return at the Bantamsklip site since the beginning of the project.

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents currents, waves, temperature and salinity and tidal data collected at Bantamsklip station for the period June 20th 2008 - August 27th 2008 (Period 4). Three service visits were undertaken: 4a (July 12th – 13th), 4b (August 5th – 6th 2008) and 4c (August 27th 2008). Water samples were collected during service 4a and 4b.

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 5 for the Bantamsklip site.

Table 5 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The initial deployment location of the mooring is given in Table 6. Table 7 and Table 8 show the locations where water samples were taken respectively.

Table 6 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34° 42.462’	19° 33.080’
10m ADCP	34° 43.187’	19° 33.635’
Biofouling	34° 43.190’	19° 33.686’
30m ADCP	34° 42.602’	19° 30.677’
T&C mooring	34° 42.605’	19° 30.659’

Table 7 – Locations where water samples were taken during service visit 4a

Station 26 Mar 2008		Latitude (°S)	Longitude (°E)
S1	30m ADCP 4m	34° 42.603’	19° 30.696’
S2	30m ADCP 12m	34° 42.603’	19° 30.696’
S3	30m ADCP 20m	34° 42.603’	19° 30.696’
S4	30m ADCP 28m	34° 42.603’	19° 30.696’
S5	10m ADCP 4m	34° 43.187’	19° 33.635’
S6	10m ADCP 8m	34° 43.187’	19° 33.635’
S7		34° 43.141’	19° 33.710’
S8		34° 43.055’	19° 33.616’
S9		34° 42.938’	19° 33.445’
S10		34° 42.901’	19° 33.287’
S11		34° 42.860’	19° 33.149’

Table 8 – Locations where water samples were taken during service visit 4b

Station 26 Mar 2008		Latitude (°S)	Longitude (°E)
S1	30m ADCP 4m	34° 42.602’	19° 30.677’
S2	30m ADCP 12m	34° 42.602’	19° 30.677’
S3	30m ADCP 20m	34° 42.602’	19° 30.677’
S4	30m ADCP 28m	34° 42.602’	19° 30.677’
S5	10m ADCP 2m	34° 43.187’	19° 33.635’
S6	10m ADCP 4m	34° 43.187’	19° 33.635’
S7	10m ADCP 6m	34° 43.187’	19° 33.635’
S8	10m ADCP 8m	34° 43.187’	19° 33.635’
S9	4m	34° 43.133’	19° 33.700’
S10	4m	34° 43.050’	19° 33.533’
S11	4m	34° 42.933’	19° 33.433’
S12	4m	34° 42.900’	19° 33.283’
S13	4m	34° 42.850’	19° 33.150’

3. OPERATIONS

3.1 SUMMARY OF EVENTS, MALFUNCTIONS AND LESSONS LEARNT

Service visit 4 was undertaken in three parts as outlined below.

Visit 4a July 12th – 13th:
Only the 10m ADCP was serviced. During service visit 3, the 10m ADCP was deployed without an external battery canister. It was anticipated that the internal battery would last for about 2 – 3 weeks. A full dataset was recovered from the instrument and following a service, it was redeployed. A set of water samples were also taken.

Visit 4b August 5th – 6th:
During this visit, both ADCPs as well as the CT Loggers were retrieved. Owing to inclement weather, the tide gauge was not serviced. Water samples were taken. A full dataset was downloaded from the 10m ADCP as well as from the CT loggers. However, the 30m ADCP was found to be faulty. Water leak (photos attached) on the 30m ADCP (s/n 10120) damaged the internal battery pack of the main unit. The unit was withdrawn.

The 10m ADCP (s/n 10119) was redeployed at the 30m site where a new concrete plinth with a fixed frame was installed (photos attached). The CT loggers were successfully re-deployed.

During data processing, it was observed that the conductivity sensor on bottom CT logger (s/n 12998) was faulty. This was also observed during the previous deployment period. Consequently, upon the next visit, this logger will be withdrawn and sent to the manufacturer for inspection/re-calibration, as necessary.

Visit 4c August 27th:
The tide gauge (s/n 014695) was recovered and re-deployed successfully. At the 10m site, ADCP s/n 10117 was re-deployed.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 41).

3.2.1 600kHz ADCP

Table 9 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Redeployment of the 10m ADCP was undertaken during service visit 4c - spare unit s/n 10117.

Table 10 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10120
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

The 30m ADCP was withdrawn during Service 4b. Instead, s/n 10119 (previously at the 10m site) was redeployed at the 30m site.

3.2.2 RBR XR420 CT LOGGER

Table 11 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (7m) and s/n 12998 (28m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

3.2.3 RBR TGR2050 HT TIDE GAUGE

Table 12 – Instrument configuration for the Tide Gauge

Parameter	Configuration
TGR 2050 HT	s/n 014695
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.4 Biofouling Mooring

Table 13 – Instrument configuration for Biofouling Mooring Line.

Parameter	Configuration
Biofouling Plates	3 plates (20cmx20cm) at 3m and 3 plates (20cmx20cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed at depth of about 1.5m outside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further. Since data for the 10m ADCP was recovered during both visits 4a and 4b, the WavesMon output was merged and presented as one full record. During service visit 4a (July 12th – 13th), the ADCP was out of the water for service and download.

4.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 25’ W for the 10m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 25’ W for the 10m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Salinity values less than 34.5psu were flagged for the bottom instrument.

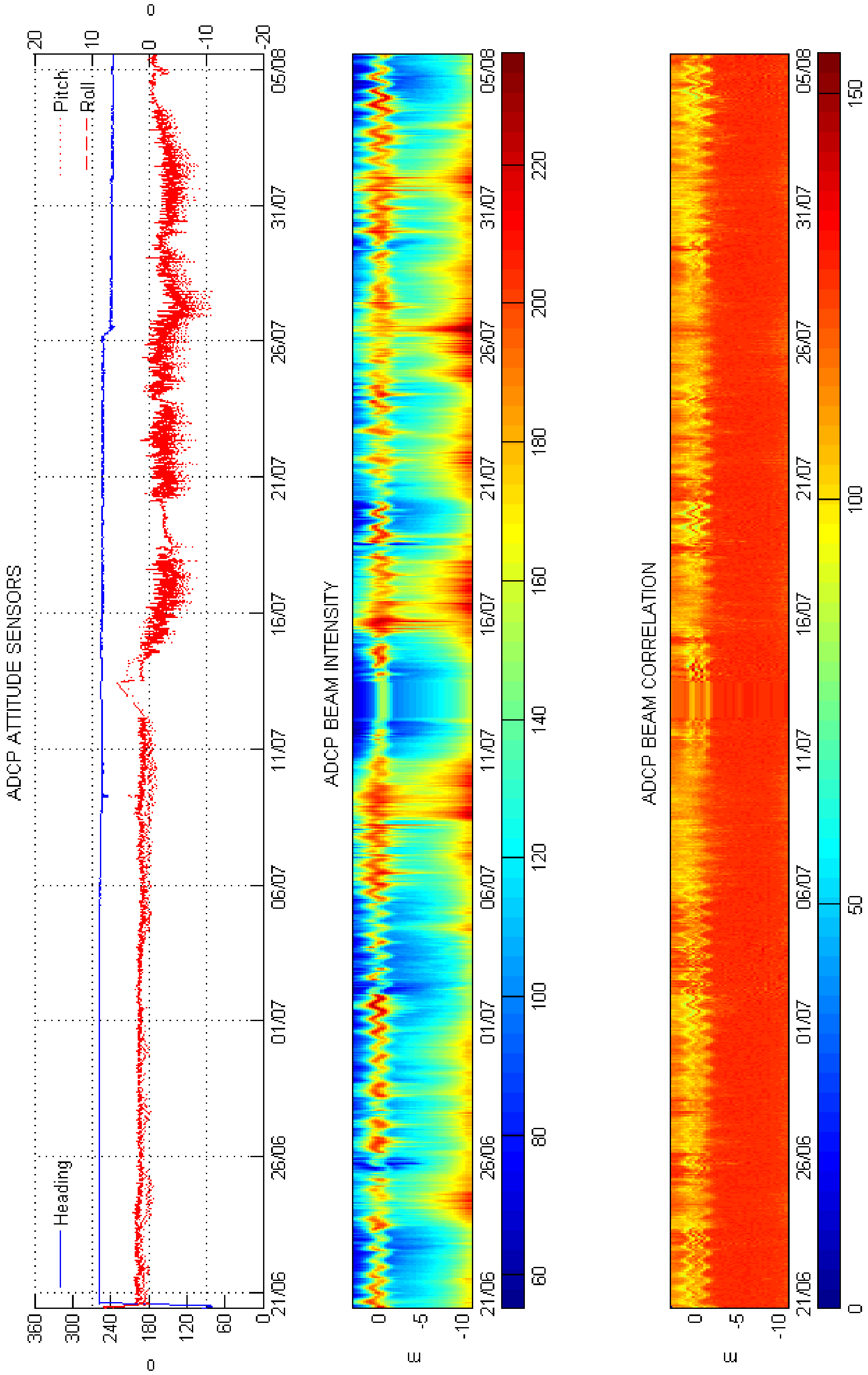


Figure 2: Attitude data for 10m ADCP – Instrument service July 12th – 13th 2008.

4.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

4.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was not scheduled for service visit 4.

4.5 WATER SAMPLE.

Water sample were collected during the first two service visits and sent to the Council for Scientific and Industrial Research (CSIR) for analysis.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

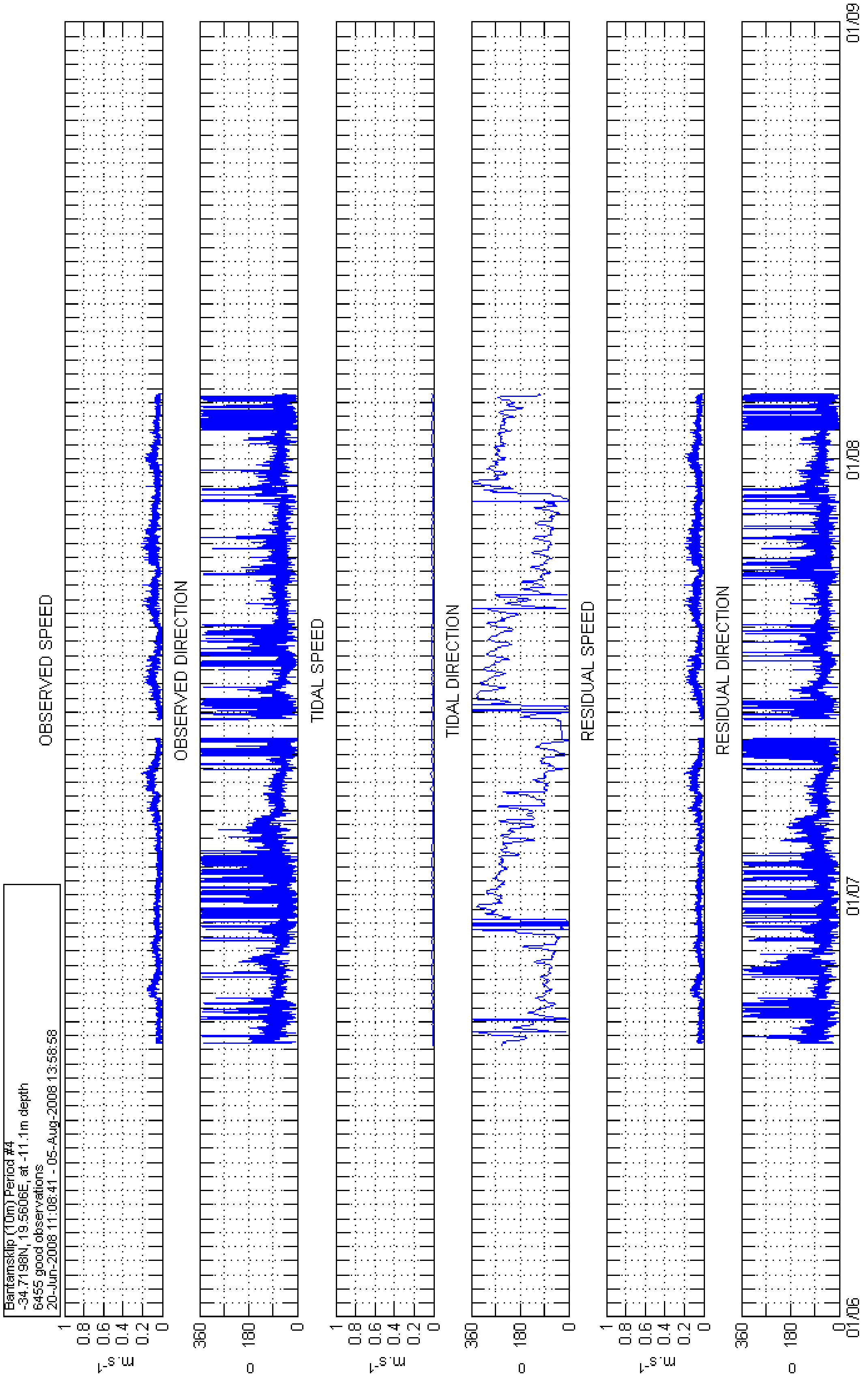


Figure 3: Time series plot for 10m ADCP current data at 11.1m.

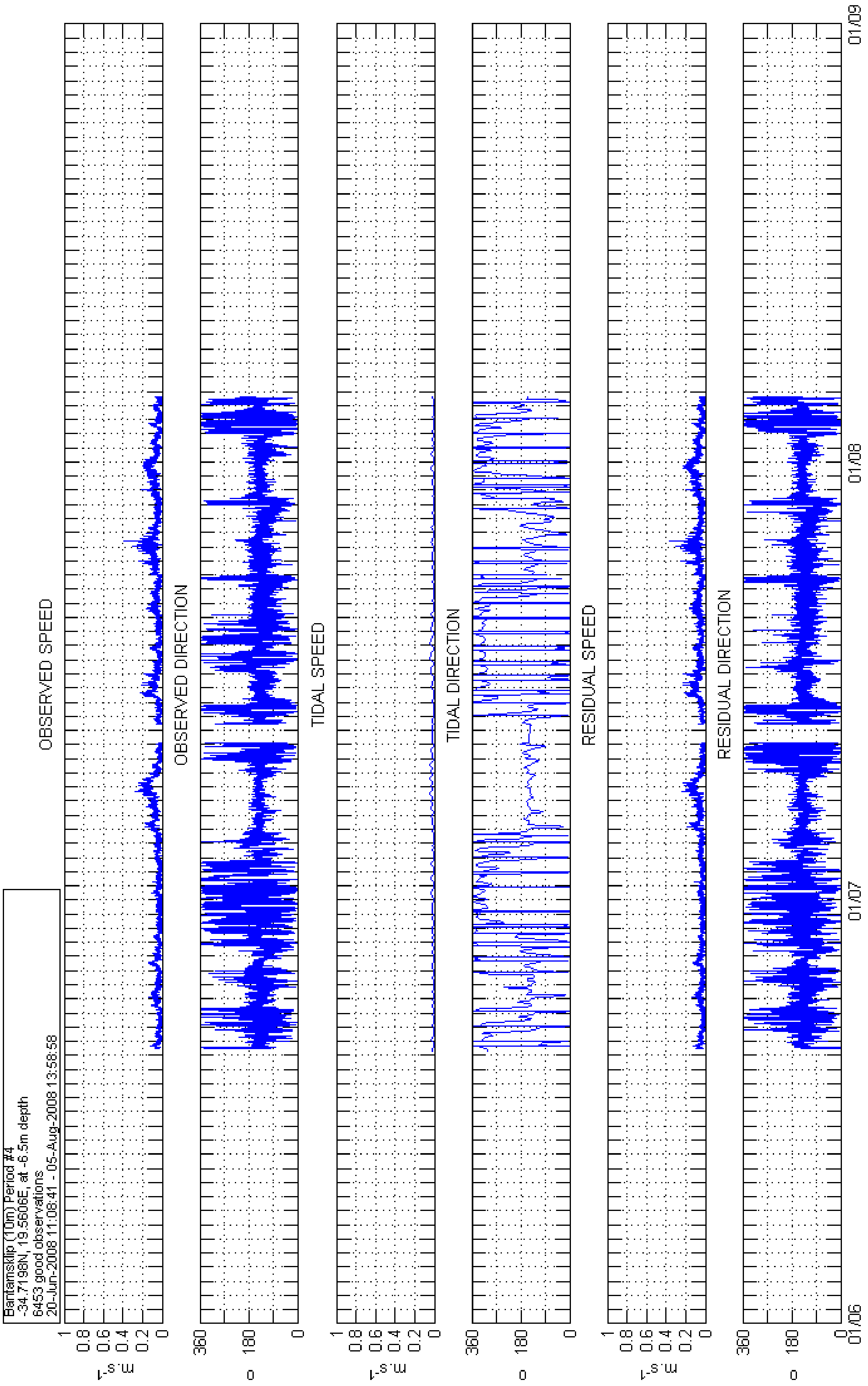


Figure 4: Time series plot for 10m ADCP current data at 6.5m.

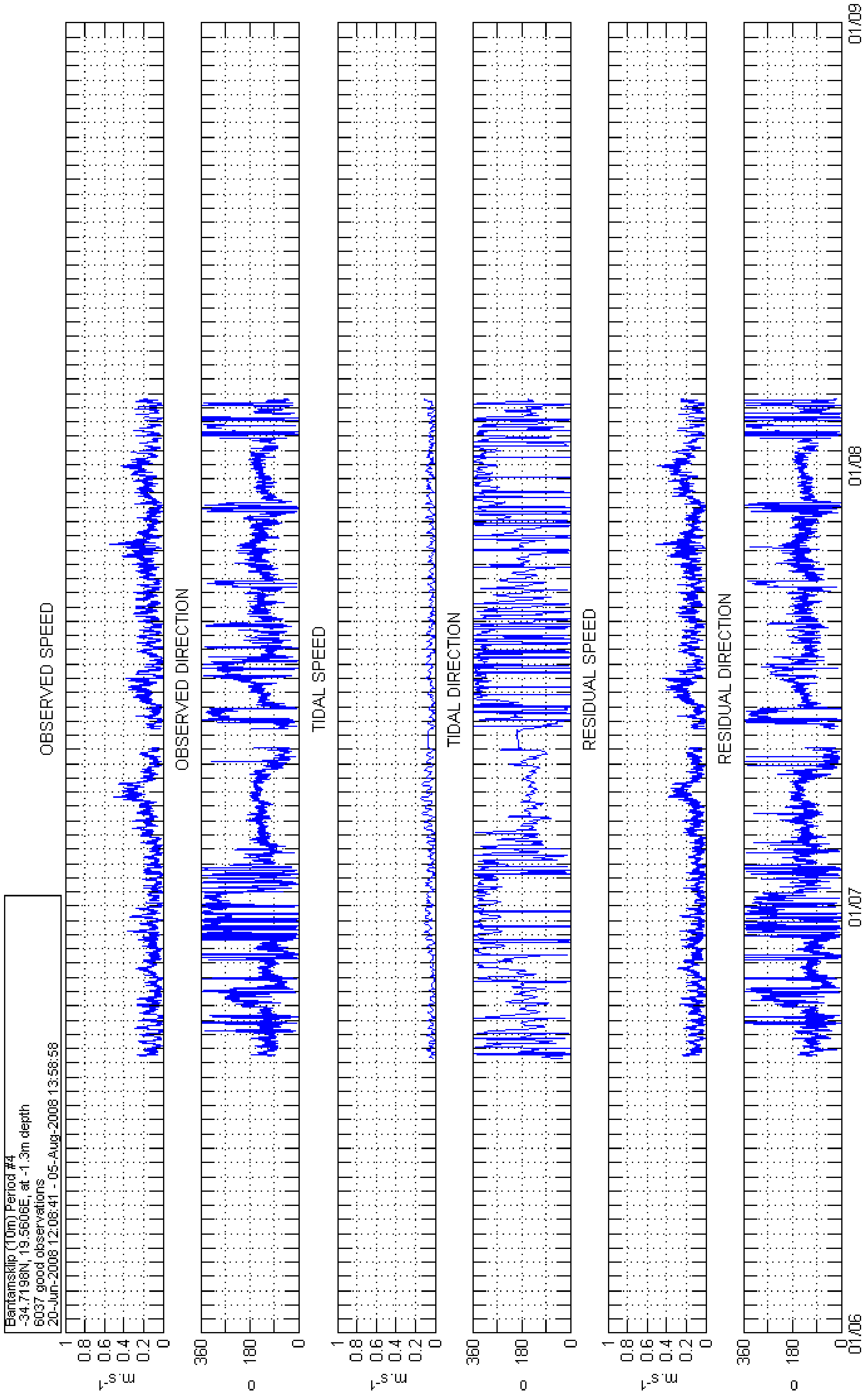


Figure 5: Time series plot for 10m ADCP current data at 1.3m.

5.1.1.2 Summary plots

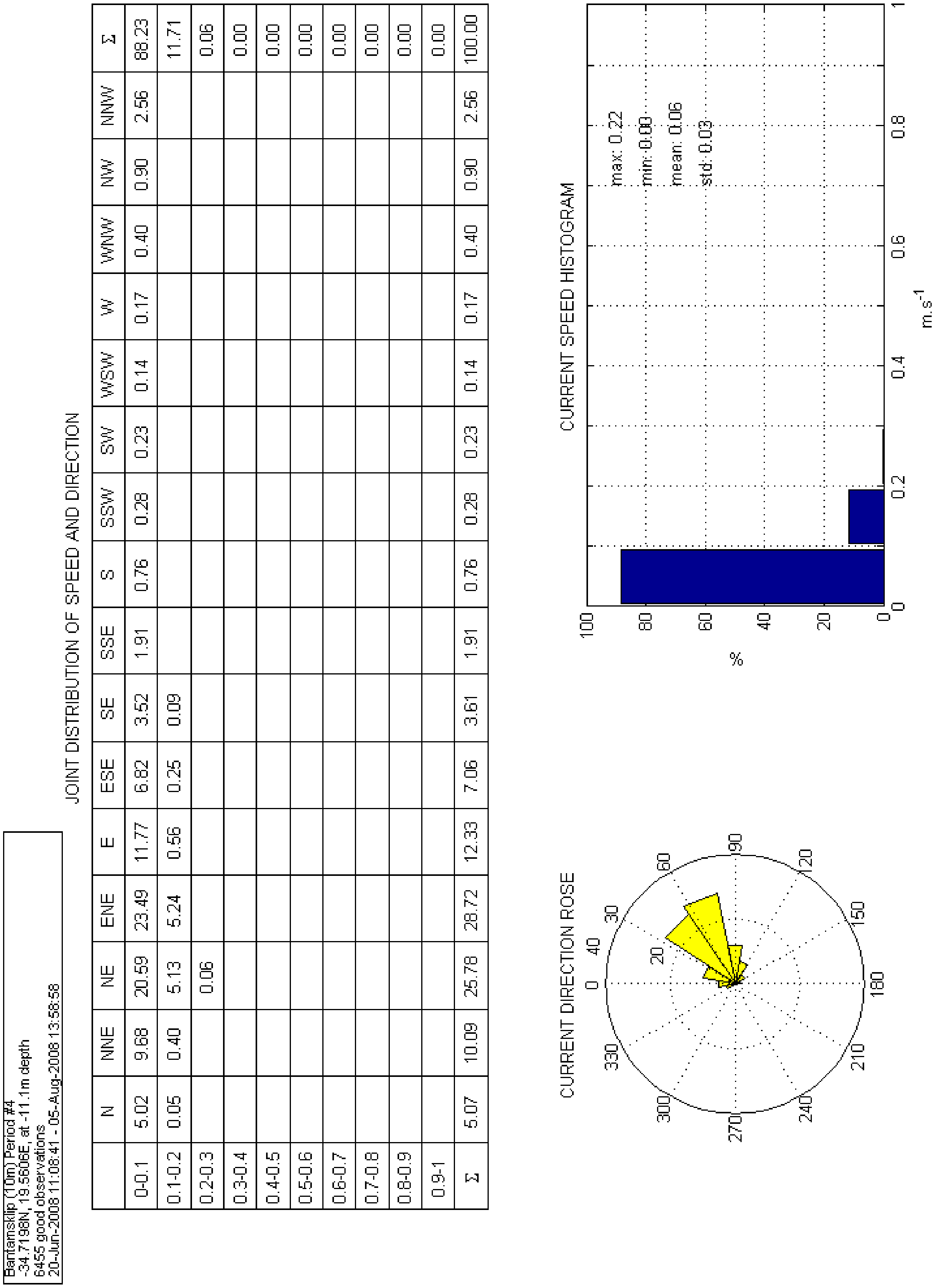
The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.



Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at -11.1m depth
6455 good observations
20-Jun-2008 11:08:41 - 05-Aug-2008 13:58:58

JOINT DISTRIBUTION OF SPEED AND DIRECTION

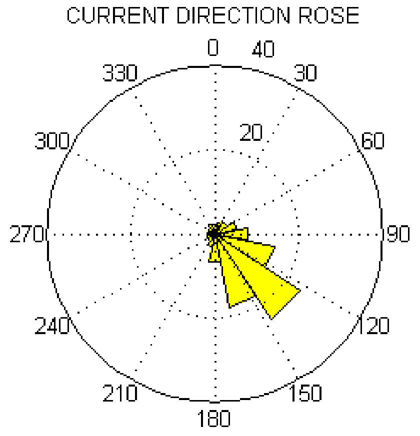
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	5.02	9.68	20.59	23.49	11.77	6.82	3.52	1.91	0.76	0.28	0.23	0.14	0.17	0.40	0.90	2.56	88.23
0.1-0.2	0.05	0.40	5.13	5.24	0.56	0.25	0.09										11.71
0.2-0.3			0.06														0.06
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	5.07	10.09	25.78	28.72	12.33	7.06	3.61	1.91	0.76	0.28	0.23	0.14	0.17	0.40	0.90	2.56	100.00

Figure 6: Summary plot for 10m ADCP current data at 11.1m.

Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at -6.5m depth
6453 good observations
20-Jun-2008 11:08:41 - 05-Aug-2008 13:58:58

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	2.28	2.85	3.42	5.35	7.92	13.54	19.25	13.50	5.86	2.90	2.09	1.83	1.52	1.91	1.84	2.22	88.27
0.1-0.2	0.06				0.12	0.91	5.25	4.00	0.62	0.09	0.02					0.08	11.16
0.2-0.3						0.05	0.06	0.26	0.17	0.02							0.56
0.3-0.4									0.02								0.02
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	2.34	2.85	3.42	5.35	8.04	14.50	24.56	17.76	6.66	3.01	2.11	1.83	1.52	1.91	1.84	2.29	100.00



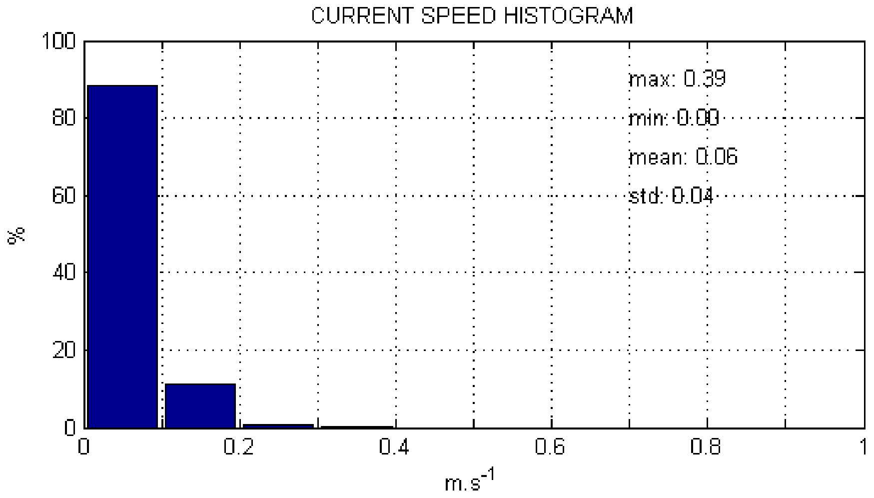


Figure 7: Summary plot for 10m ADCP current data at 6.5m

Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at -1.3m depth
6037 good observations
20-Jun-2008 12:08:41 - 05-Aug-2008 13:58:58

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.61	2.17	2.77	4.06	4.75	5.68	4.52	2.32	0.83	0.75	1.18	1.08	1.28	1.74	1.87	1.71	38.30
0.1-0.2	0.89	1.09	2.05	2.95	4.94	9.14	11.33	4.75	1.36	0.65	0.61	0.86	1.13	0.84	1.24	1.24	45.09
0.2-0.3	0.03	0.08	0.23	0.27	0.51	1.79	3.63	3.66	1.29	0.55	0.22	0.40	0.27	0.27	0.12		13.30
0.3-0.4							0.48	1.74	0.35	0.18		0.08	0.05				2.88
0.4-0.5							0.02	0.28	0.08	0.02							0.40
0.5-0.6								0.02		0.02							0.03
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	2.53	3.35	5.05	7.27	10.20	16.61	19.98	12.77	3.91	2.15	2.00	2.42	2.72	2.85	3.23	2.95	100.00

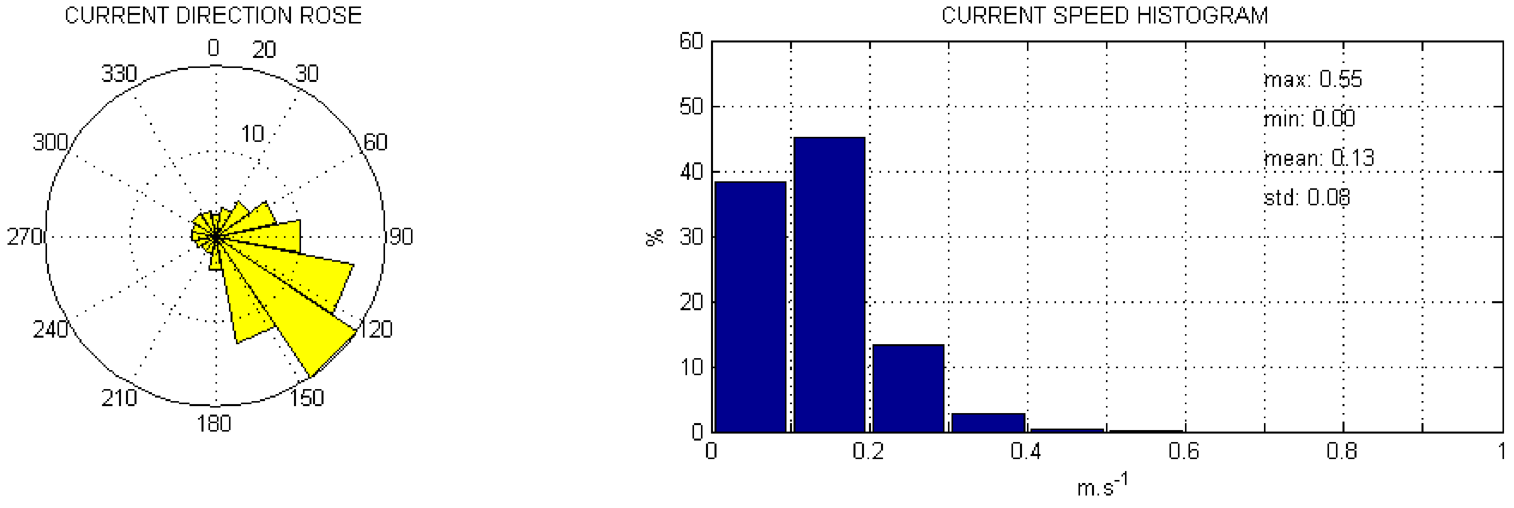


Figure 8: Summary plot for 10m ADCP current data at 1.3m.

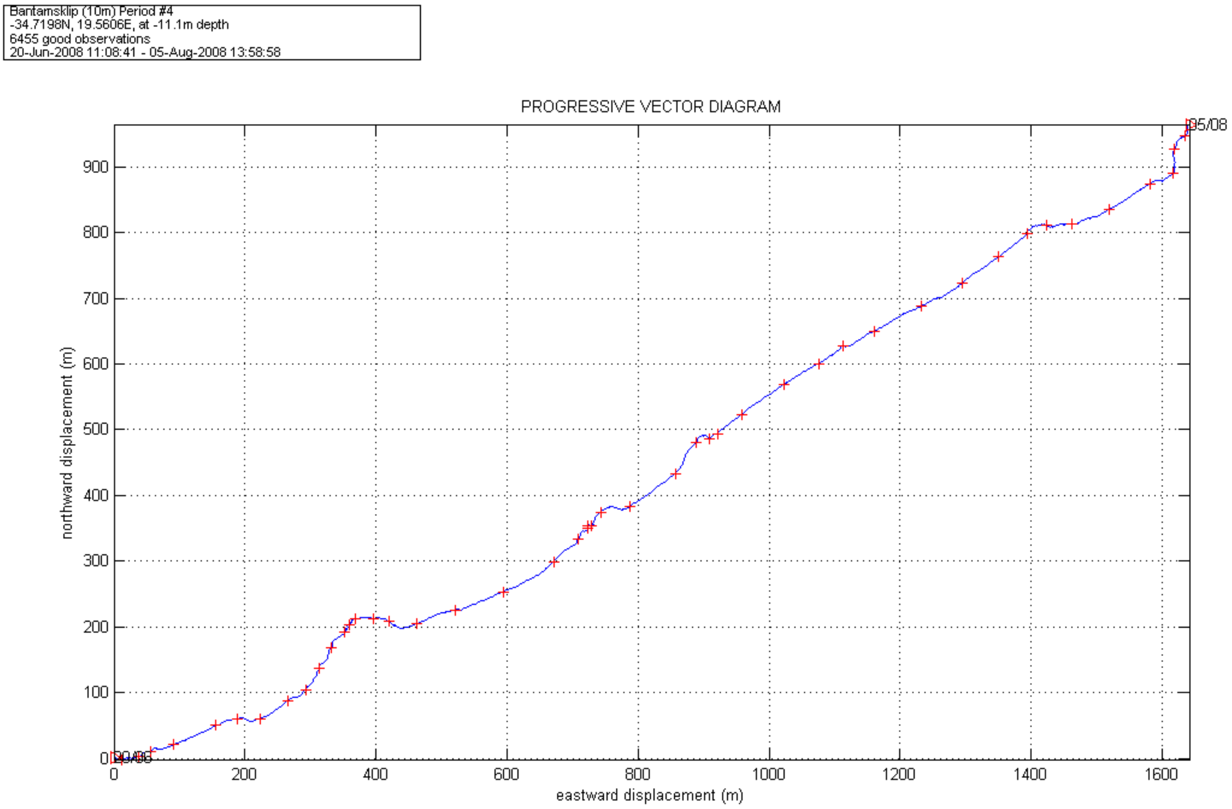


Figure 9: Progressive vector plot for 10m ADCP current data at 11.1m.

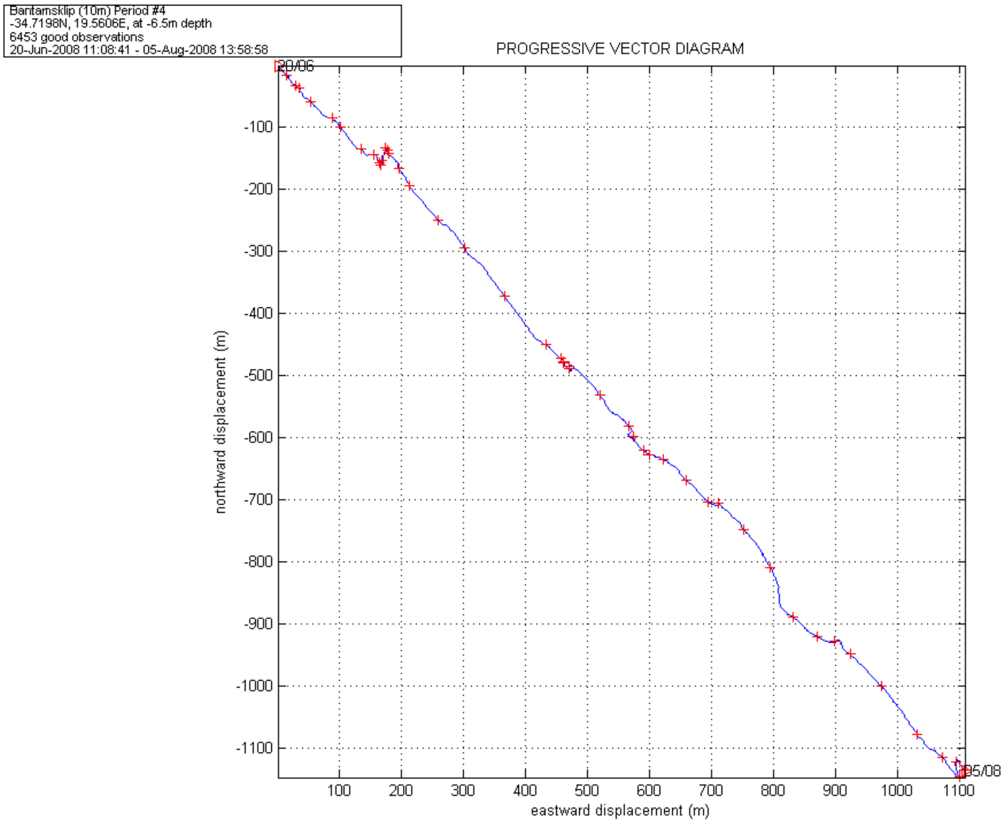


Figure 10: Progressive vector plot for 10m ADCP current data at 6.5m.

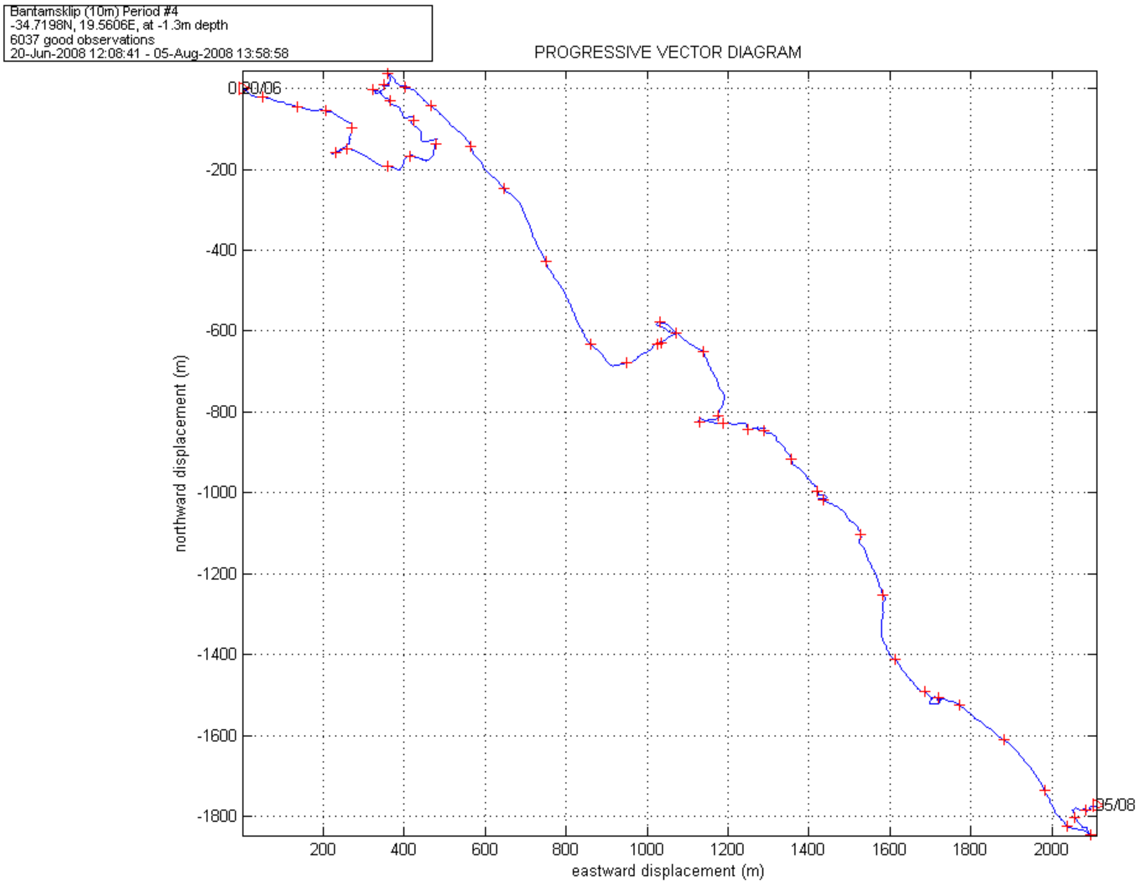


Figure 11: Progressive vector plot for 10m ADCP current data at 1.3m.

5.1.2 Wave Data.

5.1.2.1 Figure 12 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

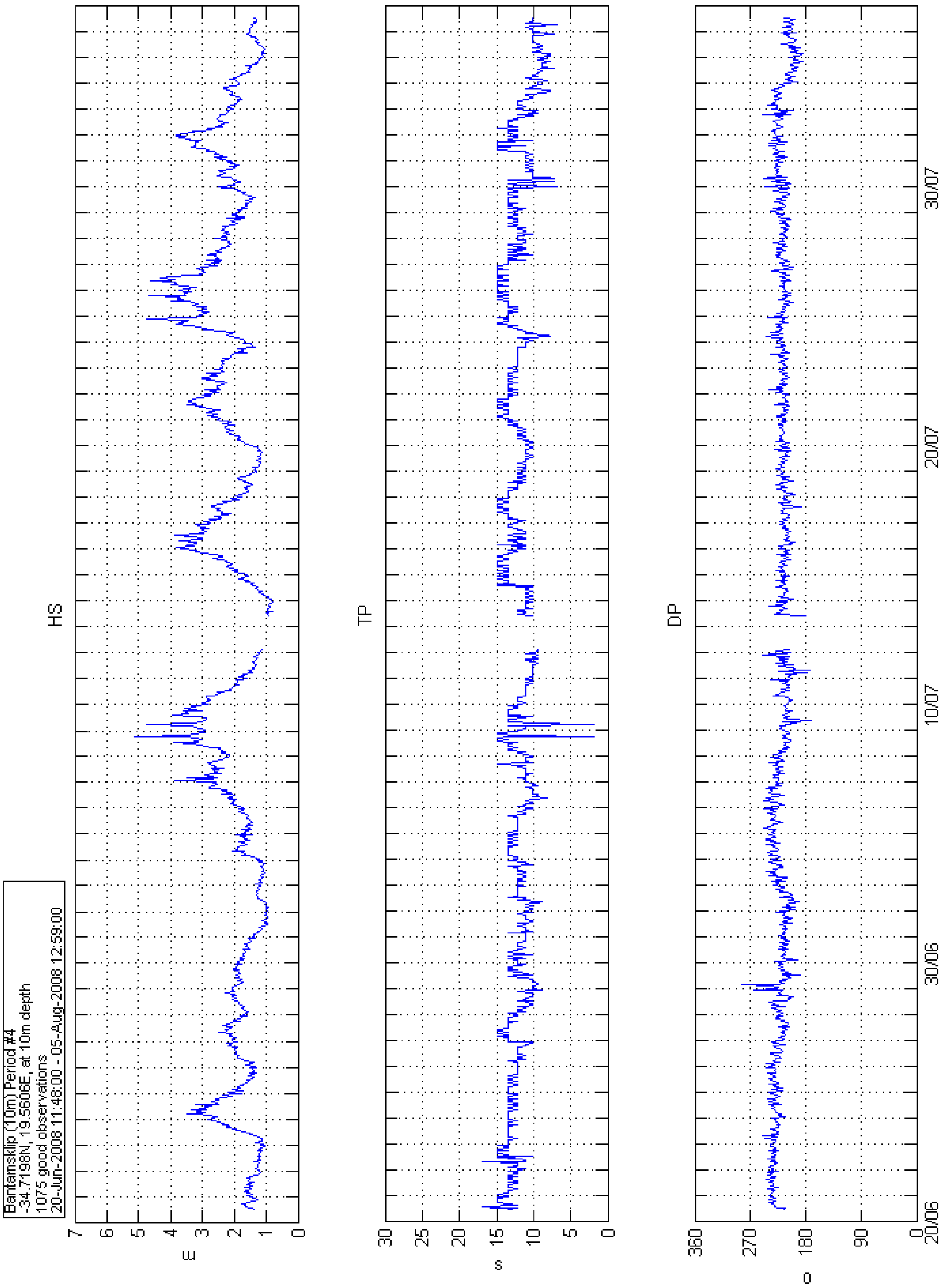


Figure 12: Time series of wave parameters Hs, Tp and Dp for 10m ADCP.

5.1.2.2 Hs and Tp summary plot

Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.3 Hs and Dp summary plot

Figure 14 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.4 Tp and Dp summary plot

Figure 15 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at 10m depth
1075 good observations
20-Jun-2008 11:48:00 - 05-Aug-2008 12:59:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1						2.23	0.28									2.51
1-1.25				0.28	1.40	4.74	3.53	0.56								10.51
1.25-1.5				0.19	0.74	5.21	5.30	0.74	0.09							12.28
1.5-1.75				0.19	0.65	2.60	9.02	0.37	0.09							12.93
1.75-2				0.09	1.02	4.65	8.00	0.28								14.05
2-2.25				0.37	0.65	4.56	5.30	0.74								11.63
2.25-2.5				0.09	0.19	2.98	5.95	0.74								9.95
2.5-2.75					0.09	2.33	4.00	0.56								6.98
2.75-3						1.12	4.00	0.84								5.95
3-3.25						0.74	3.63	1.02								5.40
3.25-3.5						0.47	2.42	0.84								3.72
3.5-3.75						0.09	1.02	0.84								1.95
3.75-4						0.09	0.74	0.47								1.30
4-4.25							0.19	0.09								0.28
4.25-4.5								0.09								0.09
4.5-4.75							0.09	0.09								0.19
4.75-5		0.09					0.09									0.19
5-5.25		0.09														0.09
5.25-5.5																0.00
Σ	0.00	0.19	0.00	1.21	4.74	31.81	53.58	8.28	0.19	0.00	0.00	0.00	0.00	0.00	0.00	100.00

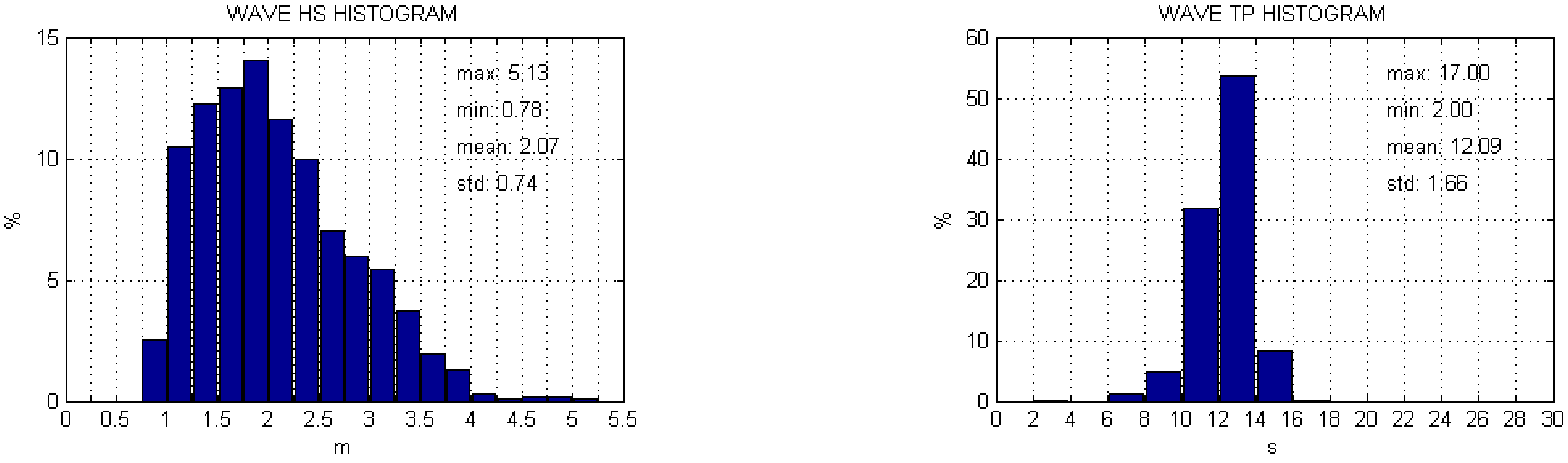
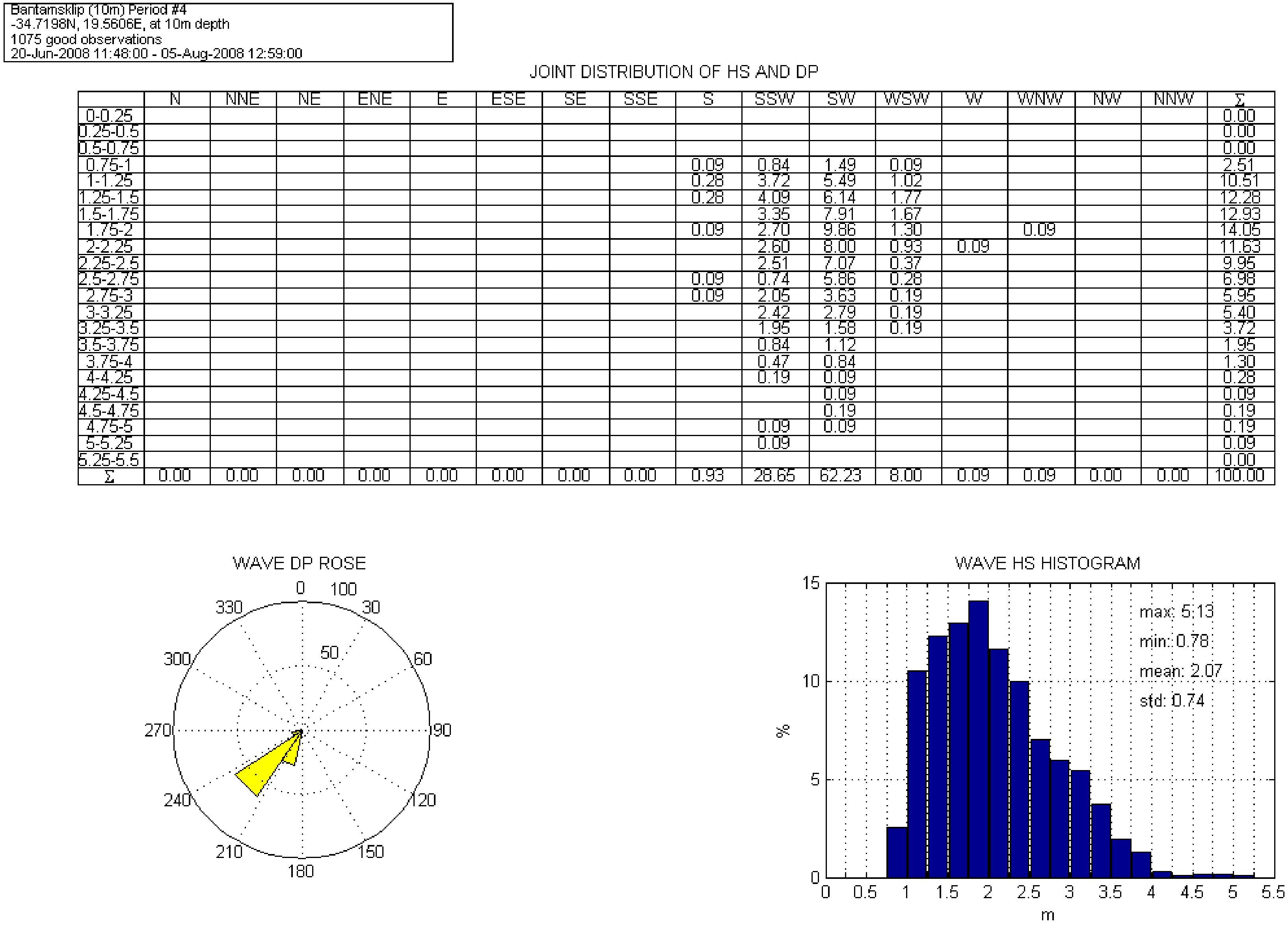


Figure 13: Summary plot of H_s and T_p.



Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at 10m depth
1075 good observations
20-Jun-2008 11:48:00 - 05-Aug-2008 12:59:00

JOINT DISTRIBUTION OF HS AND DP

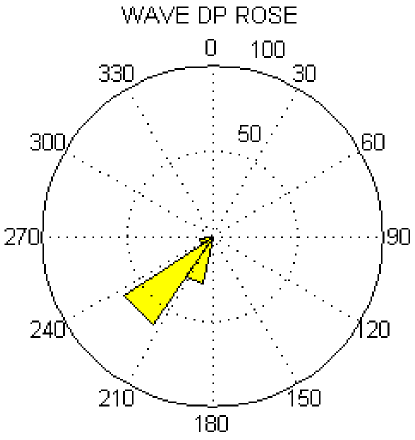
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1									0.09	0.84	1.49	0.09					2.51
1-1.25									0.28	3.72	5.49	1.02					10.51
1.25-1.5									0.28	4.09	6.14	1.77					12.28
1.5-1.75										3.35	7.91	1.67					12.93
1.75-2									0.09	2.70	9.86	1.30		0.09			14.05
2-2.25										2.60	8.00	0.93	0.09				11.63
2.25-2.5										2.51	7.07	0.37					9.95
2.5-2.75									0.09	0.74	5.86	0.28					6.98
2.75-3									0.09	2.05	3.63	0.19					5.95
3-3.25										2.42	2.79	0.19					5.40
3.25-3.5										1.95	1.58	0.19					3.72
3.5-3.75										0.84	1.12						1.95
3.75-4										0.47	0.84						1.30
4-4.25										0.19	0.09						0.28
4.25-4.5											0.09						0.09
4.5-4.75											0.19						0.19
4.75-5										0.09	0.09						0.19
5-5.25										0.09							0.09
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	28.65	62.23	8.00	0.09	0.09	0.00	0.00	100.00

Figure 14: Summary plot of H_s and D_p.

Bantamsklip (10m) Period #4
-34.7198N, 19.5606E, at 10m depth
1075 good observations
20-Jun-2008 11:48:00 - 05-Aug-2008 12:59:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4										0.19							0.19
4-6																	0.00
6-8									0.28	0.28	0.37	0.28					1.21
8-10										2.88	1.40	0.28	0.09	0.09			4.74
10-12									0.47	9.77	19.91	1.67					31.81
12-14									0.09	13.21	35.26	5.02					53.58
14-16									0.09	2.33	5.21	0.65					8.28
16-18											0.09	0.09					0.19
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	28.65	62.23	8.00	0.09	0.09	0.00	0.00	100.00



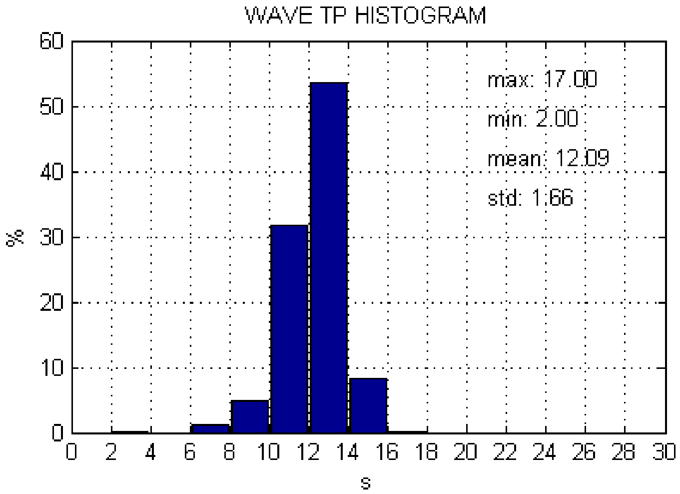


Figure 15: Summary plot of T_p and D_p.

5.1.2.5 Wave spectral plot

Figure 16 to Figure 18 display wave spectral plots for significant waves events. The time of each spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

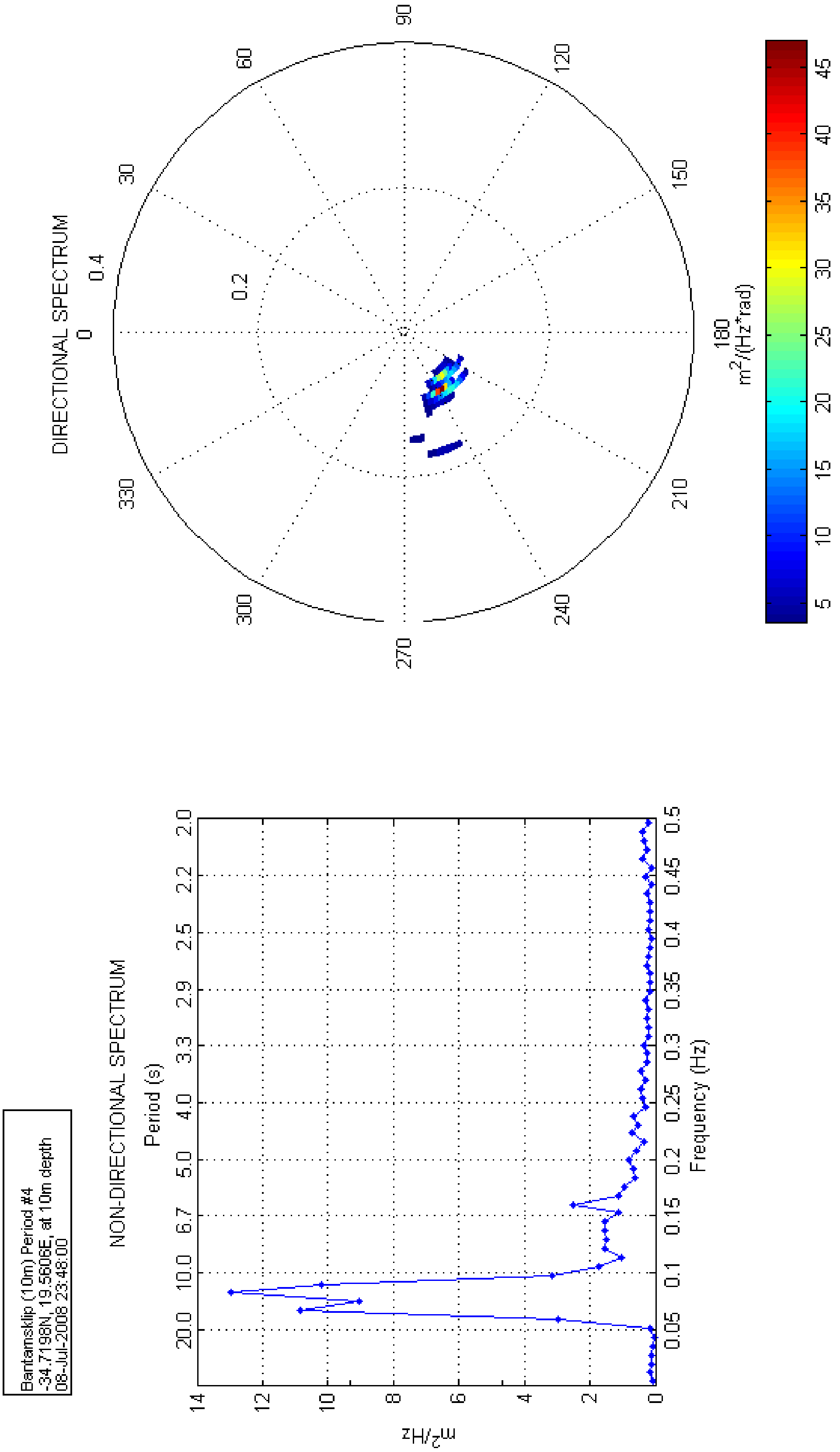


Figure 16: Wave spectra for 08th of July 2008 at 23:48:00.

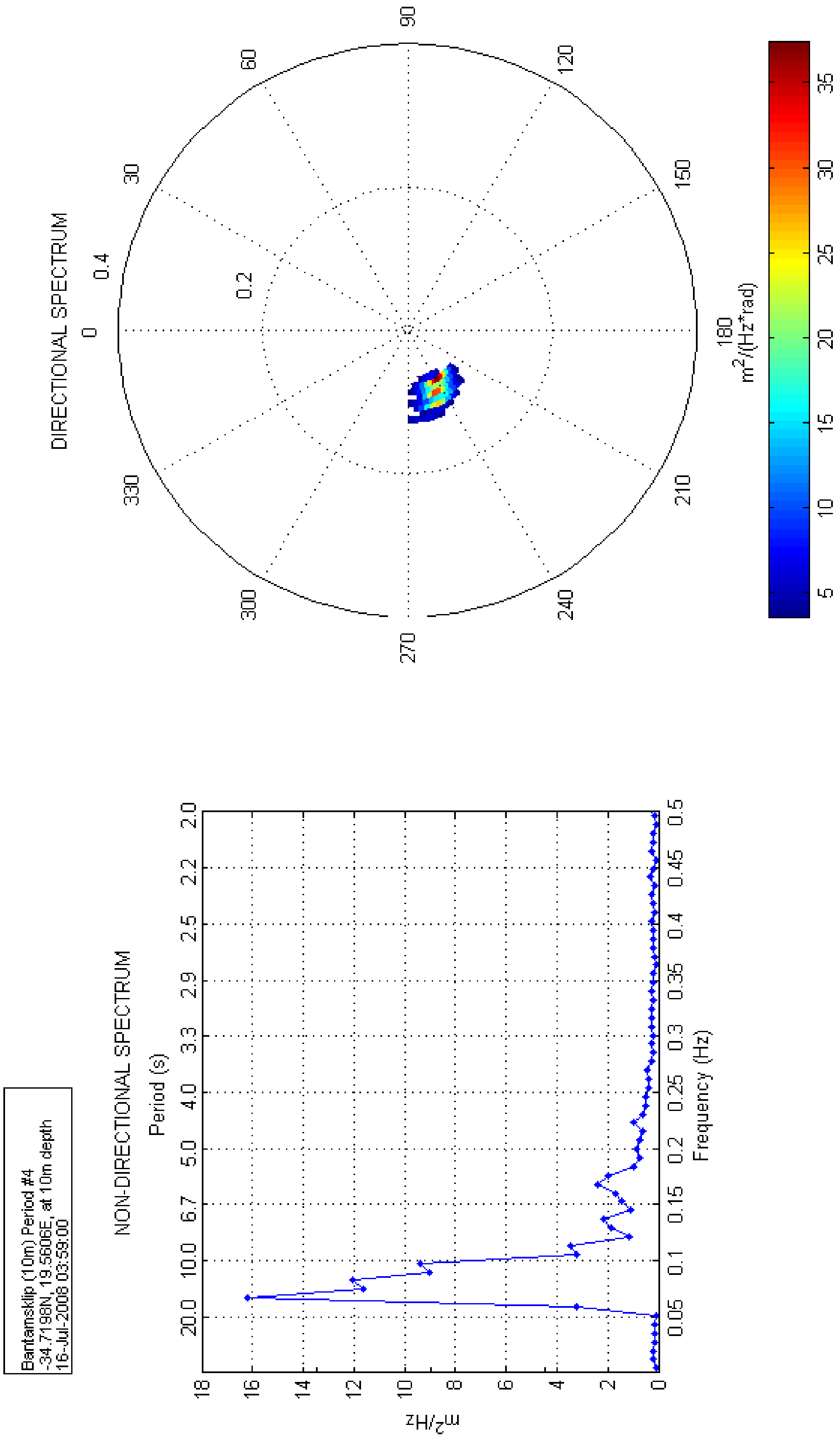


Figure 17: Wave spectra for 16th of July 2008 at 03:59:00.

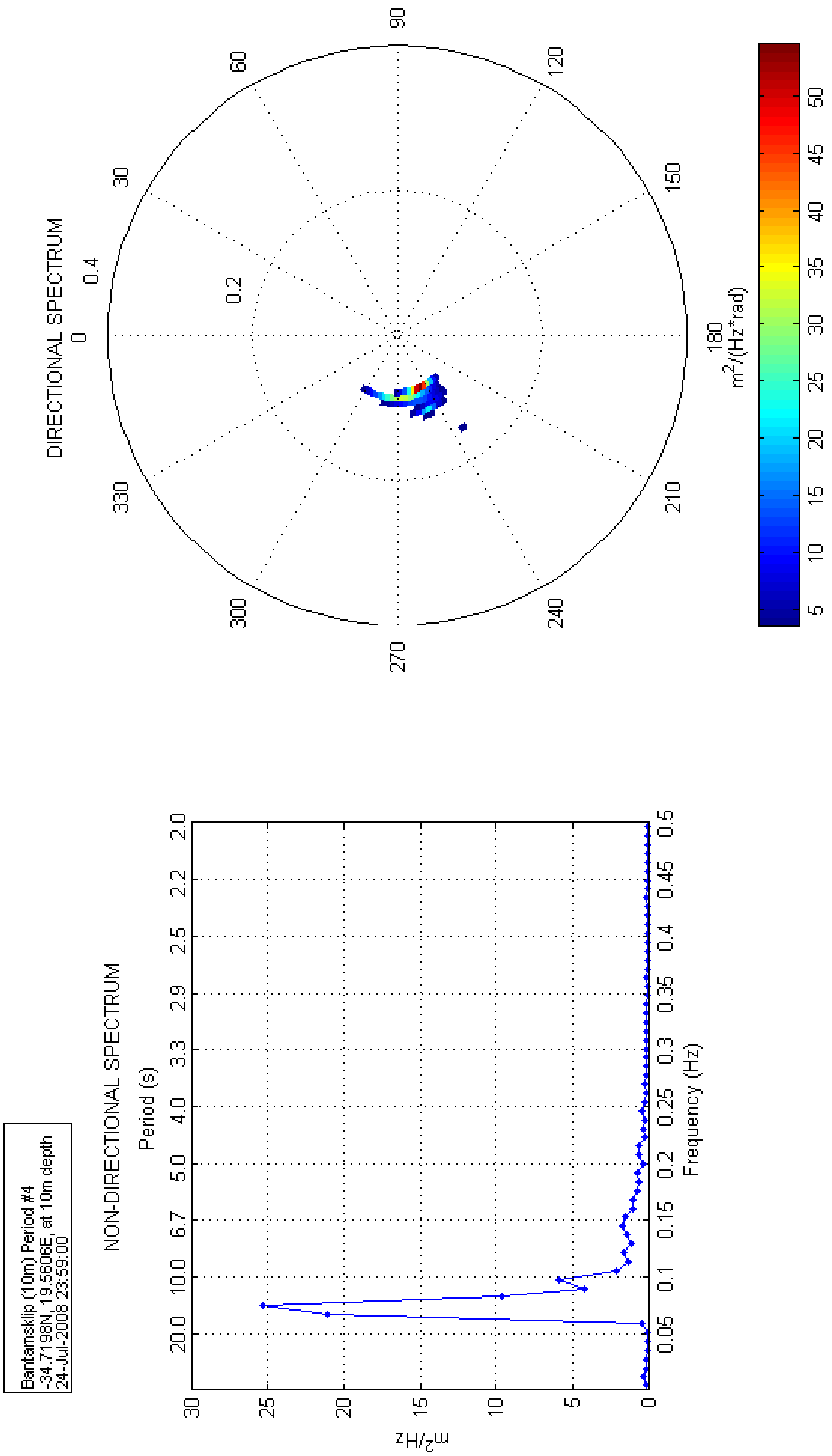


Figure 18: Wave spectra for 24th of July 2008 at 23:59:00.

5.2 COMPARISON PLOTS

5.2.1 Water properties: RBR-CT loggers and ADCP temperature sensor.

Figure 19 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCP temperature sensor against time.
- The second panel is of the derived salinity from the RBR loggers against time.

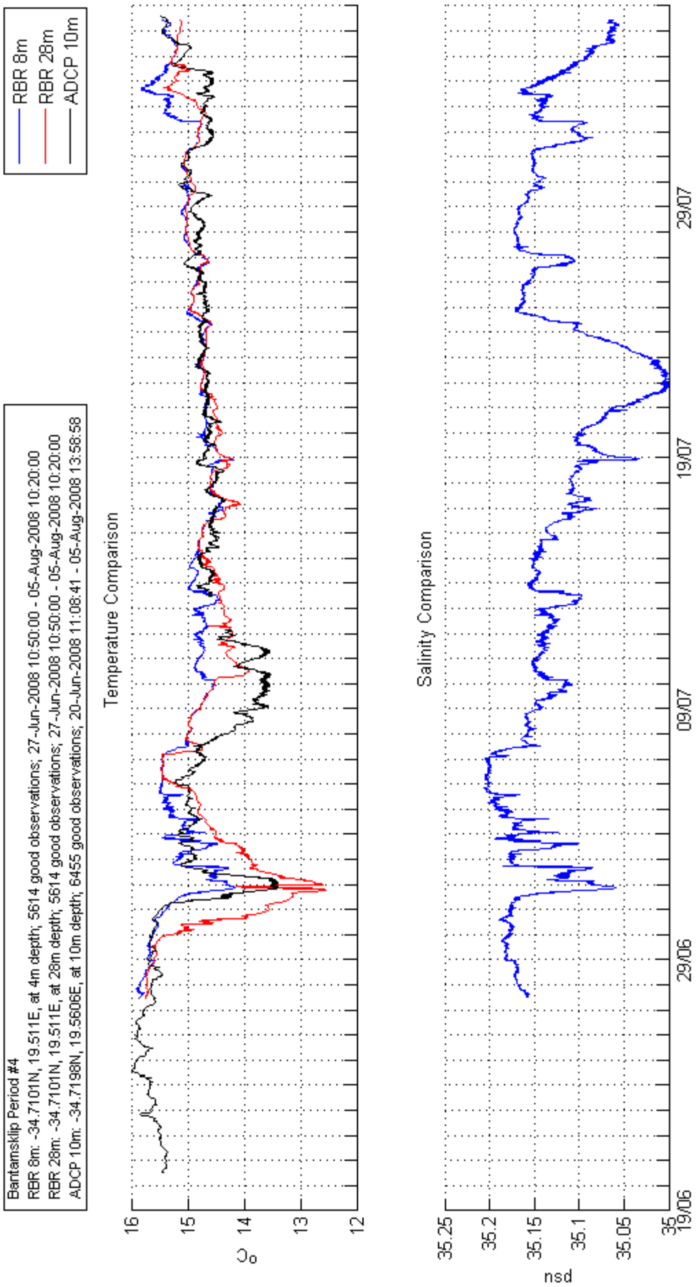


Figure 19: Time series of temperature and salinity from the RBR loggers and 10m ADCP.

5.3 TIDE GAUGE

Figure 20 displays a time series plot of the tidal height.

- The first (upper) panel is of the observed height against time.
- The second panel is of the tidal height, calculated from the observed height, against time. The tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The third panel is of the residual height against time. The residual has been calculated as the observed height minus the tidal height.

Table 14 shows the tidal harmonics resulting from the analysis.

5.4 WATER SAMPLES.

Analysis of water samples were undertaken by the CSIR and results are presented as an appendage (Section 8, page 54).

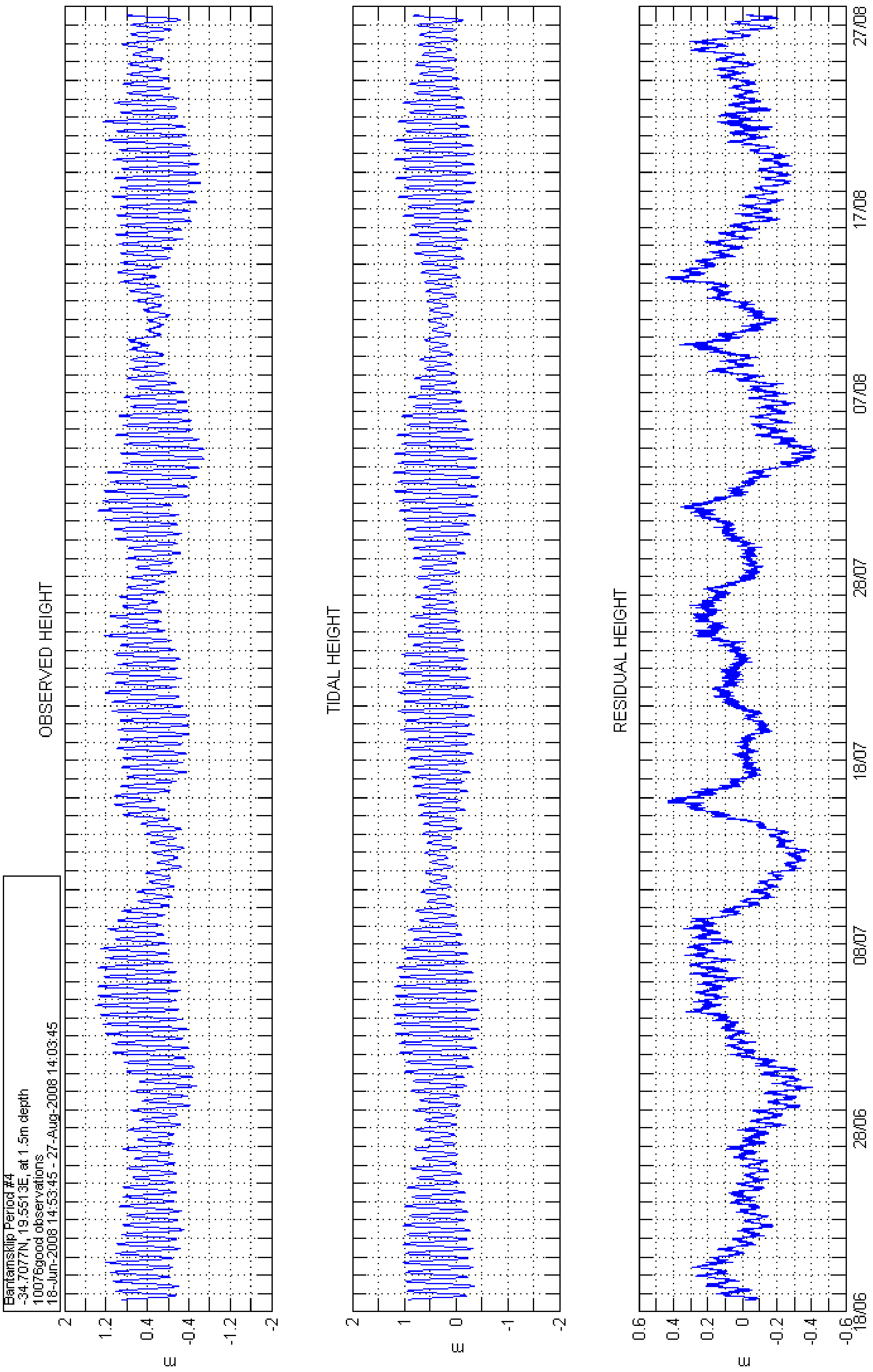
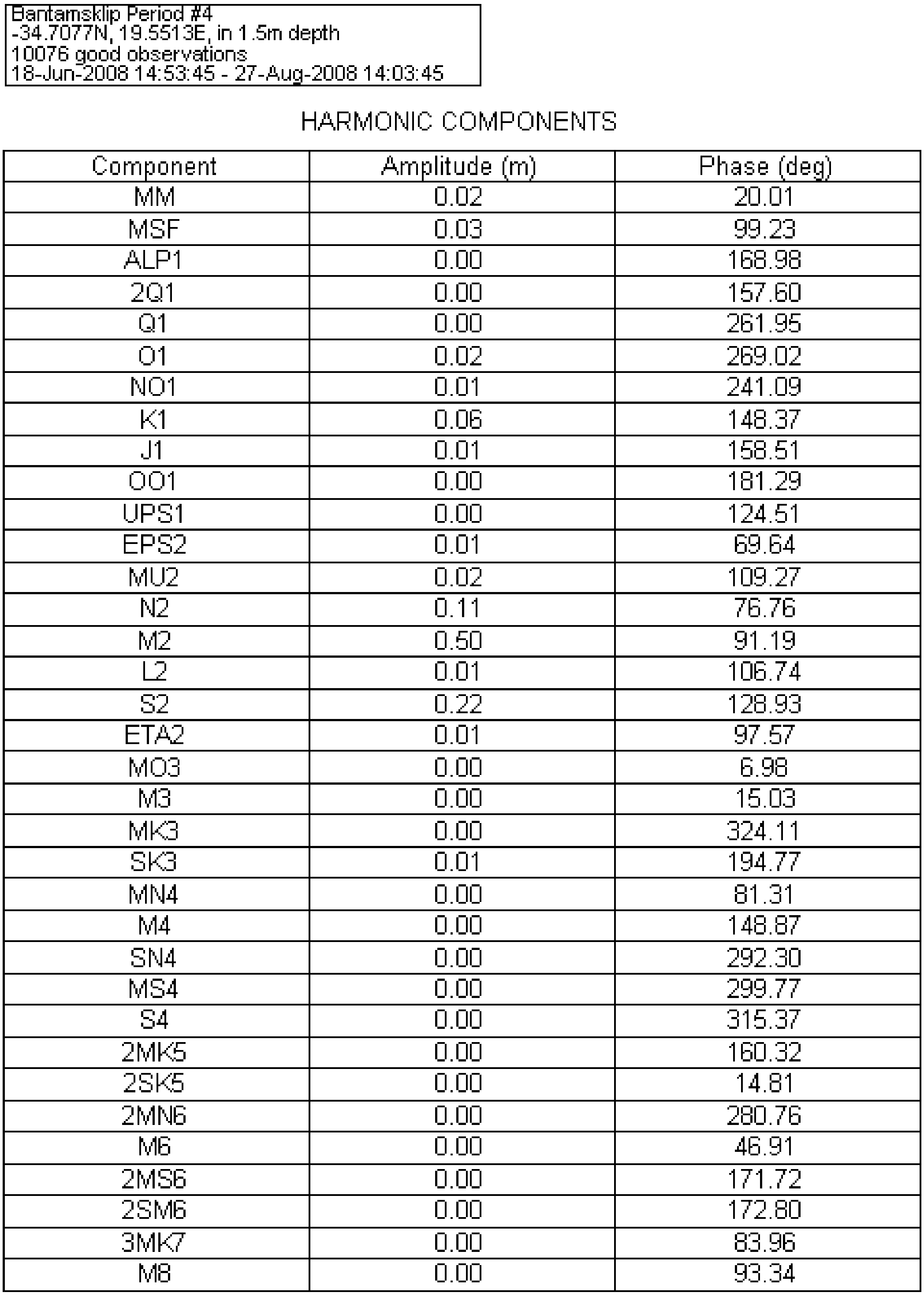


Figure 20: Tidal time series.

Table 14: Tidal harmonics.



Bantamsklip Period #4
-34.7077N, 19.5513E, in 1.5m depth
10076 good observations
18-Jun-2008 14:53:45 - 27-Aug-2008 14:03:45

HARMONIC COMPONENTS

Component	Amplitude (m)	Phase (deg)
MM	0.02	20.01
MSF	0.03	99.23
ALP1	0.00	168.98
2Q1	0.00	157.60
Q1	0.00	261.95
O1	0.02	269.02
NO1	0.01	241.09
K1	0.06	148.37
J1	0.01	158.51
OO1	0.00	181.29
UPS1	0.00	124.51
EPS2	0.01	69.64
MU2	0.02	109.27
N2	0.11	76.76
M2	0.50	91.19
L2	0.01	106.74
S2	0.22	128.93
ETA2	0.01	97.57
MO3	0.00	6.98
M3	0.00	15.03
MK3	0.00	324.11
SK3	0.01	194.77
MN4	0.00	81.31
M4	0.00	148.87
SN4	0.00	292.30
MS4	0.00	299.77
S4	0.00	315.37
2MK5	0.00	160.32
2SK5	0.00	14.81
2MN6	0.00	280.76
M6	0.00	46.91
2MS6	0.00	171.72
2SM6	0.00	172.80
3MK7	0.00	83.96
M8	0.00	93.34

6. DISCUSSION

The fouth set of oceanographic data collected off the coast of Bantamsklip for the period between June 20th and August 27th 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

At the Bantamsklip site, 2 600 kHz ADCP, 2 RBR-CT loggers and 1 RBR tide gauge have been deployed to measure currents, waves, water temperature and salinity and tidal record. The ADCP is fixed on a frame at ~10m and ~30m and the RBR loggers are moored at ~7m and ~28m below the surface.

Three service visits were undertaken over the deployment period. New ADCP frames were installed. The bottom RBR-CT logger is affixed to the 30m ADCP frame and the surface one is moored ~8m below the surface about 5m away.

This report presents data obtained from the 10m ADCP, the 2 RBR-CT loggers, the RBR tide gauge and water samples collected during the first two service visits.

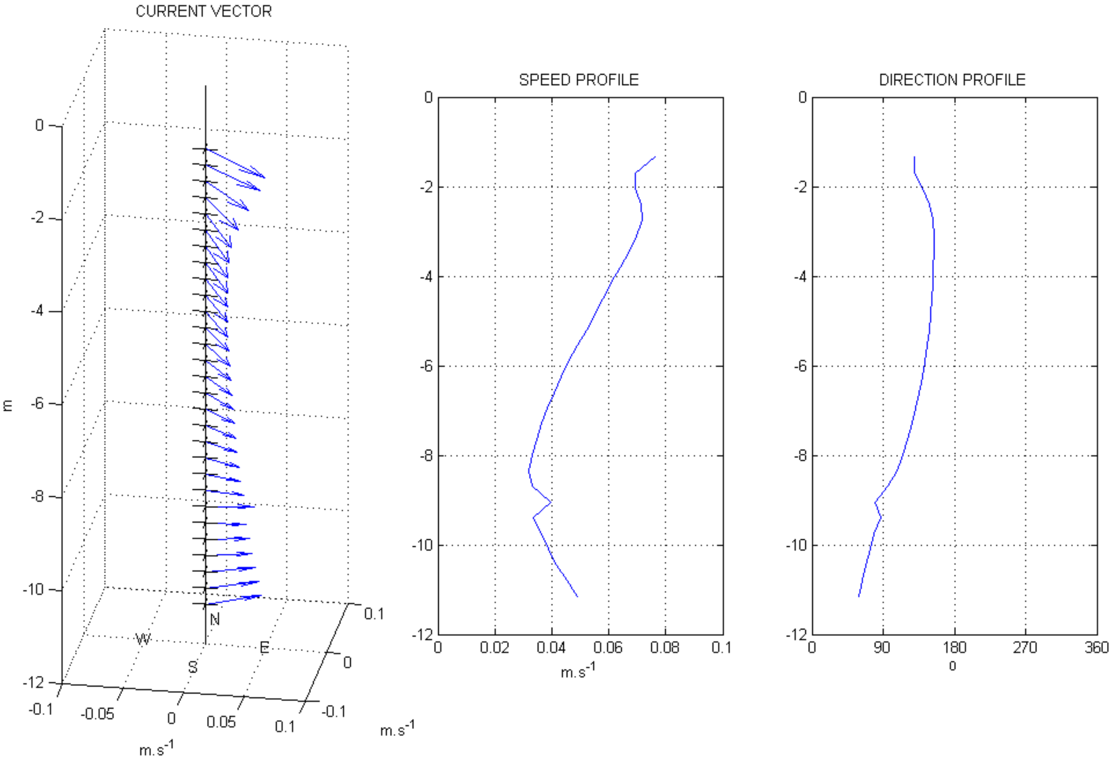


Figure 21: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.13ms^{-1}, decreasing to ~0.06ms^{-1} at 11.1m depth. The flow direction at the surface was predominantly towards the S/SE, while at depth, it was mainly towards the ENE. Average wave parameters of ~2m, ~12s and ~220^{o} were recorded for Hs, Tp and Dp respectively. These results are in agreement with previous deployments.

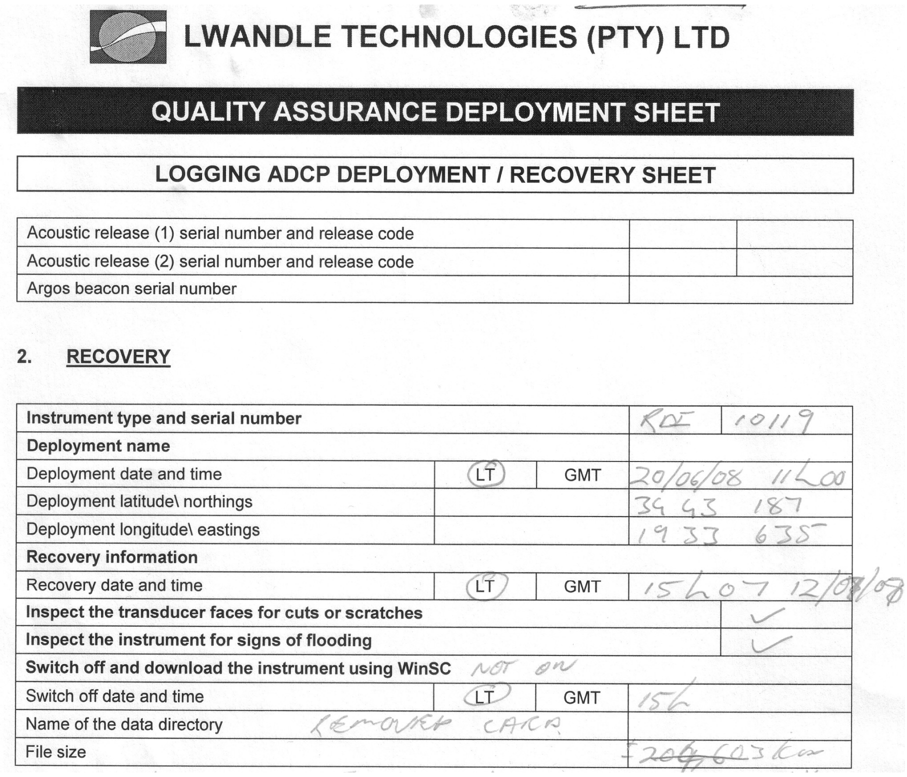
The conductivity sensor for the bottom RBR logger failed – the instrument will be withdrawn during the next recovery. Figure 19 shows the temperature sensors on board the ADCPs and RBR loggers recorded reasonably similar values during the deployment period.

The tide analysis shows some degree of semi-diurnal component in the residual height with negligible amplitude of ~0.1m.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT TWO

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.



LWANDLE TECHNOLOGIES (PTY) LTD

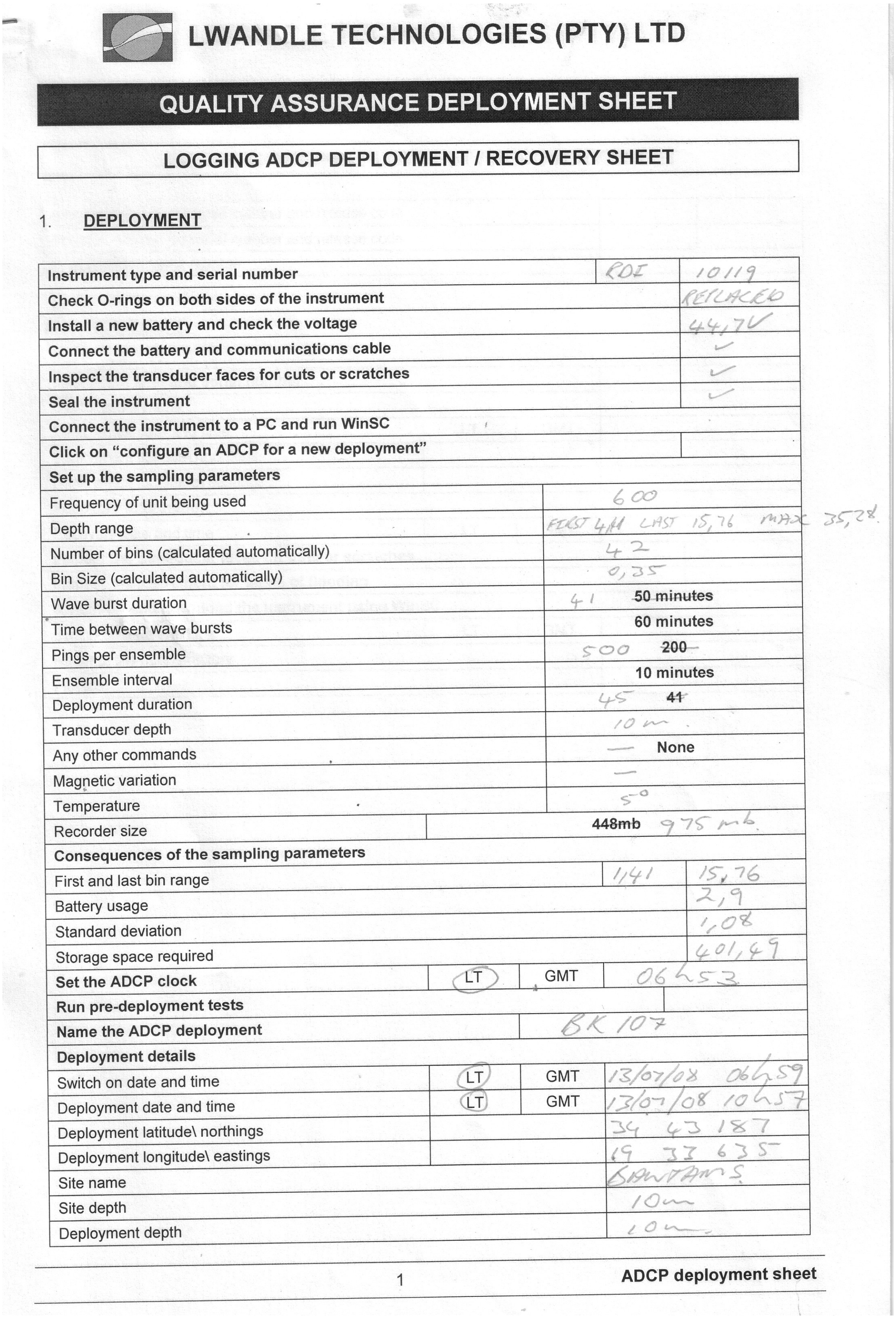
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		

2. RECOVERY

Instrument type and serial number			RDI	10119
Deployment name				
Deployment date and time	[✓ LT]	GMT	20/06/08	11h00
Deployment latitude\ northings			34 43	187
Deployment longitude\ eastings			19 33	635
Recovery information				
Recovery date and time	[✓ LT]	GMT	15h07 12/08/08	
Inspect the transducer faces for cuts or scratches				✓
Inspect the instrument for signs of flooding				✓
Switch off and download the instrument using WinSC NOT ON				
Switch off date and time	[✓ LT]	GMT	15h	
Name of the data directory REMOVED CARD				
File size			±206 603 kb	



LWANDLE TECHNOLOGIES (PTY) LTD

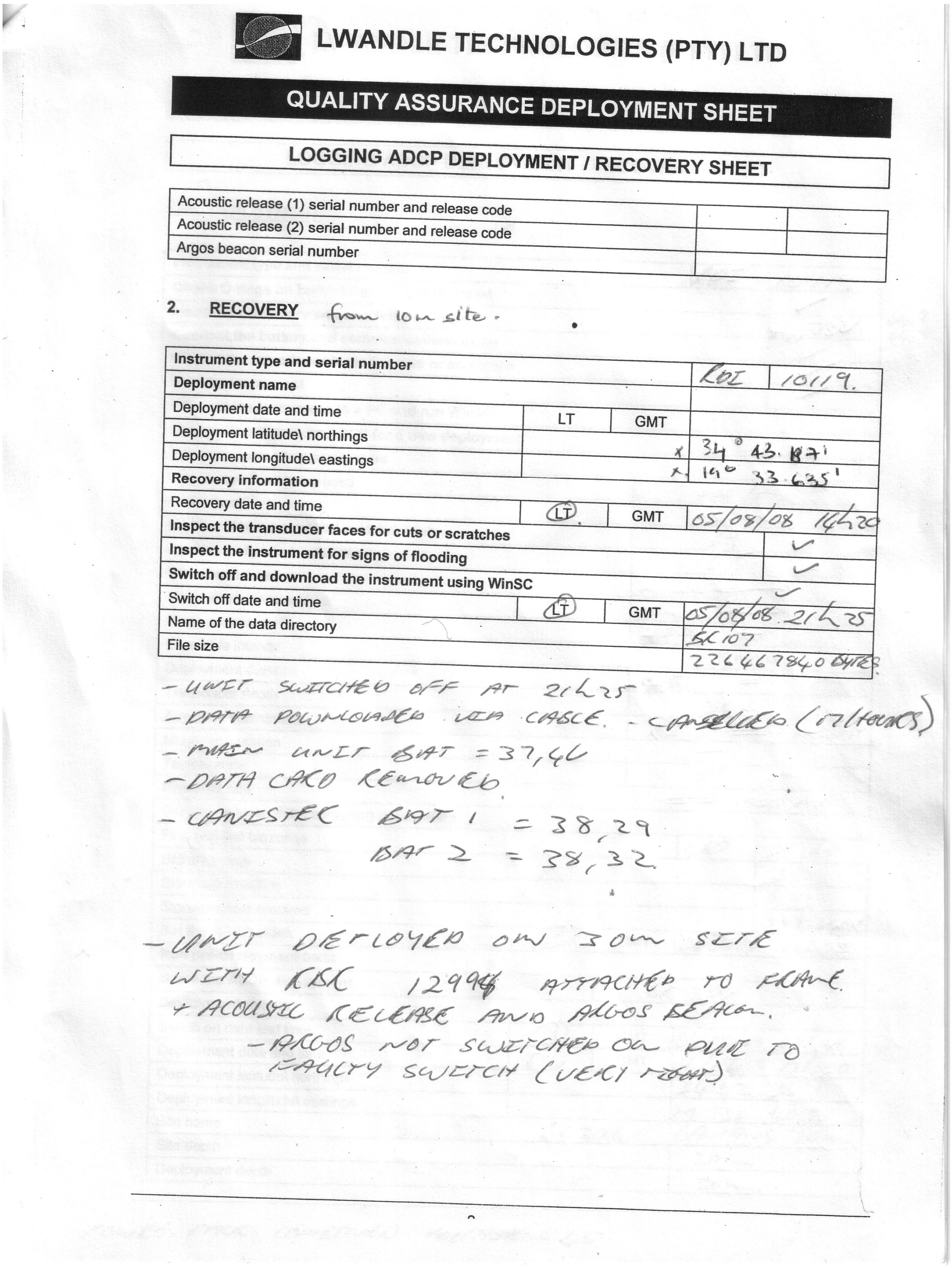
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. DEPLOYMENT

Instrument type and serial number		RDI	10119
Check O-rings on both sides of the instrument			REPLACED
Install a new battery and check the voltage			44,7V
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600		
Depth range	FIRST 1,41 LAST 15,76 MAX 35,28.		
Number of bins (calculated automatically)	42		
Bin Size (calculated automatically)	0,35		
Wave burst duration	41 ~~50 minutes~~		
Time between wave bursts	60 minutes		
Pings per ensemble	500 ~~200~~		
Ensemble interval	10 minutes		
Deployment duration	45 ~~41~~		
Transducer depth	10 m.		
Any other commands	— None		
Magnetic variation	—		
Temperature	5°		
Recorder size	~~448mb~~ 975 mb.		
Consequences of the sampling parameters			
First and last bin range		1,41	15,76
Battery usage			2,9
Standard deviation			1,08
Storage space required			401,49
Set the ADCP clock	[✓ LT]	GMT	06h53
Run pre-deployment tests			
Name the ADCP deployment		BK 107	
Deployment details			
Switch on date and time	[✓ LT]	GMT	13/07/08 06h59
Deployment date and time	[✓ LT]	GMT	13/07/08 10h57
Deployment latitude\ northings			34 43 187
Deployment longitude\ eastings			19 33 635
Site name			BANTAMS
Site depth			10m
Deployment depth			10m.

1 ADCP deployment sheet



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		

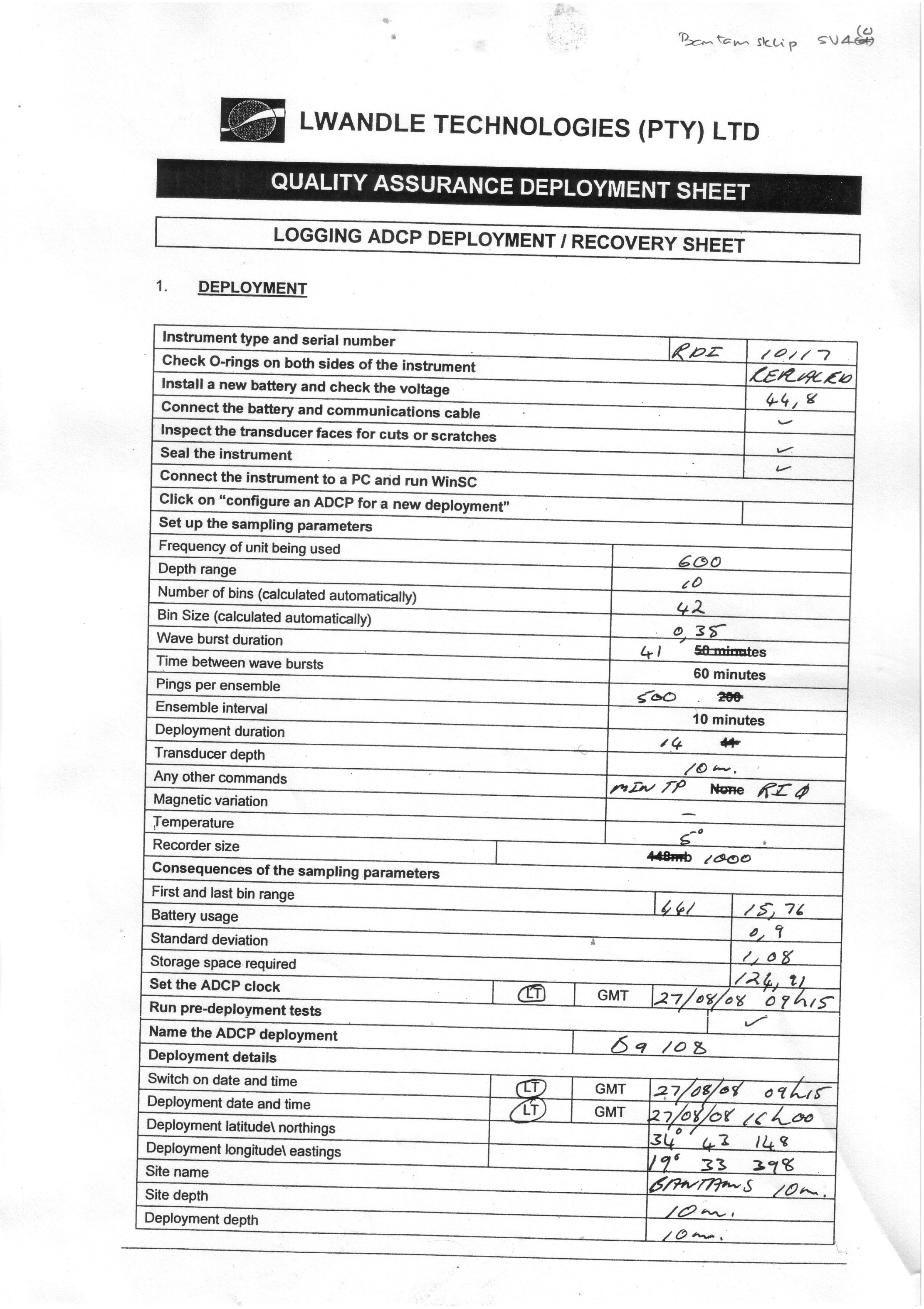
2. RECOVERY

from 10m site.

Instrument type and serial number			RDI 10119.
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings		x	34° 43.187'
Deployment longitude\ eastings		x	19° 33.635'
Recovery information			
Recovery date and time	[✓ LT].	GMT	05/08/08 14h20
Inspect the transducer faces for cuts or scratches			✓
Inspect the instrument for signs of flooding			✓
Switch off and download the instrument using WinSC			✓
Switch off date and time	[✓ LT]	GMT	05/08/08. 21h25
Name of the data directory			SC107
File size			226467840 BYTES.

- UNIT SWITCHED OFF AT 21h25
- DATA DOWNLOADED VIA CABLE. - CANCELLED ([illegible] HOURS)
- MAIN UNIT BAT = 37,46
- DATA CARD REMOVED.
- CANISTER BAT 1 = 38,29
  BAT 2 = 38,32.

- UNIT DEPLOYED ON 30m SITE WITH RBR 12994 ATTACHED TO FRAME. + ACOUSTIC RELEASE AND ARGOS BEACON.
  - ARGOS NOT SWITCHED ON DUE TO FAULTY SWITCH (VERY [illegible])



Bantam sklip SV4 ~~(E)~~ (W)

LWANDLE TECHNOLOGIES (PTY) LTD

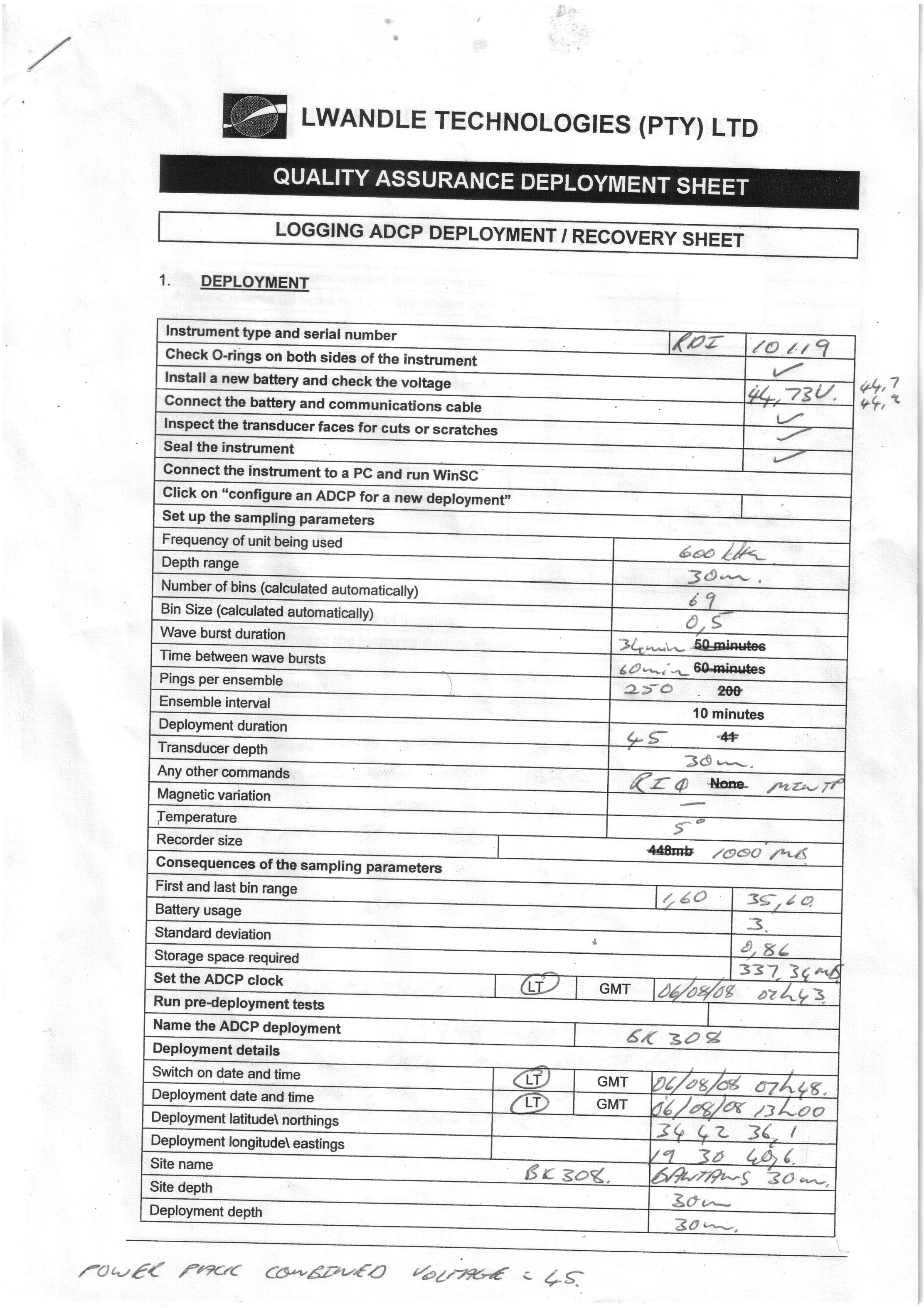
QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. **DEPLOYMENT**

Instrument type and serial number		RDI	10117
Check O-rings on both sides of the instrument			REPLACED
Install a new battery and check the voltage			44,8
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600		
Depth range	10		
Number of bins (calculated automatically)	42		
Bin Size (calculated automatically)	0,38		
Wave burst duration	41 ~~50 minutes~~		
Time between wave bursts	60 minutes		
Pings per ensemble	500 ~~200~~		
Ensemble interval	10 minutes		
Deployment duration	14 ~~44~~		
Transducer depth	10m.		
Any other commands	MIN TP ~~None~~ RI Ø		
Magnetic variation	—		
Temperature	5°		
Recorder size	~~448mb~~ 1000		
Consequences of the sampling parameters			
First and last bin range		1,41	15,76
Battery usage			0,9
Standard deviation			1,08
Storage space required			124,91
Set the ADCP clock	[✓ LT]	GMT	27/08/08 09h15
Run pre-deployment tests			✓
Name the ADCP deployment	69 108		
Deployment details			
Switch on date and time	[✓ LT]	GMT	27/08/08 09h15
Deployment date and time	[✓ LT]	GMT	27/08/08 16h00
Deployment latitude\ northings			34° 43 148
Deployment longitude\ eastings			19° 33 398
Site name			BANTAMS 10m.
Site depth			10m.
Deployment depth			10m.

30m ADCP.



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

LOGGING ADCP DEPLOYMENT / RECOVERY SHEET

1. **DEPLOYMENT**

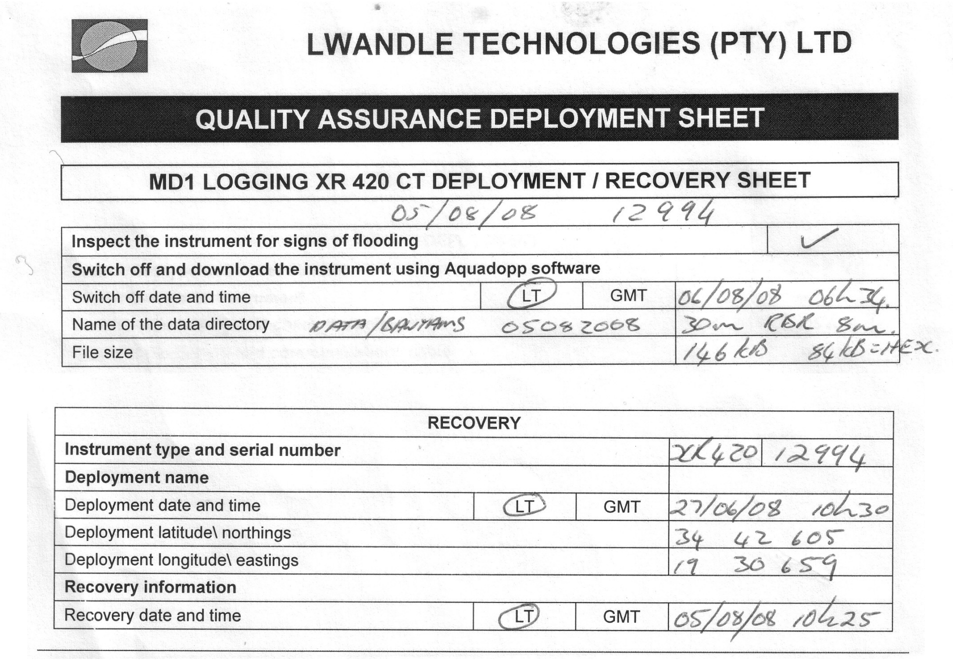
Instrument type and serial number		RDI	10.119
Check O-rings on both sides of the instrument			✓
Install a new battery and check the voltage			44,73V.
Connect the battery and communications cable			✓
Inspect the transducer faces for cuts or scratches			✓
Seal the instrument			✓
Connect the instrument to a PC and run WinSC			
Click on "configure an ADCP for a new deployment"			
Set up the sampling parameters			
Frequency of unit being used	600 kHz		
Depth range	30m.		
Number of bins (calculated automatically)	69		
Bin Size (calculated automatically)	0,5		
Wave burst duration	34min ~~50 minutes~~		
Time between wave bursts	60min ~~60 minutes~~		
Pings per ensemble	250 ~~200~~		
Ensemble interval	10 minutes		
Deployment duration	45 ~~41~~		
Transducer depth	30m.		
Any other commands	RIΦ ~~None~~ MINTP		
Magnetic variation	—		
Temperature	5°		
Recorder size	~~448mb~~ 1000 MB		
Consequences of the sampling parameters			
First and last bin range		1,60	35,60
Battery usage			3.
Standard deviation			0,86
Storage space required			337,34MB
Set the ADCP clock	[✓ LT]	GMT	06/08/08 07h43.
Run pre-deployment tests			
Name the ADCP deployment	BK 308		
Deployment details			
Switch on date and time	[✓ LT]	GMT	06/08/08 07h48.
Deployment date and time	[✓ LT]	GMT	06/08/08 13h00
Deployment latitude\ northings			34 42 36,1
Deployment longitude\ eastings			19 30 40,6.
Site name	BK308.		BANTAMS 30m.
Site depth			30m
Deployment depth			30m.

44,7
44,?

POWER PACK COMBINED VOLTAGE = 45.

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

05/08/08 12994

Inspect the instrument for signs of flooding			✓
Switch off and download the instrument using Aquadopp software			
Switch off date and time	[✓ LT]	GMT	06/08/08 06h34.
Name of the data directory	DATA/BANTAMS	05082008	30m RBR 8m.
File size			146kB 84kB=HEX.

RECOVERY			
Instrument type and serial number		XR420	12994
Deployment name			
Deployment date and time	[✓ LT]	GMT	27/06/08 10h30
Deployment latitude\ northings			34 42 605
Deployment longitude\ eastings			19 30 659
Recovery information			
Recovery date and time	[✓ LT]	GMT	05/08/08 10h25

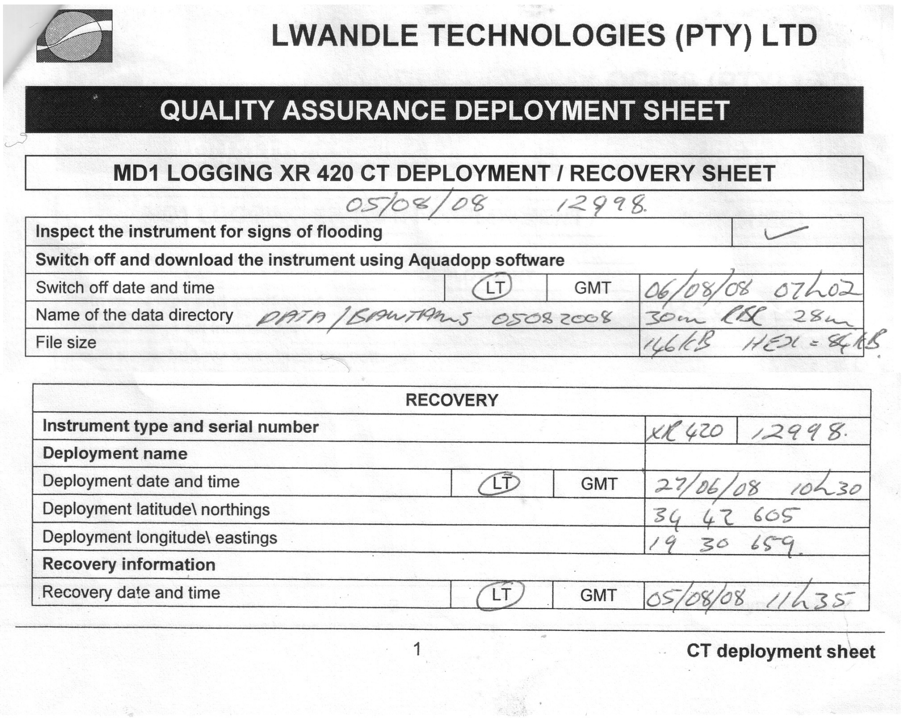
LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		XR420	12994
Check O-rings on instrument			✓
Install a new battery and check the voltage		✓	3,056 × 4.
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			✓
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		06/08/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 SEC
Averaging period			1 SEC
Deployment details			
Deployment date and time	[✓ LT]	06/08/08	13h30.
Deployment latitude\ northings			34 42 605
Deployment longitude\ eastings			19 30 659
Site name			BANTAMS 30m
Site depth			30m.
Deployment depth			± 8m.
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			

Bottom.



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

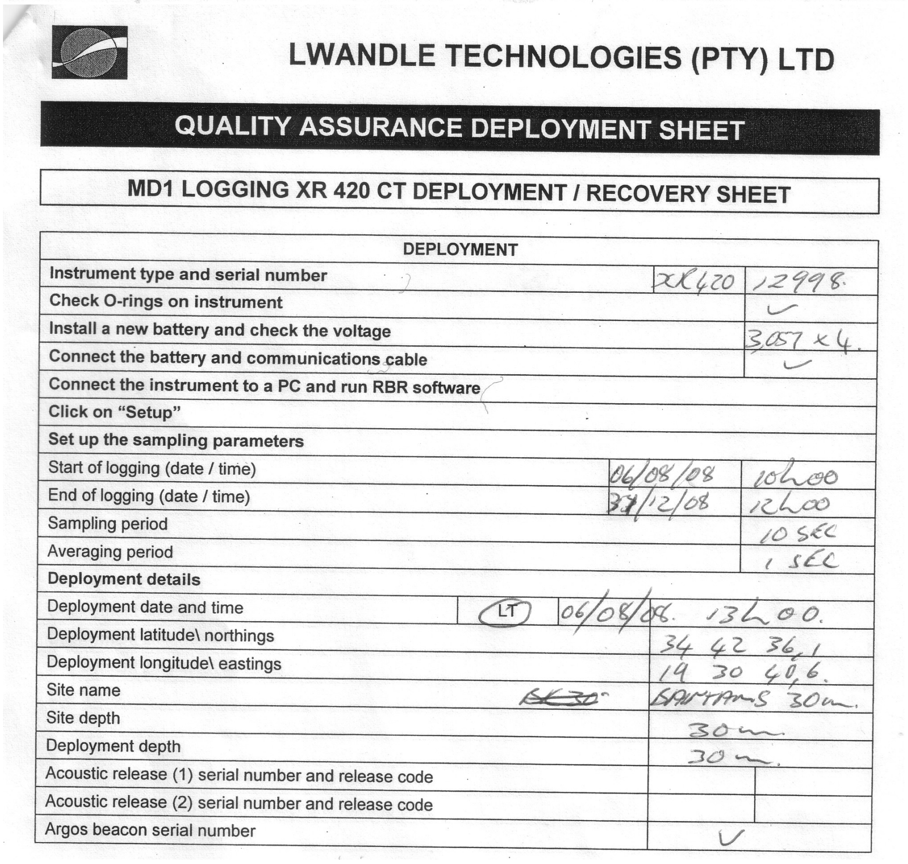
MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

05/08/08 12998.

Inspect the instrument for signs of flooding			✓
Switch off and download the instrument using Aquadopp software			
Switch off date and time	[✓ LT]	GMT	06/08/08 07h02
Name of the data directory	DATA/BANTAMS 05082008		30m RBR 28m
File size			146kB HEX = 84kB.

RECOVERY				
Instrument type and serial number			XR 420	12998.
Deployment name				
Deployment date and time	[✓ LT]	GMT	27/06/08 10h30	
Deployment latitude\ northings			34 42 605	
Deployment longitude\ eastings			19 30 659.	
Recovery information				
Recovery date and time	[✓ LT]	GMT	05/08/08 11h35	

1 CT deployment sheet



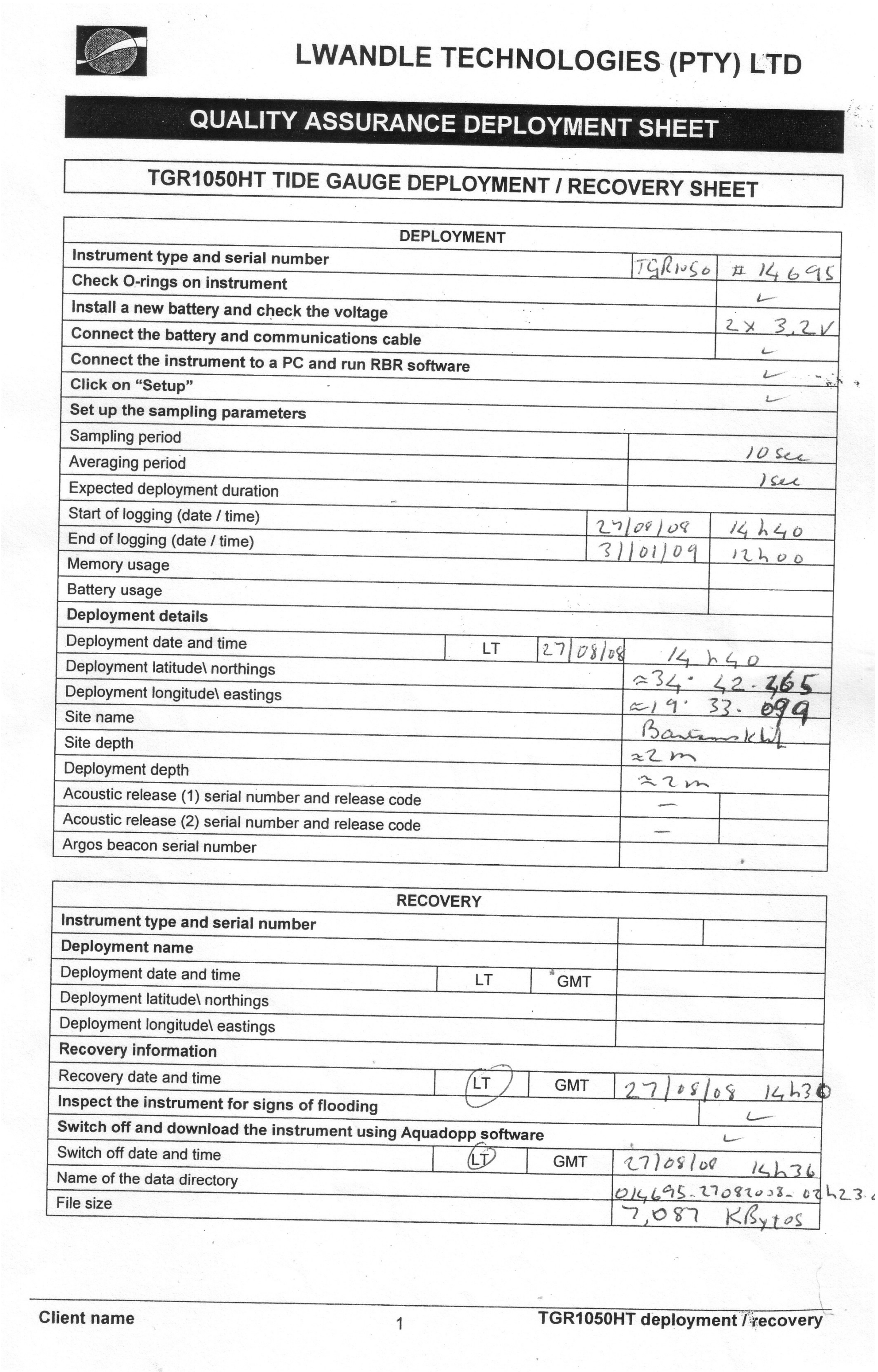
LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

MD1 LOGGING XR 420 CT DEPLOYMENT / RECOVERY SHEET

DEPLOYMENT			
Instrument type and serial number		XR420	12998.
Check O-rings on instrument			✓
Install a new battery and check the voltage			3,057 × 4.
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			
Click on "Setup"			
Set up the sampling parameters			
Start of logging (date / time)		06/08/08	10h00
End of logging (date / time)		31/12/08	12h00
Sampling period			10 SEC
Averaging period			1 SEC
Deployment details			
Deployment date and time	[✓ LT]	06/08/08.	13h00.
Deployment latitude\ northings		34 42 36,1	
Deployment longitude\ eastings		19 30 40,6.	
Site name	~~BK30~~	BANTAMS 30m.	
Site depth		30m.	
Deployment depth		30m.	
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number		✓	

7.3 TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS



LWANDLE TECHNOLOGIES (PTY) LTD

QUALITY ASSURANCE DEPLOYMENT SHEET

TGR1050HT TIDE GAUGE DEPLOYMENT / RECOVERY SHEET

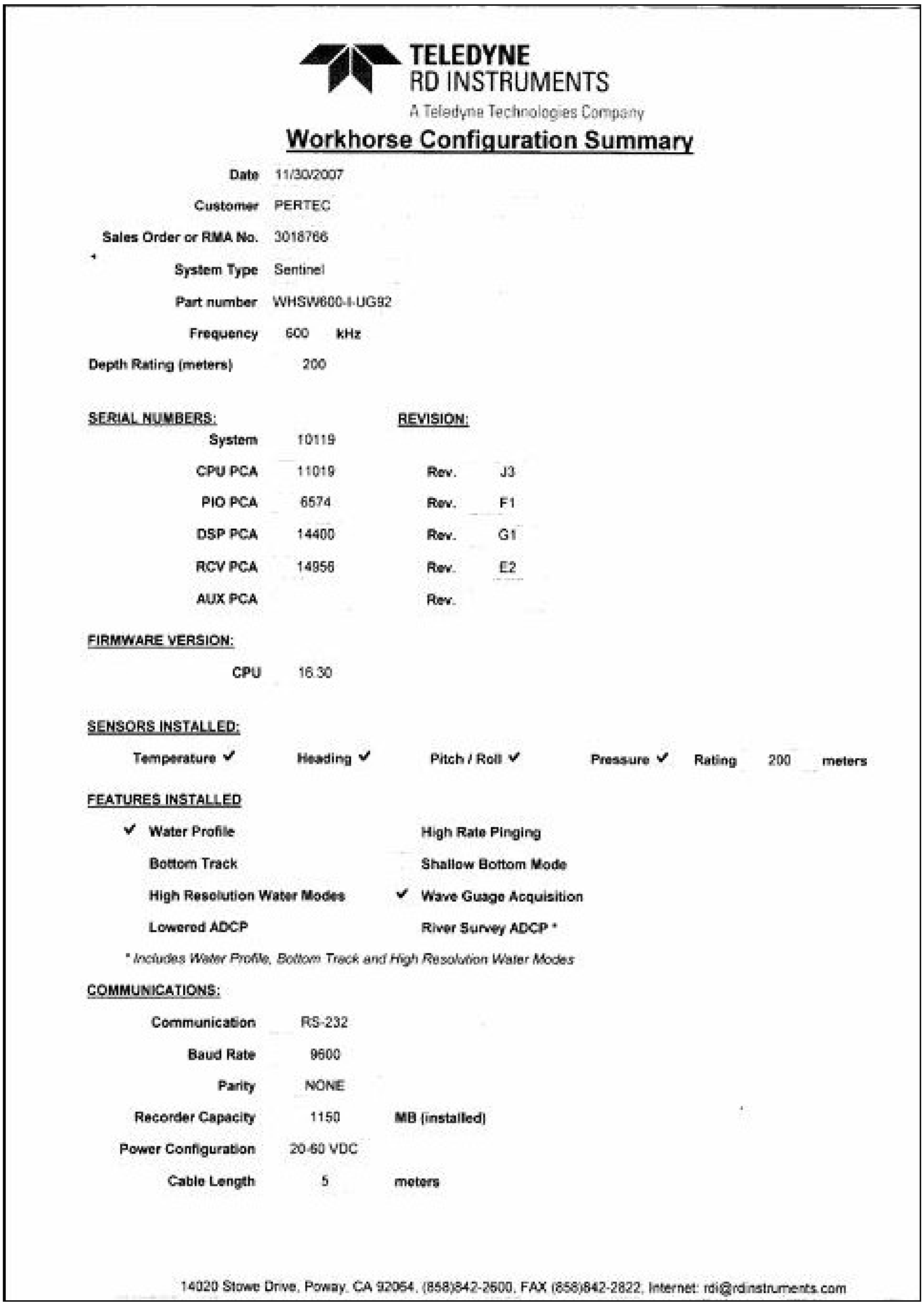
DEPLOYMENT			
Instrument type and serial number		TGR1050	# 14695
Check O-rings on instrument			✓
Install a new battery and check the voltage			2x 3,2V
Connect the battery and communications cable			✓
Connect the instrument to a PC and run RBR software			✓
Click on "Setup"			✓
Set up the sampling parameters			
Sampling period			10 sec
Averaging period			1 sec
Expected deployment duration			
Start of logging (date / time)		27/08/08	14h40
End of logging (date / time)		31/01/09	12h00
Memory usage			
Battery usage			
Deployment details			
Deployment date and time	LT	27/08/08	14h40
Deployment latitude\ northings		≈34° 42.265	
Deployment longitude\ eastings		≈19° 33.099	
Site name		Bantamsklip	
Site depth		≈2 m	
Deployment depth		≈2 m	
Acoustic release (1) serial number and release code		–	
Acoustic release (2) serial number and release code		–	
Argos beacon serial number			

RECOVERY			
Instrument type and serial number			
Deployment name			
Deployment date and time	LT	GMT	
Deployment latitude\ northings			
Deployment longitude\ eastings			
Recovery information			
Recovery date and time	[✓ LT]	GMT	27/08/08 14h30
Inspect the instrument for signs of flooding			✓
Switch off and download the instrument using Aquadopp software			✓
Switch off date and time	[✓ LT]	GMT	27/08/08 14h36
Name of the data directory			014695-27082008-02h23.
File size			7,087 KBytes

Client name 1 **TGR1050HT deployment / recovery**

* Instrument type should read "TGR2050" instead of "TGR1050".

7.4 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018766
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 **kHz**
Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10119		
CPU PCA	11019	**Rev.**	J3
PIO PCA	6574	**Rev.**	F1
DSP PCA	14400	**Rev.**	G1
RCV PCA	14956	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

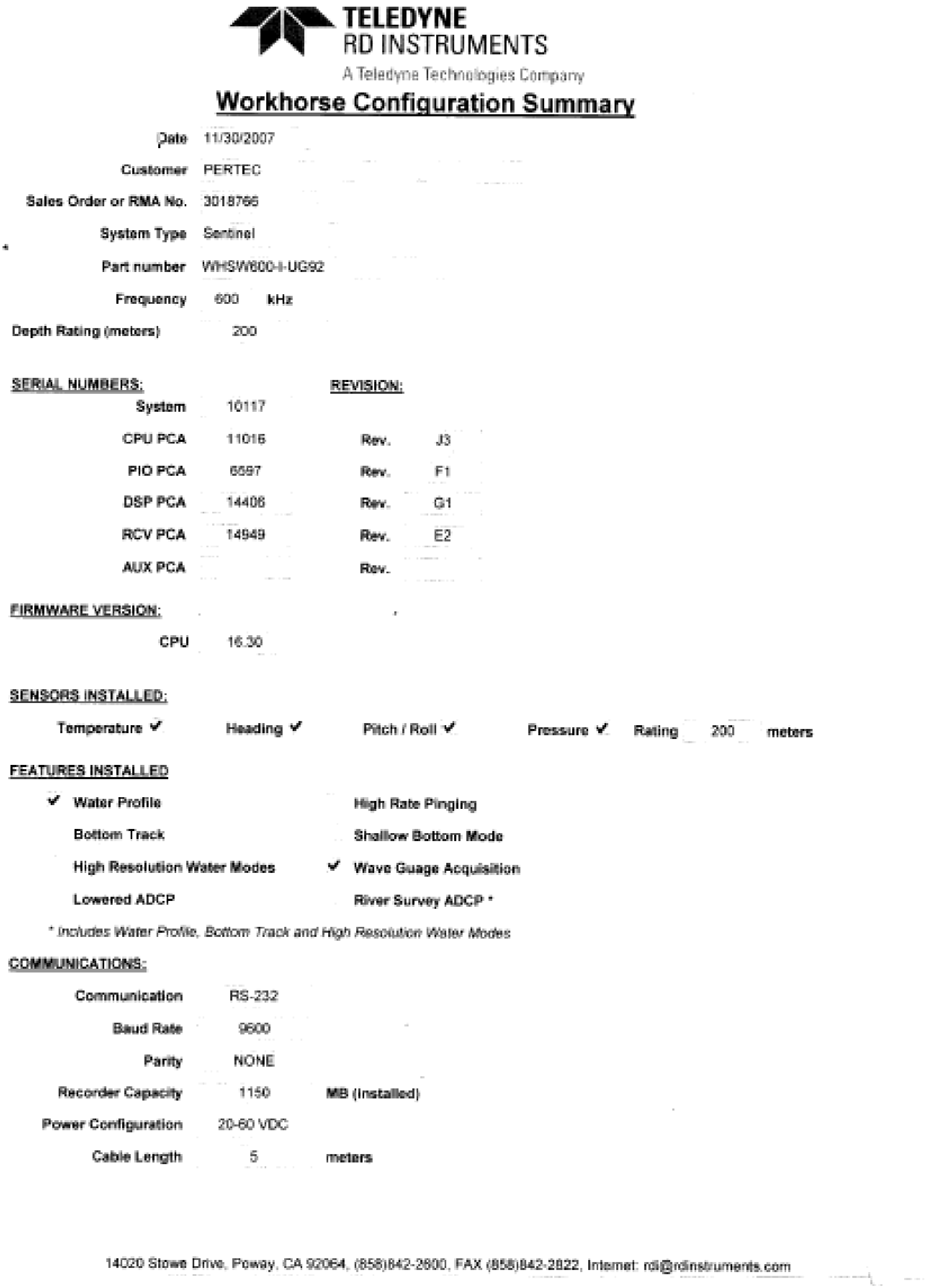
✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007

Customer PERTEC

Sales Order or RMA No. 3018766

System Type Sentinel

Part number WHSW600-I-UG92

Frequency 600 **kHz**

Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10117		
CPU PCA	11016	**Rev.**	J3
PIO PCA	6597	**Rev.**	F1
DSP PCA	14406	**Rev.**	G1
RCV PCA	14949	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

✓ **Water Profile**
Bottom Track
High Resolution Water Modes
Lowered ADCP
High Rate Pinging
Shallow Bottom Mode
✓ **Wave Guage Acquisition**
River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232

Baud Rate 9600

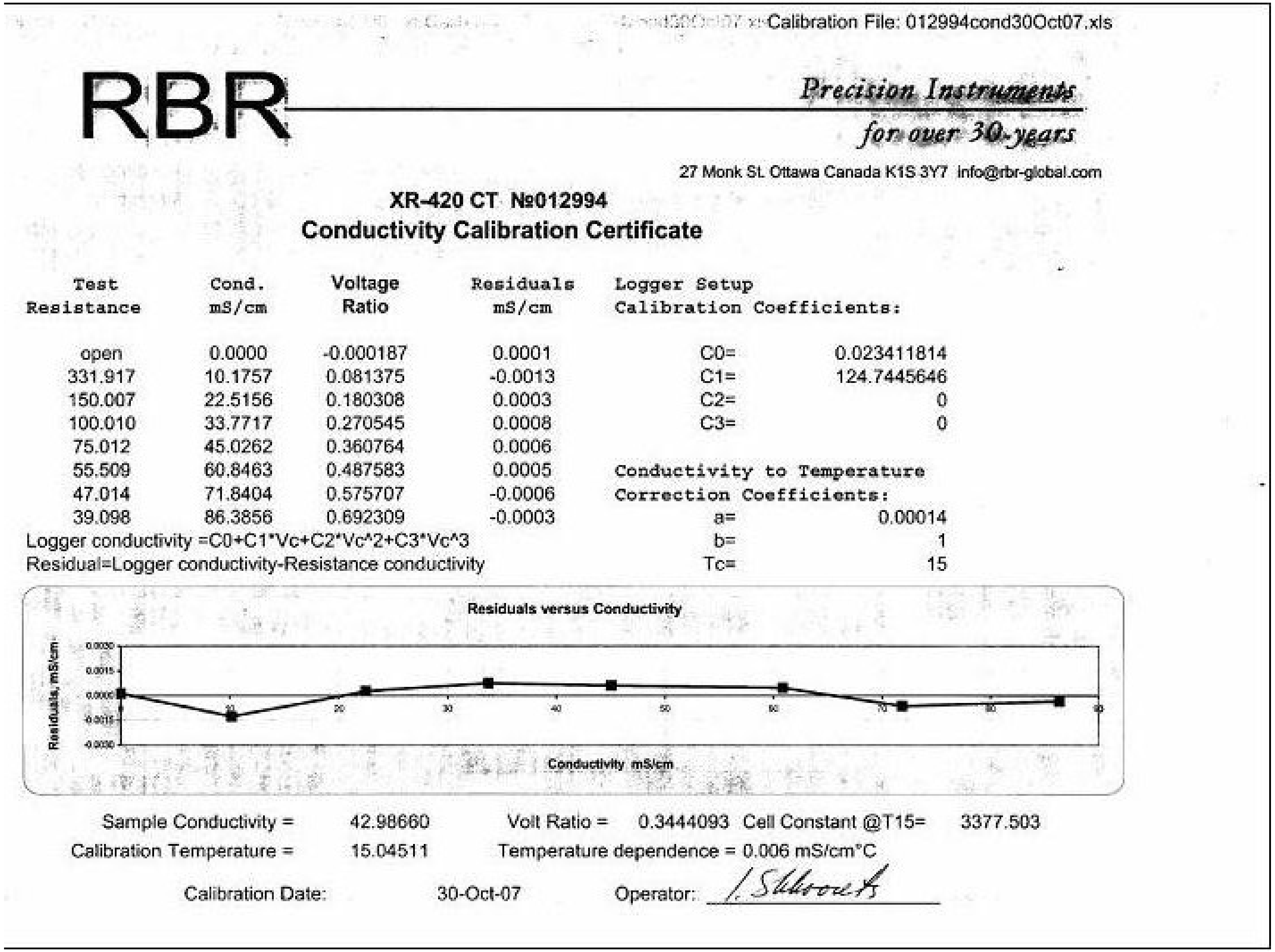
Parity NONE

Recorder Capacity 1150 **MB (installed)**

Power Configuration 20-60 VDC

Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

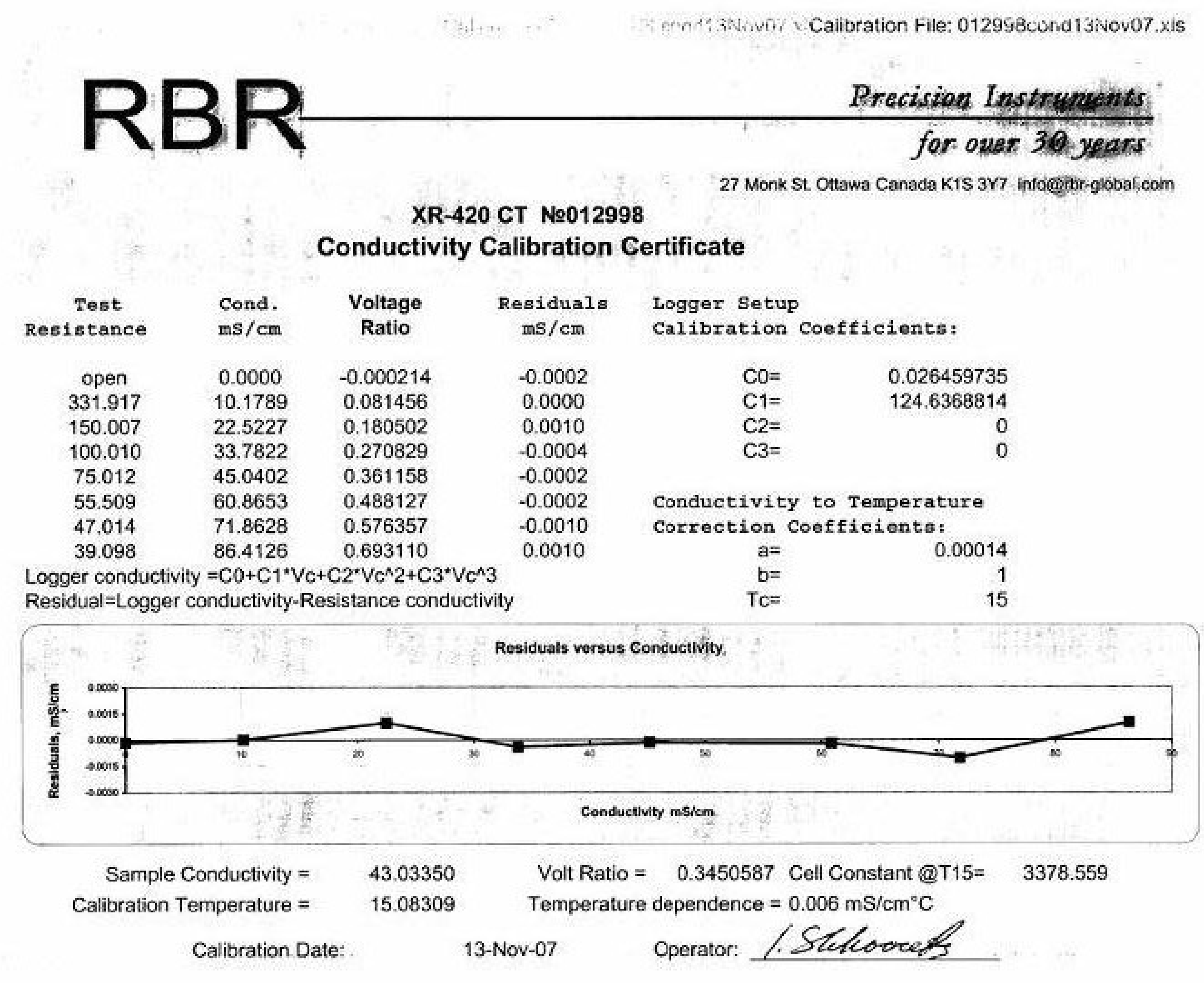
Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 42.98660 Volt Ratio = 0.3444093 Cell Constant @T15= 3377.503

Calibration Temperature = 15.04511 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07 Operator: / Shroots



Calibration File: 012998cond13Nov07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012998
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000214	-0.0002
331.917	10.1789	0.081456	0.0000
150.007	22.5227	0.180502	0.0010
100.010	33.7822	0.270829	-0.0004
75.012	45.0402	0.361158	-0.0002
55.509	60.8653	0.488127	-0.0002
47.014	71.8628	0.576357	-0.0010
39.098	86.4126	0.693110	0.0010

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

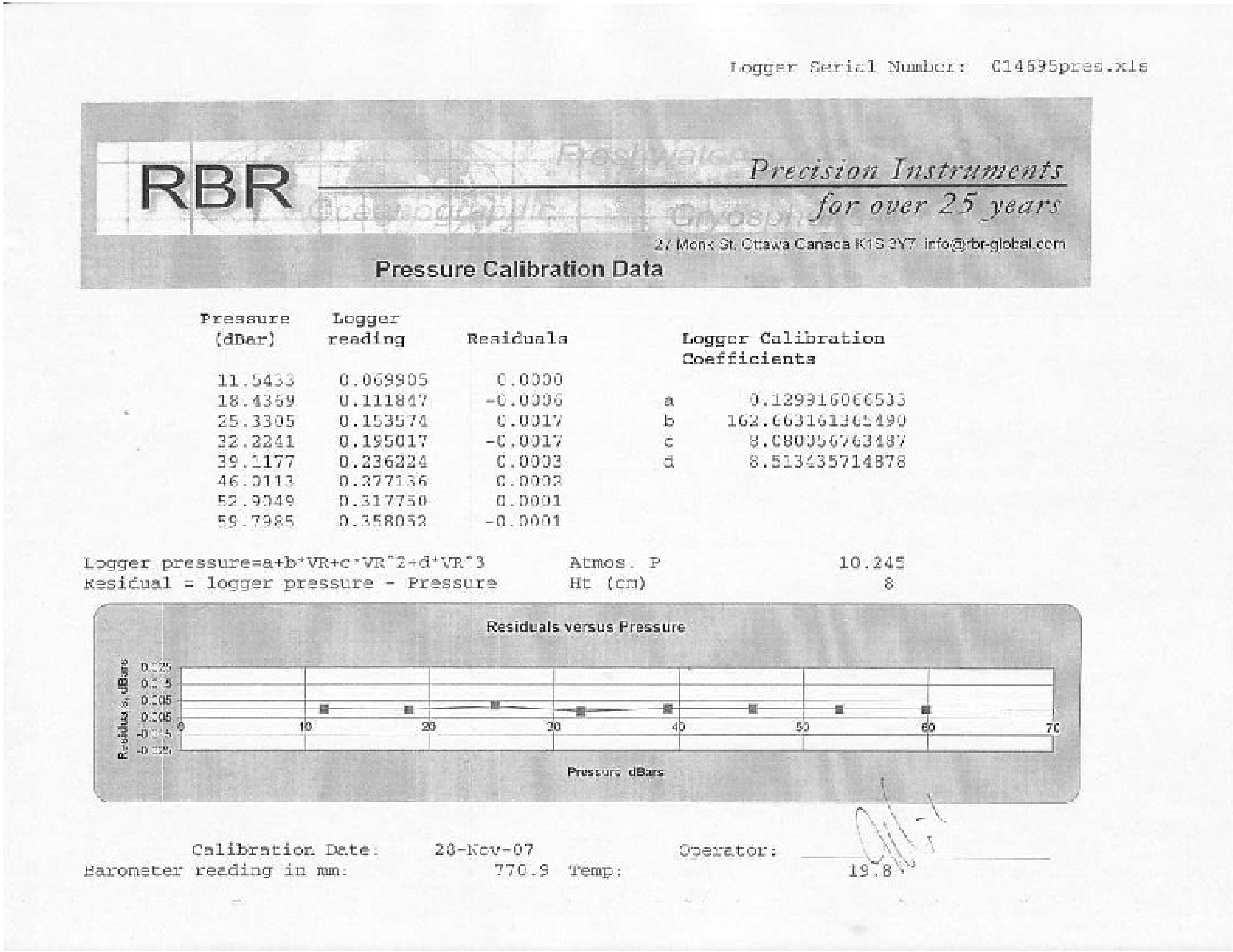
C0= 0.026459735
C1= 124.6368814
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 43.03350 Volt Ratio = 0.3450587 Cell Constant @T15= 3378.559
Calibration Temperature = 15.08309 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 13-Nov-07 Operator:



Logger Serial Number: 014595pres.xls

RBR

Precision Instruments for over 25 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

Pressure Calibration Data

Pressure (dBar)	Logger reading	Residuals
11.5433	0.069905	0.0000
18.4359	0.111847	-0.0006
25.3305	0.153574	0.0017
32.2241	0.195017	-0.0017
39.1177	0.236224	0.0003
46.0113	0.277136	0.0002
52.9049	0.317750	0.0001
59.7985	0.358052	-0.0001

Logger Calibration Coefficients

a	0.129916066533
b	162.663161365490
c	8.080056763487
d	8.513435714878

Logger pressure=a+b*VR+c*VR^2+d*VR^3

Residual = logger pressure - Pressure

Atmos. P 10.245

Ht (cm) 8

Residuals versus Pressure

Calibration Date: 28-Nov-07

Barometer reading in mm: 770.9 Temp: 19.8

Operator:

8. PHOTOS TAKEN

(a)

(b)

(c)

(d)

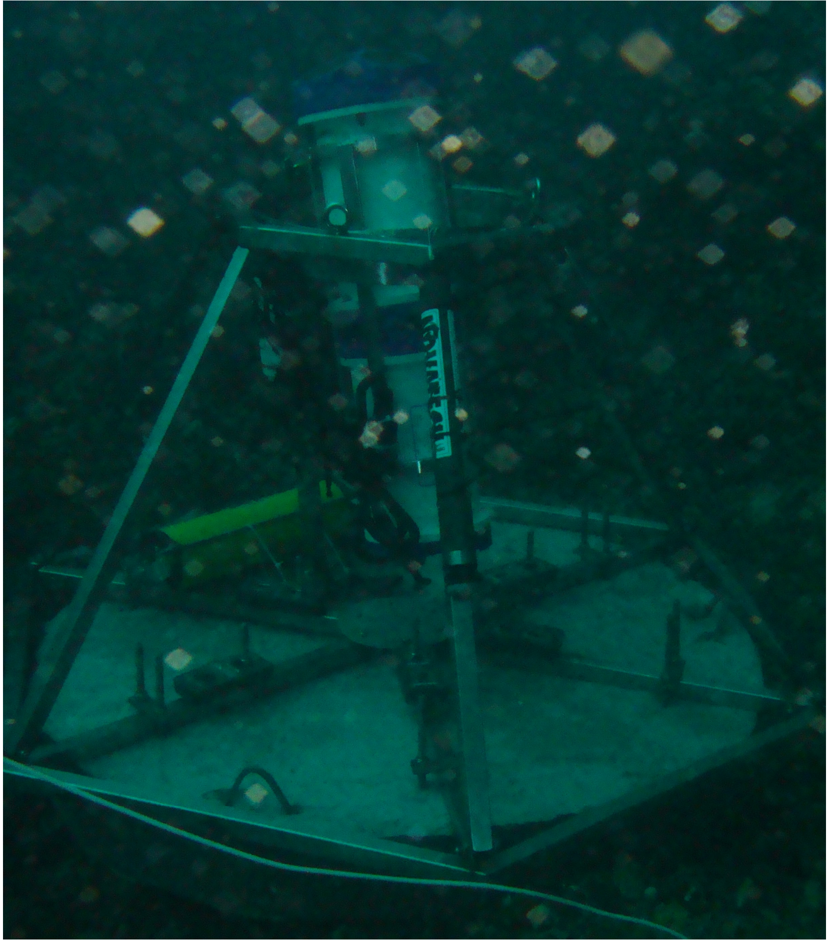


Figure 22: Photos taken during SV 4b. (a,b) Damage done to the internal battery pack of the 30m ADCP due ostensibly due to a minor leak. The instrument was withdrawn. (c) Preparation of the new setup comprising of the ADCP frame and the concrete plinth. (d) Instrument deployed.

9. REPORTS FROM THE CSIR

The reports from the CSIR are attached as an appendage.

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2766

Report Number: MALR2766

24 July 2008

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Craig Matthysen

CHEMICAL ANALYSIS: Water samples (Order No.:)
Samples received: 22/07/08
Analysis completed: 24/07/08
Sample description: Seawater in sealed plastic bottles.

Lab No	Sample Id	Sample Date	Total Suspended Solids in mg/L	EC in S/m	Salinity PSU
37074	**Bantams S1**	**12/07/08**	*<2*	*4.1*	*34.1*
37075	**Bantams S2**	**12/07/08**	*2*	*4.1*	*34.2*
37076	**Bantams S3**	**12/07/08**	*<2*	*4.1*	*34.2*
37077	**Bantams S4**	**12/07/08**	*<2*	*4.1*	*34.5*
37078	**Bantams S5**	**12/07/08**	*<2*	*4.1*	*34.5*
37079	**Bantams S6**	**12/07/08**	*6*	*4.1*	*34.4*
37080	**Bantams S7**	**12/07/08**	*3*	*4.1*	*34.4*
37081	**Bantams S8**	**12/07/08**	*<2*	*4.1*	*34.5*
37082	**Bantams S9**	**12/07/08**	*<2*	*4.1*	*34.5*
37083	**Bantams S10**	**12/07/08**	*5*	*4.1*	*34.5*
37084	**Bantams S11**	**12/07/08**	*<2*	*4.1*	*34.4*

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2784
Report Number: MALR2784
23 August 2008

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Craig Matthysen

CHEMICAL ANALYSIS: Seawater samples (Order No.:)
Samples received: 08/08/08
Analysis completed: 20/08/08
Sample description: Seawater in sealed plastic bottles.

Lab	Sample	*Total Suspended
No	Id	Solids in mg/L
34233	S1	*2*
34234	S2	*10*
34235	S3	*3*
34236	S4	*<2*
34237	S5	*<2*
34238	S6	*<2*
34239	S7	*<2*
34240	S8	*2*
34241	S9	*<2*
34242	S10	*2*
34243	S11	*3*
34244	S12	*2*
34245	S13	*<2*

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT FIVE

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

9 February 2009

Job No: LT-JOB-50

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 5 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-10.1	99.17	0.5480	0.0779	0.0790	0.0618	123.92
-9.7	99.26	0.5783	0.0805	0.0822	0.0628	121.68
-9.4	99.26	0.5833	0.0838	0.0843	0.0649	118.88
-9.0	99.17	0.6307	0.0871	0.0855	0.0674	117.20
-8.7	99.12	0.6538	0.0903	0.0858	0.0701	114.83
-8.3	98.99	0.6027	0.0917	0.0869	0.0715	113.48
-8.0	99.21	0.6033	0.0953	0.0883	0.0741	113.61
-7.6	99.34	0.6397	0.0990	0.0892	0.0770	110.93
-7.3	99.43	0.6083	0.1030	0.0916	0.0803	110.67
-6.9	99.26	0.6253	0.1042	0.0904	0.0821	109.68
-6.6	99.30	0.6670	0.1072	0.0920	0.0841	108.71
-6.2	99.21	0.6391	0.1082	0.0921	0.0845	107.55
-5.9	99.30	0.6061	0.1099	0.0929	0.0858	107.19
-5.5	99.17	0.6105	0.1113	0.0921	0.0868	106.51
-5.2	99.30	0.6151	0.1141	0.0945	0.0885	106.02
-4.8	99.17	0.6290	0.1155	0.0956	0.0900	105.45
-4.5	99.08	0.6643	0.1174	0.0958	0.0909	104.79
-4.1	99.30	0.6607	0.1207	0.0972	0.0931	104.67
-3.8	98.90	0.6454	0.1218	0.0974	0.0940	103.41
-3.4	99.12	0.6614	0.1246	0.0976	0.0959	102.82
-3.1	98.95	0.6497	0.1270	0.0987	0.0973	101.72
-2.7	99.12	0.6750	0.1295	0.0991	0.0996	100.24
-2.4	99.12	0.6522	0.1323	0.1003	0.1017	98.42
-2.0	98.99	0.7338	0.1355	0.0998	0.1042	96.29
-1.7	99.12	0.7206	0.1410	0.1011	0.1102	93.31
-1.3	98.95	0.7316	0.1473	0.0985	0.1166	88.83
-1.0	99.12	0.7212	0.1564	0.0986	0.1257	86.37

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	97.42	5.91	0.66	2.01	1.14
Tp (s)	97.42	9.50	2.00	7.85	2.33
Dp (^{o})	97.42	355.58	92.58	182.42	30.48

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-27.7	14.35	0.2029	0.0361	0.0246	0.0069	248.76
-27.2	14.31	0.2173	0.0375	0.0271	0.0045	248.79
-26.7	14.35	0.2037	0.0395	0.0282	0.0022	258.27
-26.2	14.35	0.2146	0.0412	0.0295	0.0012	248.38
-25.7	14.35	0.2348	0.0435	0.0316	0.0029	180.51
-25.2	14.38	0.3475	0.0462	0.0359	0.0028	177.23
-24.7	14.38	0.3563	0.0490	0.0377	0.0053	185.34
-24.2	14.35	0.2721	0.0494	0.0339	0.0077	199.54
-23.7	14.38	0.3679	0.0520	0.0374	0.0092	197.84
-23.2	14.35	0.2985	0.0522	0.0344	0.0121	196.27
-22.7	14.35	0.2927	0.0529	0.0334	0.0147	196.80
-22.2	14.35	0.2765	0.0539	0.0322	0.0160	194.07
-21.7	14.35	0.2945	0.0543	0.0315	0.0177	194.59
-21.2	14.35	0.2594	0.0542	0.0299	0.0187	194.53
-20.7	14.35	0.2352	0.0545	0.0280	0.0207	197.39
-20.2	14.35	0.2336	0.0542	0.0278	0.0213	198.16
-19.7	14.35	0.2124	0.0545	0.0268	0.0237	198.44
-19.2	14.35	0.2172	0.0542	0.0264	0.0245	195.52
-18.7	14.35	0.2136	0.0538	0.0275	0.0254	193.68
-18.2	14.35	0.1744	0.0549	0.0270	0.0276	192.32
-17.7	14.35	0.1632	0.0554	0.0277	0.0285	193.42
-17.2	14.35	0.2353	0.0559	0.0290	0.0286	192.95
-16.7	14.35	0.2311	0.0568	0.0292	0.0301	191.78
-16.2	14.35	0.1929	0.0564	0.0300	0.0311	190.54
-15.7	14.38	0.2464	0.0580	0.0315	0.0315	192.56
-15.2	14.38	0.2243	0.0589	0.0313	0.0314	191.70
-14.7	14.38	0.2307	0.0596	0.0318	0.0325	189.14
-14.2	14.38	0.2472	0.0595	0.0322	0.0328	190.50
-13.7	14.38	0.2581	0.0600	0.0326	0.0339	190.27
-13.2	14.38	0.2578	0.0625	0.0341	0.0358	189.93
-12.7	14.38	0.2534	0.0630	0.0353	0.0359	189.42
-12.2	14.38	0.2273	0.0638	0.0343	0.0368	188.41
-11.7	14.38	0.2338	0.0654	0.0363	0.0374	189.71
-11.2	14.38	0.1957	0.0666	0.0362	0.0389	189.87
-10.7	14.38	0.2021	0.0681	0.0363	0.0397	188.49
-10.2	14.35	0.1719	0.0682	0.0362	0.0401	188.14
-9.7	14.35	0.2126	0.0690	0.0382	0.0409	188.67
-9.2	14.35	0.2321	0.0697	0.0386	0.0404	188.64
-8.7	14.35	0.2610	0.0713	0.0389	0.0416	186.76
-8.2	14.35	0.2712	0.0728	0.0395	0.0419	186.94
-7.7	14.31	0.2544	0.0731	0.0410	0.0418	185.72
-7.2	14.31	0.2426	0.0739	0.0401	0.0429	184.45
-6.7	14.35	0.2484	0.0754	0.0399	0.0422	183.17

-6.2	14.31	0.2420	0.0777	0.0395	0.0433	180.00
-5.7	14.35	0.2342	0.0765	0.0401	0.0406	177.82
-5.2	14.31	0.2778	0.0741	0.0407	0.0363	171.80
-4.7	14.35	0.3300	0.0715	0.0405	0.0291	165.39
-4.2	14.38	0.3376	0.0725	0.0406	0.0229	126.34
-3.7	14.38	0.3237	0.0876	0.0453	0.0447	75.87
-3.2	14.38	0.3326	0.1200	0.0544	0.0821	70.87

Table 4 – Waves summary for 30m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	98.86	10.18	1.43	3.36	1.52
Tp (s)	98.36	19.50	7.30	13.31	2.35
Dp (^{o})	98.36	267.60	92.60	217.59	22.67

Table 5 – Water temperature and salinity summary (surface)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100.00	14.74	15.57	13.37
Conductivity	100.00	39.43	43.80	30.29
Salinity (psu)	53.28	35.08	35.38	34.00

1.1 DATA RETURN FOR BANTAMSKLIP SITE.

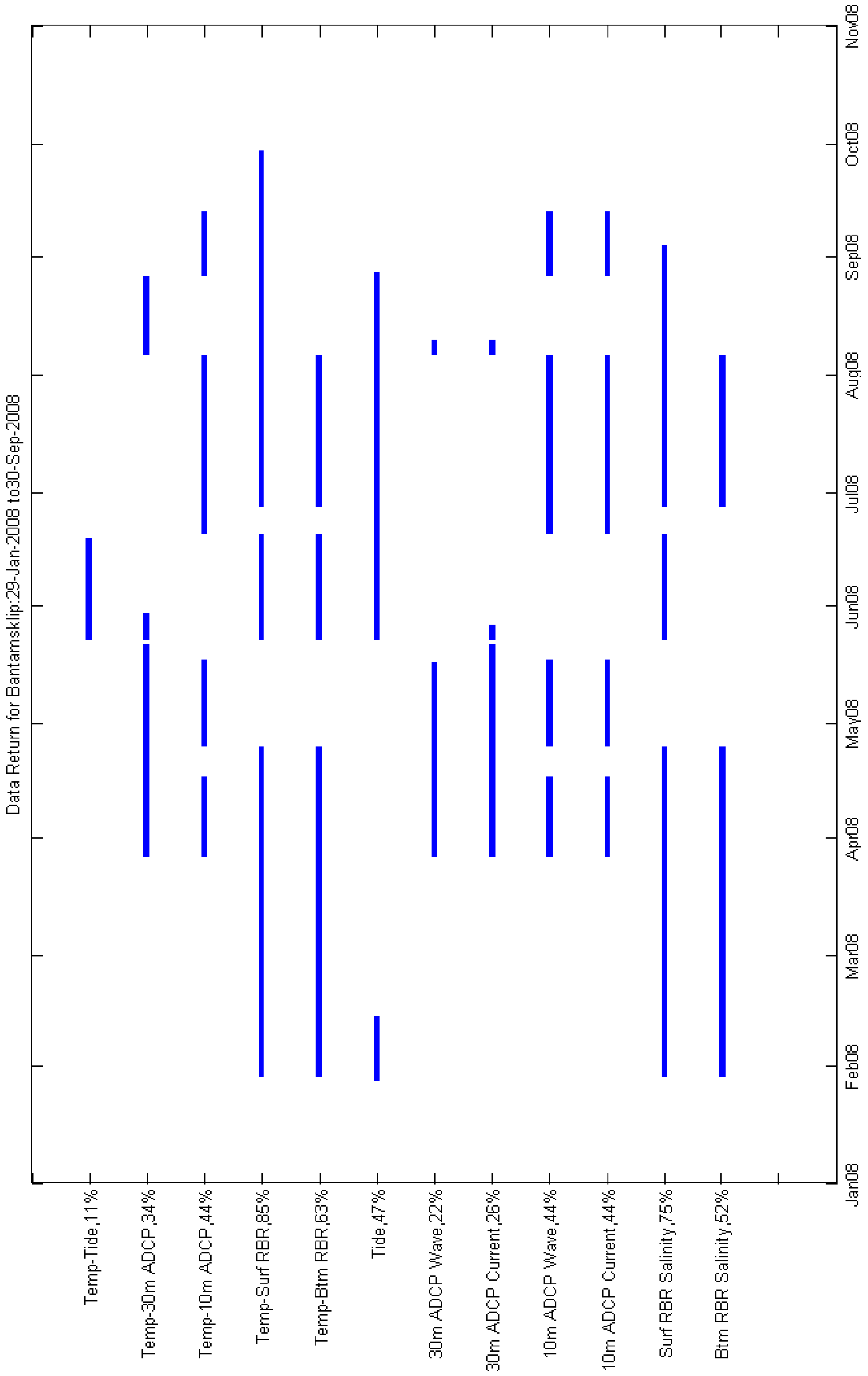


Figure 1: An indication of the data return at the Bantamsklip site since the beginning of the project.

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents currents, waves, temperature and salinity data collected at Bantamsklip station for the period August 27th 2008 – September 28th 2008 (Period 5). Three service visits were undertaken: 5a (September 27th), 5b (November 1st) and 5c (November 5th – 6th). Water samples were collected during service 5b.

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 6 for the Bantamsklip site.

Table 6 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The deployment location of the instruments is given in Table 7. Table 8 shows the locations where water samples were taken.

Table 7 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34°42.462’	19°33.080’
10m ADCP	34°43.105’	19°33.391’
Biofouling	34°43.190’	19°33.686’
30m ADCP	34°42.625’	19°30.635’
T&C mooring	34°42.625’	19°30.635’

Table 8 – Locations where water samples were taken during service visit 5b

STN #	Lat	Long	SAMPLES type (W,B,G)	Exact Time HH:MM:SS	COMMENTS (if RBR profile is taken etc..)
1	34°42.625'	34°42.625'	W	14.30	4m
2	34°42.625'	34°42.625'	W	14.32	12m
3	34°42.625'	34°42.625'	W	14.38	20m
4	34°42.625'	34°42.625'	W	14.41	28m
5	34°43.190'	19°33.611'	W	15.25	4m
6	34°43.161'	19°33.591'	W	15.32	4m
7	34°43.124'	19°33.584'	W	15.34	4m
8	34°43.097'	19°33.577'	W	15.37	4m
9	34°43.081'	19°33.541'	W	15.40	4m
10	34°43.148'	19°33.398'	W		4m

3. OPERATIONS

3.1 SUMMARY OF EVENTS

Service visit 5 was undertaken in three parts as outlined below.

Visit 5a September 27th:
Recovery of the 30m ADCP (s/n 10119) was undertaken. An attempt to locate the 10m ADCP (s/n 10117) was made – but failed. The RBR string was recovered and it was found that the bottom RBR (s/n 12998) was lost.

Visit 5b November 1st:
Deployment of the 30m ADCP (s/n 10841) and RBR TC String (s/n 12994 at 8m and s/n 15248 at 30m) was carried out. Water samples were collected. The engineers could not locate the tide gauge – it was lost.

Visit 5c November 5th – 6th:
Nov 5th: Deployment of a new unit at the 10m site (s/n 10105) at 34°43.148'S, 19°33.398'E was undertaken. Biofouling plates were installed.

Nov 6th: The 10m ADCP (s/n 10117) was recovered 400m away (34°43.105'S, 19°33.391'E).

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 53).

3.2.1 600kHz ADCP

Table 9 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10117
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Redeployment of the 10m ADCP was undertaken during service visit 5c - s/n 10105.

Table 10 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10119
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

ADCP s/n 10841 was redeployed at the 30m site – service visit 5b.

3.2.2 RBR XR420 CT LOGGER

Table 11 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (8m) and s/n 12998 (30m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

The bottom RBR logger was lost and was replaced with a new one (s/n 15248).

3.2.3 RBR TGR2050 HT TIDE GAUGE

Table 12 – Instrument configuration for the Tide Gauge

Parameter	Configuration
TGR 2050 HT	s/n 014695
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

The tide gauge was lost.

3.2.4 Biofouling Mooring

Table 13 – Instrument configuration for Biofouling Mooring Line.

Parameter	Configuration
Biofouling Plates	3 plates (20cmx20cm) at 3m and 3 plates (20cmx20cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed at depth of about 1.5m outside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

4.1.1 Current processing

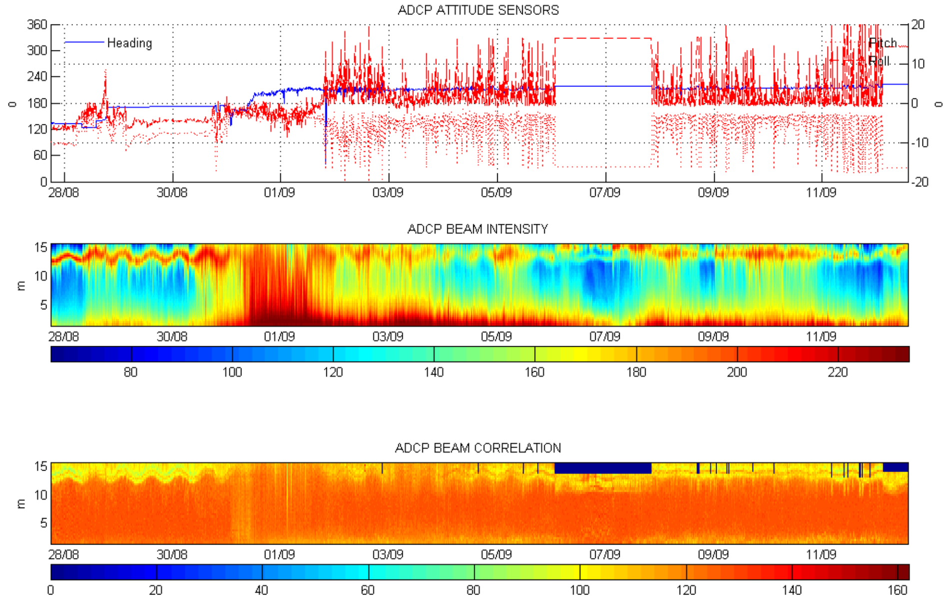
- The record was truncated to exclude times pre and post deployment.
- The pressure sensor on board the ADCP failed and depth was manually set to 11.5m.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 25’ W for the 10m ADCP and 25° 24’ W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 25’ W for the 10m ADCP and 25° 24’ W for the 30m ADCP.
- Wave data after August 9th 2008 was truncated for the 30m ADCP (viz. Figure 2b)
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

(a)



(b)

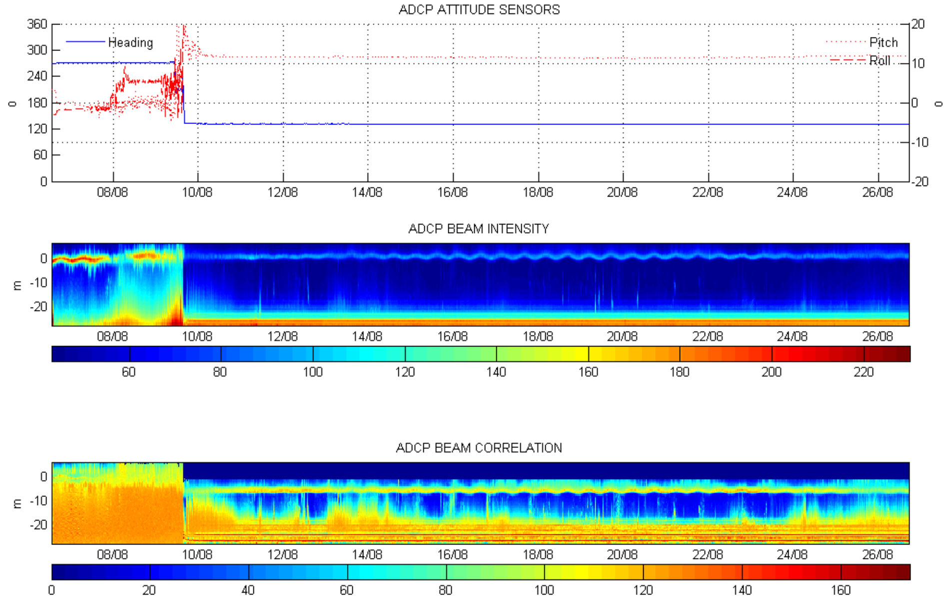


Figure 2: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Salinity values less than 34psu were flagged.

4.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

The tide gauge was lost and will be replaced with a new one.

4.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was not scheduled for service visit 5.

4.5 WATER SAMPLE.

Water sample were collected during the first two service visits and sent to the Council for Scientific and Industrial Research (CSIR) for analysis.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

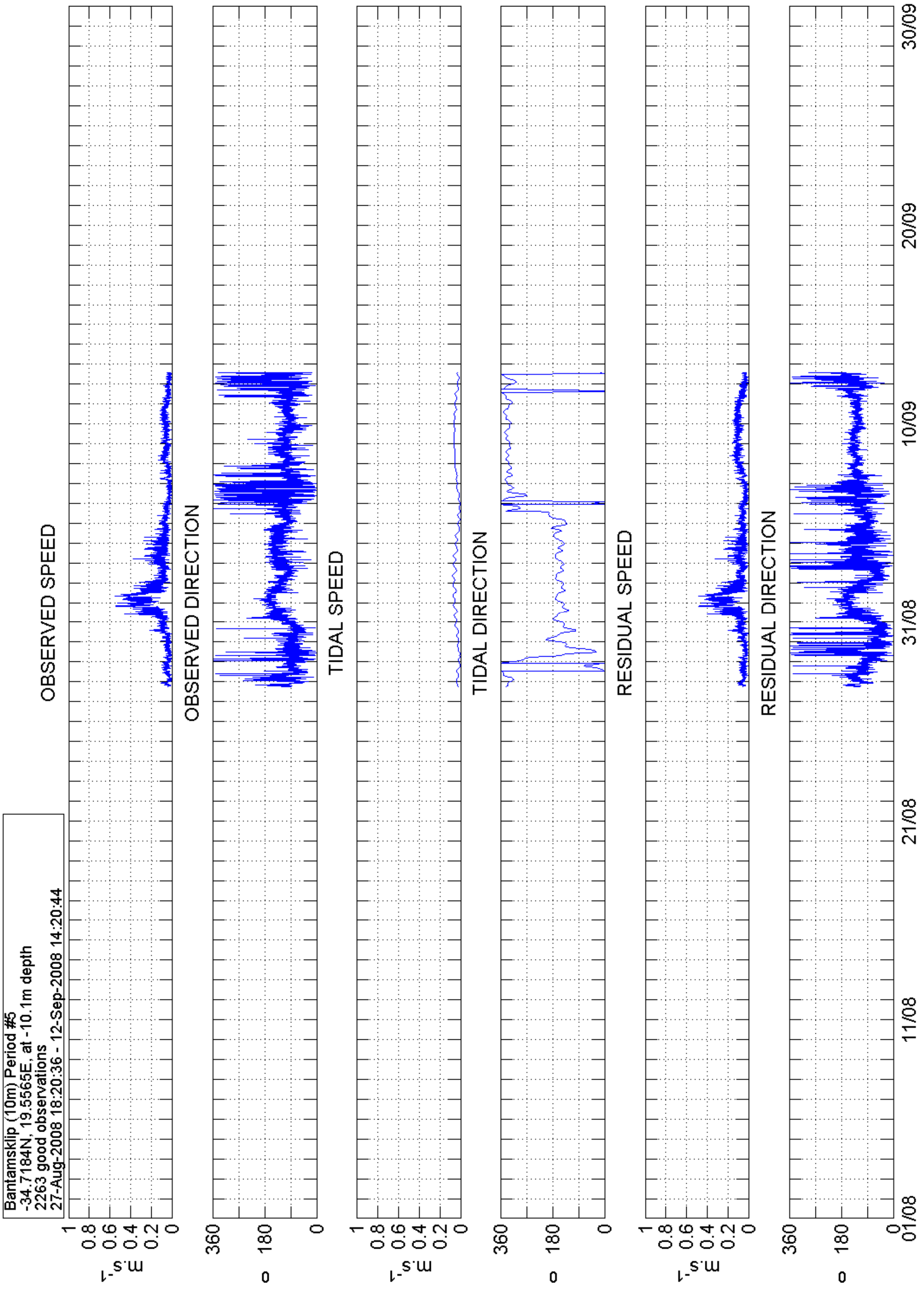


Figure 3: Time series plot for 10m ADCP current data at 10.1m.

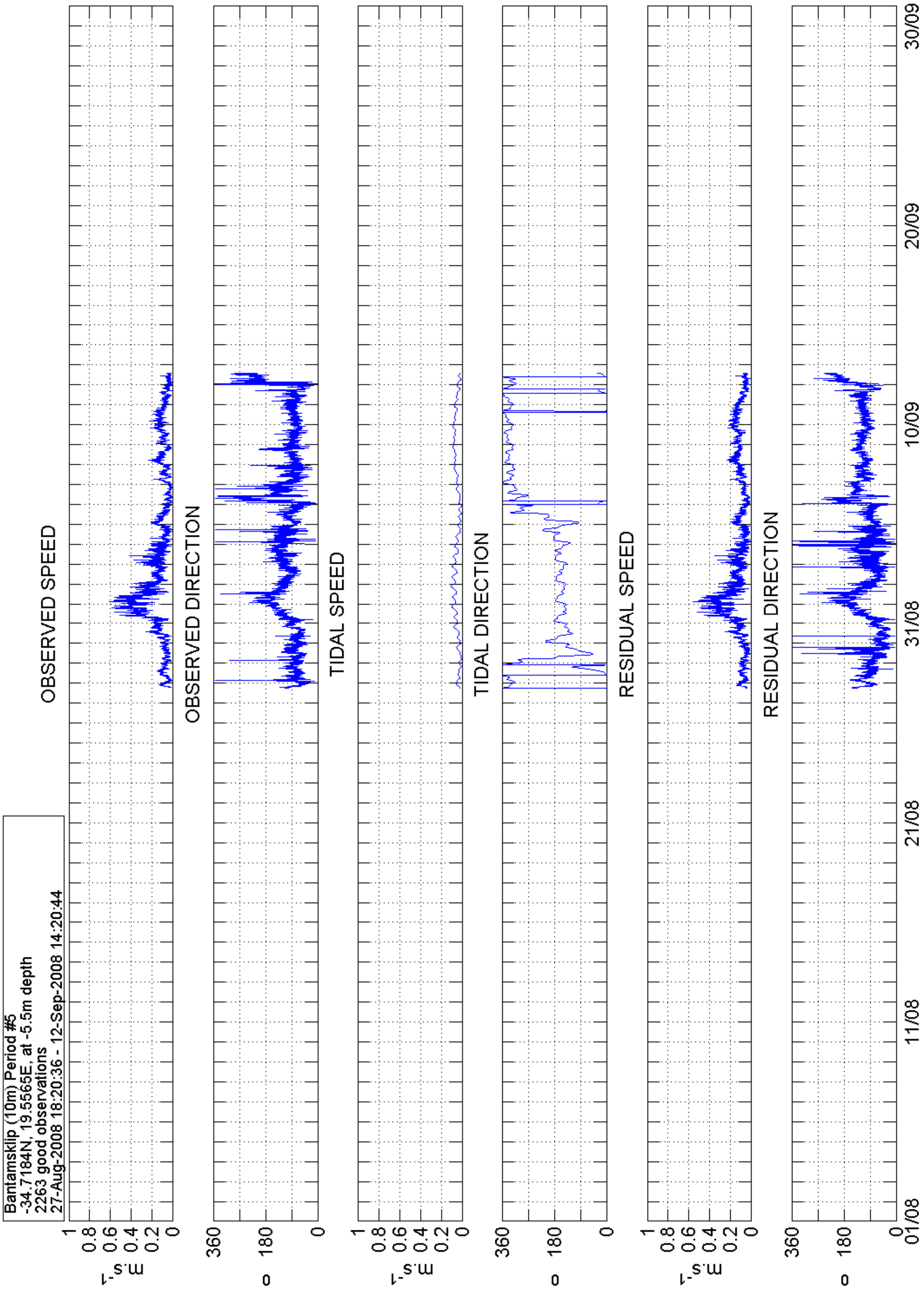


Figure 4: Time series plot for 10m ADCP current data at 5.5m.

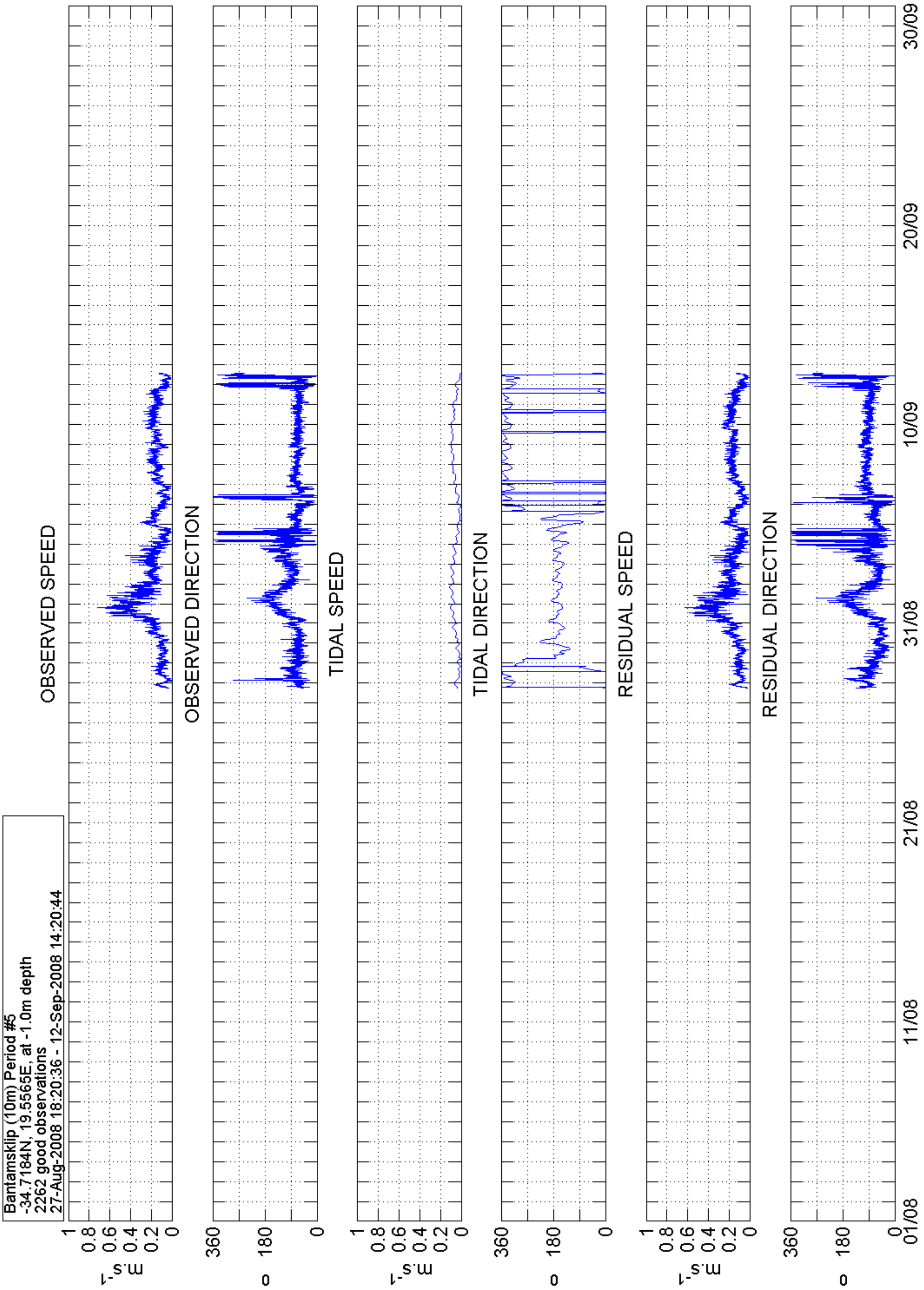


Figure 5: Time series plot for 10m ADCP current data at 1.0m.

5.1.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

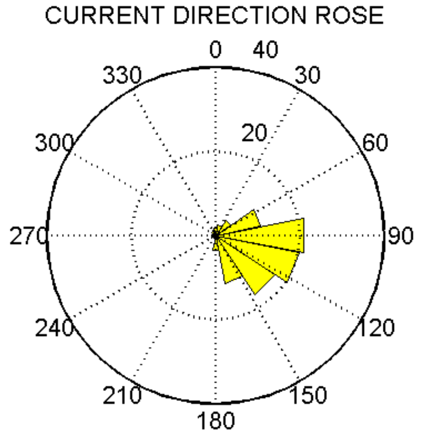
The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at -10.1m depth
2263 good observations
27-Aug-2008 18:20:36 - 12-Sep-2008 14:20:44

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.68	2.43	4.24	9.85	19.40	17.85	11.31	5.52	2.08	0.66	0.80	1.02	0.75	0.88	1.10	1.28	80.87
0.1-0.2			0.18	1.06	1.94	2.08	3.67	2.25	0.57	0.04	0.04						11.84
0.2-0.3				0.04	0.09	0.40	1.28	1.63	0.27								3.71
0.3-0.4							0.62	1.33	0.40	0.04							2.39
0.4-0.5							0.09	0.66	0.22	0.04							1.02
0.5-0.6							0.04	0.13									0.18
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	1.68	2.43	4.42	10.96	21.43	20.33	17.01	11.53	3.54	0.80	0.84	1.02	0.75	0.88	1.10	1.28	100.00



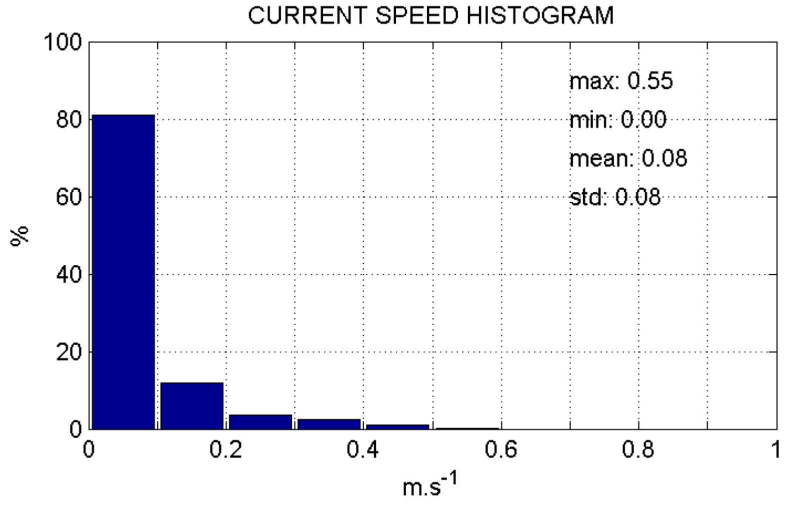


Figure 6: Summary plot for 10m ADCP current data at 10.1m.

Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at -5.5m depth
2263 good observations
27-Aug-2008 18:20:36 - 12-Sep-2008 14:20:44

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	0.57	0.97	5.83	14.10	13.79	8.79	4.55	2.61	1.02	1.37	1.19	0.84	0.62	0.53	0.13	0.22	57.14
0.1-0.2			1.77	10.16	9.90	5.97	2.74	0.88	0.27	0.04	0.09						31.82
0.2-0.3			0.18	0.49	0.31	1.59	1.81	0.84	0.18	0.04	0.04						5.48
0.3-0.4					0.09	0.49	1.02	0.88	0.40	0.13							3.00
0.4-0.5						0.18	0.62	0.62	0.27	0.09	0.04						1.81
0.5-0.6							0.13	0.35	0.22								0.71
0.6-0.7										0.04							0.04
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	0.57	0.97	7.78	24.75	24.08	17.01	10.87	6.19	2.34	1.72	1.37	0.84	0.62	0.53	0.13	0.22	100.00

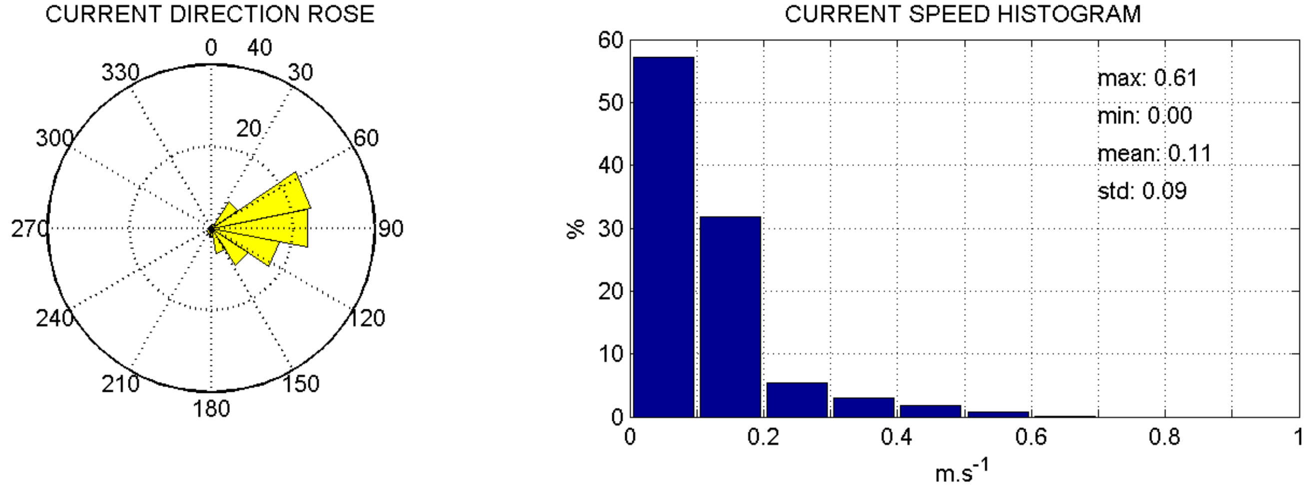


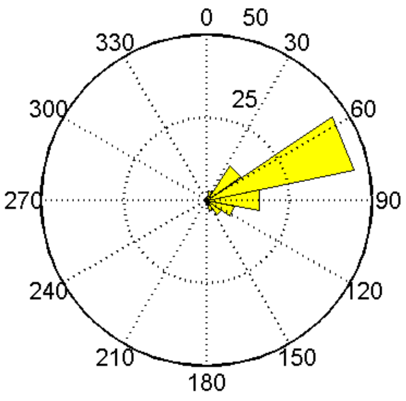
Figure 7: Summary plot for 10m ADCP current data at 5.5m

Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at -1.0m depth
2262 good observations
27-Aug-2008 18:20:36 - 12-Sep-2008 14:20:44

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	0.93	2.21	3.89	9.59	4.42	1.86	0.97	0.40	0.40	0.22	0.13	0.22	0.53	0.49	0.49	0.57	27.32
0.1-0.2		0.66	7.29	29.09	9.37	3.18	1.02	0.75	0.13			0.09	0.13	0.04			51.77
0.2-0.3			1.19	6.59	1.99	1.72	1.06	0.49	0.22	0.09							13.35
0.3-0.4			0.09	0.18	0.35	1.02	1.24	0.66	0.31	0.04							3.89
0.4-0.5				0.04	0.04	0.40	0.84	0.57	0.18	0.09							2.17
0.5-0.6						0.22	0.22	0.44	0.18		0.04						1.11
0.6-0.7						0.04	0.13	0.09	0.04								0.31
0.7-0.8							0.04	0.04									0.09
0.8-0.9																	0.00
0.9-1																	0.00
Σ	0.93	2.87	12.47	45.49	16.18	8.44	5.53	3.45	1.46	0.44	0.18	0.31	0.66	0.53	0.49	0.57	100.00

CURRENT DIRECTION ROSE



CURRENT SPEED HISTOGRAM

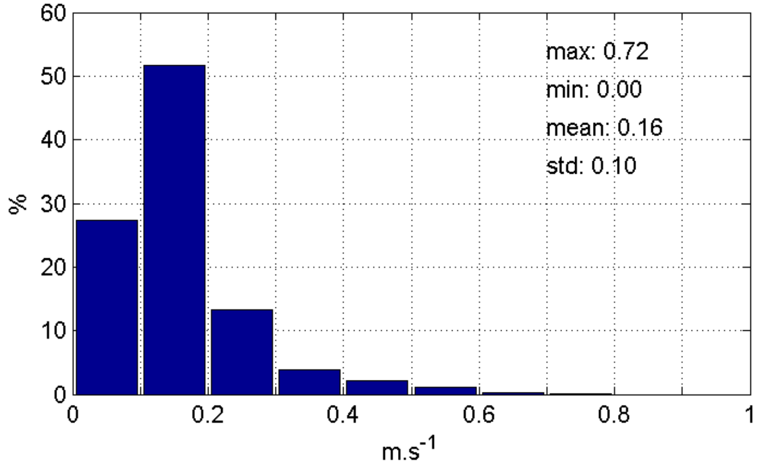


Figure 8: Summary plot for 10m ADCP current data at 1.0m.

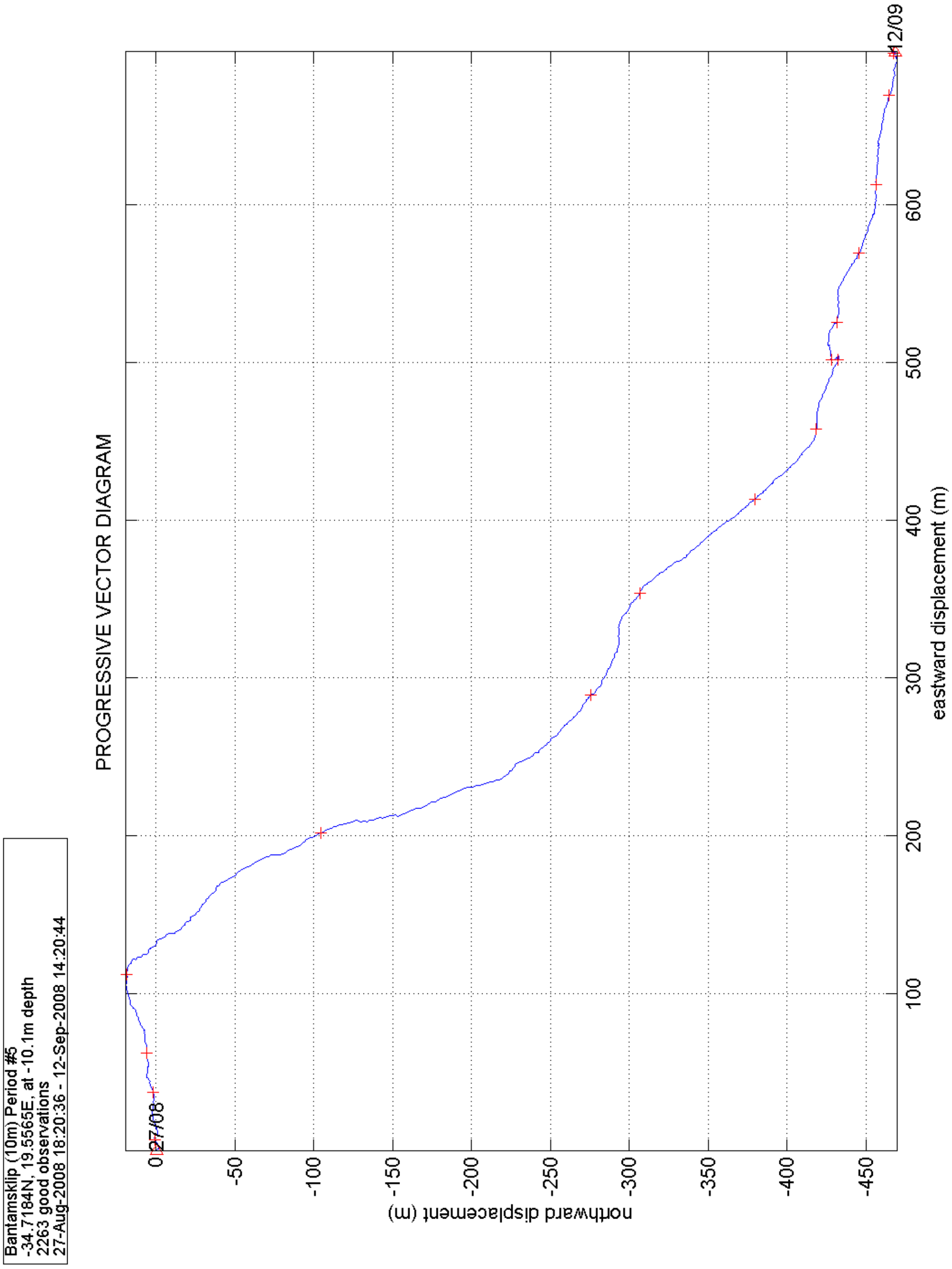


Figure 9: Progressive vector plot for 10m ADCP current data at 10.1m.

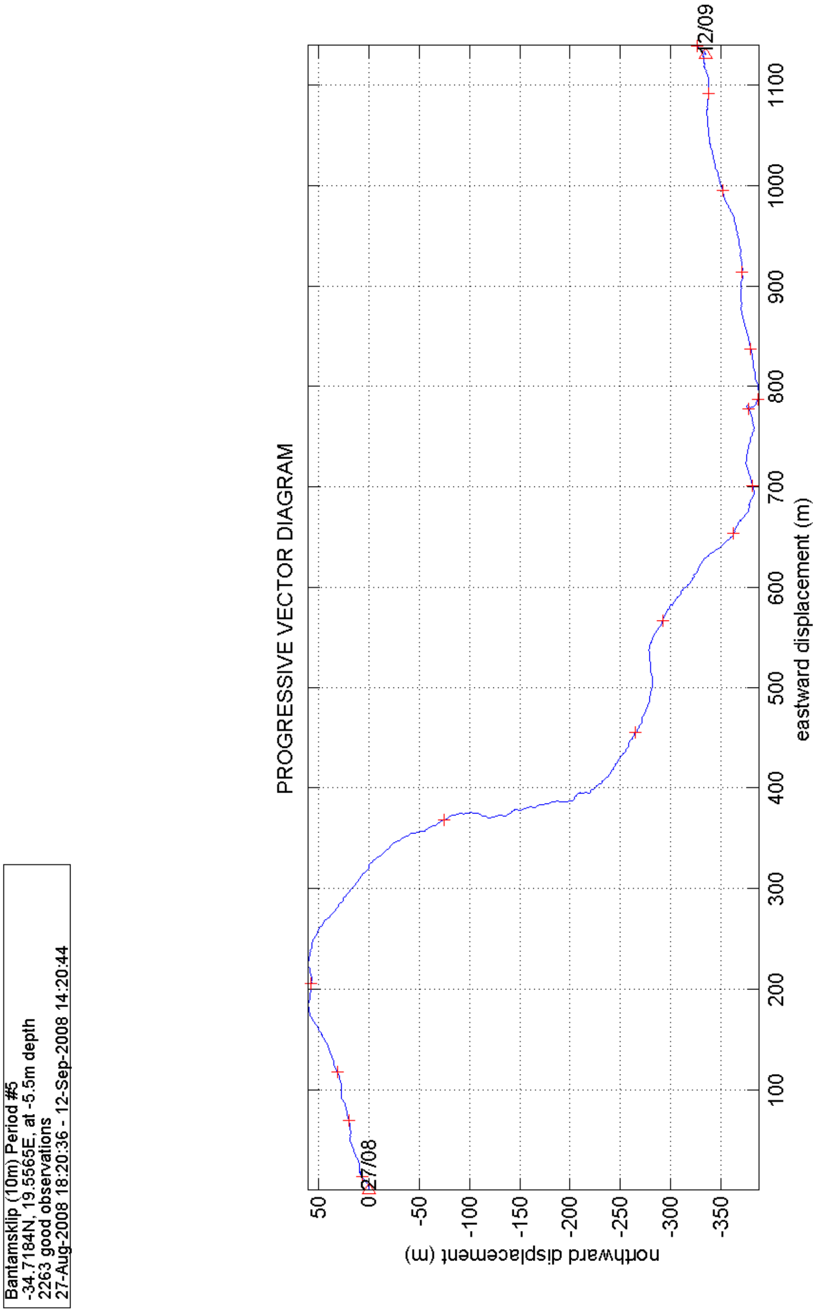


Figure 10: Progressive vector plot for 10m ADCP current data at 5.5m.

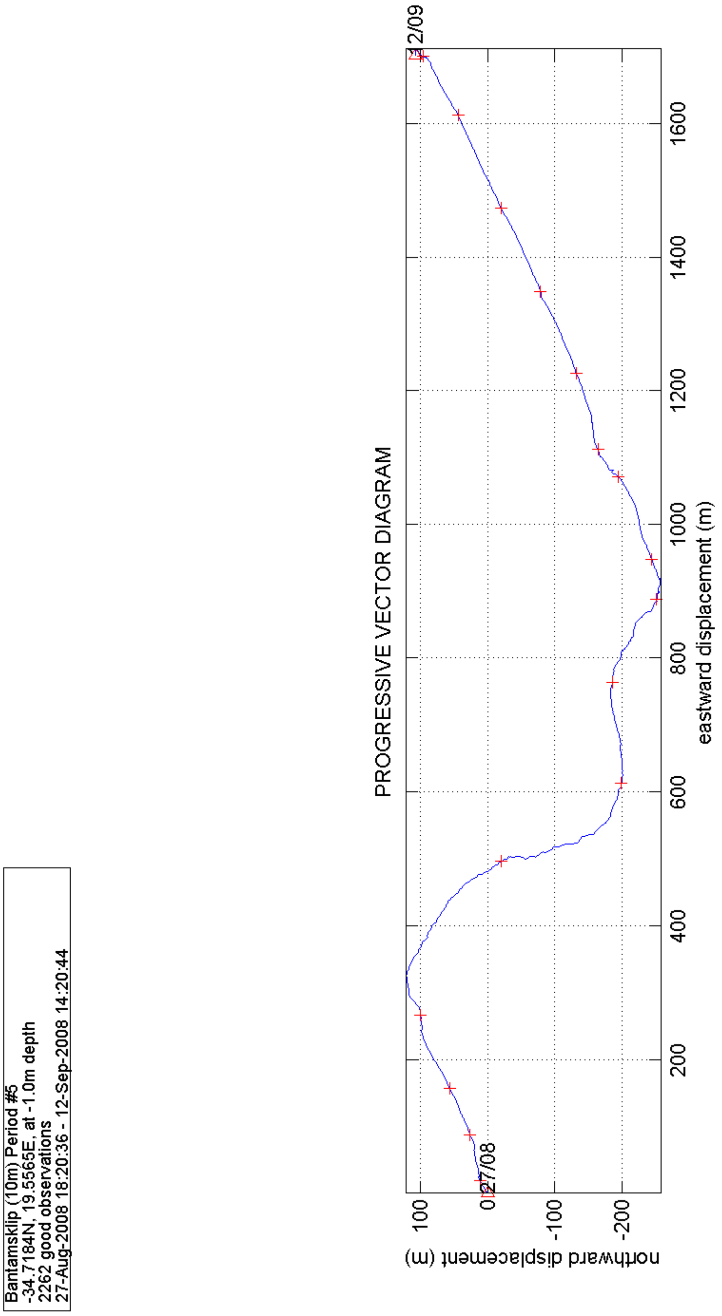


Figure 11: Progressive vector plot for 10m ADCP current data at 1.0m.

5.1.2 Wave Data.

5.1.2.1 Hs and Tp summary plot

Figure 12 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.2 Hs and Dp summary plot

Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.3 Tp and Dp summary plot

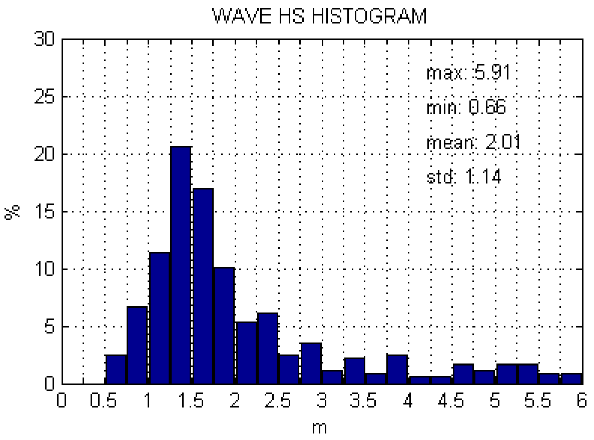
Figure 14 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at 10m depth
378 good observations
27-Aug-2008 16:20:00 - 12-Sep-2008 12:50:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75				0.26	2.12											2.38
0.75-1					6.61											6.61
1-1.25				0.26	11.11											11.38
1.25-1.5				2.12	18.52											20.63
1.5-1.75		0.79		2.12	14.02											16.93
1.75-2		1.32		3.97	4.76											10.05
2-2.25		0.53	0.26	3.44	1.06											5.29
2.25-2.5				4.23	1.85											6.08
2.5-2.75				1.85	0.53											2.38
2.75-3		0.26		2.12	1.06											3.44
3-3.25				0.53	0.53											1.06
3.25-3.5				0.53	1.59											2.12
3.5-3.75		0.26		0.26	0.26											0.79
3.75-4		0.53		0.79	1.06											2.38
4-4.25		0.53														0.53
4.25-4.5		0.53														0.53
4.5-4.75		1.32			0.26											1.59
4.75-5		1.06														1.06
5-5.25		1.59														1.59
5.25-5.5		1.59														1.59
5.5-5.75		0.79														0.79
5.75-6		0.79														0.79
Σ	0.00	11.90	0.26	22.49	65.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00



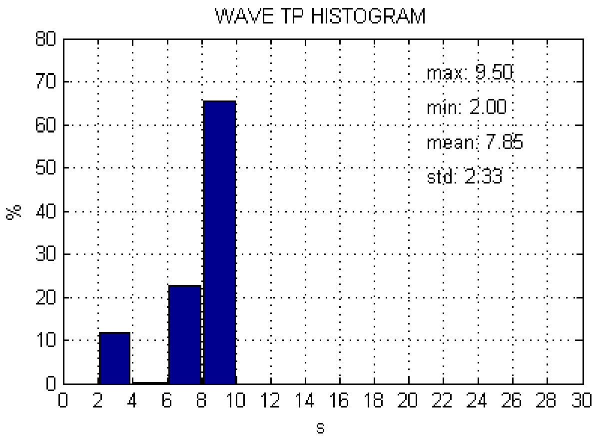
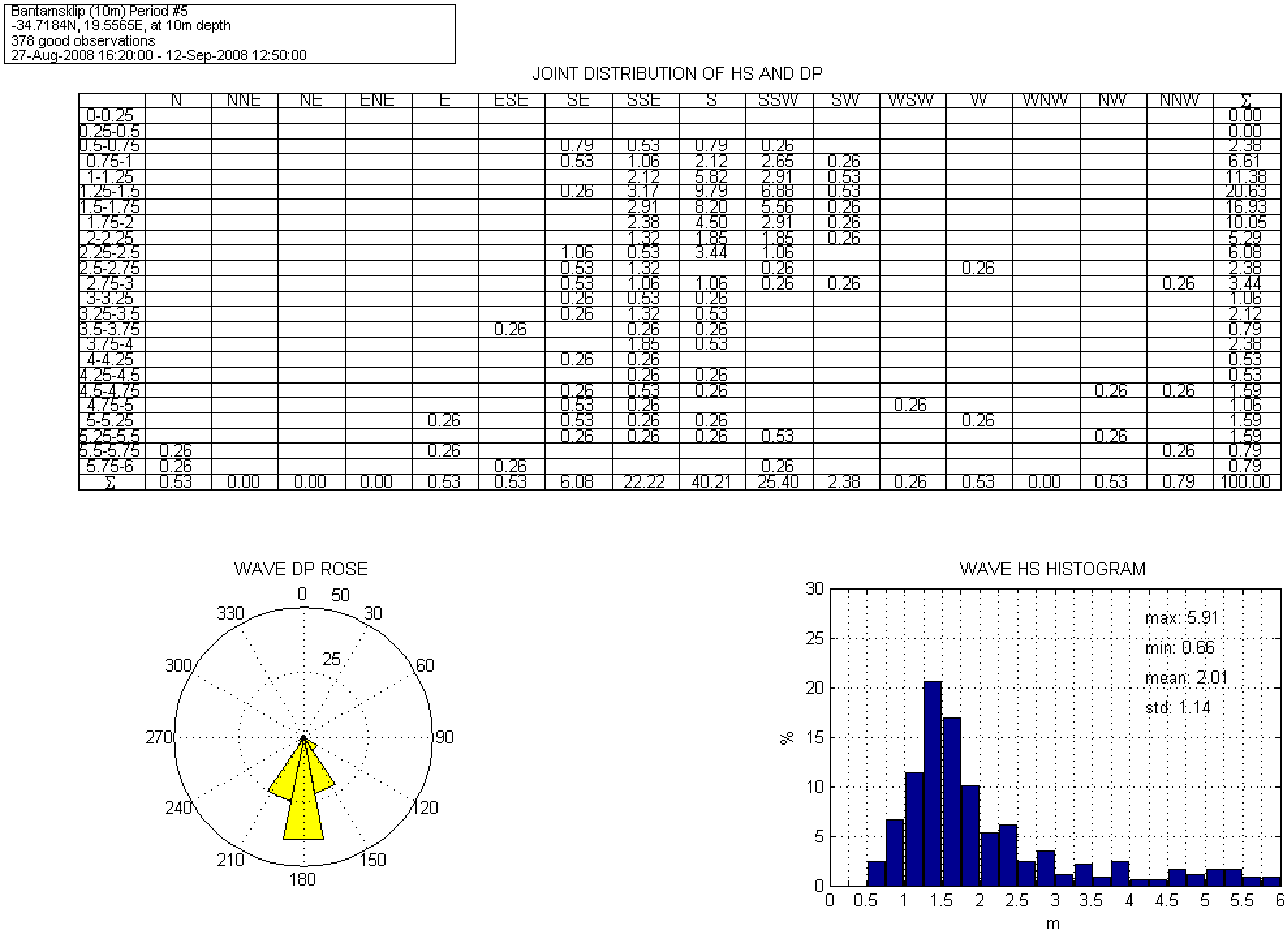


Figure 12: Summary plot of H_s and T_p.



Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at 10m depth
378 good observations
27-Aug-2008 16:20:00 - 12-Sep-2008 12:50:00

JOINT DISTRIBUTION OF HS AND DP

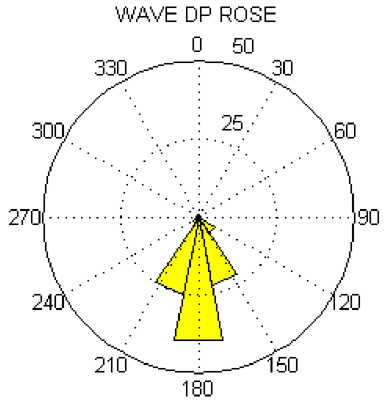
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75							0.79	0.53	0.79	0.26							2.38
0.75-1							0.53	1.06	2.12	2.65	0.26						6.61
1-1.25								2.12	5.82	2.91	0.53						11.38
1.25-1.5							0.26	3.17	9.79	6.88	0.53						20.63
1.5-1.75								2.91	8.20	5.56	0.26						16.93
1.75-2								2.38	4.50	2.91	0.26						10.05
2-2.25								1.32	1.85	1.85	0.26						5.29
2.25-2.5							1.06	0.53	3.44	1.06							6.08
2.5-2.75							0.53	1.32		0.26			0.26				2.38
2.75-3							0.53	1.06	1.06	0.26	0.26					0.26	3.44
3-3.25							0.26	0.53	0.26								1.06
3.25-3.5							0.26	1.32	0.53								2.12
3.5-3.75						0.26		0.26	0.26								0.79
3.75-4								1.85	0.53								2.38
4-4.25							0.26	0.26									0.53
4.25-4.5								0.26	0.26								0.53
4.5-4.75							0.26	0.53	0.26						0.26	0.26	1.59
4.75-5							0.53	0.26				0.26					1.06
5-5.25					0.26		0.53	0.26	0.26				0.26				1.59
5.25-5.5							0.26	0.26	0.26	0.53					0.26		1.59
5.5-5.75	0.26				0.26											0.26	0.79
5.75-6	0.26					0.26				0.26							0.79
Σ	0.53	0.00	0.00	0.00	0.53	0.53	6.08	22.22	40.21	25.40	2.38	0.26	0.53	0.00	0.53	0.79	100.00

Figure 13: Summary plot of H_s and D_p.

Bantamsklip (10m) Period #5
-34.7184N, 19.5565E, at 10m depth
378 good observations
27-Aug-2008 16:20:00 - 12-Sep-2008 12:50:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4	0.53				0.53	0.26	1.85	2.38	2.12	2.12	0.53	0.26	0.26		0.53	0.53	11.90
4-6										0.26							0.26
6-8						0.26	2.38	7.67	7.14	4.50	0.53						22.49
8-10							1.85	12.17	30.95	18.52	1.32		0.26			0.26	65.34
10-12																	0.00
12-14																	0.00
14-16																	0.00
16-18																	0.00
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.53	0.00	0.00	0.00	0.53	0.53	6.08	22.22	40.21	25.40	2.38	0.26	0.53	0.00	0.53	0.79	100.00



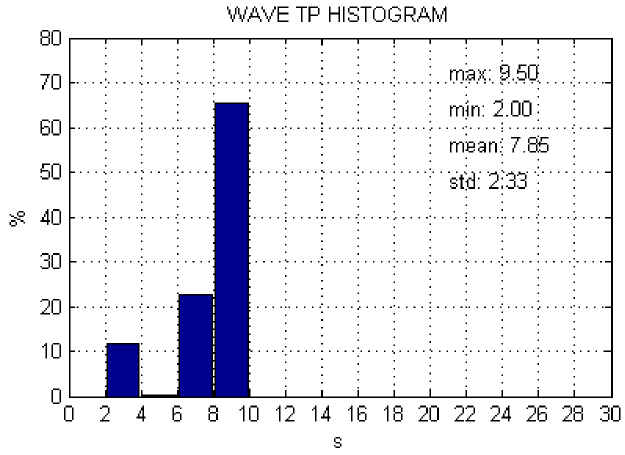


Figure 14: Summary plot of T_p and D_p.

5.1.2.4 Wave spectral plot

Figure 15 displays a wave spectral plot for a significant wave event. The time of the spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

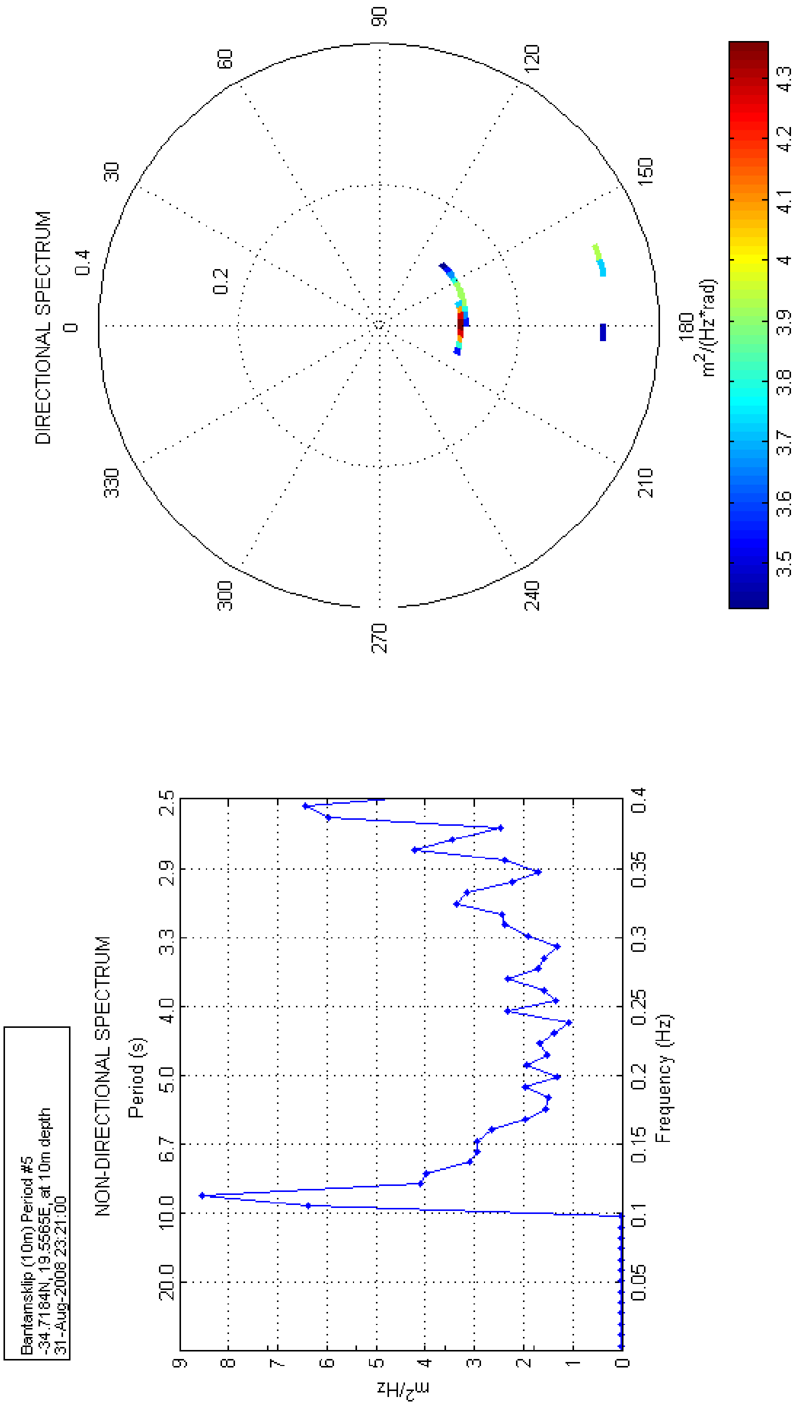


Figure 15: Wave spectra for 31st of August 2008 at 23:21:00.

5.2 30M ADCP

5.2.1 Current Data

5.2.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

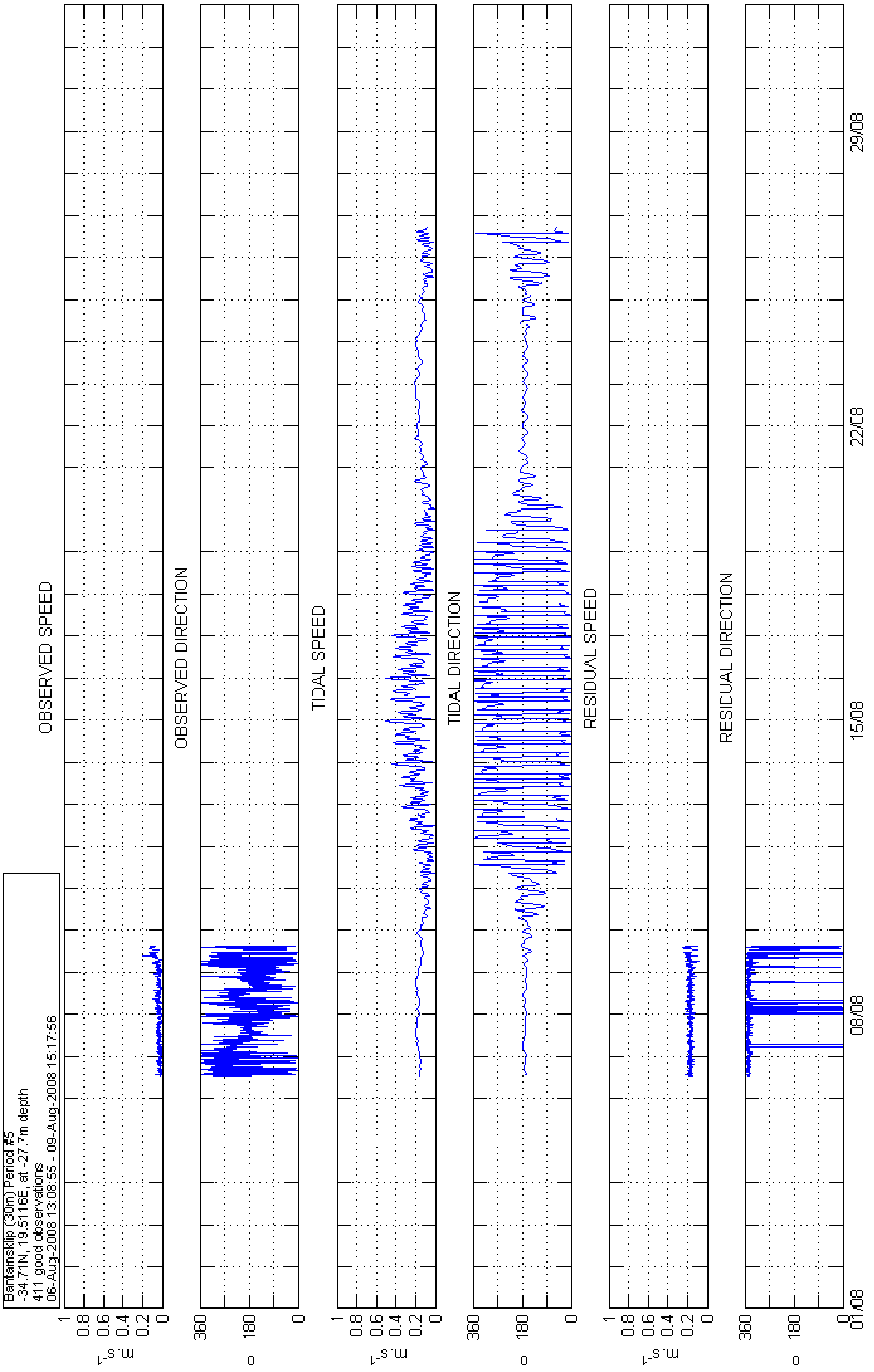


Figure 16: Time series plot for 30m ADCP current data at 27.7m.

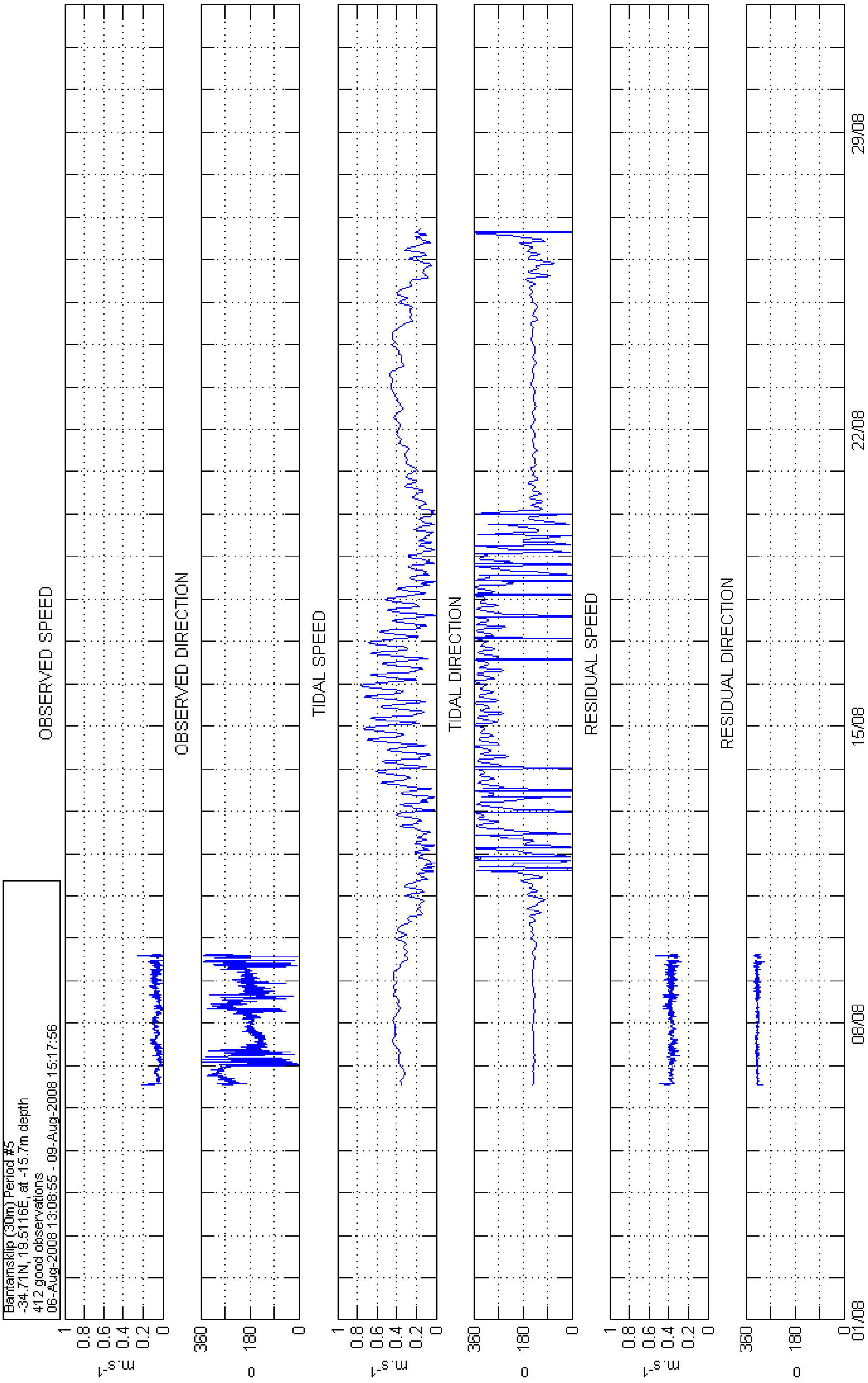


Figure 17: Time series plot for 30m ADCP current data at 15.7m.

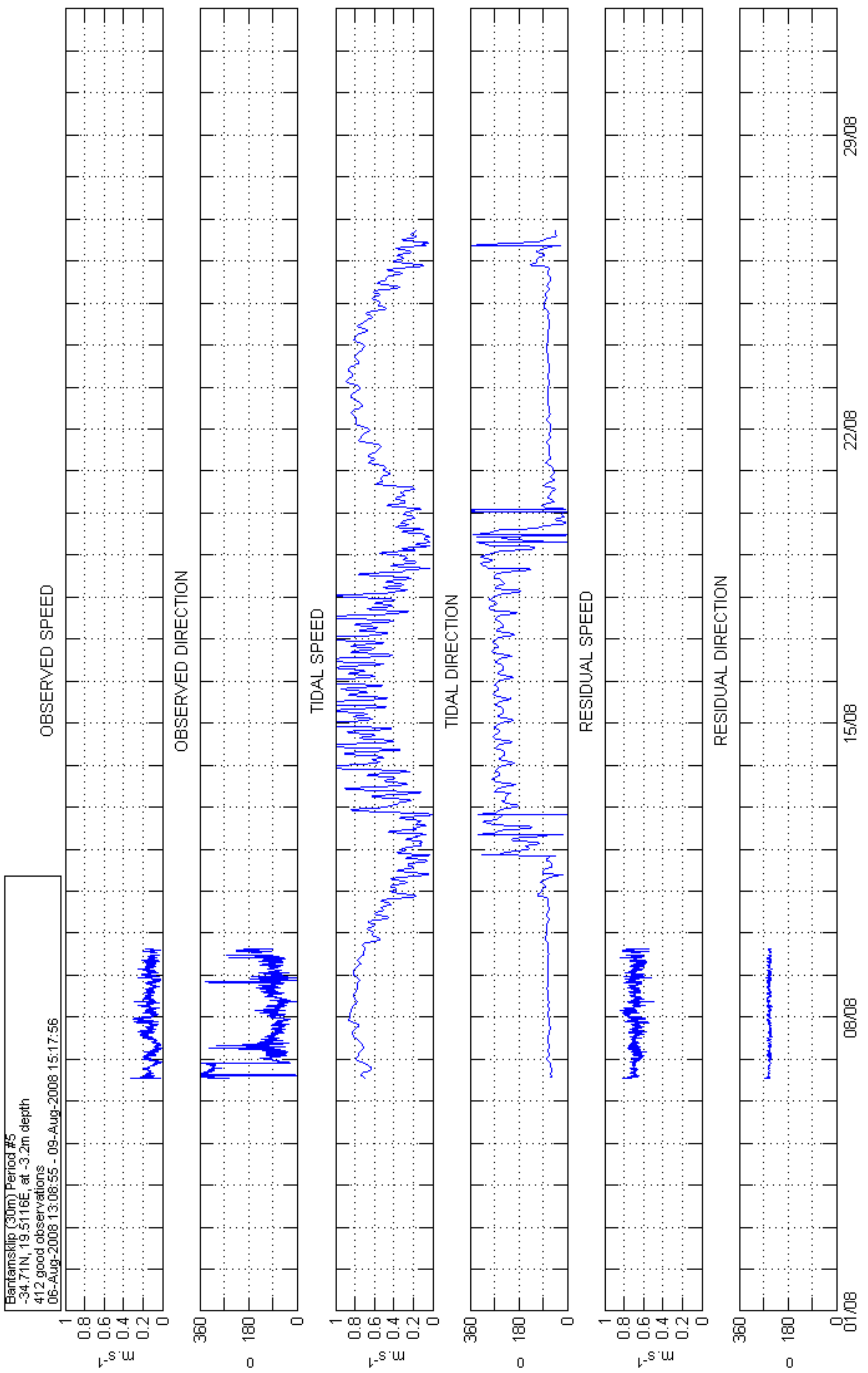


Figure 18: Time series plot for 30m ADCP current data at 3.2m.

5.2.1.2 Summary plots

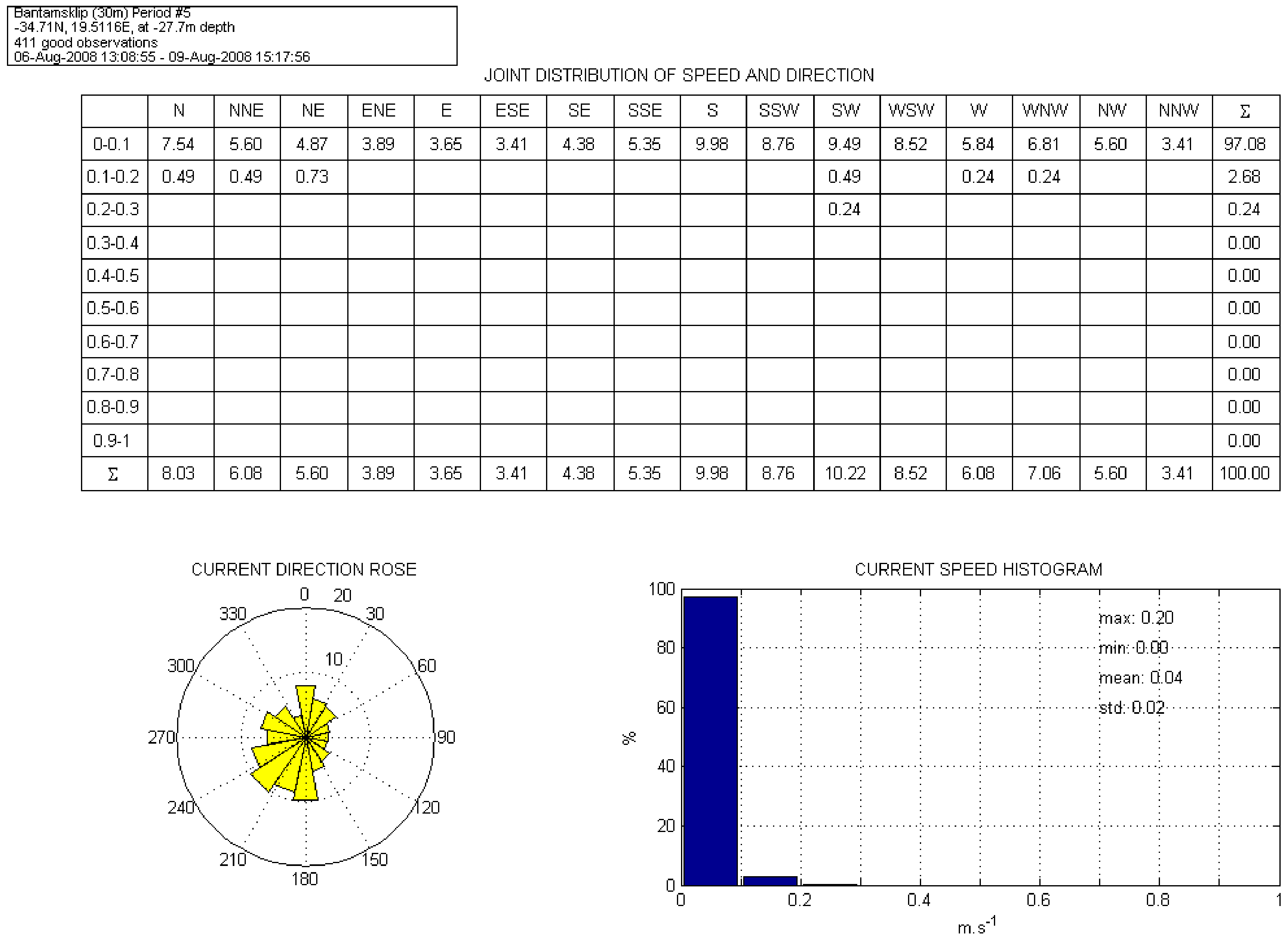
The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.2.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.



Bantamsklip (30m) Period #5
-34.71N, 19.5116E, at -27.7m depth
411 good observations
06-Aug-2008 13:08:55 - 09-Aug-2008 15:17:56

JOINT DISTRIBUTION OF SPEED AND DIRECTION

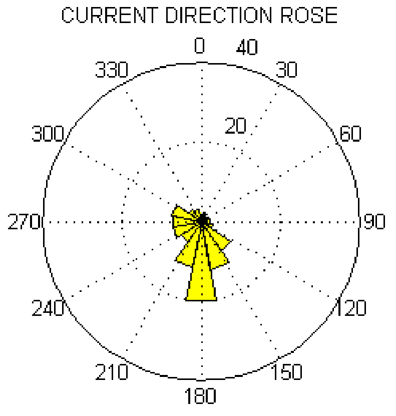
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	7.54	5.60	4.87	3.89	3.65	3.41	4.38	5.35	9.98	8.76	9.49	8.52	5.84	6.81	5.60	3.41	97.08
0.1-0.2	0.49	0.49	0.73								0.49		0.24	0.24			2.68
0.2-0.3											0.24						0.24
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	8.03	6.08	5.60	3.89	3.65	3.41	4.38	5.35	9.98	8.76	10.22	8.52	6.08	7.06	5.60	3.41	100.00

Figure 19: Summary plot for 30m ADCP current data at 27.7m.

Bantamsklip (30m) Period #5
-34.71N, 19.5116E, at -15.7m depth
412 good observations
06-Aug-2008 13:08:55 - 09-Aug-2008 15:17:56

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.70	2.18	1.46	1.46	2.43	2.67	8.01	11.41	17.72	10.44	5.58	6.80	7.04	7.28	3.64	2.43	92.23
0.1-0.2						0.24	0.97	0.97	2.67	1.21	0.24	0.24	0.24	0.24		0.24	7.28
0.2-0.3												0.24				0.24	0.49
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	1.70	2.18	1.46	1.46	2.43	2.91	8.98	12.38	20.39	11.65	5.83	7.28	7.28	7.52	3.64	2.91	100.00



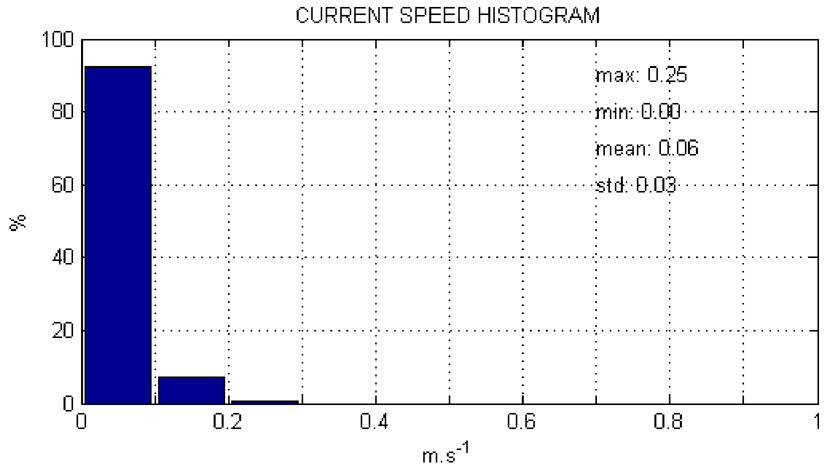


Figure 20: Summary plot for 30m ADCP current data at 15.7m

Bantamsklip (30m) Period #5
-34.71N, 19.5116E, at -3.2m depth
412 good observations
06-Aug-2008 13:08:55 - 09-Aug-2008 15:17:56

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	0.97	1.70	3.16	7.04	7.28	5.83	4.13	1.46	0.97	0.49	0.49	0.73	0.24	0.49	0.97	1.94	37.86
0.1-0.2	2.43	0.49	8.50	11.41	15.05	7.28	1.46	0.73	0.24	0.24	0.49			1.21	3.64	2.43	55.58
0.2-0.3			1.70	2.18	1.46	0.97											6.31
0.3-0.4															0.24		0.24
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	3.40	2.18	13.35	20.63	23.79	14.08	5.58	2.18	1.21	0.73	0.97	0.73	0.24	1.70	4.85	4.37	100.00

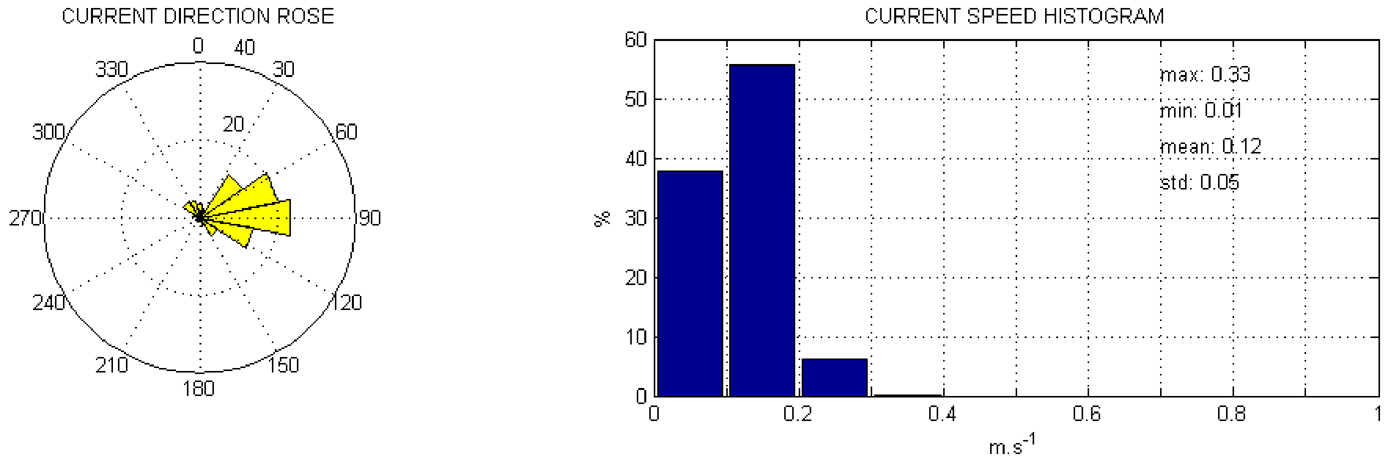


Figure 21: Summary plot for 30m ADCP current data at 3.2m.

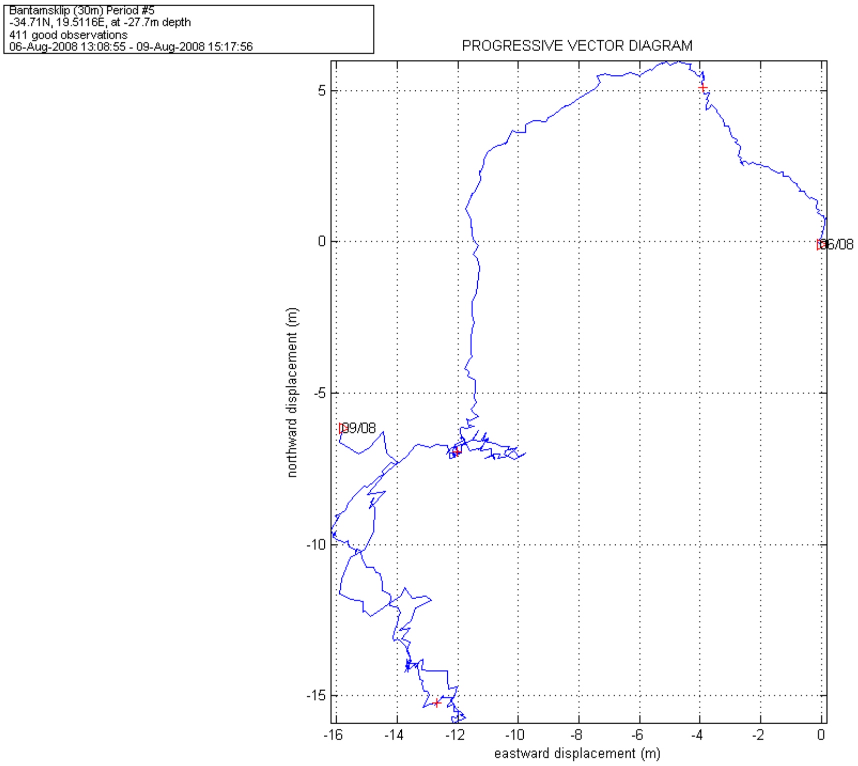


Figure 22: Progressive vector plot for 30m ADCP current data at 27.7m.

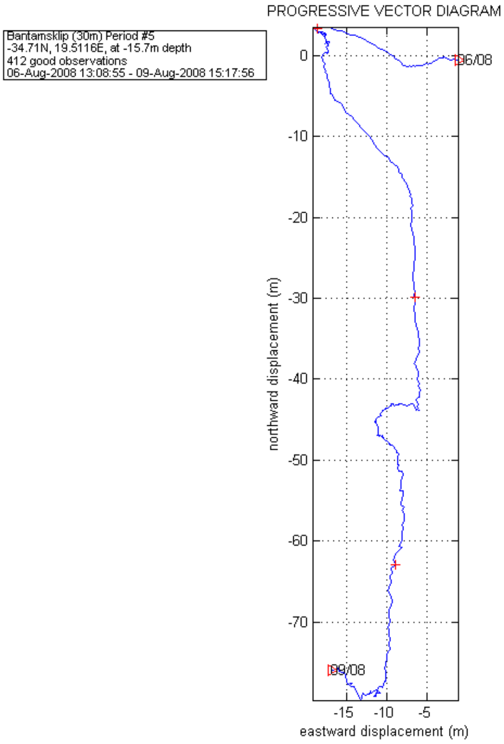


Figure 23: Progressive vector plot for 30m ADCP current data at 15.7m.

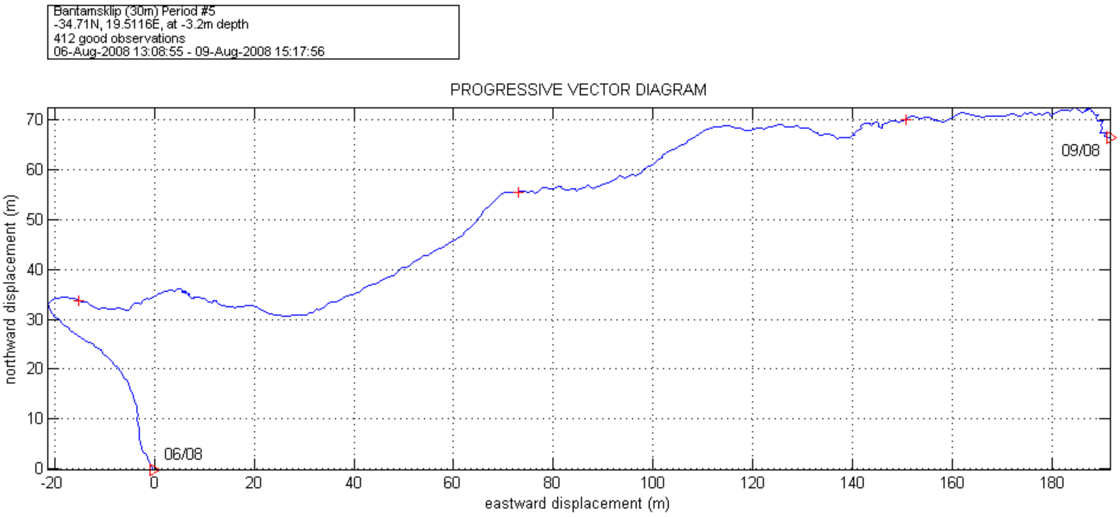


Figure 24: Progressive vector plot for 30m ADCP current data at 3.2m.

5.2.2 Wave Data.

5.2.2.1 Hs and Tp summary plot

Figure 25 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.2.2.2 Hs and Dp summary plot

Figure 26 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.2.2.3 Tp and Dp summary plot

Figure 27 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (30m) Period #5
-34.7104N, 19.5106E, at 30m depth
87 good observations
06-Aug-2008 13:48:00 - 09-Aug-2008 23:29:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.5																0.00
0.5-1																0.00
1-1.5							1.15									1.15
1.5-2					1.15	9.20	6.90									17.24
2-2.5					1.15	2.30	3.45		1.15							8.05
2.5-3						4.60	9.20	2.30								16.09
3-3.5				1.15		4.60	9.20	5.75								20.69
3.5-4						2.30	4.60	6.90	1.15							14.94
4-4.5							4.60	2.30								6.90
4.5-5							2.30	1.15								3.45
5-5.5									1.15							1.15
5.5-6									3.45	1.15						4.60
6-6.5									2.30	1.15						3.45
6.5-7																0.00
7-7.5																0.00
7.5-8																0.00
8-8.5																0.00
8.5-9										1.15						1.15
9-9.5																0.00
9.5-10																0.00
10-10.5									1.15							1.15
Σ	0.00	0.00	0.00	1.15	2.30	22.99	41.38	18.39	10.34	3.45	0.00	0.00	0.00	0.00	0.00	100.00

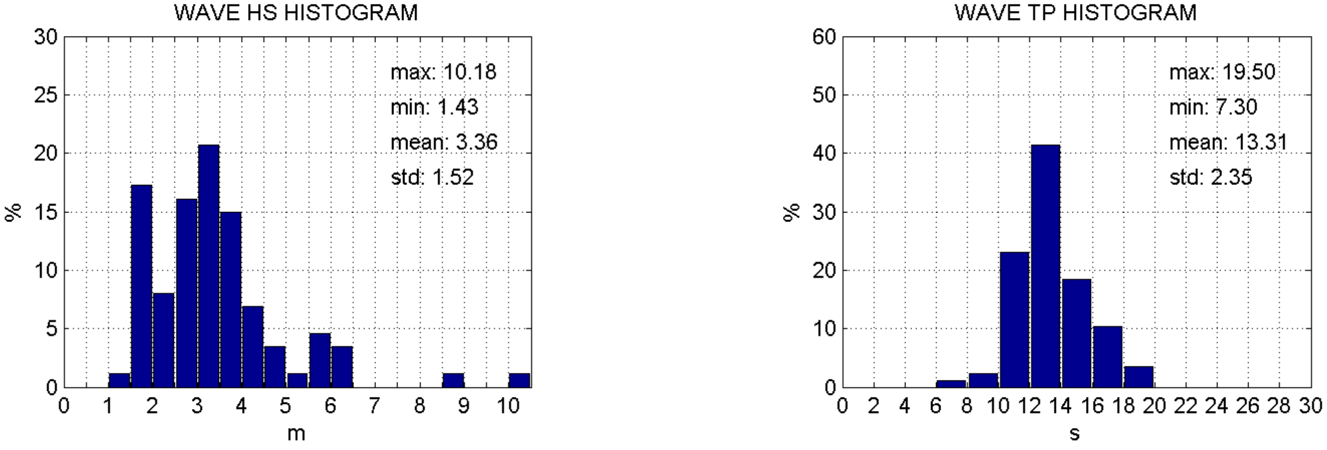
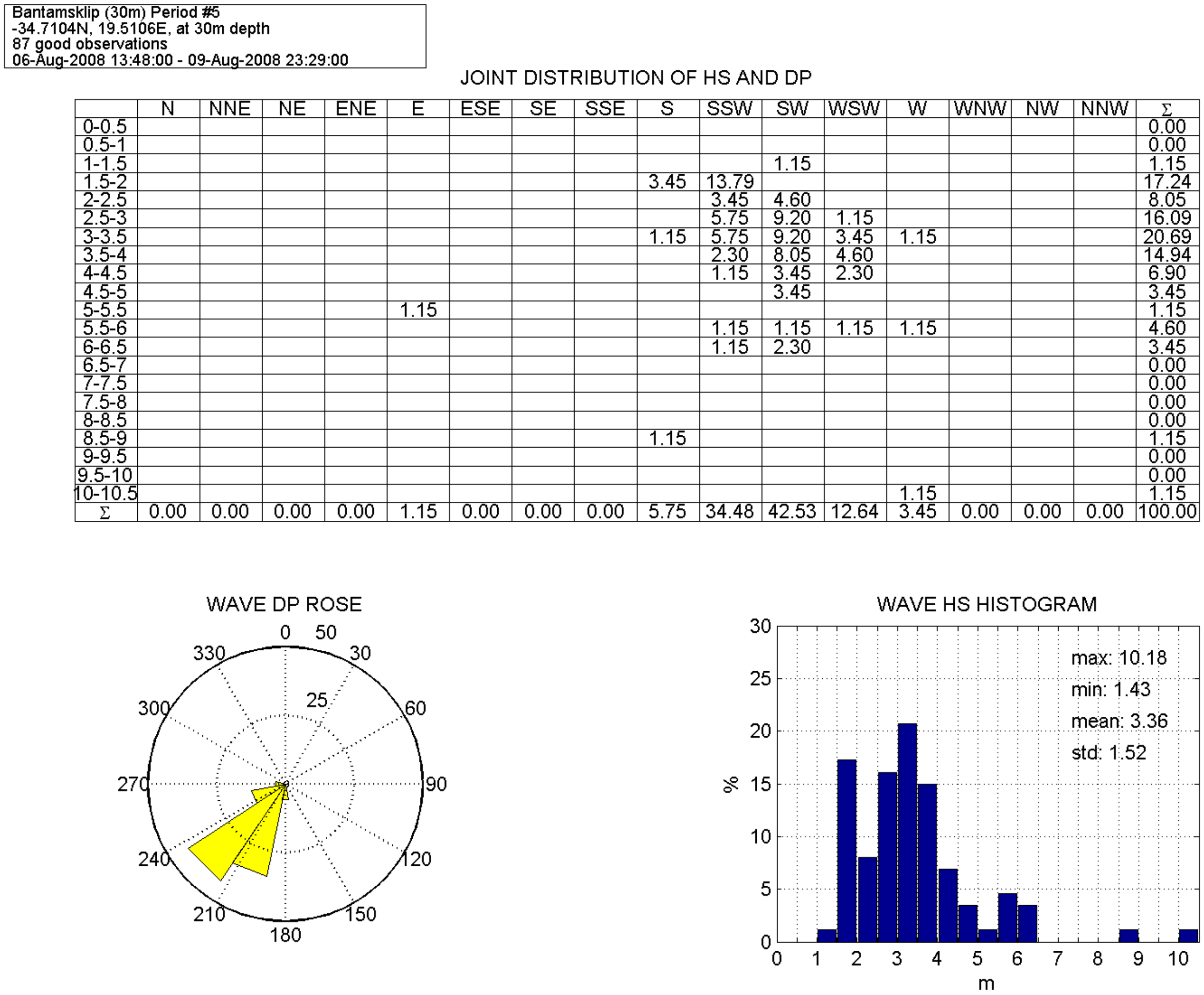


Figure 25: Summary plot of H_s and T_p.



Bantamsklip (30m) Period #5
-34.7104N, 19.5106E, at 30m depth
87 good observations
06-Aug-2008 13:48:00 - 09-Aug-2008 23:29:00

JOINT DISTRIBUTION OF HS AND DP

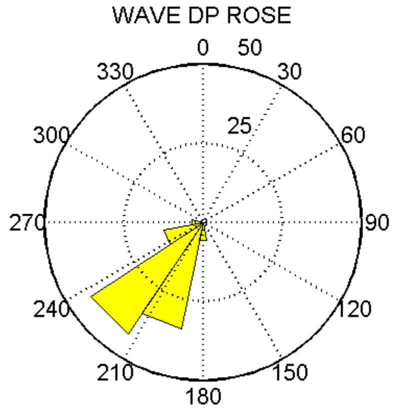
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.5																	0.00
0.5-1																	0.00
1-1.5											1.15						1.15
1.5-2									3.45	13.79							17.24
2-2.5										3.45	4.60						8.05
2.5-3										5.75	9.20	1.15					16.09
3-3.5									1.15	5.75	9.20	3.45	1.15				20.69
3.5-4										2.30	8.05	4.60					14.94
4-4.5										1.15	3.45	2.30					6.90
4.5-5											3.45						3.45
5-5.5					1.15												1.15
5.5-6										1.15	1.15	1.15	1.15				4.60
6-6.5										1.15	2.30						3.45
6.5-7																	0.00
7-7.5																	0.00
7.5-8																	0.00
8-8.5																	0.00
8.5-9									1.15								1.15
9-9.5																	0.00
9.5-10																	0.00
10-10.5													1.15				1.15
Σ	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	5.75	34.48	42.53	12.64	3.45	0.00	0.00	0.00	100.00

Figure 26: Summary plot of H_s and D_p.

Bantamsklip (30m) Period #5
-34.7104N, 19.5106E, at 30m depth
87 good observations
06-Aug-2008 13:48:00 - 09-Aug-2008 23:29:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4																	0.00
4-6																	0.00
6-8													1.15				1.15
8-10									1.15	1.15							2.30
10-12									2.30	13.79	4.60	2.30					22.99
12-14									1.15	13.79	20.69	5.75					41.38
14-16										3.45	12.64	2.30					18.39
16-18					1.15					2.30	3.45	1.15	2.30				10.34
18-20									1.15		1.15	1.15					3.45
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	5.75	34.48	42.53	12.64	3.45	0.00	0.00	0.00	100.00



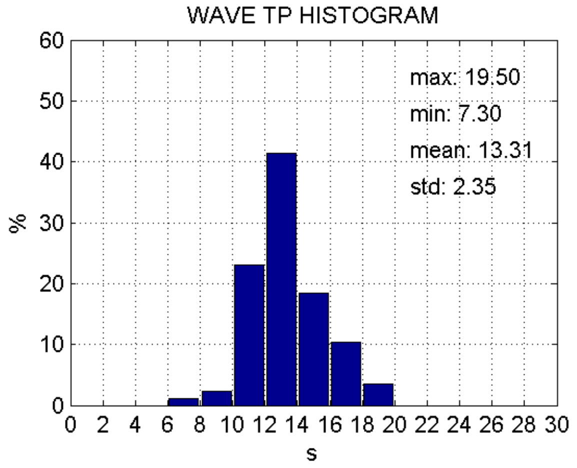


Figure 27: Summary plot of T_p and D_p.

5.2.2.4 Wave spectral plot

Figure 28 displays a wave spectral plot for a significant wave event. The time of the spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

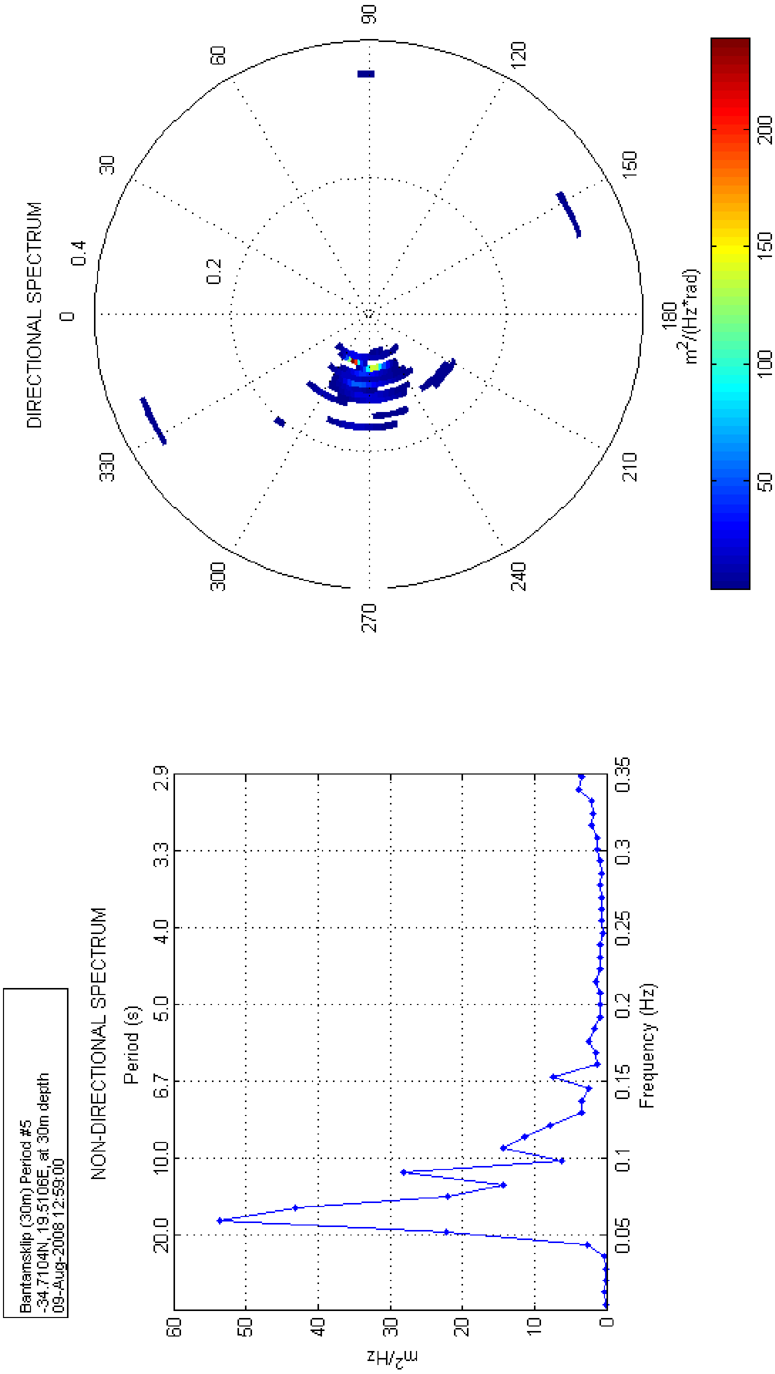


Figure 28: Wave spectra for 09th of August 2008 at 12:59:00.

5.3 COMPARISON PLOTS

5.3.1 Hs, Tp and Dp time series plots for 10m and 30m ADCPs.

Figure 29 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

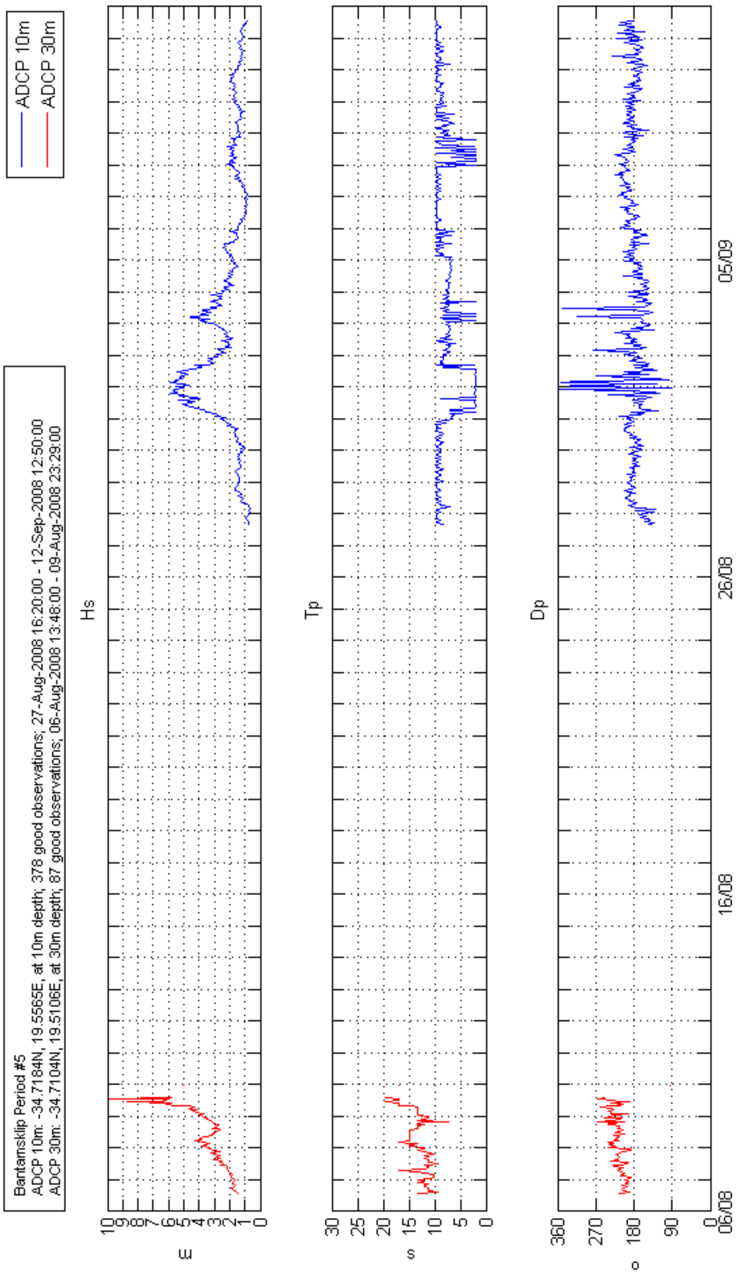


Figure 29: Time series of Hs, Tp and Dp from 10m and 30m ADCPs.

5.3.2 Water properties: RBR-CT loggers and ADCPs' temperature sensor.

Figure 30 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCPs' temperature sensor against time.
- The second panel is of the derived salinity from the RBR loggers against time.

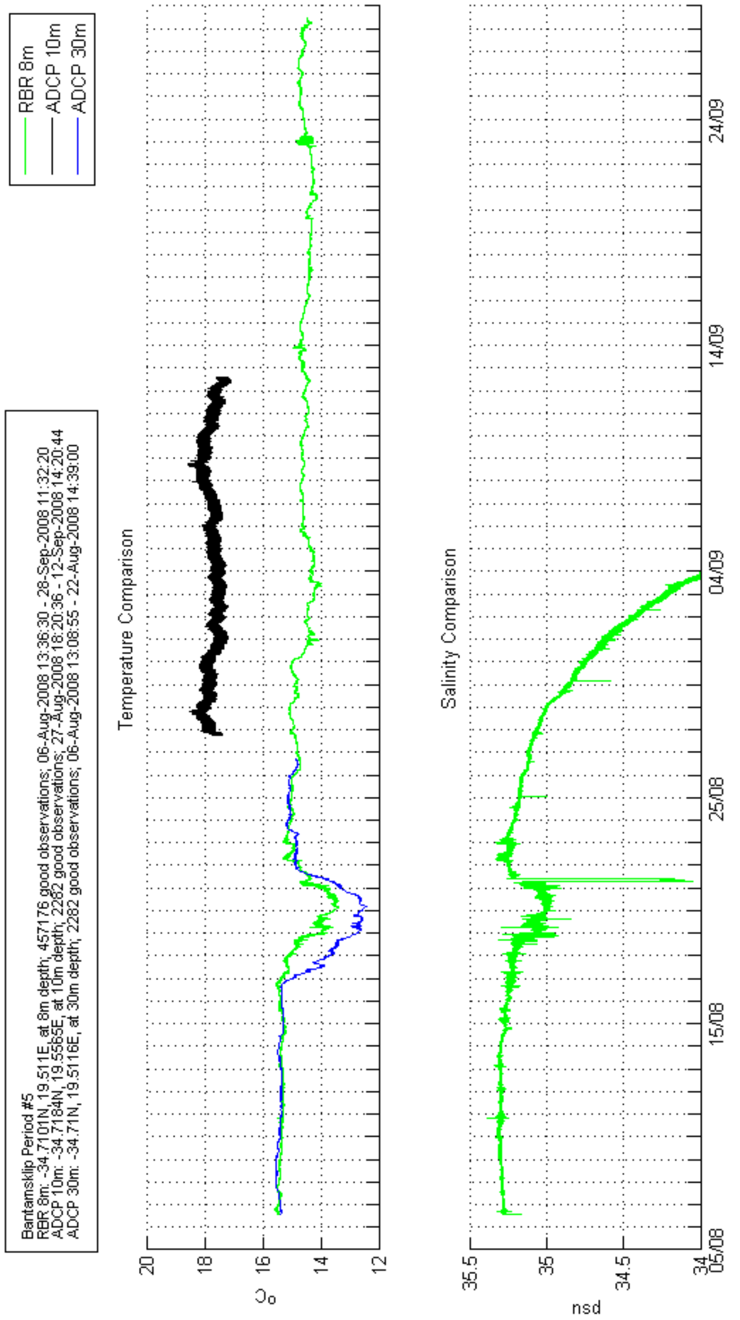


Figure 30: Time series of temperature and salinity from the RBR loggers and ADCPs.

5.4 WATER SAMPLES.

Analysis of water samples were undertaken by the CSIR and results are presented as an appendage (Section 7.4, page 62).

6. DISCUSSION

The fifth set of oceanographic data collected off the coast of Bantamsklip for the period between August 27th and September 28th 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

Three service visits were undertaken over the deployment period. This report presents data obtained from the 10m and 30m ADCPs, the surface RBR-CT logger, and water samples collected during the fifth service visit. The pressure and temperature sensors on board the 10m ADCP failed, the data is presented nonetheless solely for completeness purposes.

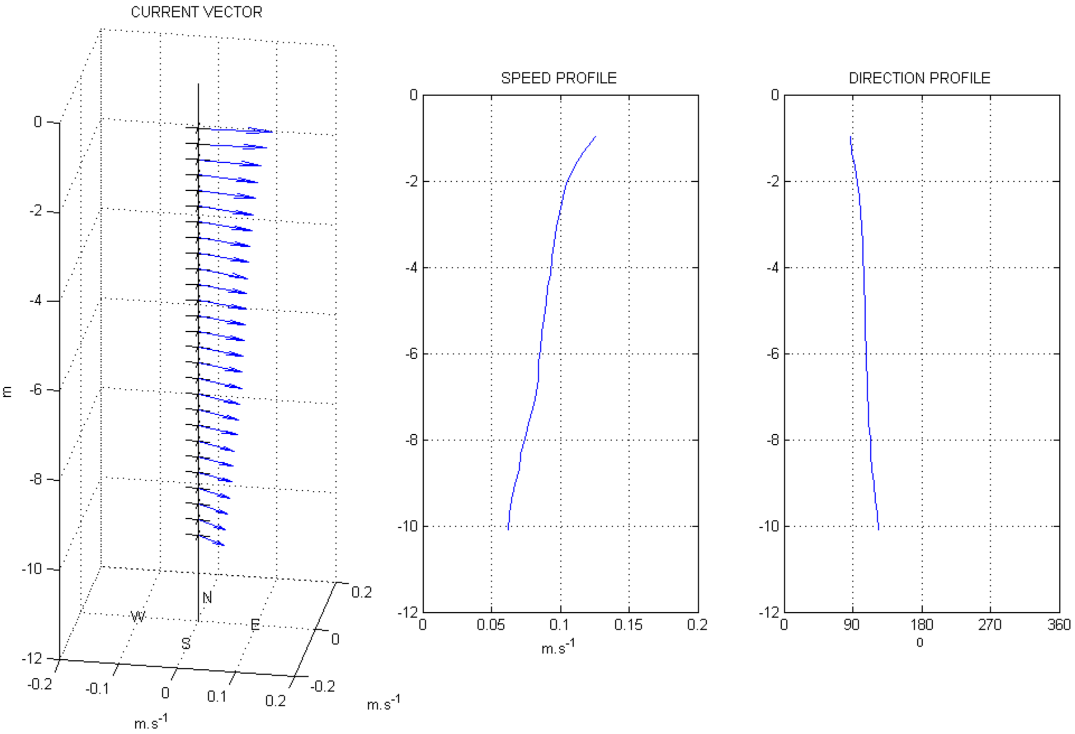


Figure 31: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.16ms^{-1}, decreasing to ~0.08ms^{-1} at ~10m depth. The flow throughout the water column was predominantly from the East. Average wave parameters of ~2m, ~8s and ~182^{o} were recorded for Hs, Tp and Dp respectively.

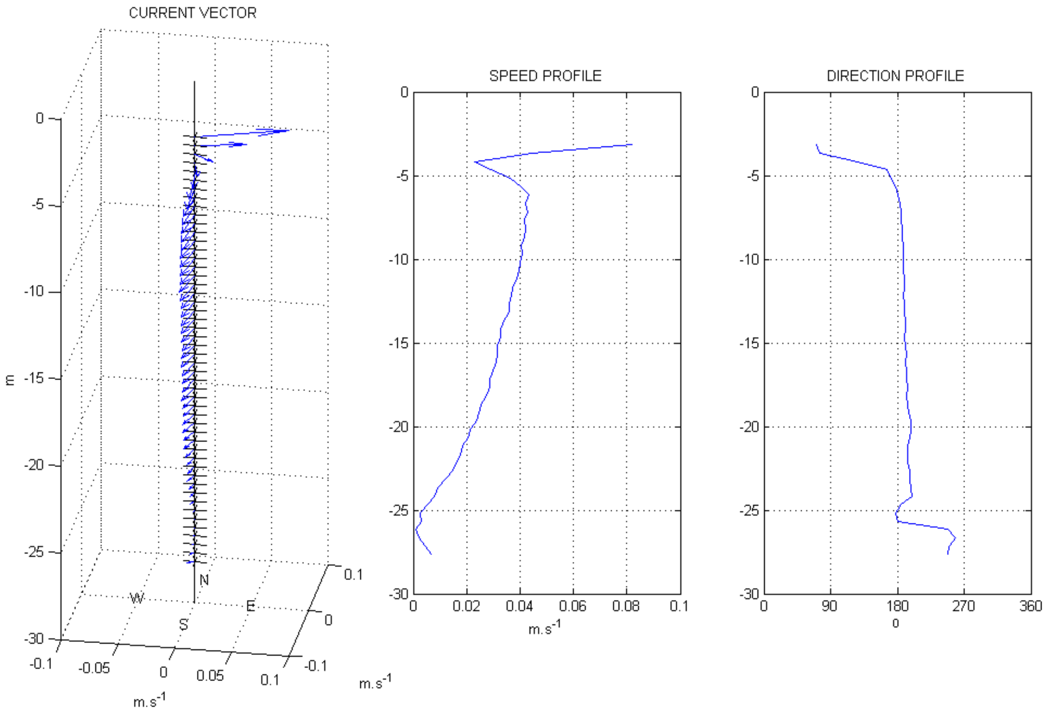


Figure 32: Mean profile plot for 30m ADCP.

The average surface flow for the 30m ADCP was 0.12ms^{-1}, decreasing to ~0.04ms^{-1} at ~27m depth. Average wave parameters of ~3m, ~13s and ~217^{o} were recorded for Hs, Tp and Dp respectively.

Figure 30 shows the temperature sensors on board the 30m ADCP and surface RBR logger recorded reasonably similar values during the deployment period. It is believed that the ~3^{o}C difference between the temperatures measured by the 10m ADCP and the 8m RBR logger is erroneous. This would be due to the failure of the temperature sensor on the 10m ADCP.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT FIVE

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1. RECOVERY Site Name: Bantamsklip 10m Site Date: 6 Nov 2008.

Instrument type and serial number			RDI	10117
Recovery date and time	LT	GMT	**Nov 6th 2008**	
Latitude **(do not ignore – if same, please indicate)**			34 43.105	
Longitude **(do not ignore – if same, please indicate)**			19 33.391	
Switch off date and time	LT	GMT		
File size				
Was the data copied to memory card?			Y	N

2. **RE-DEPLOYMENT Site Name: Bantamsklip 10 m site Date 5 Nov 2008**

Instrument type and serial number (do not ignore – if same, please indicate)			RDI	**10105**
Install a new battery and/or check the voltage				**1*44.8V**
Frequency of unit being used			**600kHz**	
Depth range			**10m**	
Number of bins (calculated automatically)			**42**	
Bin Size (calculated automatically)			**0.35**	
Wave burst duration			**41min**	
Time between wave bursts			**60min**	
Pings per ensemble			**500**	
Ensemble interval			**10min**	
Deployment duration			**15days**	
Transducer depth			**10m**	
Any other commands			**minTP,RI0**	
Temperature			**5**	
Recorder size	**1256MB**			

Consequences of the sampling parameters

First and last bin range			**1.41**	**15.76**
Battery usage				**440Wh**
Standard deviation				**1.08**
Storage space required				**133MB**
Set the ADCP clock	LT	GMT	**4 Nov 2008 19.58**	
Run pre-deployment tests				
Name the ADCP deployment			**B1011**	

Deployment details

Switch on date and time	LT	GMT	**4 Nov 2008 19.58**
Deployment date and time	LT	GMT	**5 Nov 2008 10:20**
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43 148**
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.398**

Site depth	10m	Deployment depth	**10m**
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)	**B1011**		

30m ADCP.

1. RECOVERY Site Name: Batams 30m Date: 27 Sept 2008 .

Instrument type and serial number			RDI	10119
Recovery date and time	LT	GMT	**27 Sept 2008 10:20**	
Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Longitude **(do not ignore – if same, please indicate)**			19 30.6355	
Switch off date and time	LT	GMT		
File size				
Was the data copied to memory card?			Y	N

2. **RE-DEPLOYMENT Site Name: Bantamsklip 30m site Date 1 Nov 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**10841**
Install a new battery and/or check the voltage		**1*44.8V**
Frequency of unit being used	**600kHz**	
Depth range	**30m**	
Number of bins (calculated automatically)	**69**	
Bin Size (calculated automatically)	**0.5**	
Wave burst duration	**34min**	
Time between wave bursts	**60min**	
Pings per ensemble	**250**	
Ensemble interval	**10min**	
Deployment duration	**15days**	
Transducer depth	**30m**	
Any other commands	**minTP,RI0**	
Temperature	**5**	
Recorder size	**1256MB**	

Consequences of the sampling parameters

First and last bin range		**1.6**	**35.6**
Battery usage			**447Wh**
Standard deviation			**1.08**
Storage space required			**112MB**
Set the ADCP clock	LT	GMT	**1 Nov 2008 08:00**
Run pre-deployment tests			
Name the ADCP deployment			**B3111**

Deployment details

Switch on date and time	LT	GMT	**1 Nov 2008 08:00**
Deployment date and time	LT	GMT	**1Nov 2008 14.10**
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.625
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.635

Site depth	30m	Deployment depth		**30m**
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**B3111**	

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

1. RECOVERY Site Name: Bantams Date: 27 Sep 2008 .

Instrument type and serial number			RBR	12994
Recovery date and time	LT	GMT		
Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Longitude **(do not ignore – if same, please indicate)**			19 30.635	
Switch off date and time	LT	GMT		
File size				
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)				

2. RE-DEPLOYMENT Site Name: Banatamsklip Date: 1 Nov 2008 .

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	1 Nov 2008	06:37:10
End of logging (date / time)	10 Dec 2008	12:00:00
Memory usage		.4%
Battery usage		997mAH

Deployment details

Deployment date and time	LT	GMT	1 Nov 2008 13:36	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.635	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			8m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			**012994_01112008**	

Bottom.

1. RECOVERY Site Name: Bantams Date: 27 Sep 2008 .

Instrument type and serial number			RBR	12998
Recovery date and time	LT	GMT		
Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Longitude **(do not ignore – if same, please indicate)**			19 30.635	
Switch off date and time	LT	GMT		
File size				
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			RBR LOST	

2. RE-DEPLOYMENT Site Name: Banatamsklip Date: 1 Nov 2008.

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.0V

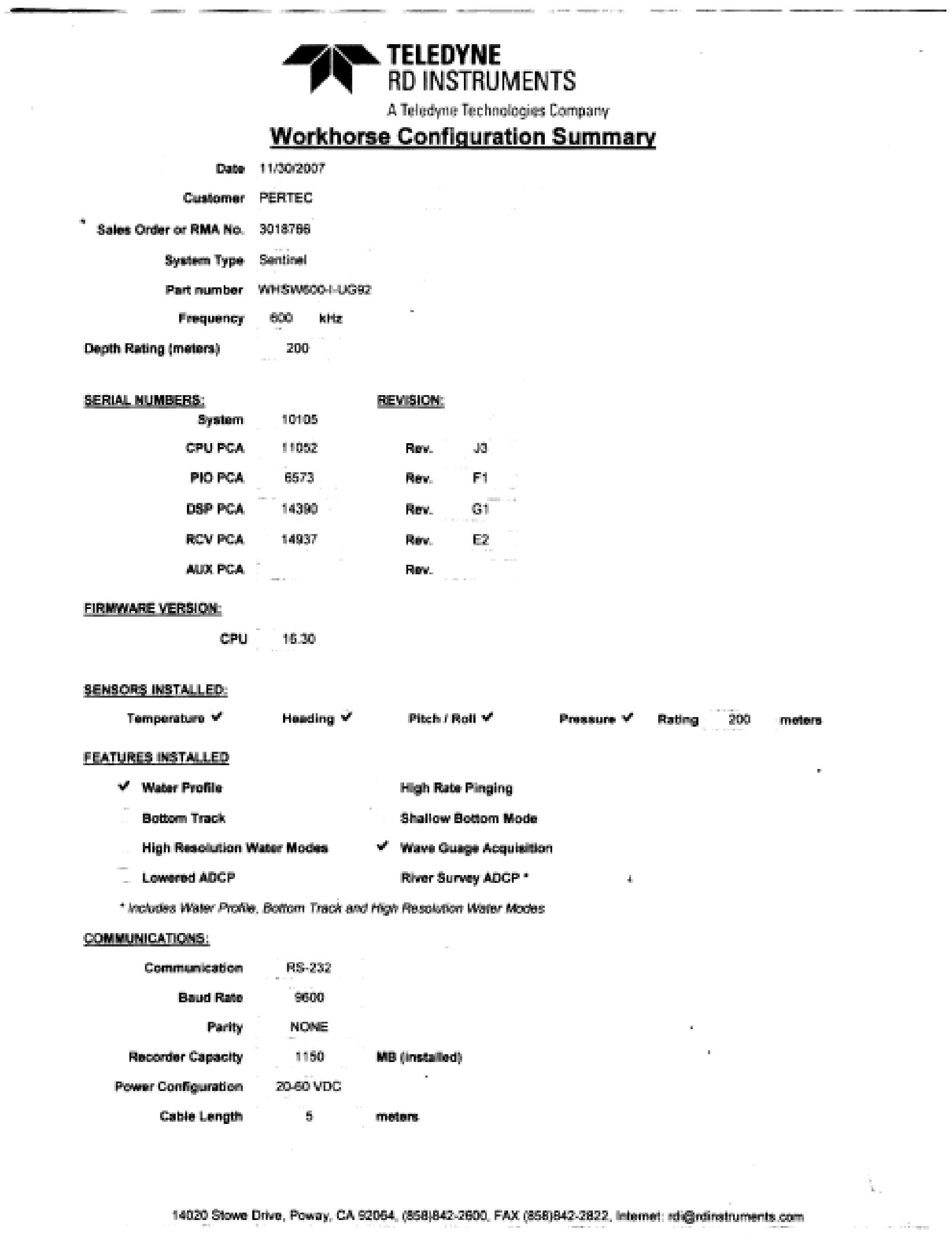
Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	1 Nov 2008	06:41:00
End of logging (date / time)	10 Dec 2008	12:00:00
Memory usage		.4%
Battery usage		997mAH

Deployment details

Deployment date and time	LT	GMT	1 Nov 2008 14.10	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.635	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			30m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			**015248_01112008**	

7.3 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007

Customer PERTEC

Sales Order or RMA No. 3018786

System Type Sentinel

Part number WHSW600-I-UG92

Frequency 600 kHz

Depth Rating (meters) 200

SERIAL NUMBERS:		**REVISION:**	
System	10105		
CPU PCA	11052	**Rev.**	J3
PIO PCA	6573	**Rev.**	F1
DSP PCA	14390	**Rev.**	G1
RCV PCA	14937	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

✓	**Water Profile**		**High Rate Pinging**
	Bottom Track		**Shallow Bottom Mode**
	High Resolution Water Modes	✓	**Wave Guage Acquisition**
	Lowered ADCP		**River Survey ADCP ***

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232

Baud Rate 9600

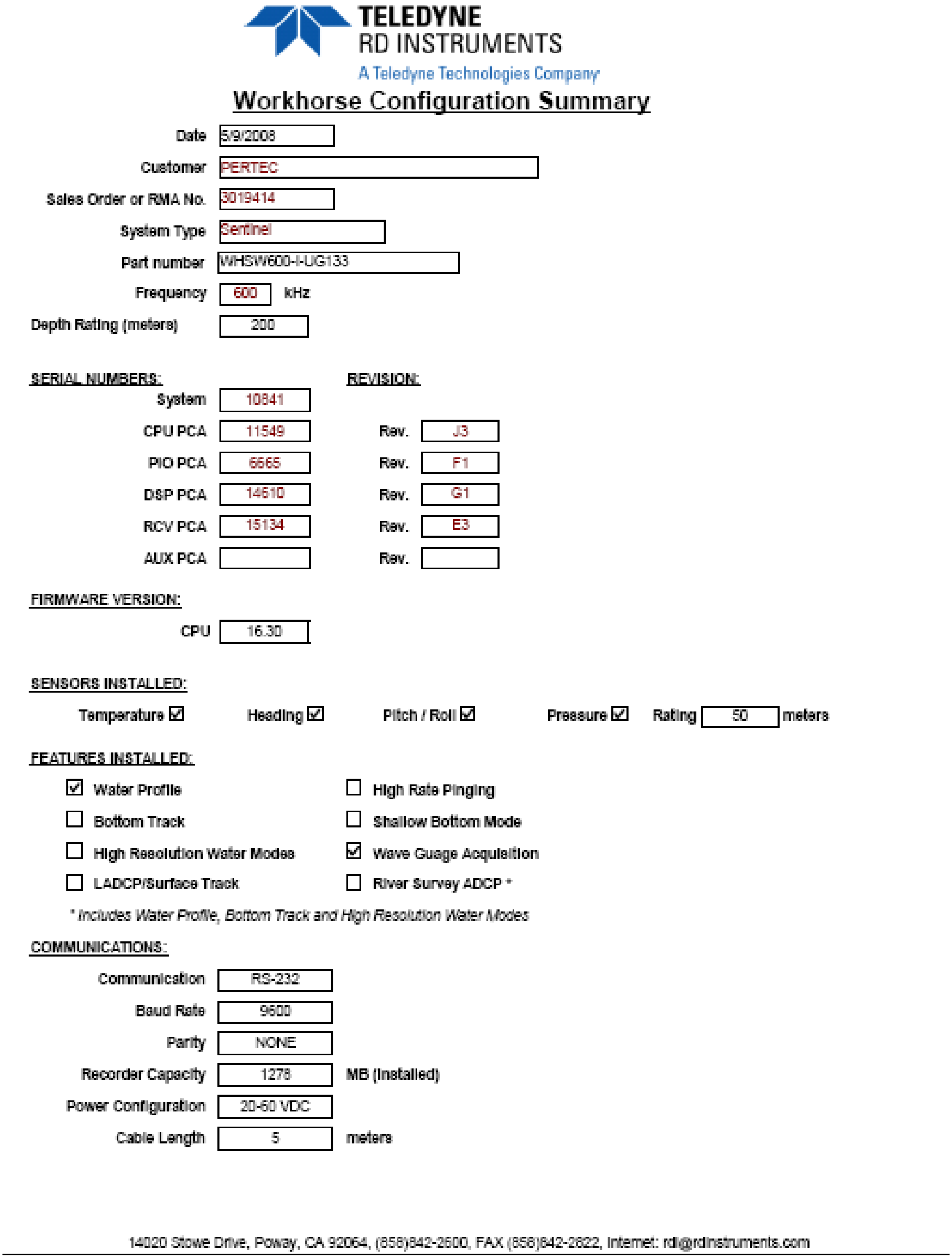
Parity NONE

Recorder Capacity 1150 **MB (installed)**

Power Configuration 20-60 VDC

Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date	5/9/2008
Customer	PERTEC
Sales Order or RMA No.	3019414
System Type	Sentinel
Part number	WHSW600-I-UG133
Frequency	600 kHz
Depth Rating (meters)	200

SERIAL NUMBERS:		REVISION:	
System	10841		
CPU PCA	11549	Rev.	J3
PIO PCA	6665	Rev.	F1
DSP PCA	14610	Rev.	G1
RCV PCA	15134	Rev.	E3
AUX PCA		Rev.	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ☑ Heading ☑ Pitch / Roll ☑ Pressure ☑ Rating 50 meters

FEATURES INSTALLED:

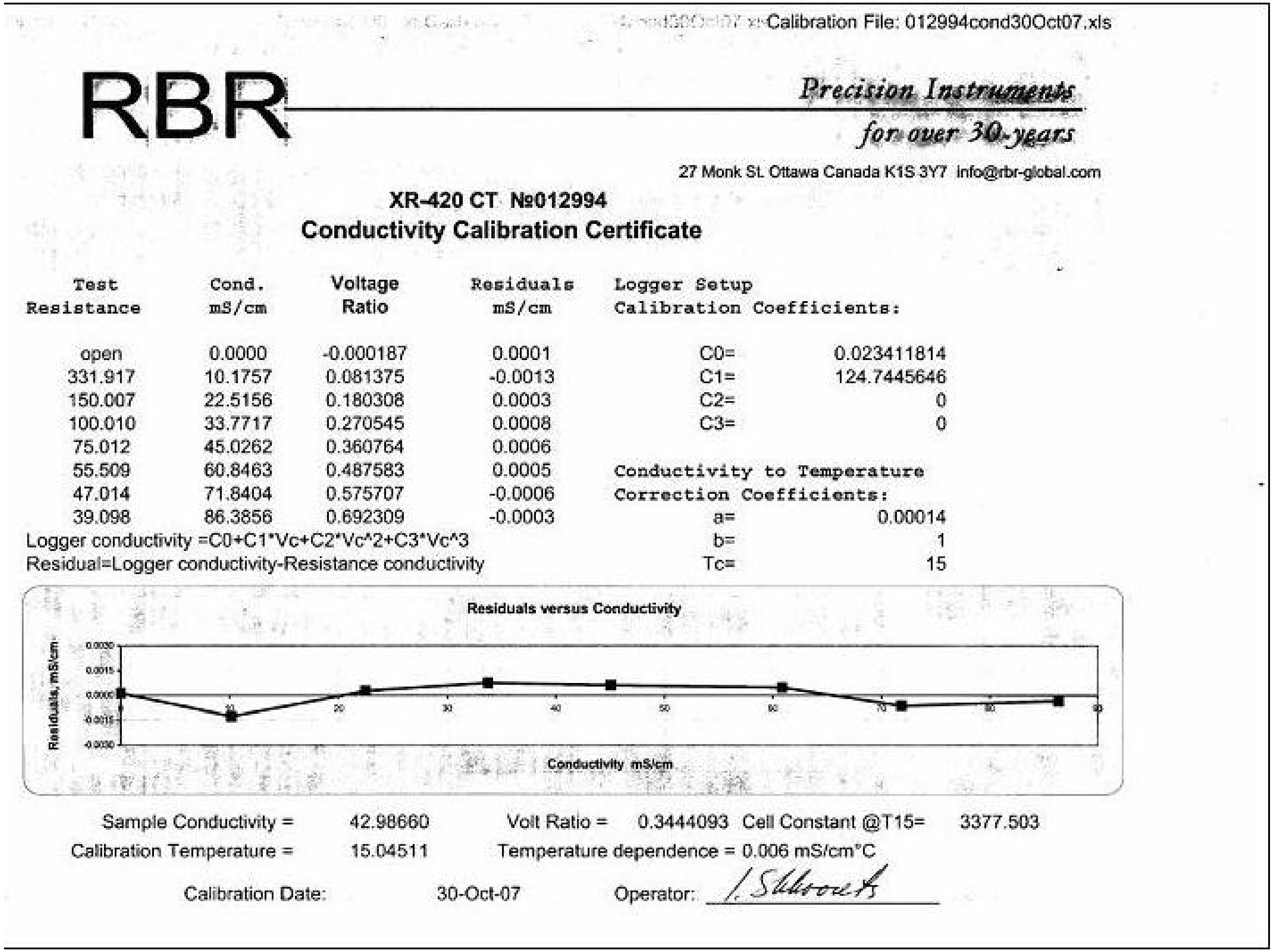
☑ Water Profile
☐ Bottom Track
☐ High Resolution Water Modes
☐ LADCP/Surface Track
☐ High Rate Pinging
☐ Shallow Bottom Mode
☑ Wave Guage Acquisition
☐ River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication	RS-232
Baud Rate	9600
Parity	NONE
Recorder Capacity	1278 MB (Installed)
Power Configuration	20-60 VDC
Cable Length	5 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2622, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994

Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

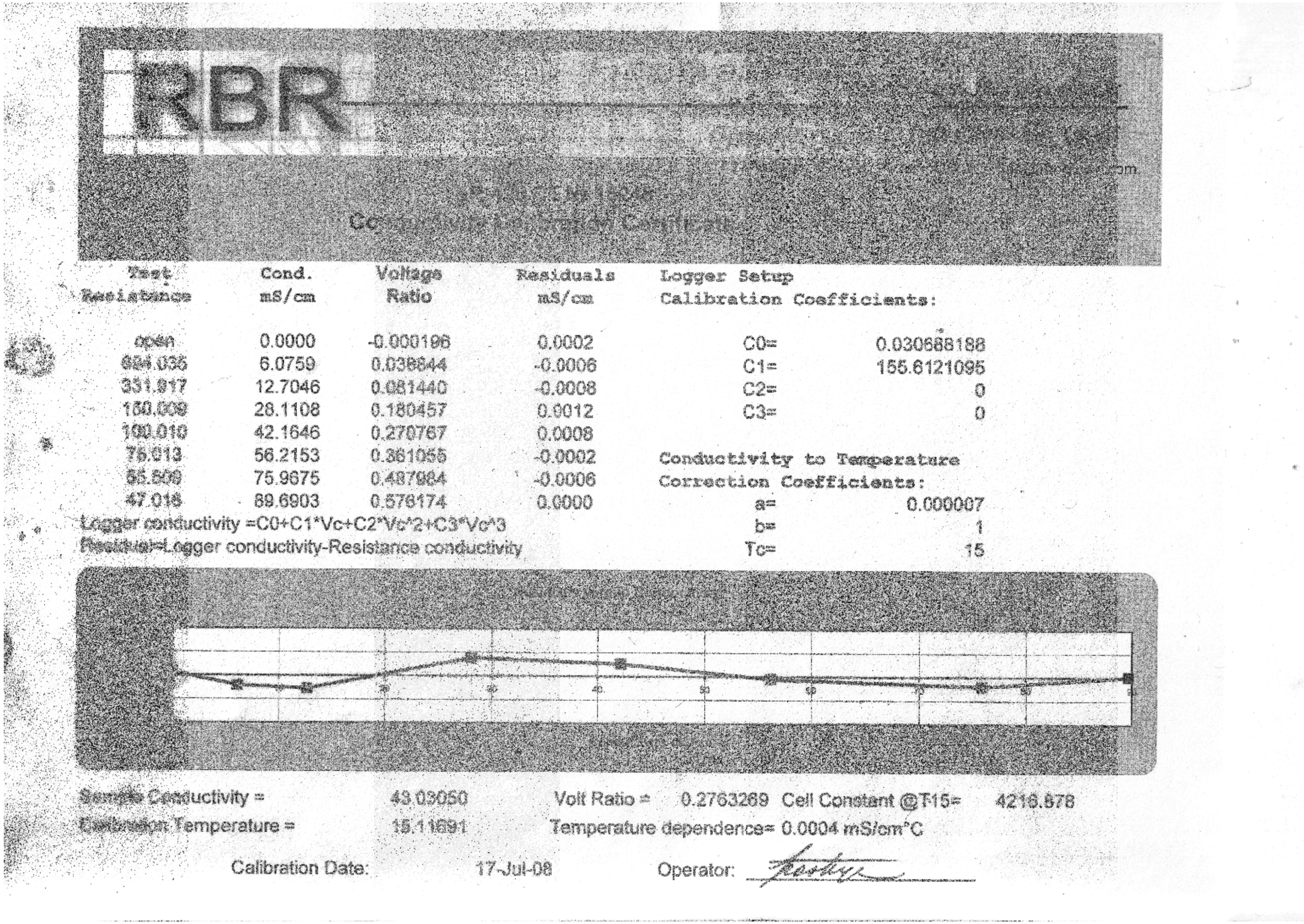
a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

Sample Conductivity = 42.98660 Volt Ratio = 0.3444093 Cell Constant @T15= 3377.503

Calibration Temperature = 15.04511 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07 Operator:



RBR

Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000196	0.0002
694.035	6.0759	0.038844	-0.0006
331.917	12.7046	0.081440	-0.0008
150.009	28.1108	0.180457	0.0012
100.010	42.1646	0.270767	0.0008
75.013	56.2153	0.361055	-0.0002
55.509	75.9675	0.487984	-0.0006
47.016	89.6903	0.576174	0.0000

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.030688188
C1= 155.6121095
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.000007
b= 1
Tc= 15

Sample Conductivity = 43.03050

Calibration Temperature = 15.11691

Volt Ratio = 0.2763269

Cell Constant @T15= 4216.878

Temperature dependence= 0.0004 mS/cm°C

Calibration Date: 17-Jul-08

Operator:

7.4 ADCP CONFIGURATION FILES

10m ADCP.

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 2000
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 133.83 MB (140329440 bytes)
;Power usage         = 440.26 Wh
;Battery usage       = 1.0
;Samples / Wv Burst = 4920
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
```

```
;Bytes / Wave Burst = 383840
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP.

```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP2400
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1256
;Saved Screen        = 3
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.60 m
;Last cell range     = 35.60 m
;Max range           = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size       = 1534 bytes
;Storage required    = 67.46 MB (70734240 bytes)
```

```
;Power usage        = 321.01 Wh
;Battery usage      = 0.7
;Samples / Wv Burst = 2400
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 187280
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

8. REPORTS FROM THE CSIR

The reports from the CSIR are attached as an appendage.

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2861

Report Number: MALR2861

13 November 2008

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Craig Matthysen

CHEMICAL ANALYSIS: Water samples (Order No.:)
Samples received: 11/11/08
Analysis completed: 12/11/08
Sample description: Seawater in sealed plastic bottles.

Lab No	Sample Id	* Total Suspended Solids in mg/L
34926	**S1**	*5*
34927	**S2**	*2*
34928	**S3**	*3*
34929	**S4**	*<2*
34930	**S5**	*<2*
34931	**S6**	*6*
34932	**S7**	*3*
34933	**S8**	*2*
34934	**S9**	*<2*
34935	**S10**	*5*

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT SIX

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

9 February 2009

Job No: LT-JOB-50

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 6 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-10.9	100.00	0.0962	0.0408	0.0197	0.0291	12.79
-10.6	100.00	0.1094	0.0386	0.0190	0.0239	11.23
-10.2	100.00	0.1077	0.0378	0.0184	0.0191	13.32
-9.9	100.00	0.1072	0.0372	0.0187	0.0162	16.22
-9.5	100.00	0.1244	0.0362	0.0191	0.0121	16.85
-9.2	100.00	0.1405	0.0368	0.0188	0.0099	22.03
-8.8	100.00	0.1440	0.0369	0.0201	0.0081	26.10
-8.5	100.00	0.1634	0.0371	0.0208	0.0073	39.71
-8.1	100.00	0.1686	0.0371	0.0203	0.0078	56.13
-7.8	100.00	0.1977	0.0373	0.0204	0.0076	65.26
-7.4	100.00	0.1742	0.0375	0.0205	0.0071	86.42
-7.1	100.00	0.2030	0.0379	0.0214	0.0075	94.68
-6.7	100.00	0.2009	0.0383	0.0224	0.0070	102.11
-6.4	100.00	0.2218	0.0403	0.0234	0.0055	112.28
-6.0	100.00	0.2140	0.0420	0.0254	0.0054	122.82
-5.7	100.00	0.2413	0.0439	0.0269	0.0052	136.41
-5.3	100.00	0.2303	0.0458	0.0280	0.0060	148.54
-5.0	100.00	0.2597	0.0481	0.0287	0.0051	153.29
-4.6	100.00	0.2575	0.0503	0.0298	0.0058	166.27
-4.3	100.00	0.2576	0.0520	0.0292	0.0073	181.54
-3.9	100.00	0.2644	0.0540	0.0299	0.0088	184.35
-3.6	100.00	0.2315	0.0581	0.0314	0.0108	193.17
-3.2	100.00	0.2312	0.0614	0.0327	0.0120	199.53
-2.9	100.00	0.2184	0.0650	0.0344	0.0140	199.16
-2.5	100.00	0.1903	0.0681	0.0356	0.0146	204.45
-2.2	100.00	0.2031	0.0709	0.0377	0.0138	209.02
-1.8	100.00	0.2083	0.0756	0.0407	0.0036	304.26
-1.5	100.00	0.2250	0.0911	0.0453	0.0319	353.84
-1.1	88.10	0.3564	0.1109	0.0600	0.0530	342.13

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	91.22	2.51	0.63	1.43	0.49
Tp (s)	91.22	15.00	4.20	10.05	1.81
Dp (°)	91.22	246.55	165.55	201.48	11.38

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-27.5	99.96	0.1653	0.0414	0.0265	0.0130	132.02
-27.0	100.00	0.1840	0.0464	0.0301	0.0155	133.99
-26.5	100.00	0.2027	0.0512	0.0334	0.0182	132.98
-26.0	100.00	0.2299	0.0554	0.0361	0.0202	130.66
-25.5	100.00	0.2260	0.0600	0.0381	0.0227	126.98
-25.0	100.00	0.2222	0.0639	0.0397	0.0246	124.15
-24.5	100.00	0.3302	0.0669	0.0404	0.0260	120.90
-24.0	100.00	0.4361	0.0703	0.0419	0.0275	116.90
-23.5	100.00	0.4764	0.0722	0.0425	0.0287	115.17
-23.0	100.00	0.4998	0.0742	0.0432	0.0291	113.18
-22.5	100.00	0.5424	0.0758	0.0439	0.0290	111.65
-22.0	100.00	0.5456	0.0773	0.0445	0.0288	109.49
-21.5	100.00	0.5416	0.0781	0.0450	0.0284	107.03
-21.0	100.00	0.5624	0.0789	0.0457	0.0276	104.32
-20.5	100.00	0.6015	0.0794	0.0464	0.0262	102.67
-20.0	100.00	0.6064	0.0799	0.0471	0.0243	101.14
-19.5	100.00	0.6768	0.0805	0.0482	0.0229	99.21
-19.0	100.00	0.6588	0.0820	0.0484	0.0208	95.98
-18.5	100.00	0.6921	0.0836	0.0490	0.0181	93.99
-18.0	100.00	0.6630	0.0858	0.0493	0.0159	90.44
-17.5	100.00	0.6114	0.0880	0.0496	0.0125	85.43
-17.0	100.00	0.6127	0.0903	0.0497	0.0081	78.44
-16.5	100.00	0.6125	0.0918	0.0504	0.0061	62.96
-16.0	100.00	0.5507	0.0929	0.0507	0.0045	47.82
-15.5	100.00	0.5013	0.0943	0.0514	0.0038	6.44
-15.0	100.00	0.5114	0.0952	0.0519	0.0043	332.13
-14.5	100.00	0.5147	0.0964	0.0527	0.0060	314.20
-14.0	100.00	0.5006	0.0974	0.0530	0.0077	301.20
-13.5	100.00	0.4355	0.0987	0.0537	0.0094	291.03
-13.0	100.00	0.3940	0.0995	0.0537	0.0117	282.41
-12.5	100.00	0.3475	0.1009	0.0536	0.0137	278.19
-12.0	100.00	0.3389	0.1008	0.0534	0.0163	274.21
-11.5	100.00	0.3501	0.1018	0.0533	0.0181	269.79
-11.0	100.00	0.3902	0.1029	0.0534	0.0213	267.54
-10.5	100.00	0.4042	0.1042	0.0535	0.0238	263.90
-10.0	99.96	0.3769	0.1057	0.0546	0.0275	262.63
-9.5	99.96	0.3808	0.1072	0.0552	0.0298	261.59
-9.0	99.96	0.3643	0.1086	0.0562	0.0324	261.55
-8.5	100.00	0.3725	0.1107	0.0578	0.0349	260.26
-8.0	100.00	0.3988	0.1127	0.0592	0.0378	260.25
-7.5	100.00	0.3800	0.1143	0.0607	0.0400	260.95
-7.0	100.00	0.3731	0.1168	0.0621	0.0432	261.75
-6.5	100.00	0.3893	0.1186	0.0631	0.0448	262.96

-6.0	100.00	0.4112	0.1211	0.0648	0.0468	265.41
-5.5	100.00	0.4518	0.1229	0.0664	0.0465	269.75
-5.0	100.00	0.4575	0.1245	0.0670	0.0442	276.39
-4.5	99.89	0.4281	0.1247	0.0664	0.0303	301.08
-4.0	99.92	0.3912	0.1255	0.0654	0.0354	5.48
-3.5	99.81	0.4497	0.1296	0.0663	0.0544	359.25
-3.0	99.58	0.7061	0.1680	0.0891	0.1122	298.67
-2.5	96.47	0.6881	0.2210	0.1043	0.1489	287.87
-2.0	67.93	0.6535	0.2508	0.1090	0.1506	283.87

Table 4 – Waves summary for 30m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	97.98	4.39	0.76	2.07	0.76
Tp (s)	97.98	14.90	4.20	10.45	1.99
Dp (^{o})	97.98	262.57	127.57	195.27	22.85

Table 5 – Water temperature and salinity summary (surface, 8m)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100.00	14.23	16.92	11.16
Conductivity	100.00	42.20	45.12	39.07
Salinity (psu)	100.00	35.03	35.33	34.49

Table 6 – Water temperature and salinity summary (bottom, 30m)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	100.00	12.27	16.52	10.46
Conductivity	100.00	40.34	44.77	38.45
Salinity (psu)	100.00	35.07	35.34	34.92

1.1 DATA RETURN FOR BANTAMSKLIP SITE.

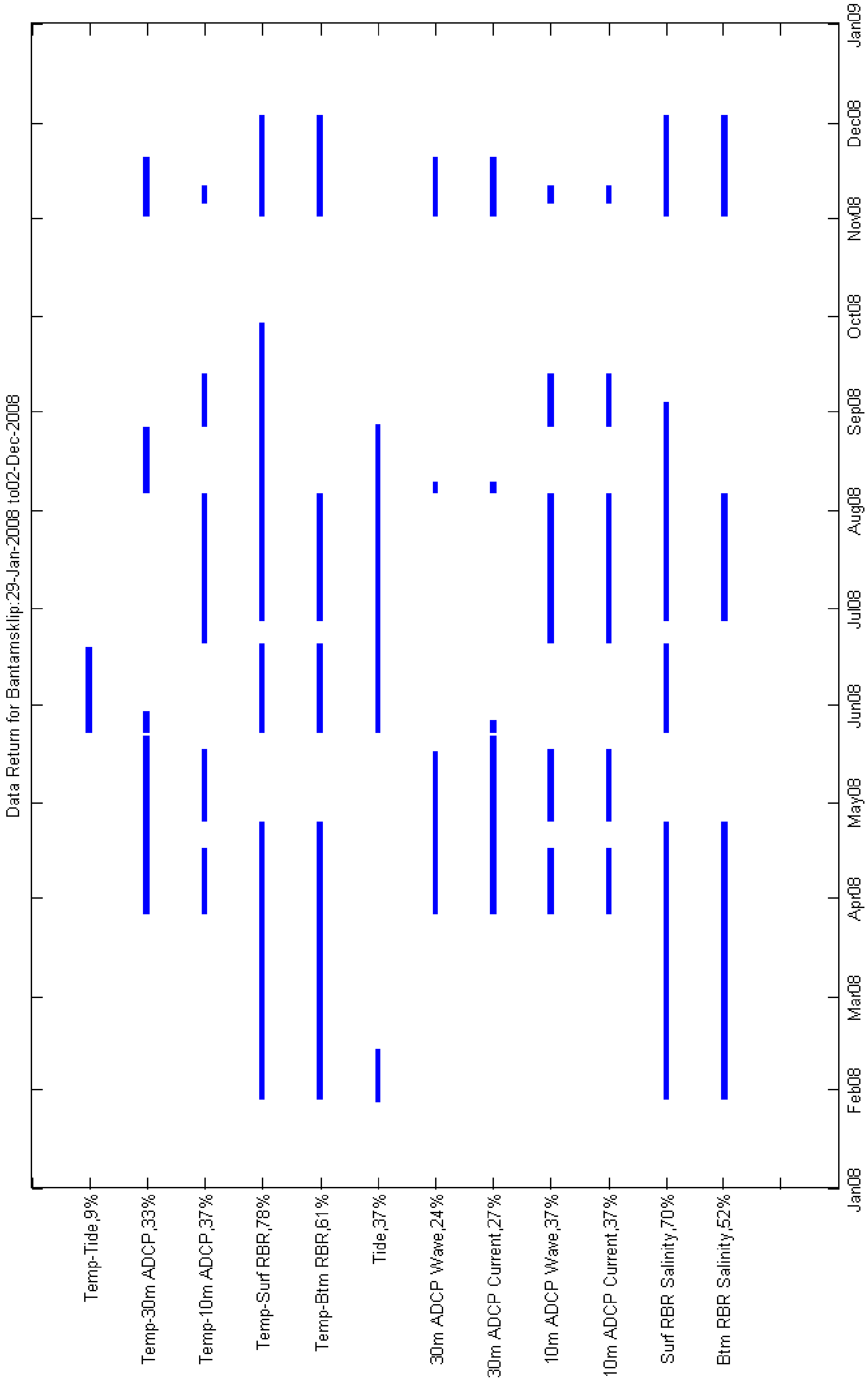


Figure 1: An indication of the data return at the Bantamsklip site since the beginning of the project.

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents currents, waves, temperature and salinity data collected at Bantamsklip station for the period November 1st 2008 – December 2nd 2008 (Period 6). The service visit was undertaken between December 2nd and 5th 2008. Water samples were collected on December 5th.

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 7 for the Bantamsklip site.

Table 7 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The deployment location of the instruments is given in Table 8. Table 9 shows the locations where water samples were taken.

Table 8 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	-	-
10m ADCP	34°43.148’	19°33.398’
Biofouling	34°43.190’	19°33.686’
30m ADCP	34°42.625’	19°30.635’
T&C mooring	34°42.625’	19°30.635’

Table 9 – Locations where water samples were taken during the service

STN #	Lat	Long	SAMPLES type (W,B,G)	Exact Time HH:MM:SS	COMMENTS (if RBR profile is taken etc..)
1	34 42.625	19 30.676	W	10.28	4m
2	34 42.625	19 30.676	W	10.30	12m
3	34 42.625	19 30.676	W	10.33	20m
4	34 42.625	19 30.676	w	10.36	28m
5	34 43.190	19 33.611	W	11.27	4m
6	34 43.161	19 33.591	W	11.30	8m
7	34 43.190	19 33.611	W	11.34	4m
8	34 43.161	19 33.591	W	11.37	4m
9	34 43.124	10 33.584	W	11.39	4m
10	34 43.097	19 33.577	W	11.41	4m
11	34 43.081	19 33.541	W	11.41	4m

3. OPERATIONS

3.1 SUMMARY OF EVENTS

Service visit 6 was undertaken as outlined below.

December 2nd:
Recovery of the 10m ADCP (s/n 10105) and the RBR String (s/n 12994 and 15248) was undertaken.

December 5th:
- Recovery of the 30m ADCP (s/n 10841).
- Redeployment of all instruments: RBR String (s/n 12994 at 8m and s/n 15248 at 30m), 10m ADCP (s/n 10105) and 30m ADCP (s/n 11424).
- Water samples were collected.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 54).

3.2.1 600kHz ADCP

Table 10 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10105
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Table 11 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10841
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

ADCP s/n 11424 was redeployed at the 30m site.

3.2.2 RBR XR420 CT LOGGER

Table 12 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (8m) and s/n 15248 (30m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

3.2.3 RBR TGR2050 HT TIDE GAUGE

Table 13 – Instrument configuration for the Tide Gauge

Parameter	Configuration
TGR 2050 HT	No tide gauge (found lost during SV5)
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.4 Biofouling Mooring

Table 14 – Instrument configuration for Biofouling Mooring Line.

Parameter	Configuration
Biofouling Plates	3 plates (20cmx20cm) at 3m and 3 plates (20cmx20cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed at depth of about 1.5m outside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

4.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 27’ W for the 10m ADCP and 25° 26’ W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 27’ W for the 10m ADCP and 25° 26’ W for the 30m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

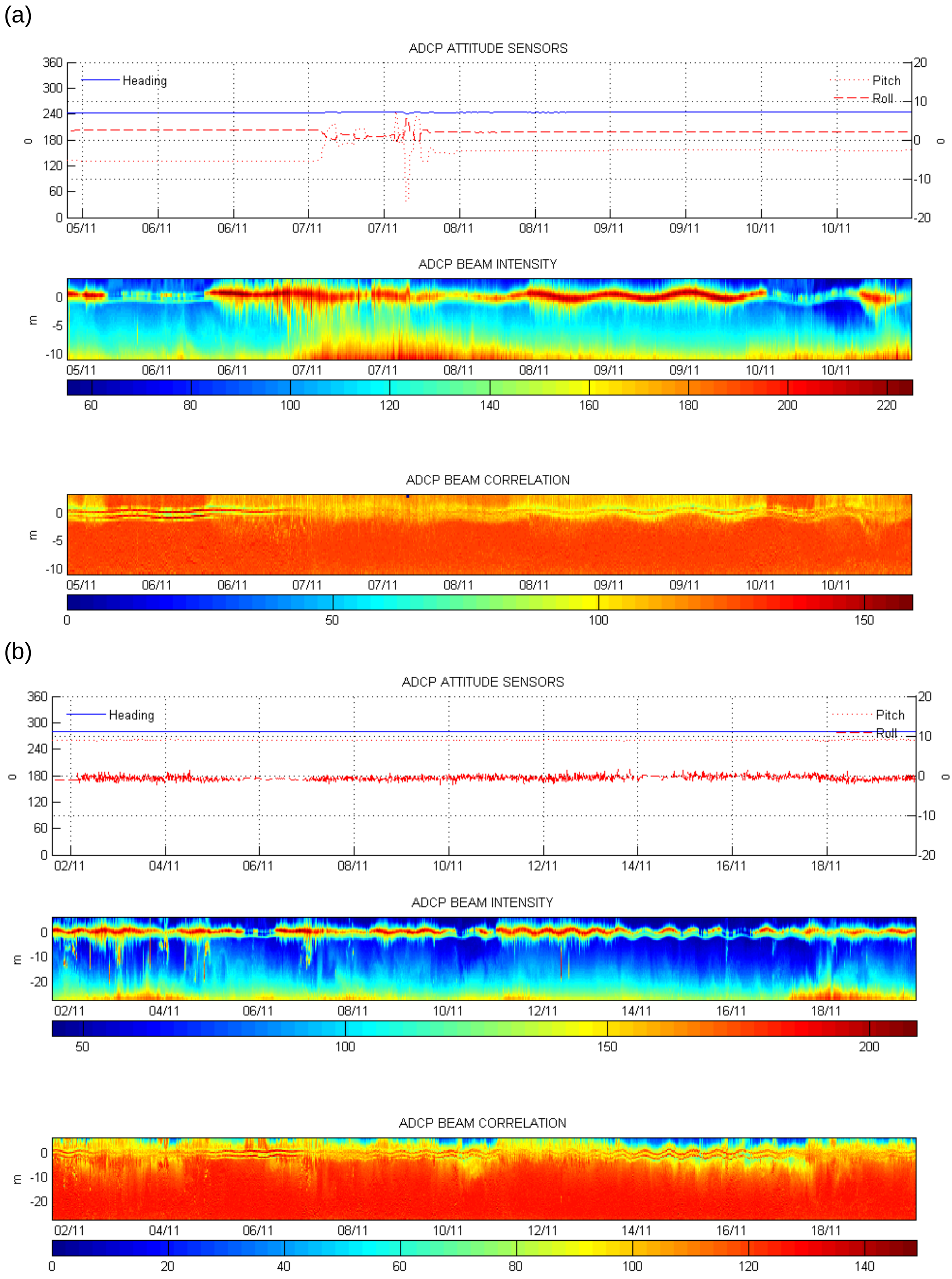


Figure 2: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.

4.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

The tide gauge was found lost during SV5 and will be replaced with a new one.

4.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was not scheduled for service visit 6

4.5 WATER SAMPLE.

Water sample were collected during the first two service visits and sent to the Council for Scientific and Industrial Research (CSIR) for analysis.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 <u>Time series plots</u>

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

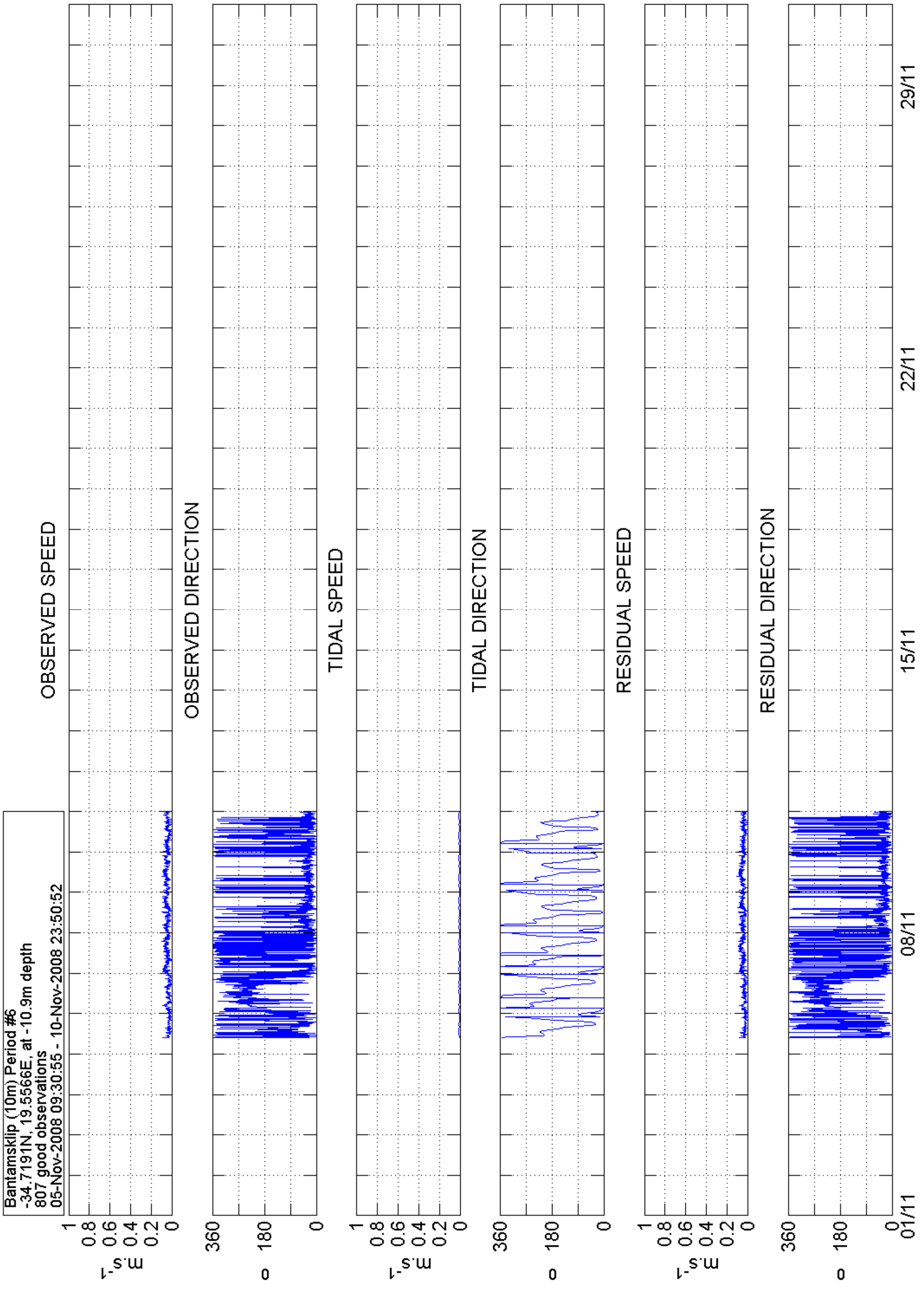


Figure 3: Time series plot for 10m ADCP current data at 10.9m.

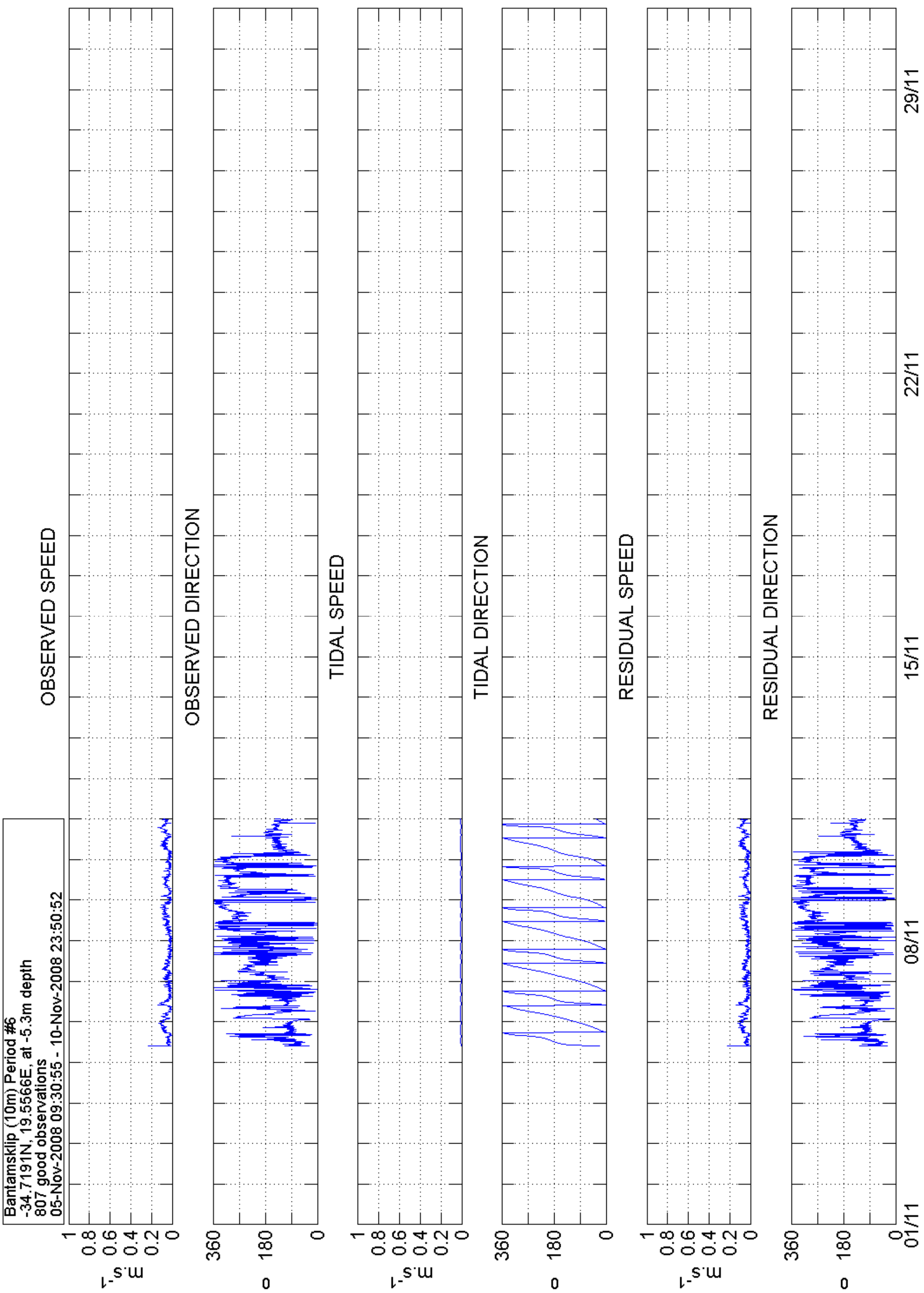


Figure 4: Time series plot for 10m ADCP current data at 5.3m.

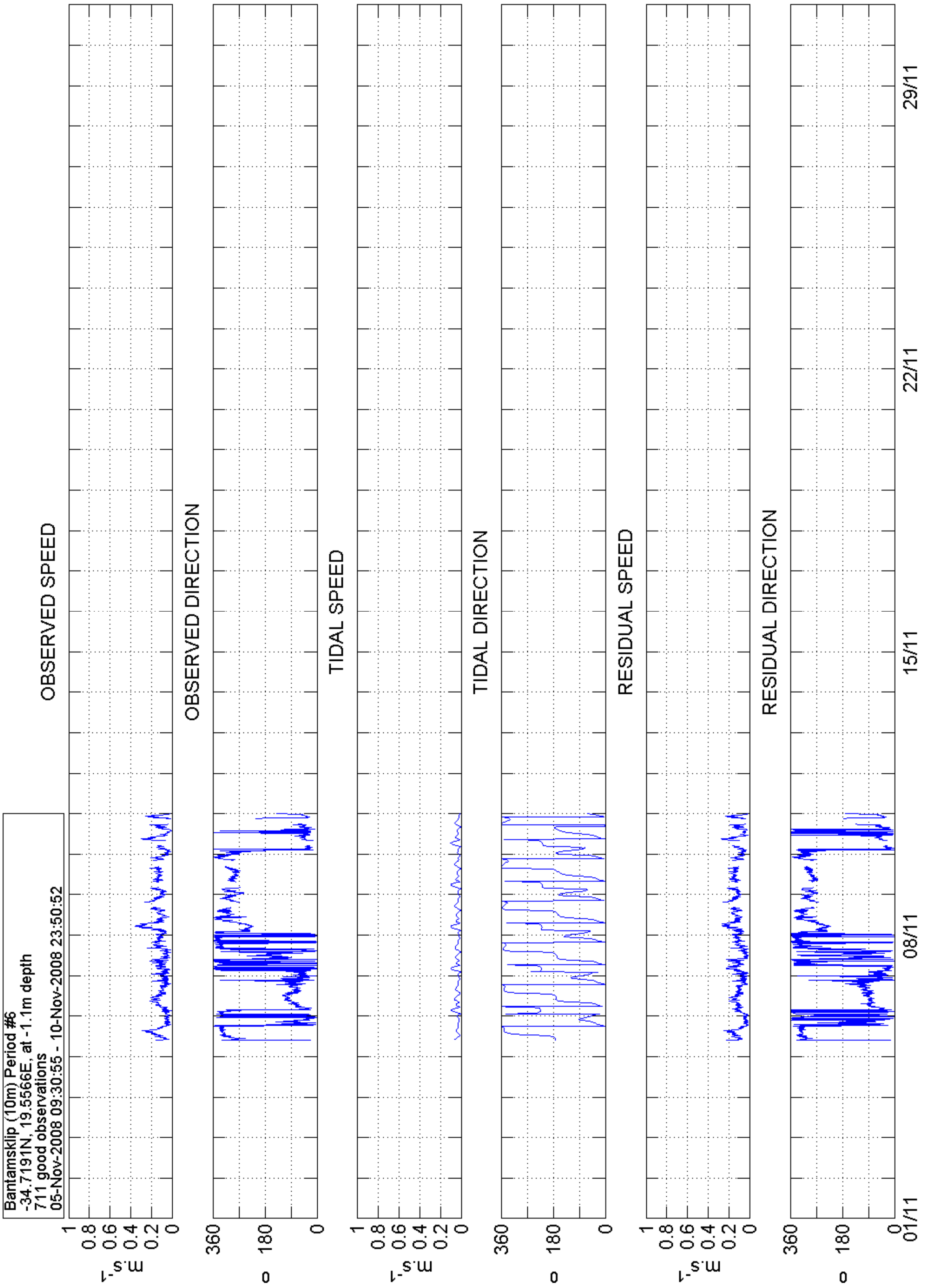


Figure 5: Time series plot for 10m ADCP current data at 1.1m.

5.1.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at -10.9m depth
807 good observations
05-Nov-2008 09:30:55 - 10-Nov-2008 23:50:52

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	20.32	29.37	13.14	4.83	1.98	1.24	1.12	1.73	0.99	1.49	3.10	2.73	2.35	2.60	4.21	8.80	100.00
0.1-0.2																	0.00
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	20.32	29.37	13.14	4.83	1.98	1.24	1.12	1.73	0.99	1.49	3.10	2.73	2.35	2.60	4.21	8.80	100.00

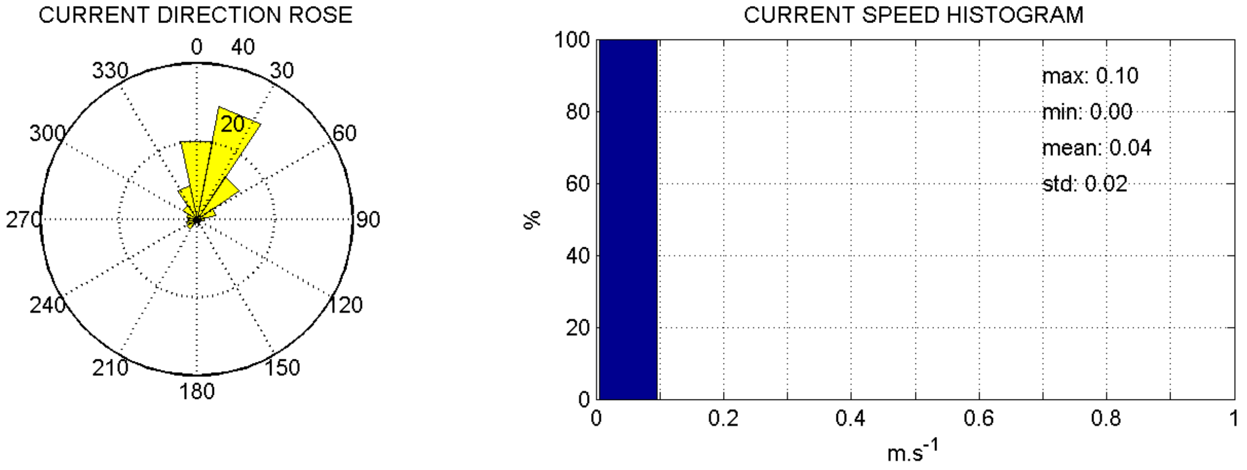


Figure 6: Summary plot for 10m ADCP current data at 10.9m.

Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at -5.3m depth
807 good observations
05-Nov-2008 09:30:55 - 10-Nov-2008 23:50:52

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	4.21	3.72	3.35	4.83	7.06	8.30	8.18	8.05	4.58	5.08	4.34	5.33	8.18	7.31	7.81	5.33	95.66
0.1-0.2				0.12	1.36	0.74	0.74	0.50	0.12			0.12	0.25		0.25		4.21
0.2-0.3			0.12														0.12
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	4.21	3.72	3.47	4.96	8.43	9.05	8.92	8.55	4.71	5.08	4.34	5.45	8.43	7.31	8.05	5.33	100.00

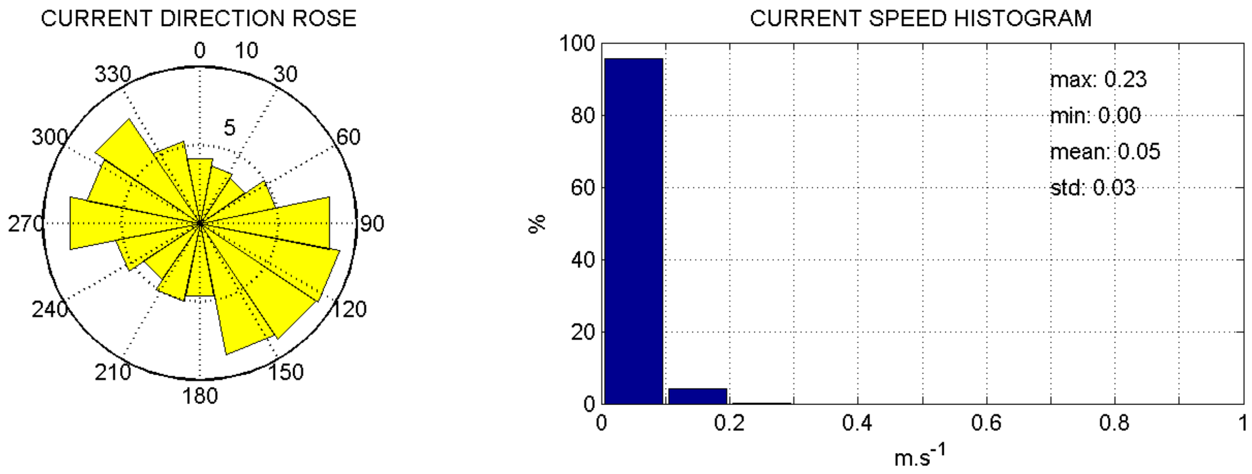


Figure 7: Summary plot for 10m ADCP current data at 5.3m

Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at -1.1m depth
711 good observations
05-Nov-2008 09:30:55 - 10-Nov-2008 23:50:52

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	3.94	5.77	5.34	4.78	2.95	2.25	0.98	0.84	1.13	0.42	0.28	1.13	2.95	4.36	4.64	4.36	46.13
0.1-0.2	5.91	2.25	4.50	3.23	2.67	1.97		0.14			0.56	0.84	3.38	7.03	7.31	6.89	46.69
0.2-0.3	0.28		1.55	0.14	0.28						0.84	0.70	0.70	0.42	1.13	0.42	6.47
0.3-0.4											0.42	0.28					0.70
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	10.13	8.02	11.39	8.16	5.91	4.22	0.98	0.98	1.13	0.42	2.11	2.95	7.03	11.81	13.08	11.67	100.00

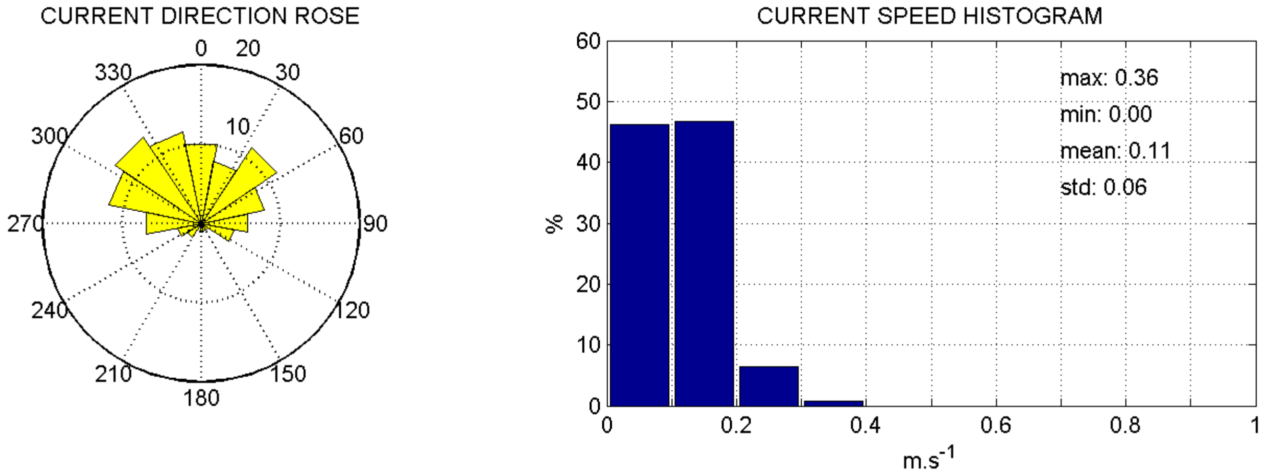


Figure 8: Summary plot for 10m ADCP current data at 1.1m.

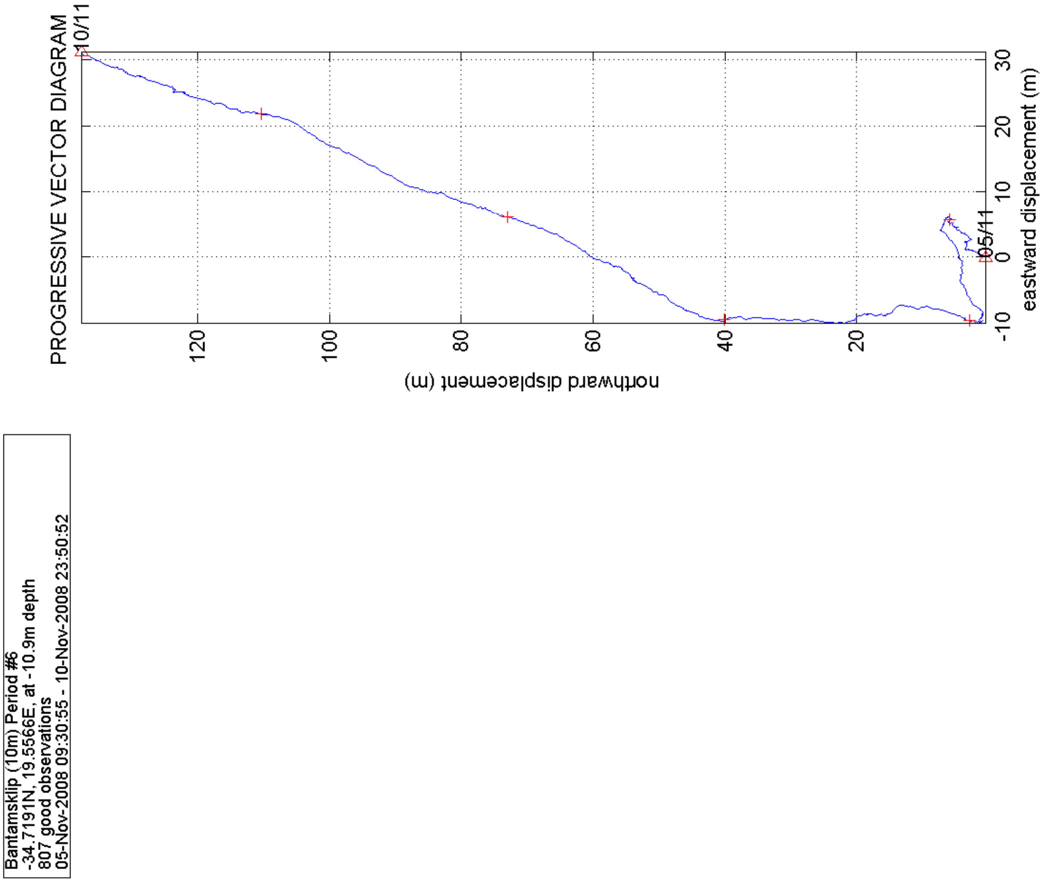


Figure 9: Progressive vector plot for 10m ADCP current data at 10.9m.

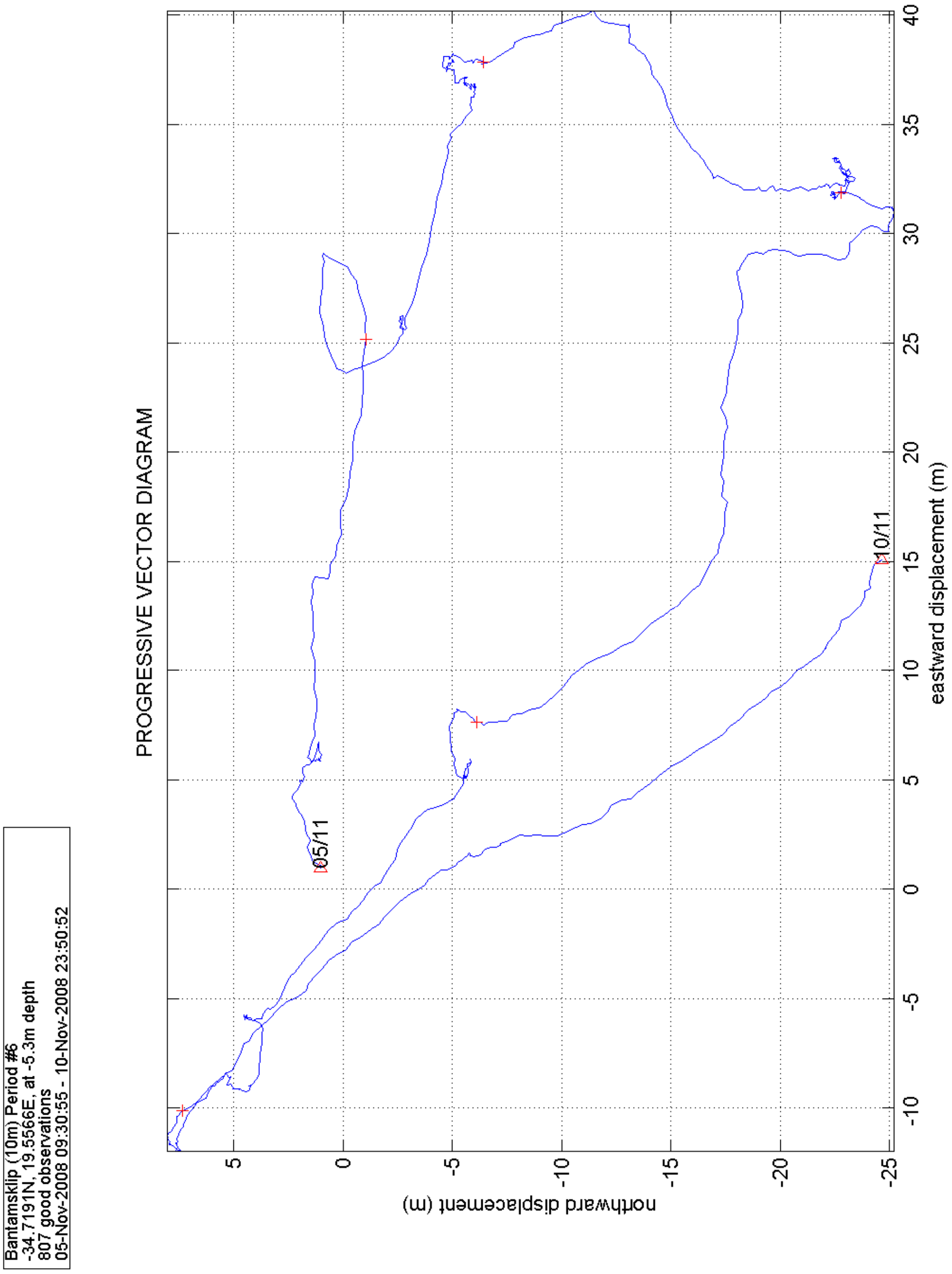


Figure 10: Progressive vector plot for 10m ADCP current data at 5.3m.

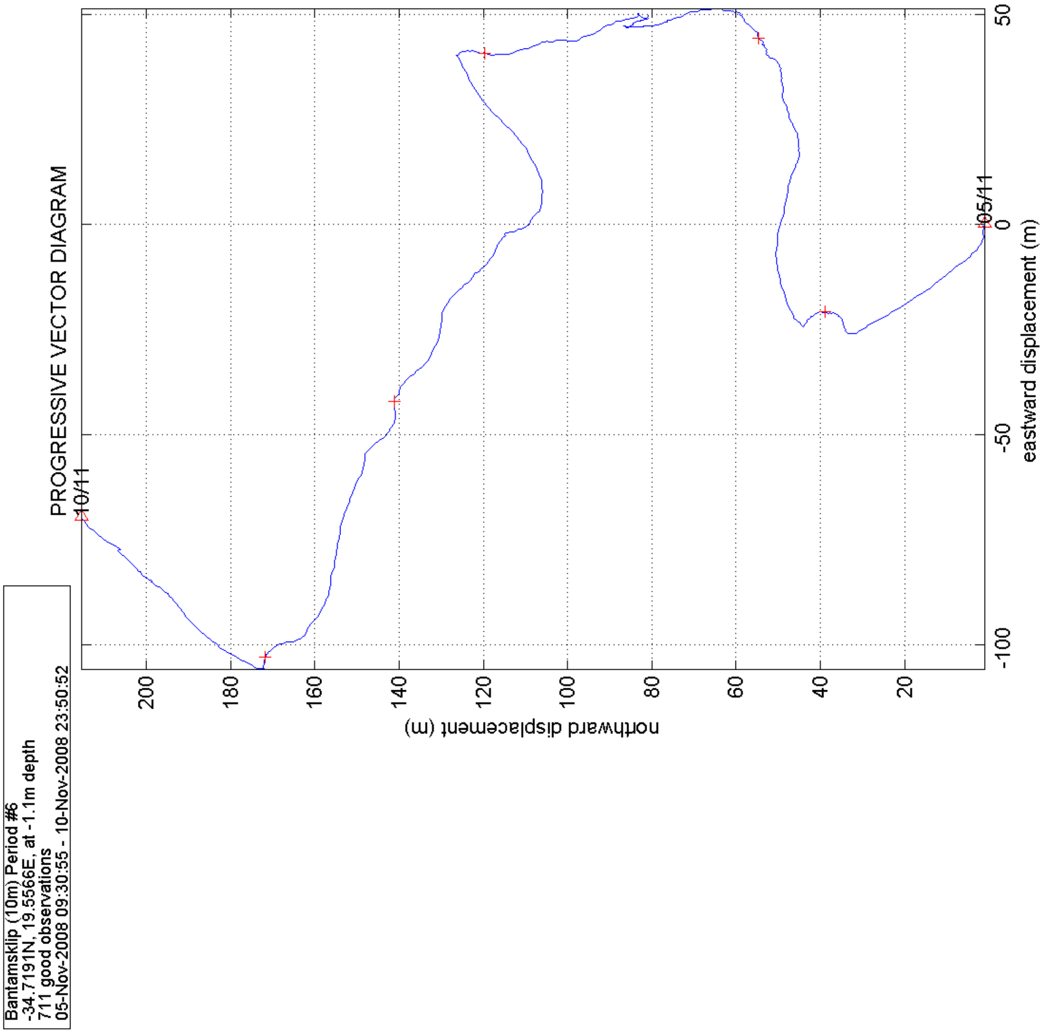


Figure 11: Progressive vector plot for 10m ADCP current data at 1.1m.

5.1.2 Wave Data.

5.1.2.1 Hs and Tp summary plot

Figure 12 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.2 Hs and Dp summary plot

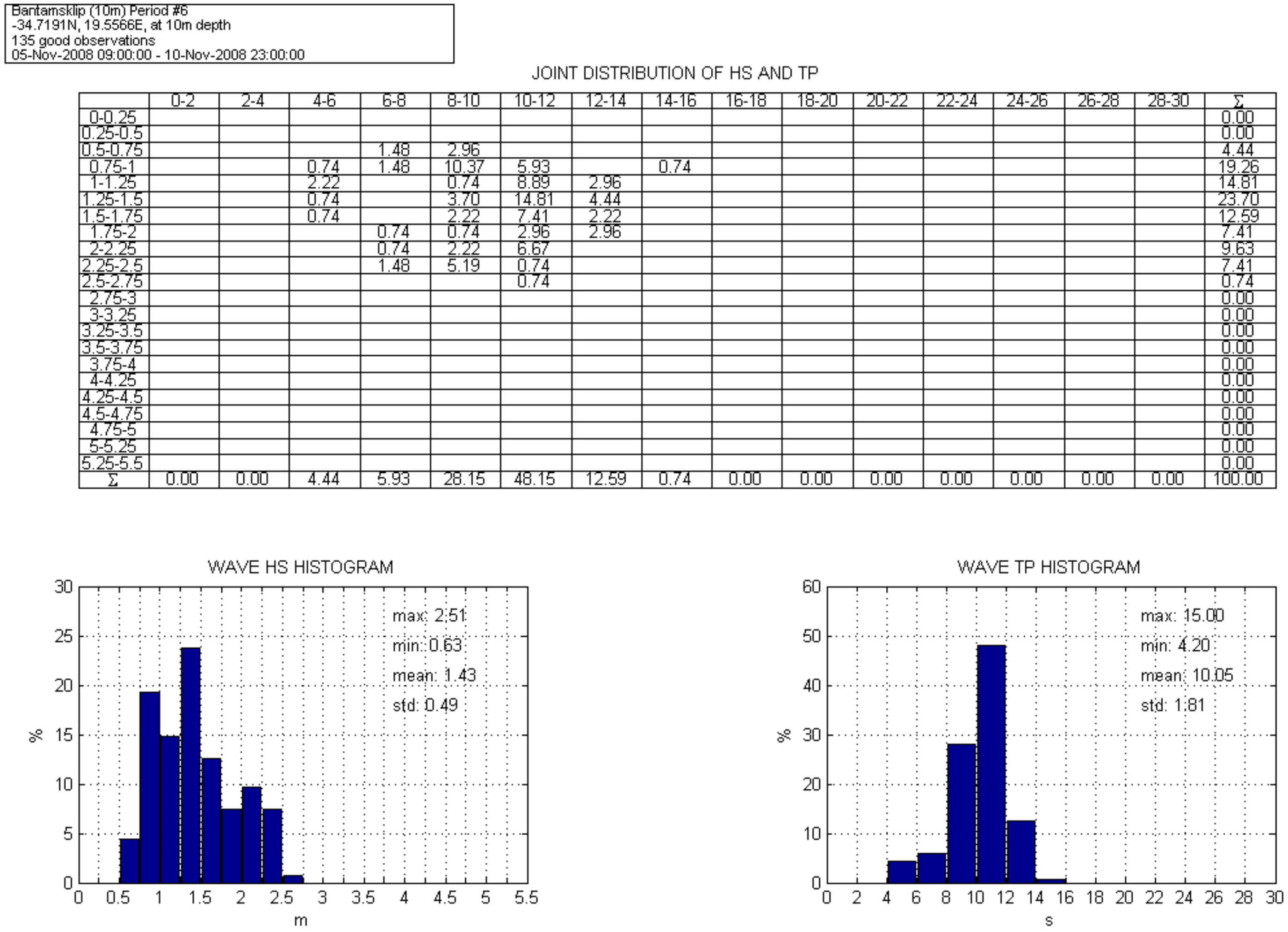
Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.3 Tp and Dp summary plot

Figure 14 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.



Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at 10m depth
135 good observations
05-Nov-2008 09:00:00 - 10-Nov-2008 23:00:00

JOINT DISTRIBUTION OF HS AND TP

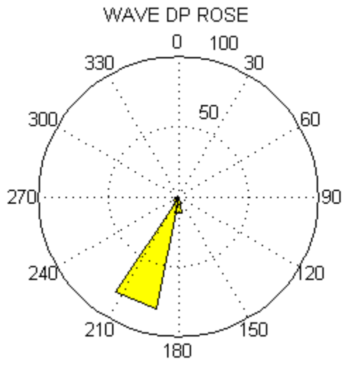
	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75				1.48	2.96											4.44
0.75-1			0.74	1.48	10.37	5.93		0.74								19.26
1-1.25			2.22		0.74	8.89	2.96									14.81
1.25-1.5			0.74		3.70	14.81	4.44									23.70
1.5-1.75			0.74		2.22	7.41	2.22									12.59
1.75-2				0.74	0.74	2.96	2.96									7.41
2-2.25				0.74	2.22	6.67										9.63
2.25-2.5				1.48	5.19	0.74										7.41
2.5-2.75						0.74										0.74
2.75-3																0.00
3-3.25																0.00
3.25-3.5																0.00
3.5-3.75																0.00
3.75-4																0.00
4-4.25																0.00
4.25-4.5																0.00
4.5-4.75																0.00
4.75-5																0.00
5-5.25																0.00
5.25-5.5																0.00
Σ	0.00	0.00	4.44	5.93	28.15	48.15	12.59	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Figure 12: Summary plot of H_s and T_p.

Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at 10m depth
135 good observations
05-Nov-2008 09:00:00 - 10-Nov-2008 23:00:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75									2.22	2.22							4.44
0.75-1								0.74	5.93	11.11	0.74	0.74					19.26
1-1.25									0.74	11.85	0.74	1.48					14.81
1.25-1.5										22.22	1.48						23.70
1.5-1.75										11.85	0.74						12.59
1.75-2									0.74	6.67							7.41
2-2.25									0.74	8.89							9.63
2.25-2.5									1.48	5.93							7.41
2.5-2.75										0.74							0.74
2.75-3																	0.00
3-3.25																	0.00
3.25-3.5																	0.00
3.5-3.75																	0.00
3.75-4																	0.00
4-4.25																	0.00
4.25-4.5																	0.00
4.5-4.75																	0.00
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	11.85	81.48	3.70	2.22	0.00	0.00	0.00	0.00	100.00



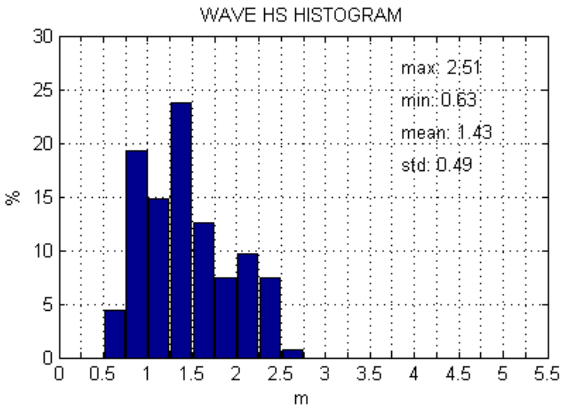


Figure 13: Summary plot of H_s and D_p.

Bantamsklip (10m) Period #6
-34.7191N, 19.5566E, at 10m depth
135 good observations
05-Nov-2008 09:00:00 - 10-Nov-2008 23:00:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4																	0.00
4-6											2.22	2.22					4.44
6-8									2.22	3.70							5.93
8-10									6.67	21.48							28.15
10-12								0.74	2.96	43.70	0.74						48.15
12-14										12.59							12.59
14-16											0.74						0.74
16-18																	0.00
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	11.85	81.48	3.70	2.22	0.00	0.00	0.00	0.00	100.00

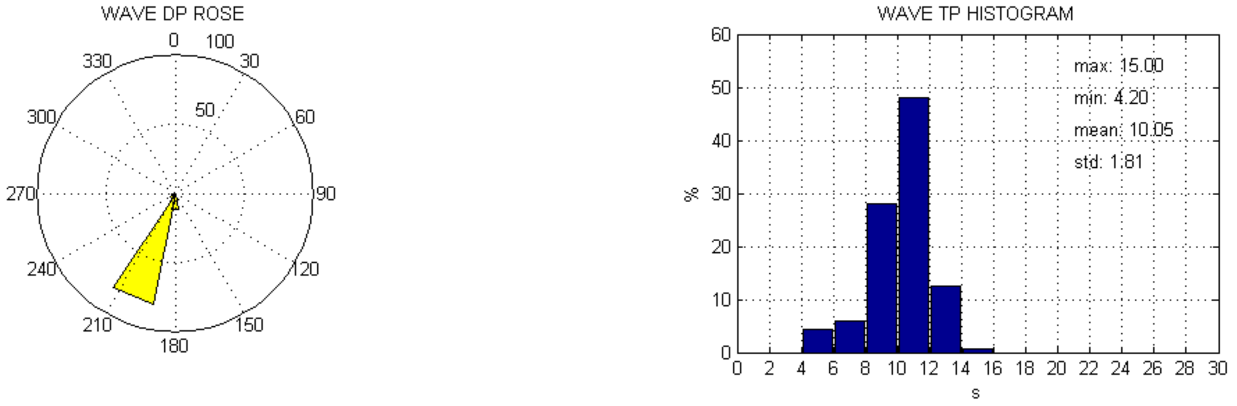


Figure 14: Summary plot of T_p and D_p.

5.1.2.4 Wave spectral plot

Figure 15 displays a wave spectral plot for a significant wave event. The time of the spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

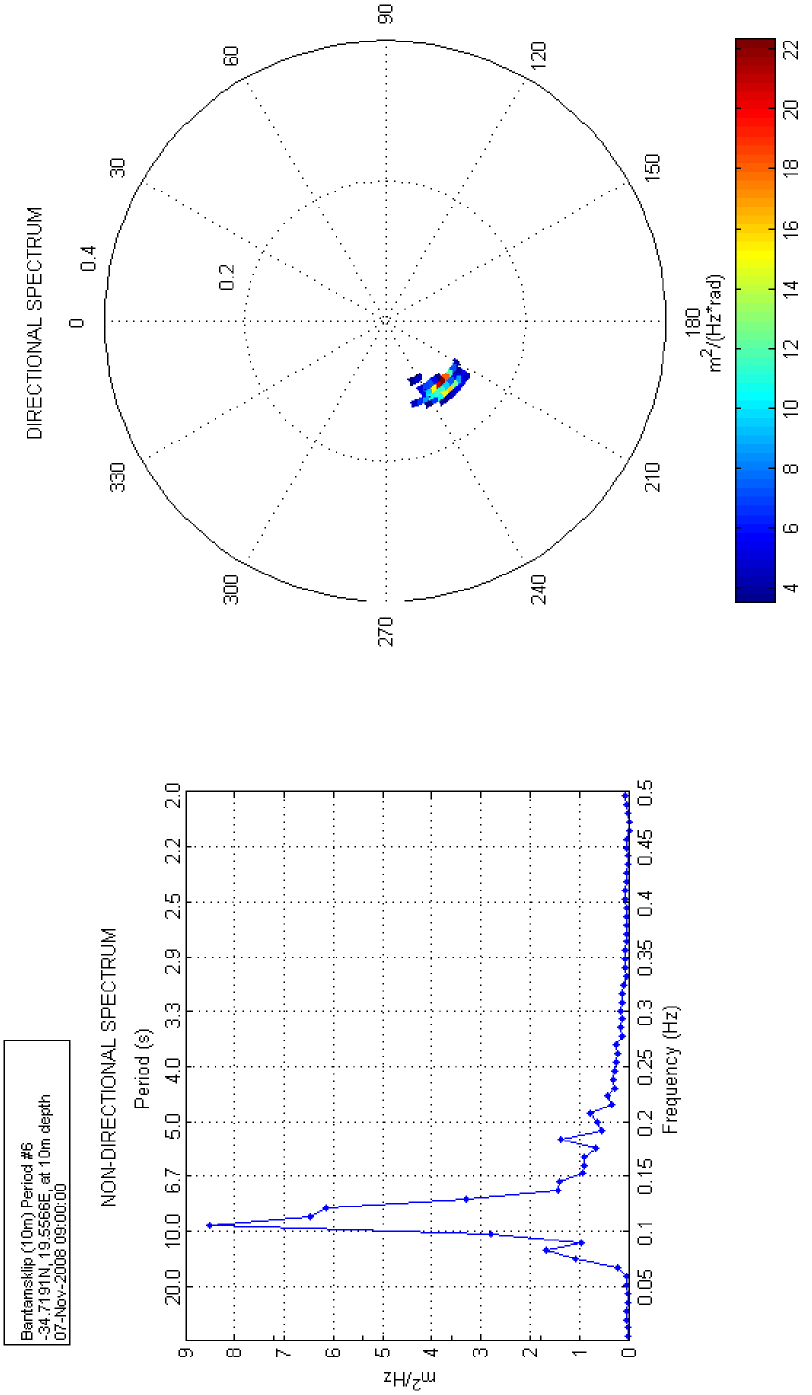


Figure 15: Wave spectra for 7th of November 2008 at 09:00:00.

5.2 30M ADCP

5.2.1 Current Data

5.2.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

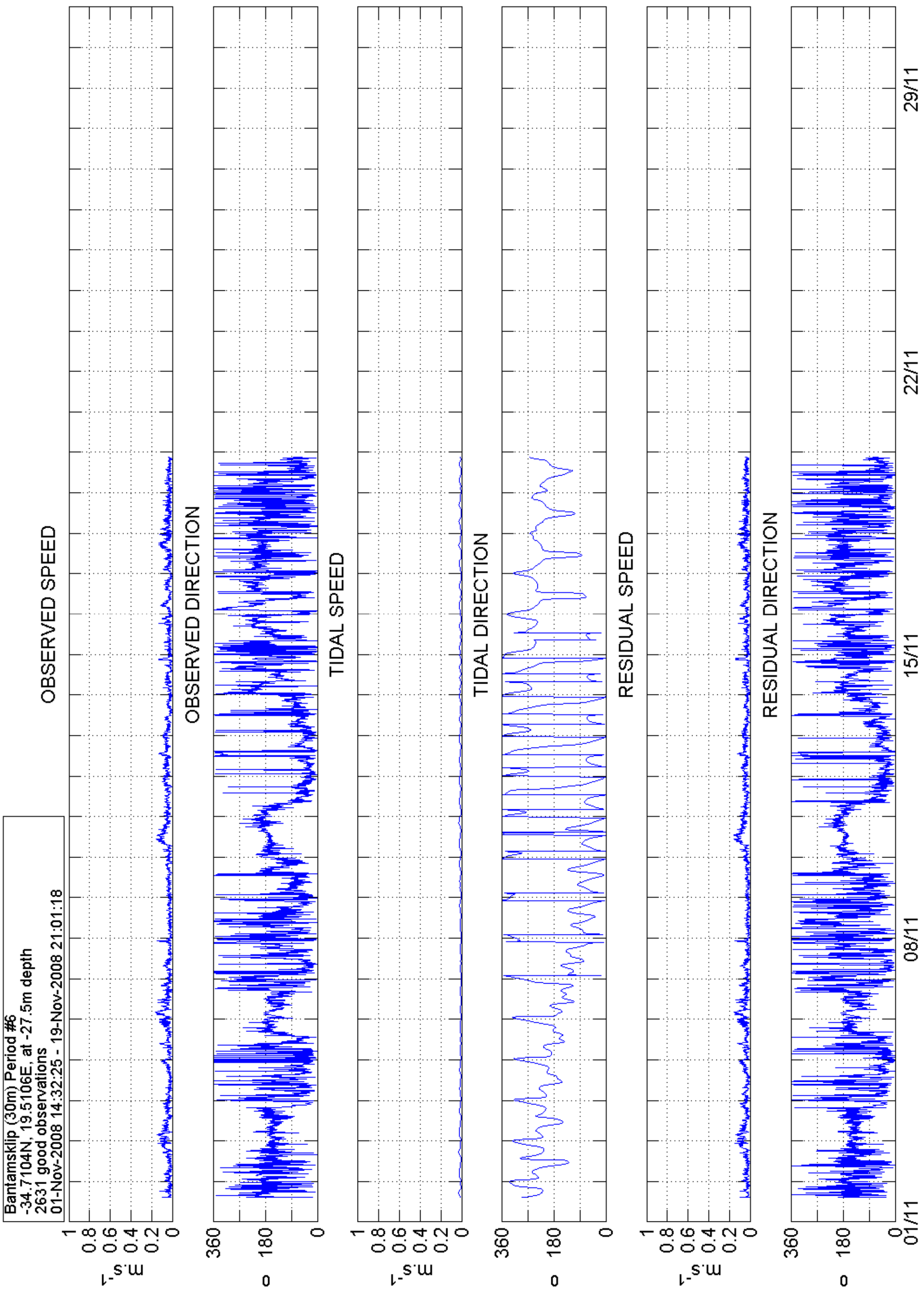


Figure 16: Time series plot for 30m ADCP current data at 27.5m.

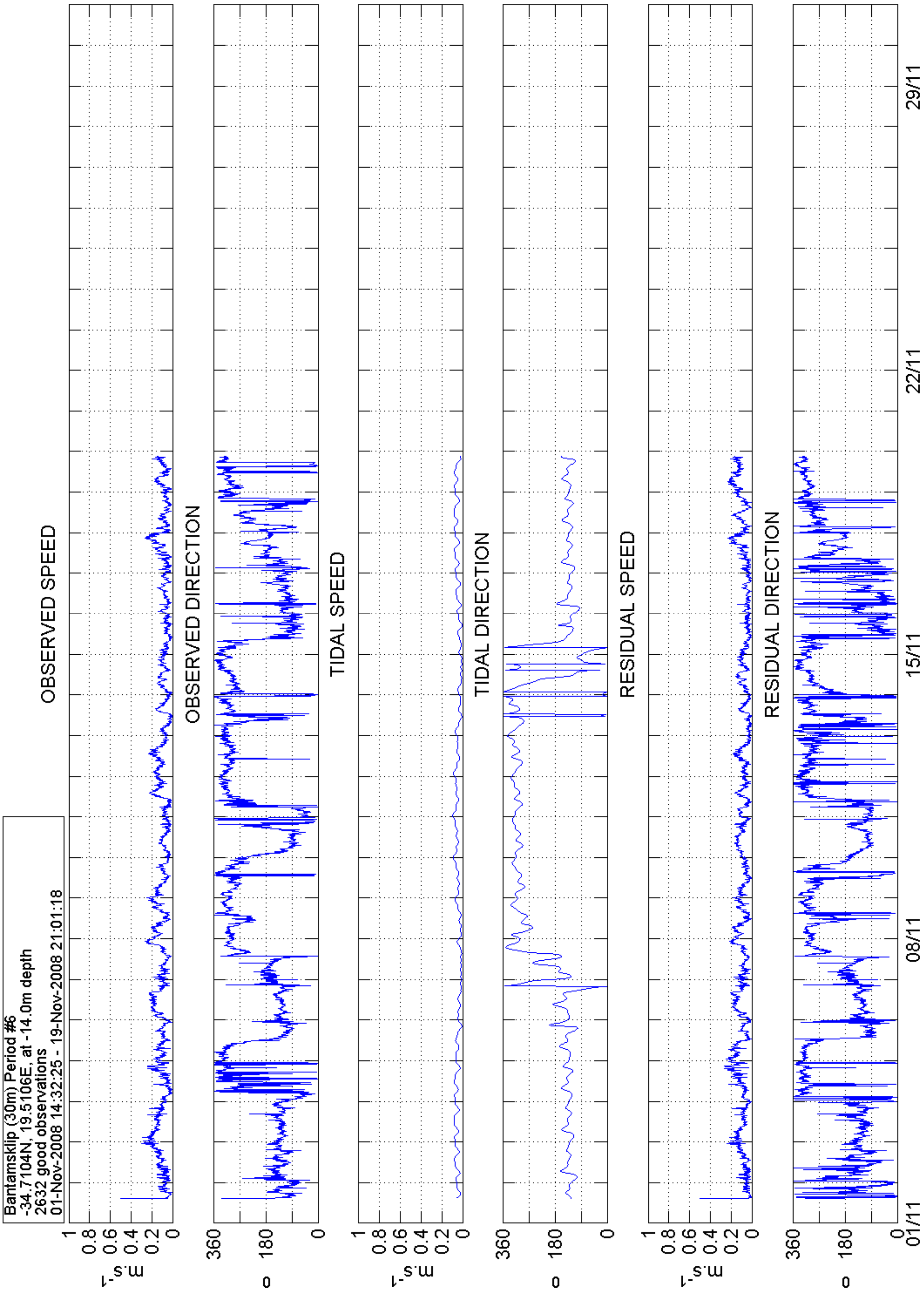


Figure 17: Time series plot for 30m ADCP current data at 14.0m.

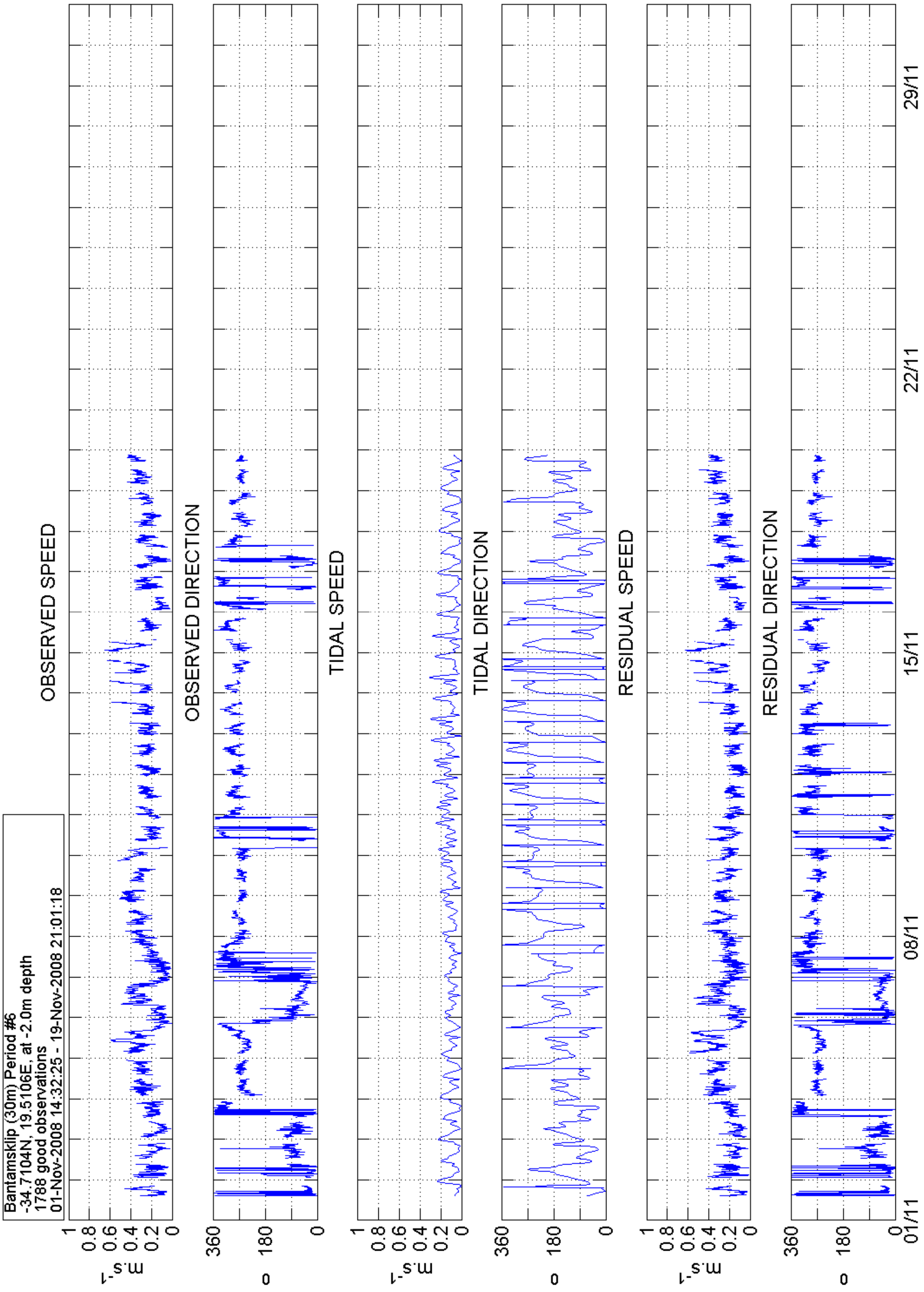


Figure 18: Time series plot for 30m ADCP current data at 2.0m.

5.2.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.2.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at -27.5m depth
2631 good observations
01-Nov-2008 14:32:25 - 19-Nov-2008 21:01:18

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	6.08	10.72	11.10	9.01	6.20	5.17	6.54	9.50	10.26	7.26	5.09	2.62	1.37	1.33	1.33	2.36	95.93
0.1-0.2	0.04	0.04	0.04				0.11	1.48	1.33	0.61	0.23					0.19	4.07
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	6.12	10.76	11.14	9.01	6.20	5.17	6.65	10.98	11.59	7.87	5.32	2.62	1.37	1.33	1.33	2.55	100.00

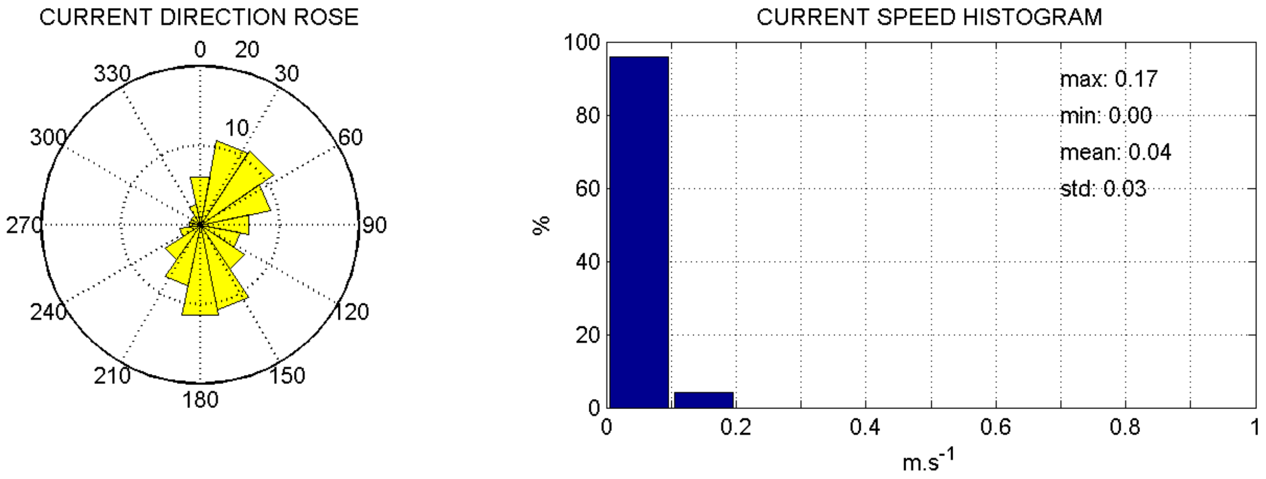
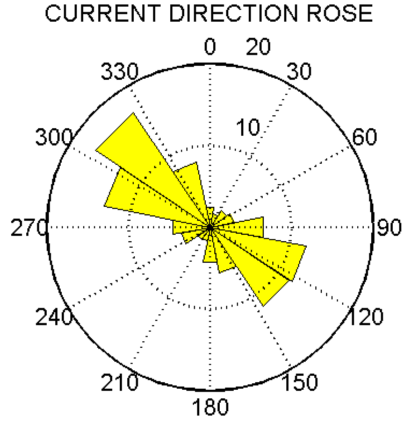


Figure 19: Summary plot for 30m ADCP current data at 27.5m.

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at -14.0m depth
2632 good observations
01-Nov-2008 14:32:25 - 19-Nov-2008 21:01:18

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	2.01	1.52	2.51	2.77	5.40	7.07	4.67	3.31	2.81	1.14	1.63	2.93	2.89	5.93	6.65	5.02	58.24
0.1-0.2	0.49	0.19		0.23	1.29	4.37	6.08	1.79	1.14	0.49	0.23	0.65	1.71	6.50	8.97	3.15	37.27
0.2-0.3						0.61	0.87	0.61	0.34	0.04		0.04		0.72	1.22		4.45
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6										0.04							0.04
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	2.51	1.71	2.51	3.00	6.69	12.04	11.63	5.70	4.29	1.71	1.86	3.61	4.60	13.15	16.83	8.17	100.00



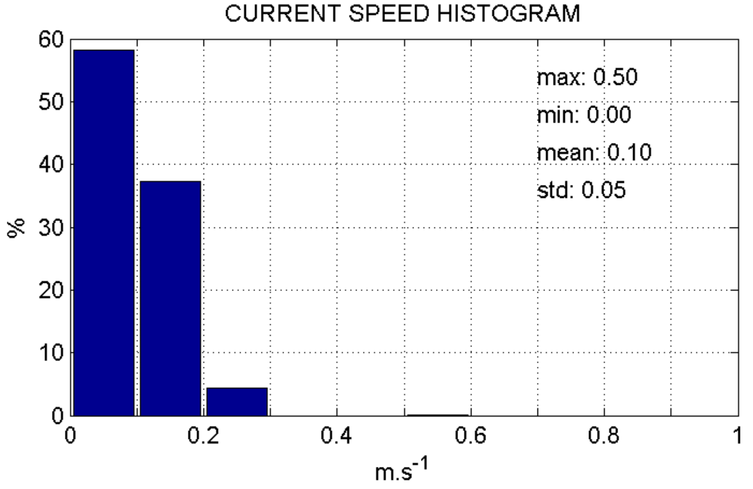


Figure 20: Summary plot for 30m ADCP current data at 14.0m

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at -2.0m depth
1788 good observations
01-Nov-2008 14:32:25 - 19-Nov-2008 21:01:18

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	0.78	1.01	0.56	1.01	1.01	0.62	0.17	0.34	0.50	0.34	0.17	0.11	0.39	0.34	0.50	0.95	8.78
0.1-0.2	1.90	1.17	1.68	1.57	2.18	0.50	0.11	0.06	0.11	0.28	0.67	1.23	2.13	3.47	3.47	2.68	23.21
0.2-0.3	1.40	1.12	1.06	1.51	0.89	0.73	0.06		0.11	0.06	0.95	5.20	9.00	7.49	4.14	1.51	35.23
0.3-0.4	0.11	0.67	1.34	1.01	0.34	0.06			0.06		0.56	7.16	9.28	3.02	0.78	0.22	24.61
0.4-0.5		0.39	0.84								0.11	2.13	2.52	0.28			6.26
0.5-0.6											0.11	0.78	0.56	0.17			1.62
0.6-0.7													0.11	0.17			0.28
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	4.19	4.36	5.48	5.09	4.42	1.90	0.34	0.39	0.78	0.67	2.57	16.61	23.99	14.93	8.89	5.37	100.00

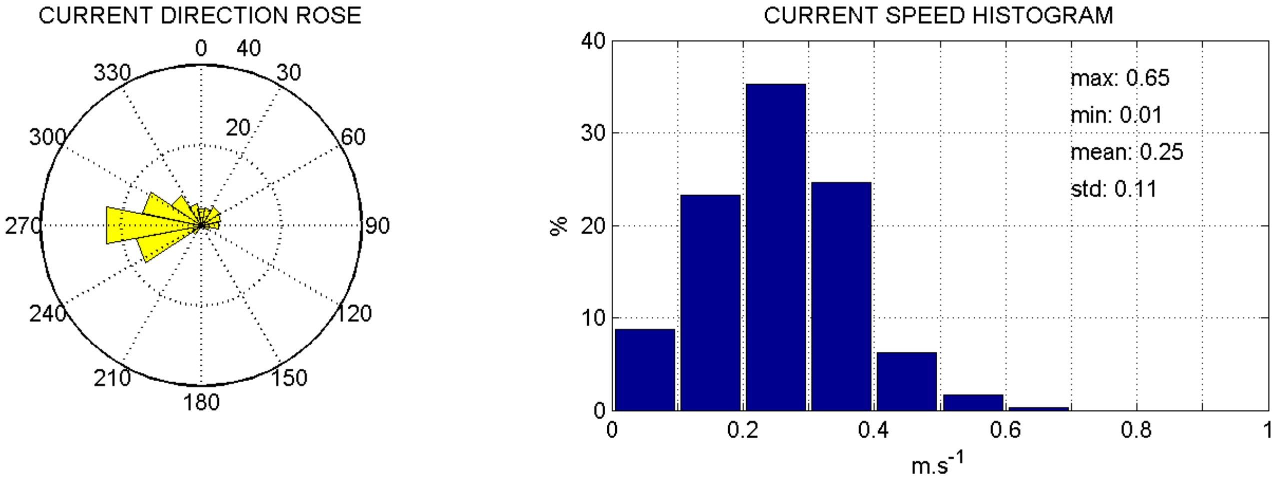


Figure 21: Summary plot for 30m ADCP current data at 2.0m.

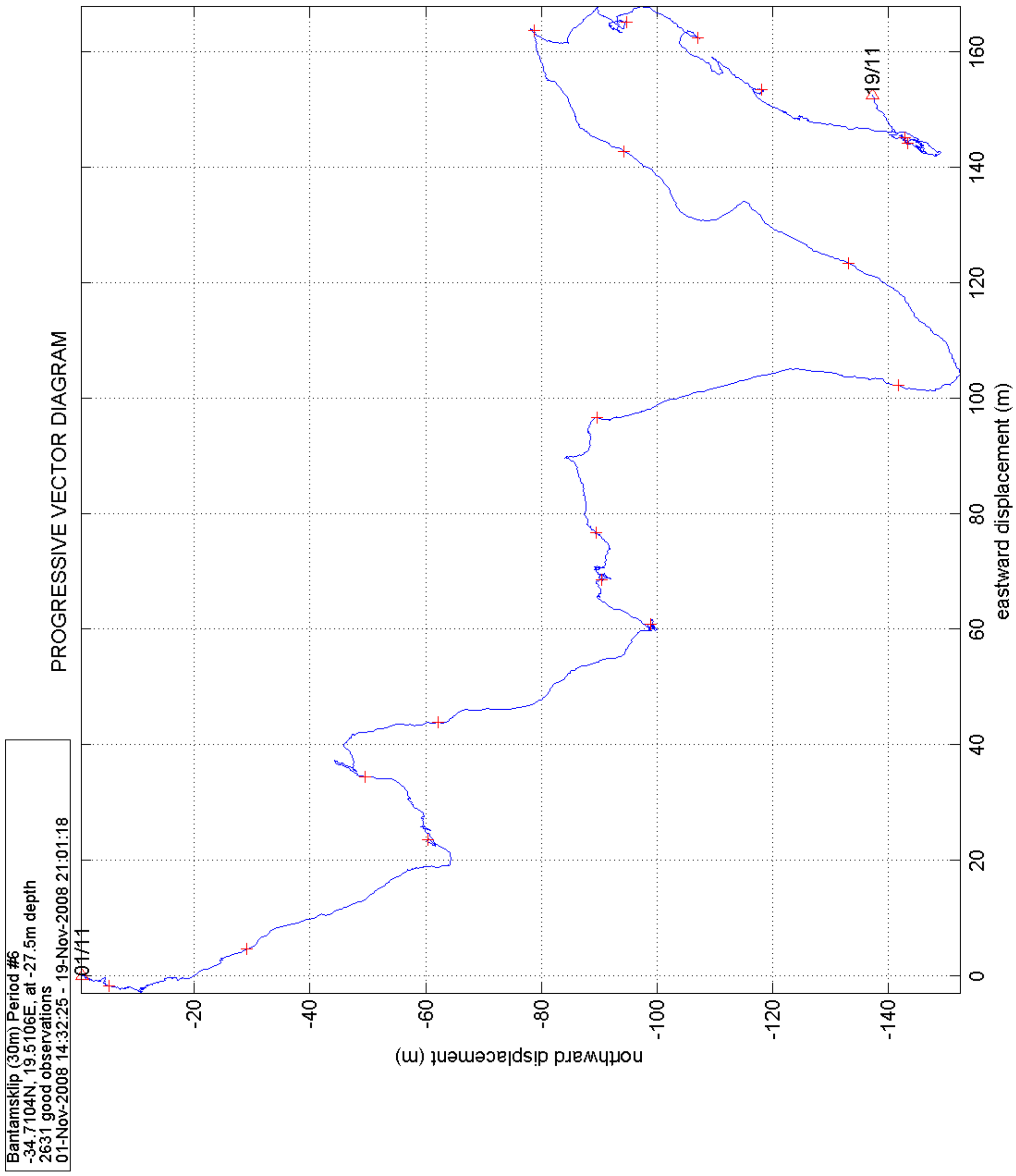


Figure 22: Progressive vector plot for 30m ADCP current data at 27.5m.

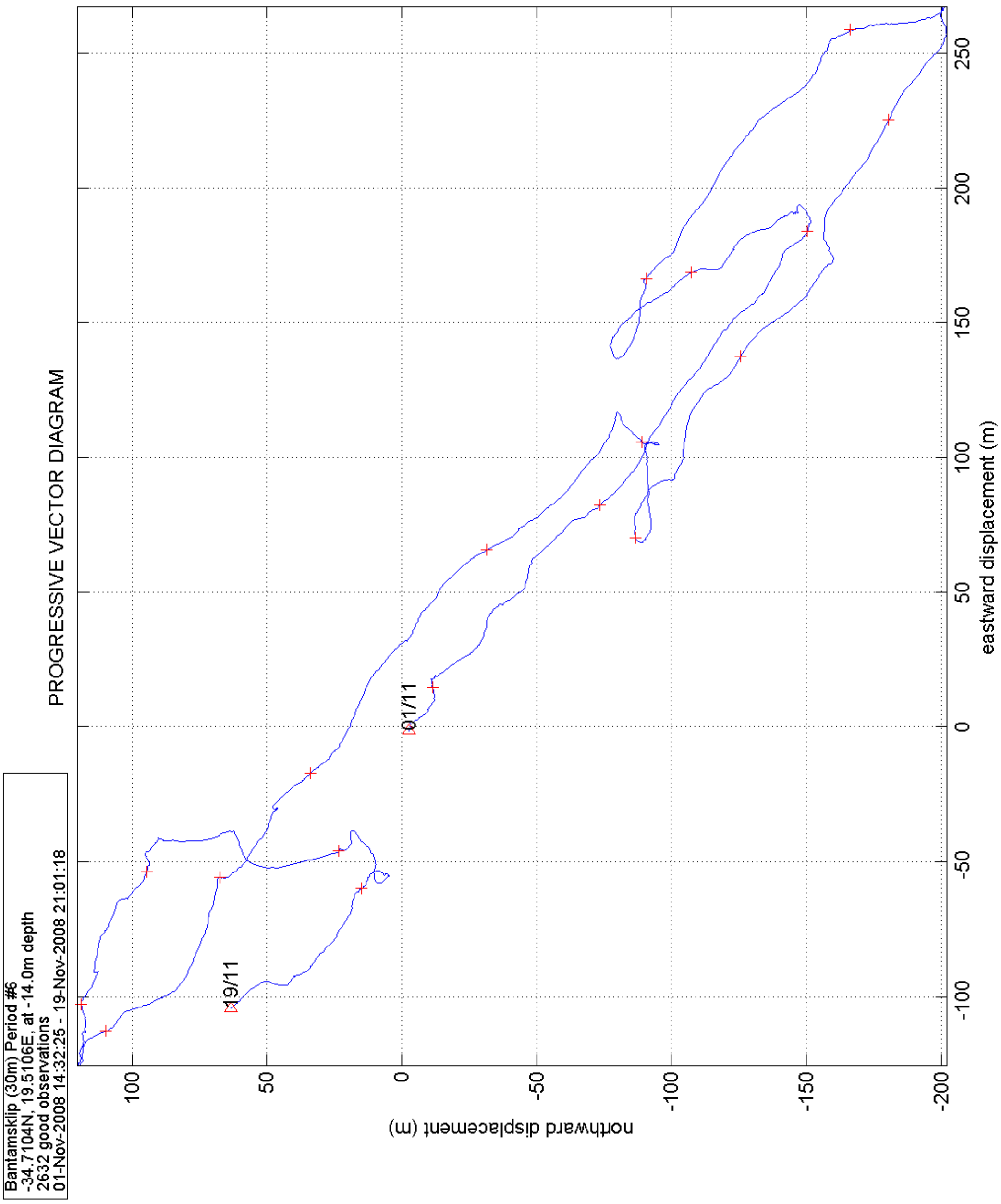


Figure 23: Progressive vector plot for 30m ADCP current data at 14.0m.

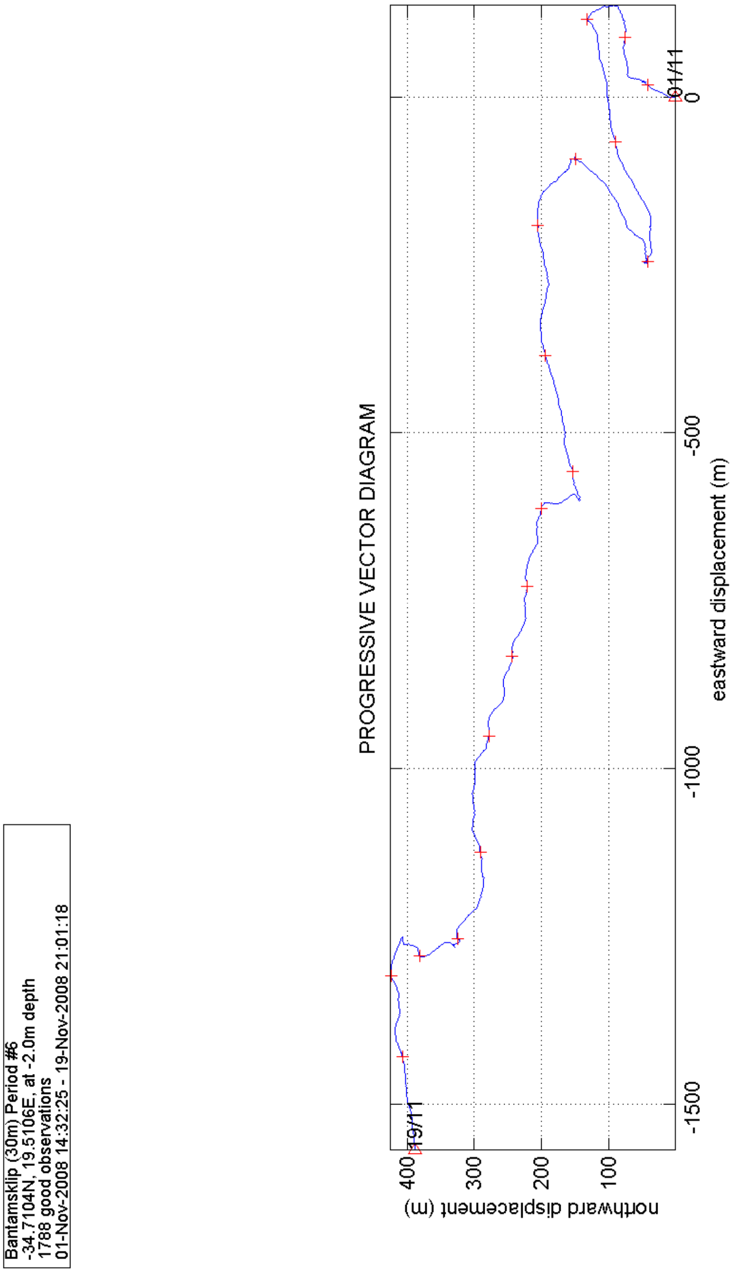


Figure 24: Progressive vector plot for 30m ADCP current data at 2.0m.

5.2.2 Wave Data.

5.2.2.1 Hs and Tp summary plot

Figure 25 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.2.2.2 Hs and Dp summary plot

Figure 26 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.2.2.3 Tp and Dp summary plot

Figure 27 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at 30m depth
436 good observations
01-Nov-2008 15:02:00 - 19-Nov-2008 20:02:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1			0.23	1.38	2.29											3.90
1-1.25			0.69	0.46	2.98	4.82										8.94
1.25-1.5			0.23		3.67	8.03	1.61									13.53
1.5-1.75			0.23		3.67	9.86	2.52									16.28
1.75-2					2.75	3.67	2.75	0.23								9.40
2-2.25			0.46	1.15	2.52	2.98	2.75	0.23								10.09
2.25-2.5			0.23	0.92	3.21	2.06	2.98	0.23								9.63
2.5-2.75				1.38	4.36	0.92	2.06									8.72
2.75-3				0.69	2.06	0.69	1.61	0.23								5.28
3-3.25				0.23	1.38	2.52	0.92	0.69								5.73
3.25-3.5					0.92	0.92	1.15	0.69								3.67
3.5-3.75					0.23		0.92	1.38								2.52
3.75-4						0.23	0.69	0.46								1.38
4-4.25							0.23	0.23								0.46
4.25-4.5							0.23	0.23								0.46
4.5-4.75																0.00
4.75-5																0.00
5-5.25																0.00
5.25-5.5																0.00
Σ	0.00	0.00	2.06	6.19	30.05	36.70	20.41	4.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

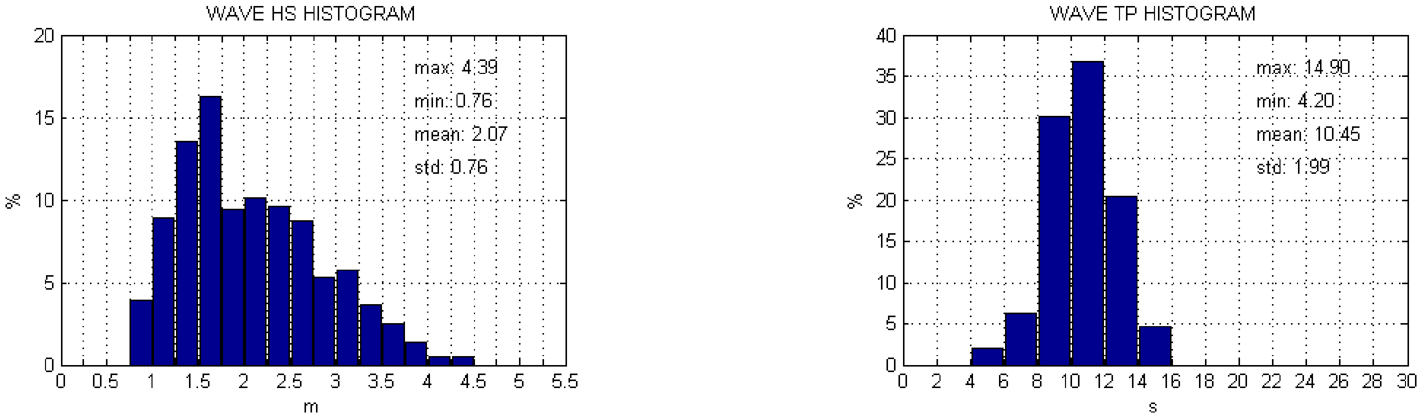


Figure 25: Summary plot of H_s and T_p.

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at 30m depth
436 good observations
01-Nov-2008 15:02:00 - 19-Nov-2008 20:02:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1							0.46	1.15	0.23	1.61	0.23	0.23					3.90
1-1.25								1.61	2.06	2.75	2.29		0.23				8.94
1.25-1.5							0.23	1.15	2.29	8.26	1.61						13.53
1.5-1.75								0.69	2.06	12.16	1.38						16.28
1.75-2							0.69	0.69	1.38	5.73	0.92						9.40
2-2.25							1.38	0.92	1.83	4.59	1.15	0.23					10.09
2.25-2.5							0.46	1.83	2.52	3.21	1.15	0.46					9.63
2.5-2.75							0.46	1.15	1.15	3.90	2.06						8.72
2.75-3								0.69	1.15	1.61	1.83						5.28
3-3.25								1.15	0.46	2.75	1.38						5.73
3.25-3.5									1.15	2.06	0.46						3.67
3.5-3.75								0.46	0.46	0.92	0.46	0.23					2.52
3.75-4									0.23	0.69	0.46						1.38
4-4.25										0.46							0.46
4.25-4.5										0.23		0.23					0.46
4.5-4.75																	0.00
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	3.67	11.47	16.97	50.92	15.37	1.38	0.23	0.00	0.00	0.00	100.00

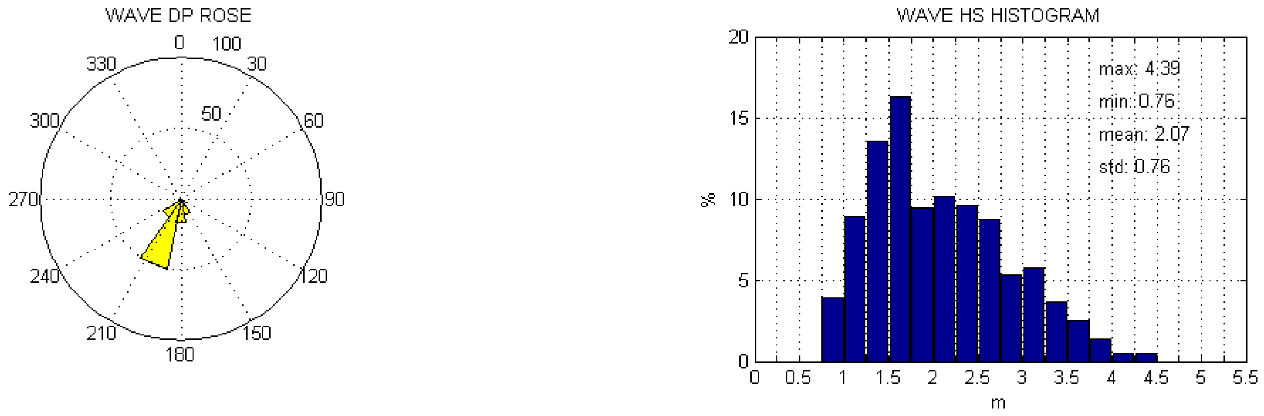


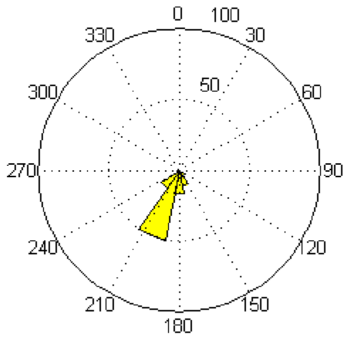
Figure 26: Summary plot of H_s and D_p.

Bantamsklip (30m) Period #6
-34.7104N, 19.5106E, at 30m depth
436 good observations
01-Nov-2008 15:02:00 - 19-Nov-2008 20:02:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4																	0.00
4-6							0.23		0.23	0.23	0.46	0.69	0.23				2.06
6-8							0.46	2.29	0.92	2.06	0.46						6.19
8-10							2.98	6.88	5.28	10.78	4.13						30.05
10-12								2.06	7.57	22.02	4.82	0.23					36.70
12-14								0.23	2.52	13.53	4.13						20.41
14-16									0.46	2.29	1.38	0.46					4.59
16-18																	0.00
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	3.67	11.47	16.97	50.92	15.37	1.38	0.23	0.00	0.00	0.00	100.00

WAVE DP ROSE



WAVE TP HISTOGRAM

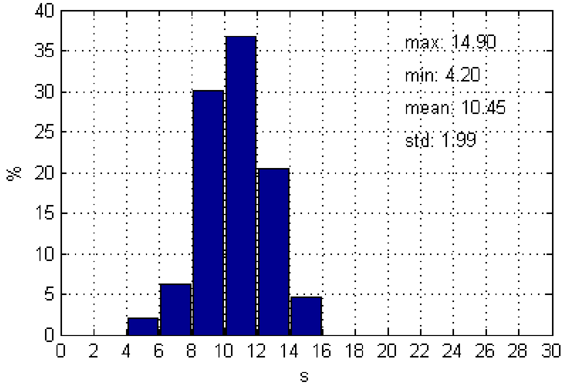


Figure 27: Summary plot of T_p and D_p.

5.2.2.4 Wave spectral plot

Figure 28 displays a wave spectral plot for a significant wave event. The time of the spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

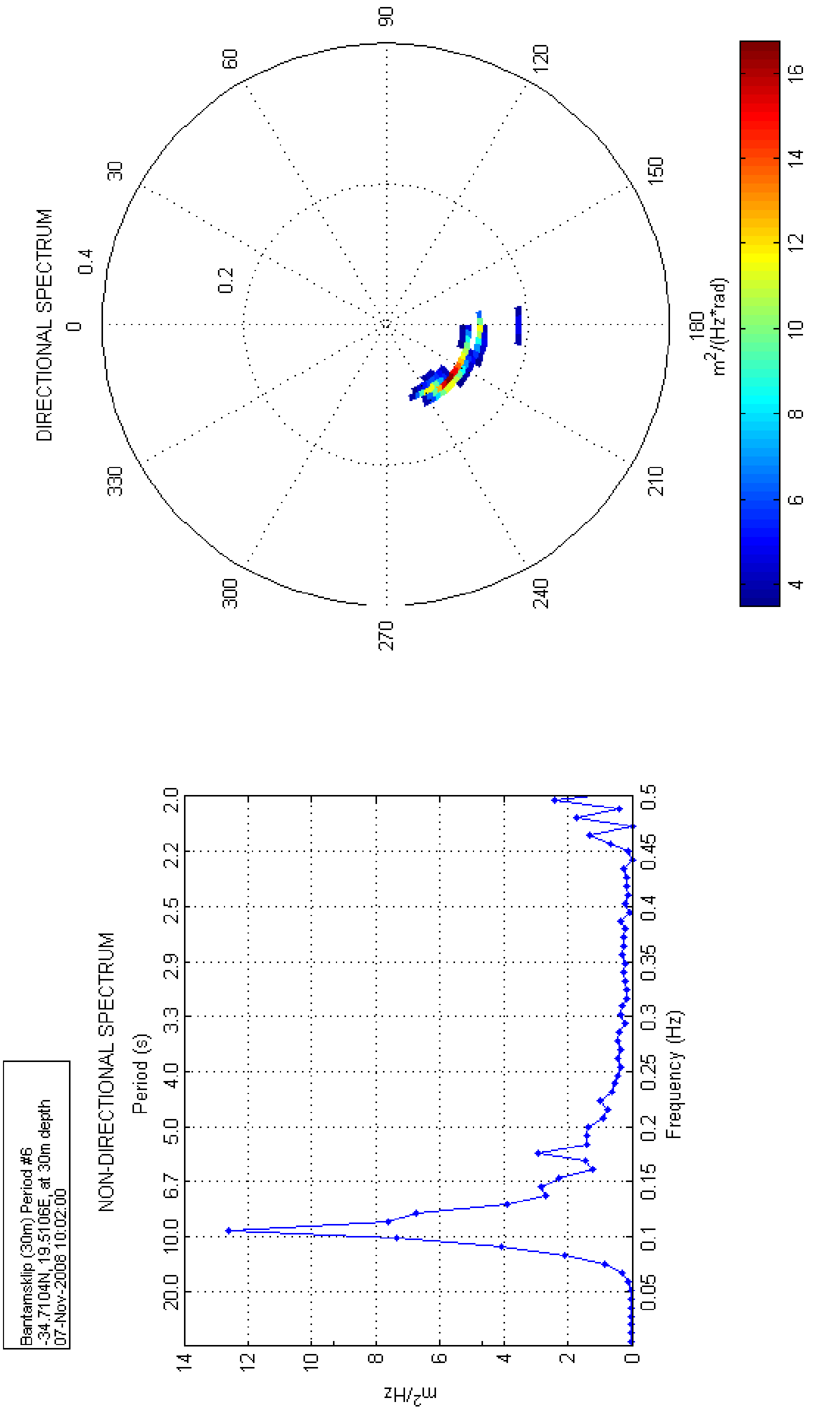


Figure 28: Wave spectra for 7th of November 2008 at 10:02:00.

5.3 COMPARISON PLOTS

5.3.1 Hs, Tp and Dp time series plots for 10m and 30m ADCPs.

Figure 29 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

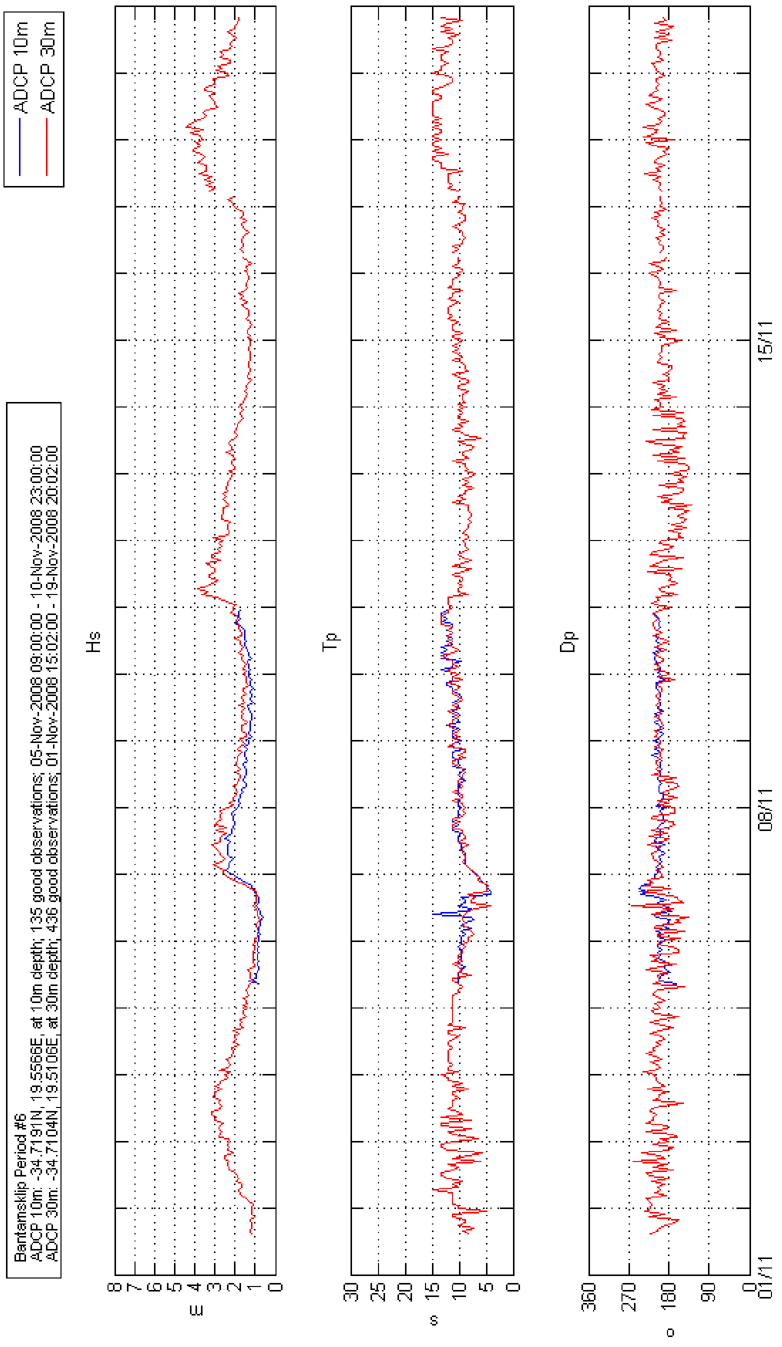


Figure 29: Time series of Hs, Tp and Dp from 10m and 30m ADCPs.

5.3.2 Water properties: RBR-CT loggers and ADCPs' temperature sensor.

Figure 30 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCPs' temperature sensor against time.
- The second panel is of the derived salinity from the RBR loggers against time.

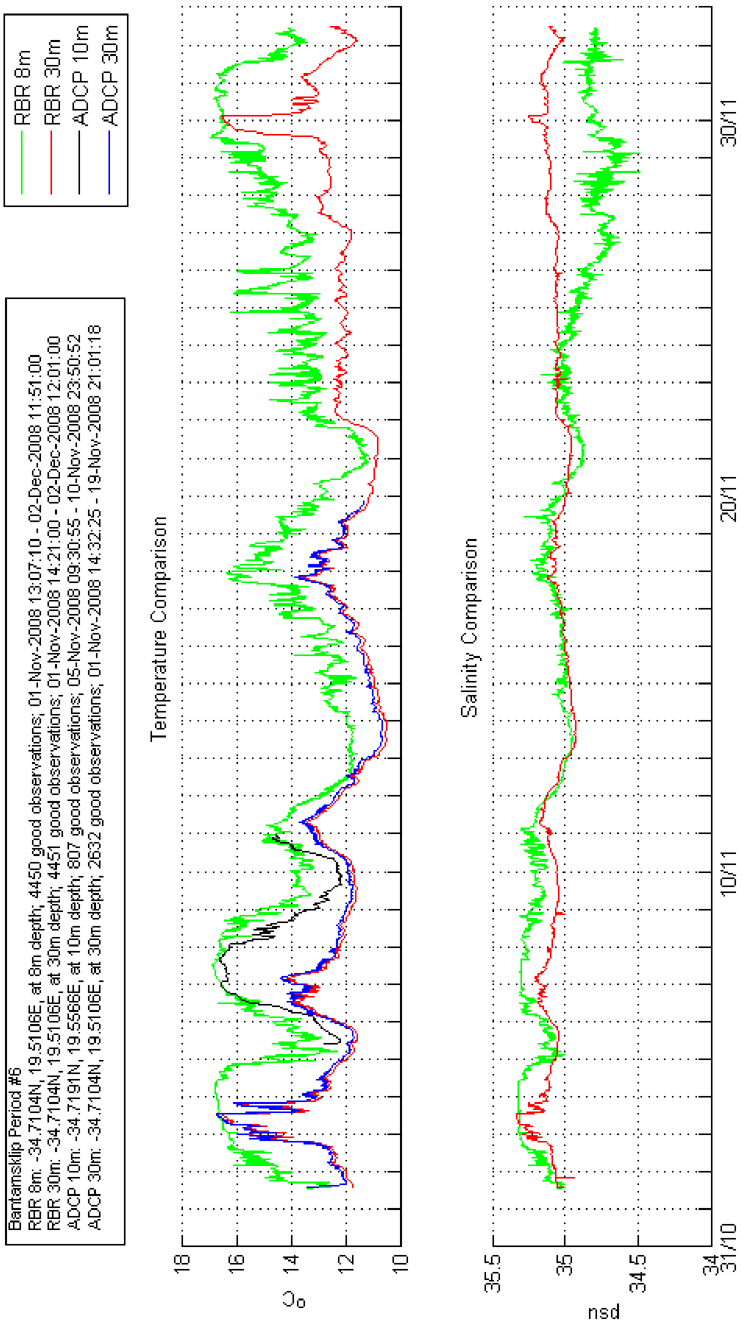


Figure 30: Time series of temperature and salinity from the RBR loggers and ADCPs.

5.4 WATER SAMPLES.

Analysis of water samples were undertaken by the CSIR and results are presented as an appendage (Section 7.4, page 64).

6. DISCUSSION

The sixth set of oceanographic data collected off the coast of Bantamsklip for the period between November 1st 2008 – December 2nd 2008 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom.

This report presents data obtained from the 10m and 30m ADCPs, the surface and bottom RBR-CT loggers, and water samples collected during the sixth service visit.

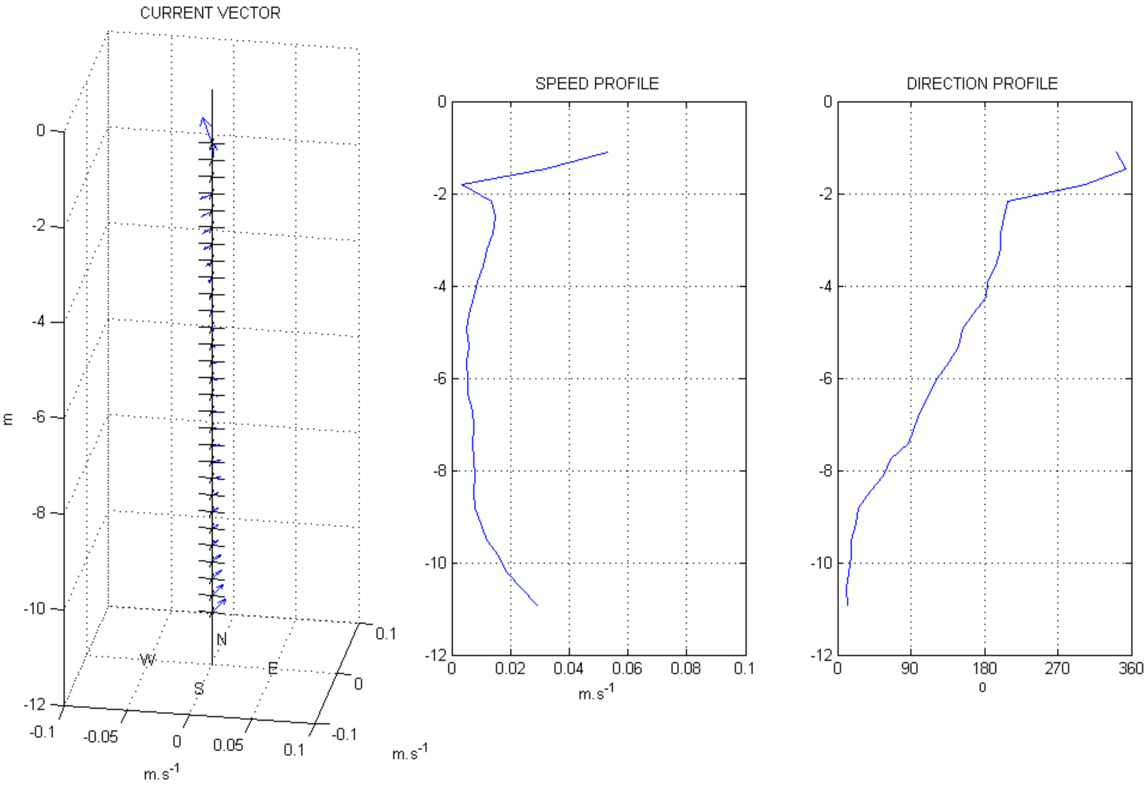


Figure 31: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.11ms^{-1}, decreasing to ~0.04ms^{-1} at ~10m depth. The flow throughout the water column was predominantly from the East. Average wave parameters of ~1.4m, ~10s and ~200^{o} were recorded for Hs, Tp and Dp respectively.

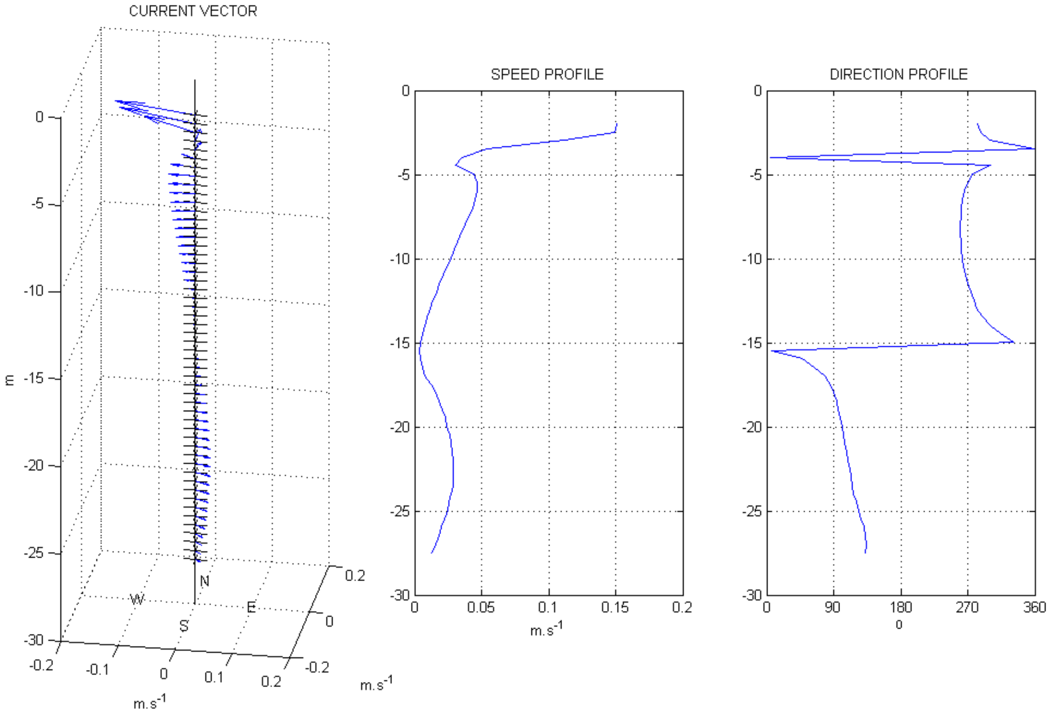


Figure 32: Mean profile plot for 30m ADCP.

The average surface flow for the 30m ADCP was 0.25ms^{-1}, decreasing to ~0.04ms^{-1} at ~27m depth. Average wave parameters of ~2m, ~10.5s and ~195^{o} were recorded for Hs, Tp and Dp respectively.

Figure 30 shows the temperature sensors on board the 30m ADCP and surface RBR logger recorded reasonably similar values during the deployment period.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT FIVE

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1. RECOVERY Site Name: Bantams 10 m site Date: 2 Dec 2008

Instrument type and serial number			RDI	10105
Recovery date and time	LT	GMT	**2 Dec 2008 13:07**	
Latitude **(do not ignore – if same, please indicate)**			**34 43 148**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.398**	
Switch off date and time	LT	GMT	3 Dec 2008 07:47	
File size			57MB	
Was the data copied to memory card?			Y*	N

2. **RE-DEPLOYMENT Site Name: Bantams 10 m site Date 5 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**10105**
Install a new battery and/or check the voltage		**1*44.8V**
Frequency of unit being used	**600kHz**	
Depth range	**10m**	
Number of bins (calculated automatically)	**42**	
Bin Size (calculated automatically)	**0.35**	
Wave burst duration	**41min**	
Time between wave bursts	**60min**	
Pings per ensemble	**500**	
Ensemble interval	**10min**	
Deployment duration	**15days**	
Transducer depth	**10m**	
Any other commands	**minTP,RI0**	
Temperature	**5**	
Recorder size	**1256MB**	

Consequences of the sampling parameters

First and last bin range		**1.41**	**15.76**
Battery usage			**440Wh**
Standard deviation			**1.08**
Storage space required			**133MB**
Set the ADCP clock	LT	GMT	**4 Dec 2008 22:35:33**
Run pre-deployment tests			
Name the ADCP deployment			**B1012**

Deployment details

Switch on date and time	LT	GMT	**4 Dec 2008 22:35:33**
Deployment date and time	LT	GMT	**5 Dec 2008 11:15**
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43.186**
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.637**
Site depth	10m	Deployment depth	**10m**

Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)	**Bantams 5 December 2008/ADCP_newDeployFiles/B1012**	

30m ADCP.

1. RECOVERY Site Name: Bantamsklip 30m site Date: 5 Dec 2008

Instrument type and serial number			RDI	10841
Recovery date and time	LT*	GMT	5 Dec 2008 09:20	
Latitude **(do not ignore – if same, please indicate)**			34 42.625	
Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Switch off date and time	LT	GMT	5 Dec 2008 16:20	
File size			145MB	
Was the data copied to memory card?			Y*	N

2. **RE-DEPLOYMENT Site Name: Bantams 30m site Date: 5 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**11424**
Install a new battery and/or check the voltage		**1*44.8V**
Frequency of unit being used	**600kHz**	
Depth range	**30m**	
Number of bins (calculated automatically)	**69**	
Bin Size (calculated automatically)	**0.5**	
Wave burst duration	**34min**	
Time between wave bursts	**60min**	
Pings per ensemble	**250**	
Ensemble interval	**10min**	
Deployment duration	**15days**	
Transducer depth	**30m**	
Any other commands	**minTP,RI0**	
Temperature	**5**	
Recorder size	**1256MB**	

Consequences of the sampling parameters

First and last bin range			**1.6**	**35.6**
Battery usage				**447Wh**
Standard deviation				**1.08**
Storage space required				**112MB**
Set the ADCP clock	LT	GMT	**5 Dec 2008 04:07:14**	
Run pre-deployment tests				**yes**
Name the ADCP deployment			**B3012**	

Deployment details

Switch on date and time	LT	GMT	**5 Dec 2008 04:07:14**
Deployment date and time	LT	GMT	**5 Dec 2008 09:20**
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.676

Site depth	30m	Deployment depth		**30m**
Acoustic release (1) serial number and release code			**32383**	**642016**
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 5 December 2008/ADCP_newDeployFiles/B3012**	

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

1. **RECOVERY** **Site Name: Bantams 30m site** **Date: 2 Dec 2008**

Instrument type and serial number			RBR 420ct	12994
Recovery date and time	LT	GMT	**2 Dec 2008 08:30**	
Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Switch off date and time	LT	GMT	3 Dec 2008 13:43:22	
File size			101KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 5 December 2008/RBR_RecoveredData	

2. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 5 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period		**10min**
Averaging period		**1min**
Expected deployment duration		**30days**
Start of logging (date / time)	5 Dec 2008	04:15:30
End of logging (date / time)	7 Jan 2009	12:00:00
Memory usage		.3%
Battery usage		830mAH

Deployment details

Deployment date and time	LT	GMT	5 Dec 2008 10:20	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			8m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 5 December 2008/RBR_RecoveredData/012994.log	

Bottom.

1. **RECOVERY** **Site Name: Bantams 30m site** **Date: 2 Dec 2008**

Instrument type and serial number			RBR 420ct	15248
Recovery date and time	LT	GMT	**2 Dec 2008 11:45**	
Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Switch off date and time	LT	GMT	3 Dec 2008 13:39:49	
File size			101KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 5 December 2008/RBR_RecoveredData	

2. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 5 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.0V

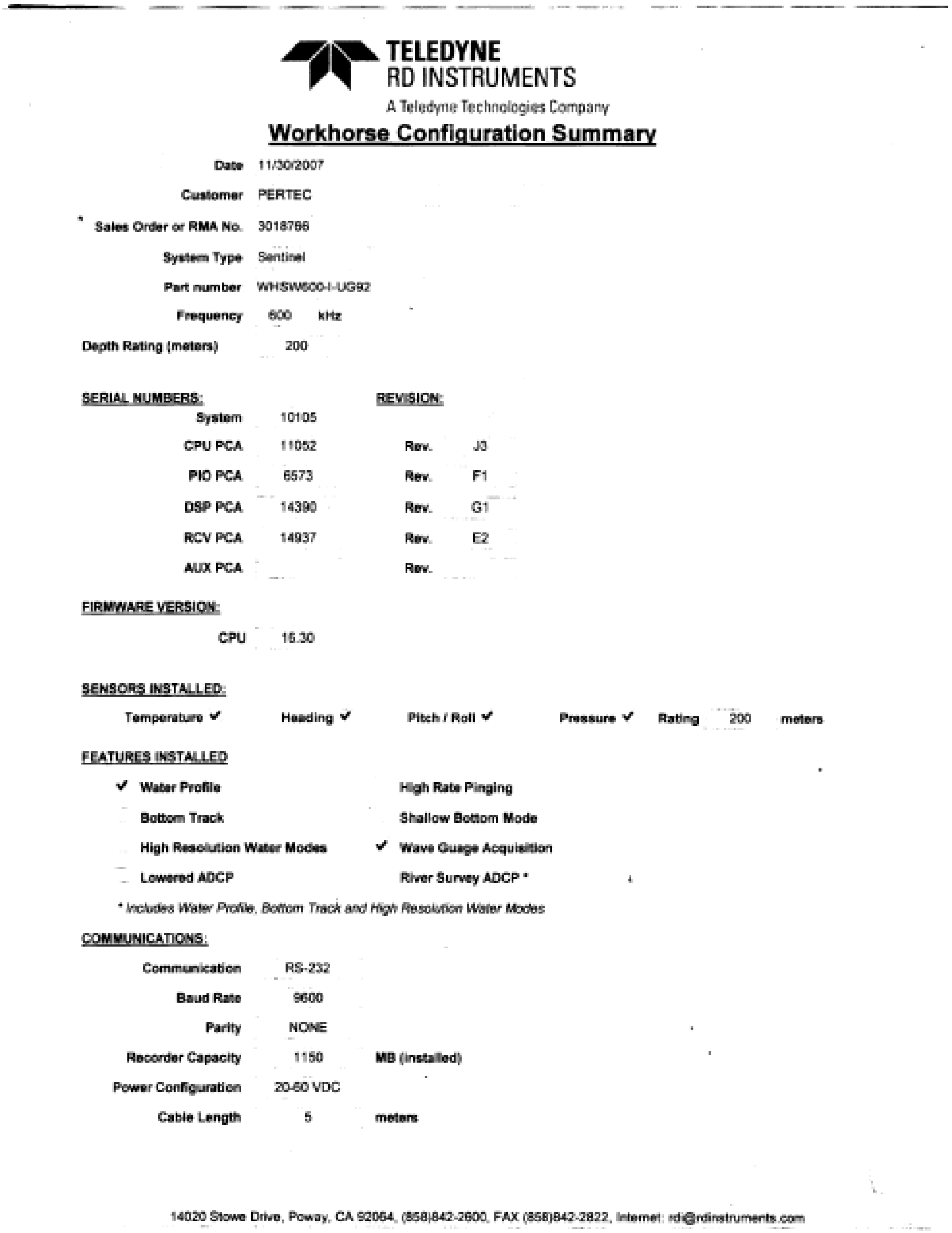
Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	5 Dec 2008	04:13:50
End of logging (date / time)	7 Jan 2009	12:00:00
Memory usage		.3%
Battery usage		830mAH

Deployment details

Deployment date and time	LT	GMT	5 Dec 2008 09:20	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			30m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 5 December 2008/RBR_RecoveredData/**015248.log**	

7.3 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 11/30/2007
Customer PERTEC
Sales Order or RMA No. 3018786
System Type Sentinel
Part number WHSW600-I-UG92
Frequency 600 kHz
Depth Rating (meters) 200

SERIAL NUMBERS: / **REVISION:**

System	10105		
CPU PCA	11052	**Rev.**	J3
PIO PCA	6573	**Rev.**	F1
DSP PCA	14390	**Rev.**	G1
RCV PCA	14937	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

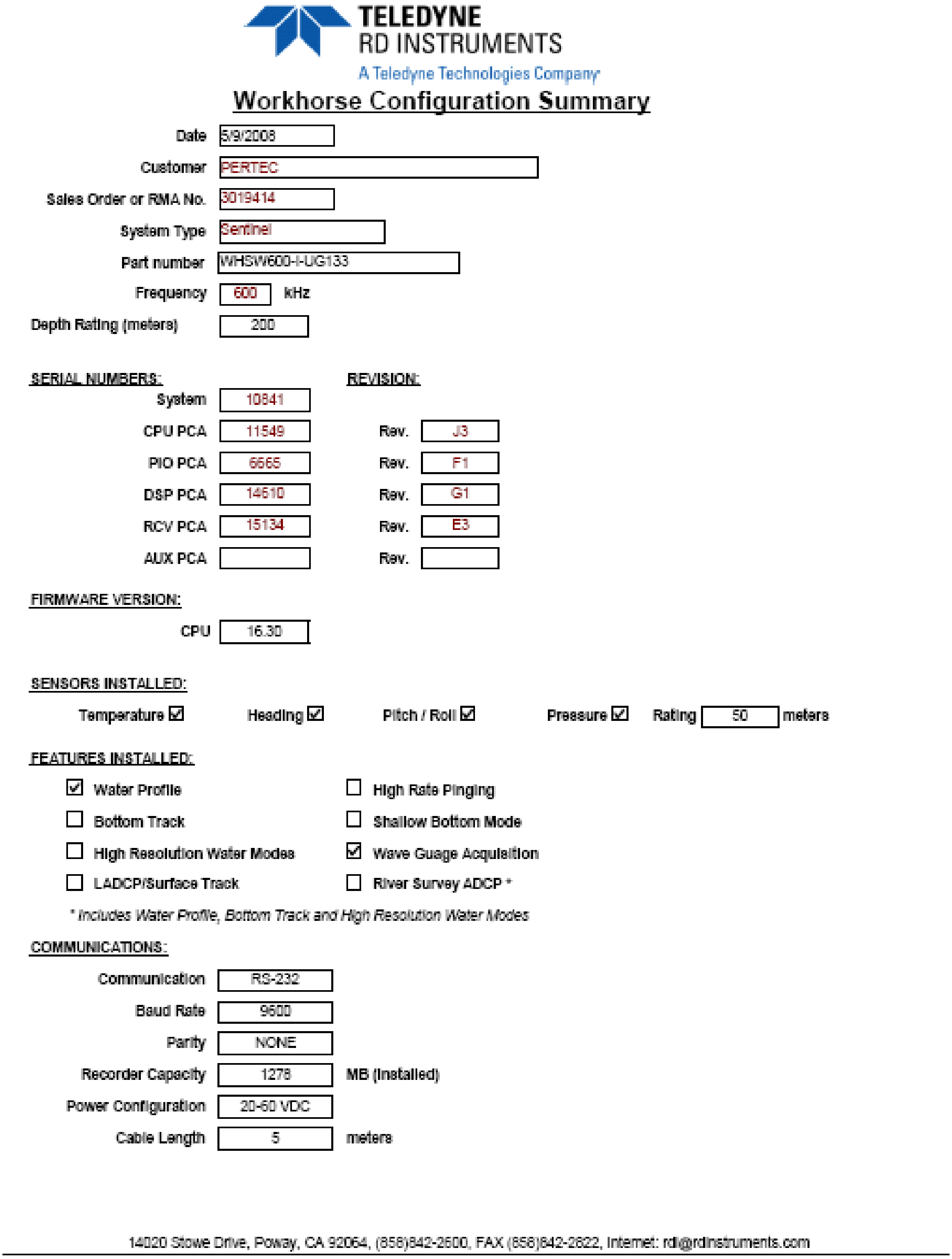
✓	**Water Profile**		**High Rate Pinging**
	Bottom Track		**Shallow Bottom Mode**
	High Resolution Water Modes	✓	**Wave Guage Acquisition**
	Lowered ADCP		**River Survey ADCP ***

* *Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 **MB (installed)**
Power Configuration 20-60 VDC
Cable Length 5 **meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date: 5/9/2008
Customer: PERTEC
Sales Order or RMA No.: 3019414
System Type: Sentinel
Part number: WHSW600-I-UG133
Frequency: 600 kHz
Depth Rating (meters): 200

SERIAL NUMBERS:		REVISION:
System	10841	
CPU PCA	11549	Rev. J3
PIO PCA	6665	Rev. F1
DSP PCA	14610	Rev. G1
RCV PCA	15134	Rev. E3
AUX PCA		Rev.

FIRMWARE VERSION:

CPU: 16.30

SENSORS INSTALLED:

Temperature ☑ Heading ☑ Pitch / Roll ☑ Pressure ☑ Rating 50 meters

FEATURES INSTALLED:

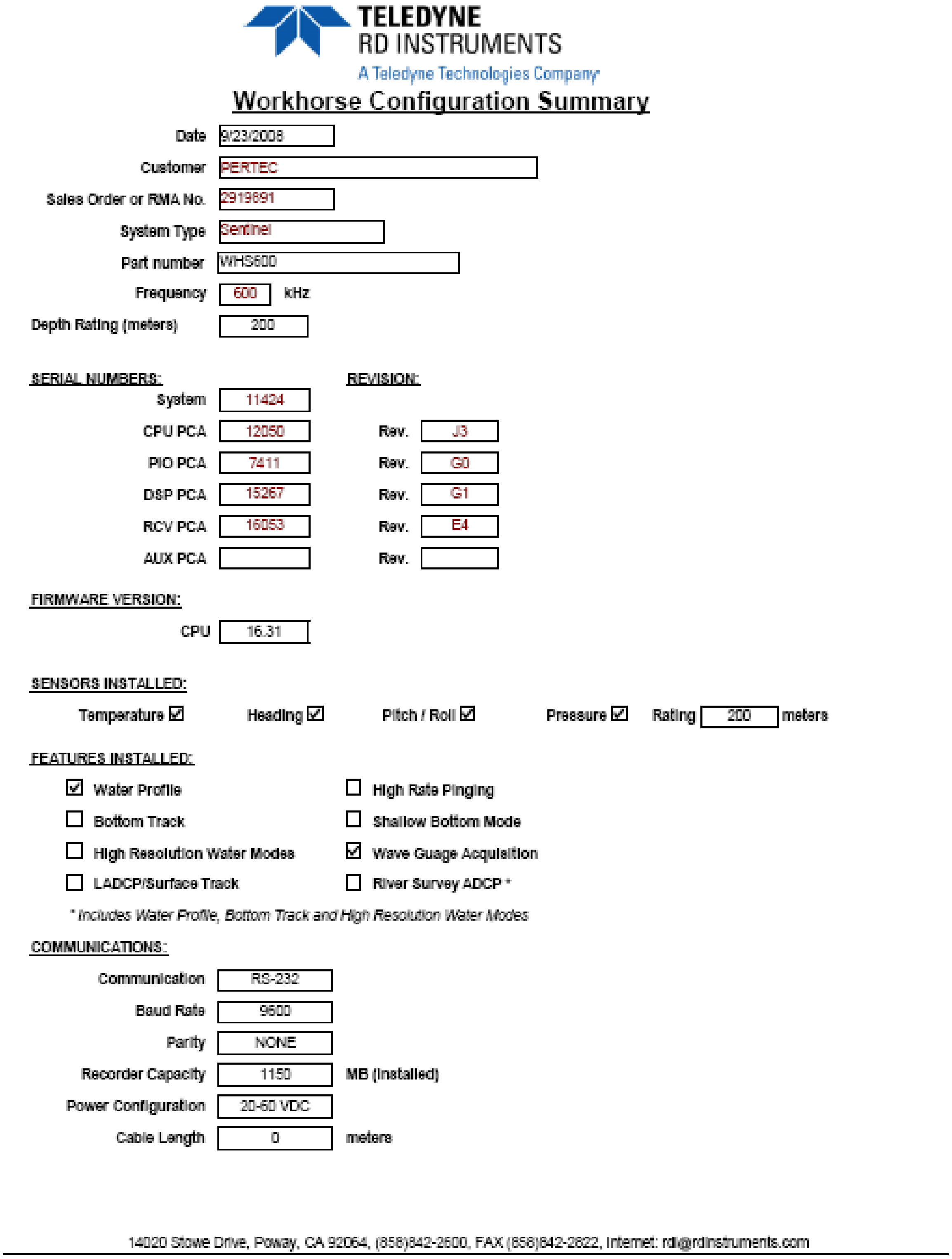
☑ Water Profile
☐ Bottom Track
☐ High Resolution Water Modes
☐ LADCP/Surface Track
☐ High Rate Pinging
☐ Shallow Bottom Mode
☑ Wave Guage Acquisition
☐ River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication: RS-232
Baud Rate: 9600
Parity: NONE
Recorder Capacity: 1278 MB (Installed)
Power Configuration: 20-60 VDC
Cable Length: 5 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date 9/23/2008
Customer PERTEC
Sales Order or RMA No. 2919691
System Type Sentinel
Part number WHS600
Frequency 600 kHz
Depth Rating (meters) 200

SERIAL NUMBERS: **REVISION:**

System 11424
CPU PCA 12050 Rev. J3
PIO PCA 7411 Rev. G0
DSP PCA 15267 Rev. G1
RCV PCA 16053 Rev. E4
AUX PCA Rev.

FIRMWARE VERSION:

CPU 16.31

SENSORS INSTALLED:

Temperature ☑ Heading ☑ Pitch / Roll ☑ Pressure ☑ Rating 200 meters

FEATURES INSTALLED:

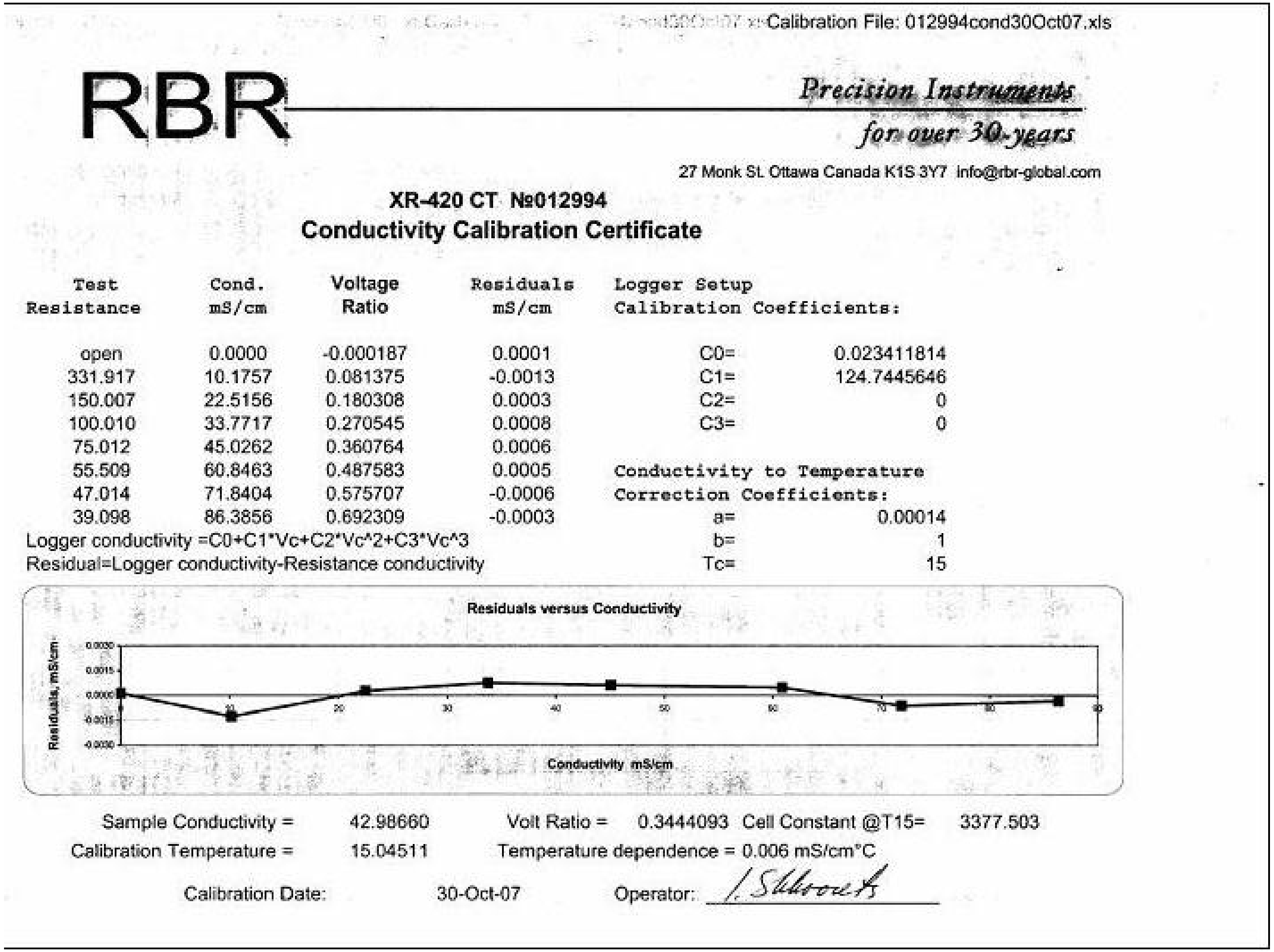
- ☑ Water Profile
- ☐ Bottom Track
- ☐ High Resolution Water Modes
- ☐ LADCP/Surface Track
- ☐ High Rate Pinging
- ☐ Shallow Bottom Mode
- ☑ Wave Guage Acquisition
- ☐ River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication RS-232
Baud Rate 9600
Parity NONE
Recorder Capacity 1150 MB (installed)
Power Configuration 20-60 VDC
Cable Length 0 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2622, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

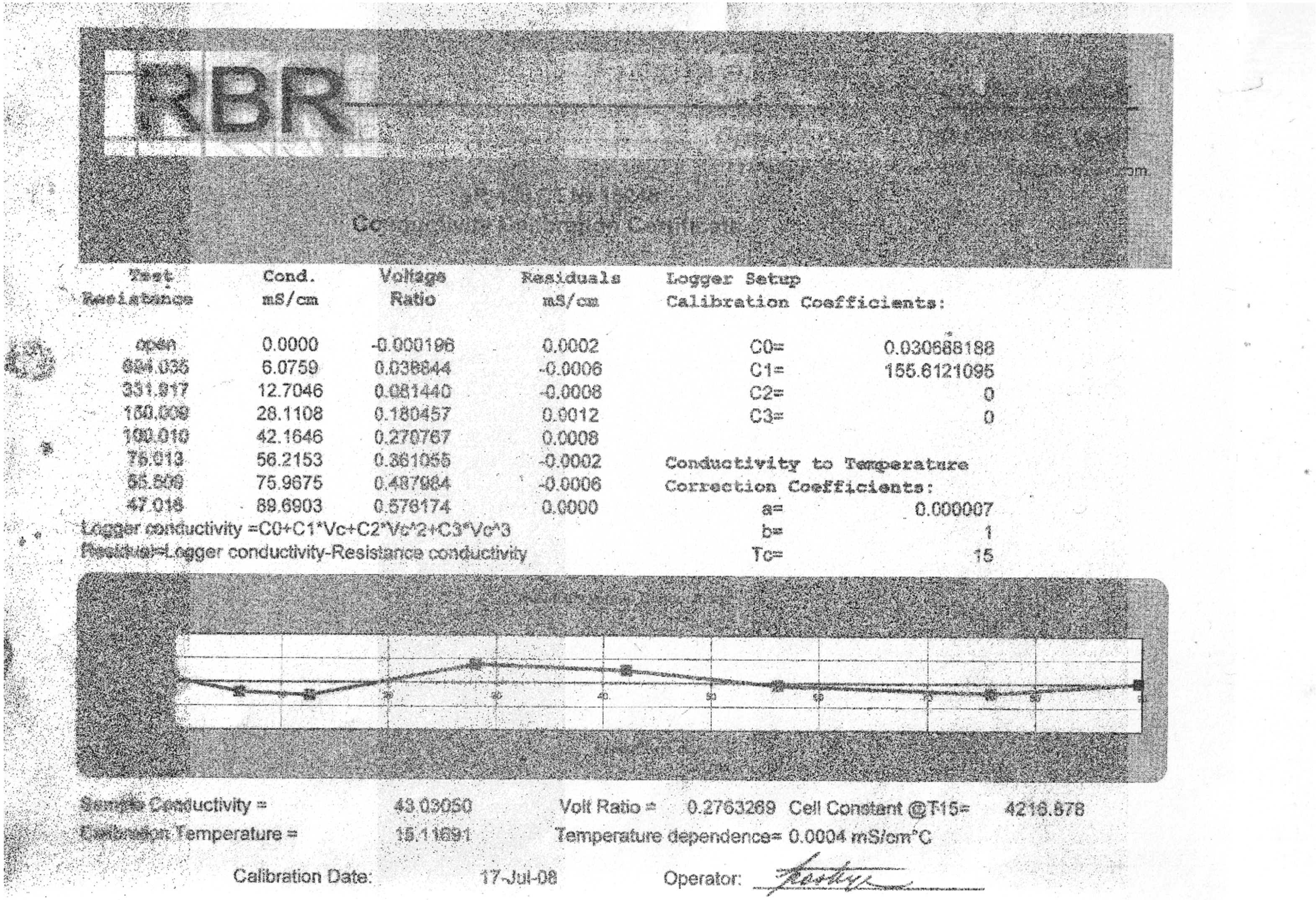
Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Residuals versus Conductivity

Sample Conductivity = 42.98660 Volt Ratio = 0.3444093 Cell Constant @T15= 3377.503
Calibration Temperature = 15.04511 Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07 Operator:



RBR

[illegible]

Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000196	0.0002
694.035	6.0759	0.038844	-0.0006
331.917	12.7046	0.081440	-0.0008
150.009	28.1108	0.180457	0.0012
100.010	42.1646	0.270767	0.0008
75.013	56.2153	0.361055	-0.0002
55.509	75.9675	0.487984	-0.0006
47.016	89.6903	0.576174	0.0000

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup

Calibration Coefficients:

C0= 0.030688188

C1= 155.6121095

C2= 0

C3= 0

Conductivity to Temperature

Correction Coefficients:

a= 0.000007

b= 1

Tc= 15

Sample Conductivity = 43.03050

Calibration Temperature = 15.11691

Volt Ratio = 0.2763269

Cell Constant @T15= 4216.878

Temperature dependence= 0.0004 mS/cm°C

Calibration Date: 17-Jul-08

Operator:

7.4 ADCP CONFIGURATION FILES

10m ADCP.

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 133.83 MB (140329440 bytes)
;Power usage         = 440.26 Wh
;Battery usage       = 1.0
;Samples / Wv Burst = 4920
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
```

```
;Bytes / Wave Burst = 383840
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP.

```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4080
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.60 m
;Last cell range     = 35.60 m
;Max range           = 38.22 m
;Standard deviation = 0.86 cm/s
```

```
;Ensemble size      = 1534 bytes
;Storage required   = 112.45 MB (117908640 bytes)
;Power usage        = 447.68 Wh
;Battery usage      = 1.0
;Samples / Wv Burst = 4080
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 318320
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

8. REPORTS FROM THE CSIR

The reports from the CSIR are attached as an appendage.

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2887

Report Number: MALR2887

18 December 2008

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Craig Matthysen

CHEMICAL ANALYSIS: Water samples (Order No.:)
Samples received: 15/12/08
Analysis completed: 18/12/08

Sample description: Seawater in sealed plastic bottles.

Lab No	Sample Id	Total Suspended Solids in mg/L
35244	**B 1**	*5*
35245	**B 2**	*5*
35246	**B 3**	*4*
35247	**B 4**	*10*
35248	**B 5**	*3*
35249	**B 6**	*4*
35250	**B 7**	*6*
35251	**B 8**	*7*
35252	**B 9**	*4*
35253	**B 10**	*2*
35254	**B 11**	*<2*

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT SEVEN

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

9 February 2009

Job No: LT-JOB-50

LWANDLE TECHNOLOGIES (PTY) LTD

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

1st floor Gabriel Place, 1 Gabriel Road, Plumstead, 7800, South Africa

Co Reg. No. 2003/015524/07

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 7 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-10.8	74.75	0.2386	0.0733	0.0496	0.0672	37.88
-10.5	74.75	0.1987	0.0680	0.0466	0.0591	40.58
-10.1	74.75	0.1873	0.0621	0.0381	0.0505	42.50
-9.8	74.75	0.1792	0.0581	0.0336	0.0451	43.75
-9.4	74.75	0.1696	0.0567	0.0312	0.0423	46.26
-9.1	74.75	0.1684	0.0536	0.0282	0.0374	51.37
-8.7	74.75	0.1939	0.0526	0.0276	0.0338	55.32
-8.4	74.75	0.2093	0.0514	0.0271	0.0307	62.00
-8.0	74.75	0.1894	0.0511	0.0266	0.0292	66.8
-7.7	74.75	0.1753	0.0502	0.0268	0.0274	75.51
-7.3	74.75	0.2060	0.0505	0.0270	0.0263	86.24
-7.0	74.75	0.2226	0.0507	0.0281	0.0272	100.16
-6.6	74.75	0.2220	0.0505	0.0279	0.0269	108.00
-6.3	74.75	0.2242	0.0514	0.0298	0.0296	117.78
-5.9	74.51	0.1543	0.0517	0.0294	0.0297	123.42
-5.6	74.75	0.2567	0.0555	0.0332	0.0337	133.99
-5.2	74.75	0.2675	0.0591	0.0348	0.0363	141.00
-4.9	74.75	0.3024	0.0639	0.0366	0.0406	143.69
-4.5	74.51	0.1649	0.0672	0.0351	0.0400	147.61
-4.2	74.75	0.3152	0.0739	0.0398	0.0451	146.75
-3.8	74.75	0.3250	0.0788	0.0429	0.0469	144.36
-3.5	74.75	0.3155	0.0831	0.0431	0.0486	145.88
-3.1	74.75	0.3317	0.0848	0.0439	0.0473	143.29
-2.8	74.51	0.1966	0.0871	0.0435	0.0453	139.90
-2.4	74.51	0.2093	0.0922	0.0453	0.0436	132.35
-2.1	74.75	0.3595	0.0979	0.0479	0.0412	125.51
-1.7	74.75	0.3660	0.1041	0.0511	0.0387	113.19
-1.4	74.51	0.2485	0.1151	0.0562	0.0492	102.26

Table 2 – Waves summary for 10m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	11.39	4.07	1.17	2.28	0.79
Tp (s)	11.39	13.40	2.10	11.35	1.85
Dp (^{o})	11.39	236.53	203.53	219.23	7.30

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Data return (%)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-27.3	100.00	0.1476	0.0329	0.0188	0.0113	120.27
-26.8	100.00	0.1424	0.0353	0.0203	0.0112	124.88
-26.3	100.00	0.1520	0.0365	0.0219	0.0104	124.25
-25.8	100.00	0.1872	0.0388	0.0234	0.0092	123.46
-25.3	100.00	0.2466	0.0407	0.0240	0.0094	122.94
-24.8	100.00	0.2648	0.0427	0.0255	0.0097	125.14
-24.3	100.00	0.2805	0.0441	0.0261	0.0104	124.96
-23.8	100.00	0.2860	0.0453	0.0270	0.0107	121.88
-23.3	100.00	0.3014	0.0472	0.0277	0.0116	121.10
-22.8	100.00	0.3048	0.0493	0.0284	0.0137	117.97
-22.3	100.00	0.3005	0.0511	0.0292	0.0153	118.21
-21.8	100.00	0.3487	0.0520	0.0301	0.0161	115.09
-21.3	100.00	0.3850	0.0524	0.0308	0.0164	111.13
-20.8	100.00	0.3822	0.0531	0.0315	0.0163	108.51
-20.3	100.00	0.3914	0.0535	0.0320	0.0165	103.22
-19.8	99.91	0.3497	0.0535	0.0318	0.0162	96.53
-19.3	99.86	0.3561	0.0533	0.0314	0.0158	90.86
-18.8	99.91	0.3247	0.0537	0.0317	0.0158	85.75
-18.3	99.91	0.3474	0.0537	0.0320	0.0156	78.41
-17.8	99.91	0.3529	0.0542	0.0321	0.0157	73.89
-17.3	100.00	0.3227	0.0549	0.0329	0.0160	65.56
-16.8	99.95	0.2979	0.0554	0.0330	0.0155	59.16
-16.3	99.95	0.3214	0.0562	0.0329	0.0160	54.49
-15.8	99.95	0.3217	0.0577	0.0336	0.0164	49.12
-15.3	100.00	0.2955	0.0591	0.0350	0.0164	44.96
-14.8	99.91	0.2569	0.0593	0.0346	0.0166	38.42
-14.3	99.91	0.2853	0.0609	0.0358	0.0163	32.57
-13.8	100.00	0.2908	0.0622	0.0376	0.0161	28.14
-13.3	99.95	0.2895	0.0630	0.0381	0.0161	25.15
-12.8	99.95	0.3077	0.0633	0.0400	0.0148	19.37
-12.3	99.95	0.2919	0.0644	0.0408	0.0150	13.94
-11.8	99.95	0.3111	0.0659	0.0430	0.0151	4.44
-11.3	99.95	0.3328	0.0676	0.0449	0.0151	356.41
-10.8	99.95	0.3305	0.0687	0.0461	0.0155	347.47
-10.3	99.91	0.3170	0.0699	0.0469	0.0152	340.86
-9.8	99.91	0.3299	0.0715	0.0478	0.0168	331.88
-9.3	99.82	0.3269	0.0743	0.0495	0.0180	321.38
-8.8	99.72	0.4546	0.0771	0.0522	0.0206	311.76
-8.3	99.72	0.4467	0.0806	0.0552	0.0237	305.92
-7.8	99.77	0.4304	0.0835	0.0566	0.0270	301.07
-7.3	99.58	0.3895	0.0854	0.0569	0.0304	295.39
-6.8	99.58	0.4097	0.0868	0.0574	0.0325	291.87
-6.3	99.68	0.4501	0.0864	0.0590	0.0315	284.48

-5.8	99.86	0.5304	0.0903	0.0581	0.0180	173.33
-5.3	99.77	0.5800	0.0983	0.0595	0.0209	168.24
-4.8	99.82	0.4950	0.1337	0.0772	0.0484	294.65
-4.3	99.72	0.5904	0.2033	0.1144	0.1494	321.33
-3.8	99.63	0.5646	0.2656	0.1243	0.2171	317.35
-3.3	99.68	0.6421	0.2721	0.1333	0.2205	302.93
-2.8	99.45	0.6432	0.2673	0.1380	0.2144	283.28
-2.3	91.27	0.7051	0.2865	0.1469	0.2394	268.66

Table 4 – Waves summary for 30m ADCP

	Data Return (%)	Max	Min	Mean	Std
Hs (m)	95.99	3.22	1.04	1.71	0.41
Tp (s)	95.99	14.90	2.70	10.76	1.66
Dp (^{o})	95.99	282.57	151.57	223.13	18.95

Table 5 – Water temperature and salinity summary (surface, 8m)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	96.63	13.97	19.20	11.21
Conductivity	96.63	41.85	47.43	37.75
Salinity (psu)	96.63	34.92	35.28	32.79

Table 6 – Water temperature and salinity summary (bottom, 30m)

Parameter	Data Return (%)	Mean	Max	Min
Temperature (^{o}C)	96.65	11.97	19.20	10.51
Conductivity	96.65	39.99	47.62	38.15
Salinity (psu)	96.65	35.00	35.44	31.85

1.1 DATA RETURN FOR BANTAMSKLIP SITE.

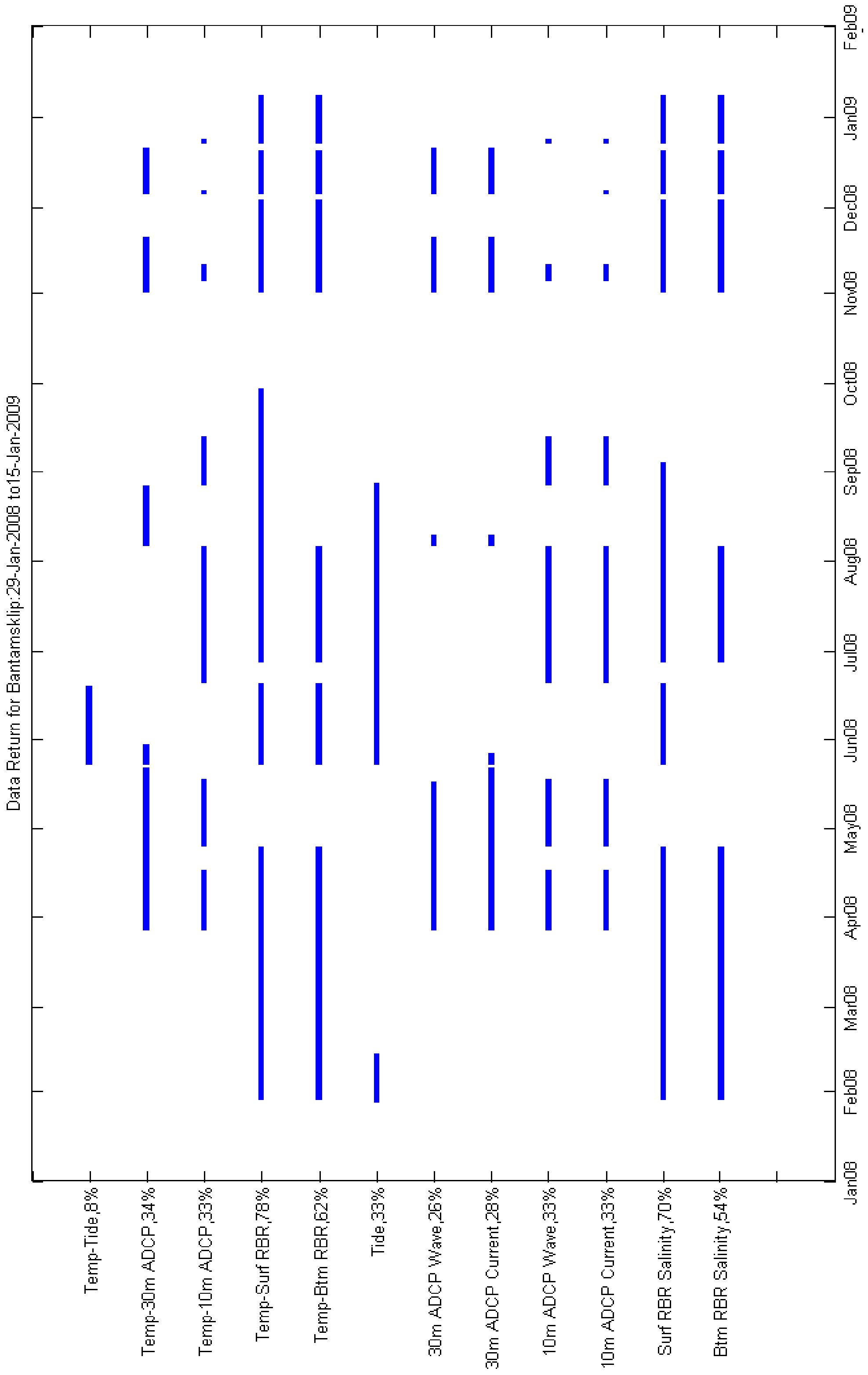


Figure 1: An indication of the data return at the Bantamsklip site since the beginning of the project.

2. INTRODUCTION

2.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents waves, currents, temperature and salinity data collected at Bantamsklip station for the period December 5th 2008 - January 7th 2009 (Period 7). Service of the instruments was undertaken twice: December 20th – 21st 2008 and January 7th/February 2nd 2009.

2.2 EQUIPMENT LIST

Lwandle provided the equipment as listed in Table 7 for the Bantamsklip site.

Table 7 – List of equipment provided.

Item	Operational (on site)	Spare (for whole project)
TRDI 600kHz ADCP	2	1
RBR XR420 CT logger	2	1
RBR TGR 2050 HT Tide Gauge	1	0

2.3 MEASUREMENT LOCATION

The deployment location of the instruments is given in Table 8.

Table 8 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34° 42.241’	19° 33.101’
10m ADCP	34° 43.148’	19° 33.398’
Biofouling	34° 43.190’	19° 33.686’
30m ADCP	34° 42.625’	19° 30.635’
T&C mooring	34° 42.625’	19° 30.635’

3. OPERATIONS

3.1 SUMMARY OF EVENTS

December 20th 2008.
Recovery of the 10m (s/n 10105) and 30m (s/n 11424) ADCPs as well as the RBR-CT loggers (s/n 12994 and 15248) that was attached on the respective frames was undertaken.

December 21st 2008.
Redeployment of all the instruments was successful.

January 7th 2009.
Recovery of the 10m and 30m ADCPs as well as the RBR-CT loggers that was attached on the respective frames was undertaken. A new Tide gauge was deployed (s/n 13084).

February 2nd 2009.
Redeployment of all the instruments was successful. The RBR mooring was moved to 34.7101^{o}S, 19.5111^{o}E with the surface sensor at 13m below the sea-surface. The bottom RBR logger was strapped to the 30m ADPC frame.

3.2 INSTRUMENT CONFIGURATIONS

The as deployed instrumentation configurations are given in this section and completed deployment / recovery sheets are given in Section 7 (page 51).

3.2.1 600kHz ADCP

Table 9 – Instrument configuration for 10m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	10105
Wave burst duration	41 min
Time between wave bursts	60 min
Number of bins	42
Bin size	0.35 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	500
Edgetech Acoustic Release	s/n 32380 release code 641722

Table 10 – Instrument configuration for 30m Bantamsklip ADCP

Parameter	Configuration
ADCP model	600KHz WH ADCP
ADCP serial number	11424
Wave burst duration	34 min
Time between wave bursts	60 min
Number of bins	69
Bin size	0.5 m
Sampling/ ensemble interval	10 minutes
Pings per ensemble	250
Edgetech Acoustic Release	s/n 32383 release code 642016

3.2.2 RBR XR420 CT LOGGER

Table 11 – Instrument configuration for T&C Mooring Line.

Parameter	Configuration
XR 420 Temperature and Conductivity	s/n 12994 (8m) and s/n 15248 (30m)
Sampling and Averaging	Sample at 1Hz for 1 minute every 10 minutes

Surface RBR s/n 12994 redeployed at 13m.

3.2.3 RBR TGR2050 HT TIDE GAUGE

Table 12 – Instrument configuration for the Tide Gauge

Parameter	**Configuration**
TGR 2050 HT	s/n 13084
Sampling and Averaging	10sec sampling and 1sec @ 4Hz averaging

3.2.4 Biofouling Mooring

Table 13 – Instrument configuration for Biofouling Mooring Line.

Parameter	**Configuration**
Biofouling Plates	3 plates (20cmx20cm) at 3m and 3 plates (20cmx20cm) at 8m
Edgetech Acoustic Release	s/n 32387 release code 642144

3.3 RECOVER AND REDEPLOYMENT METHODOLOGY

3.3.1 T&C mooring

The T&C mooring line was deployed by lowering the array down via a rope through the anchor weights. The mooring line is recovered using divers to undo a single shackle that connects the mooring line to the anchor weights. Divers reattach the line onto the weights, after the instruments have been serviced.

3.3.2 ADCP mooring

The ADCP Frame is lowered to the bottom and moved into position by divers, who also attach chain sections that act as anchors. To retrieve the frame divers have to locate the mooring, take of the anchor chains and surface the frame using air lift bags that they attach.

3.3.3 Tidal Gauge.

The Druck pressure sensor was installed at depth of about 1.5m outside a stilling well, which was attached to a permanent steel frame in 1.87m depth of water.

3.3.4 Biofouling mooring

The biofouling mooring line was deployed by lowering the array down via a rope through the anchor weights. Divers will locate the mooring line and retrieve a surface and bottom plate from the line at the required sampling periods.

4. DATA QUALITY CONTROL

4.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

4.1.1 Current processing

- The record was truncated to exclude times pre and post deployment as well for Dec 20 – 21's service visit when the instruments were out of the water.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 28' W for the 10m ADCP and 25° 26' W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP's pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of $0.2ms^{-1}$ was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 2).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

4.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 28' W for the 10m ADCP and 25° 26' W for the 30m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

The instruments were recovered, serviced and redeployed on December 20 – 21 2008.

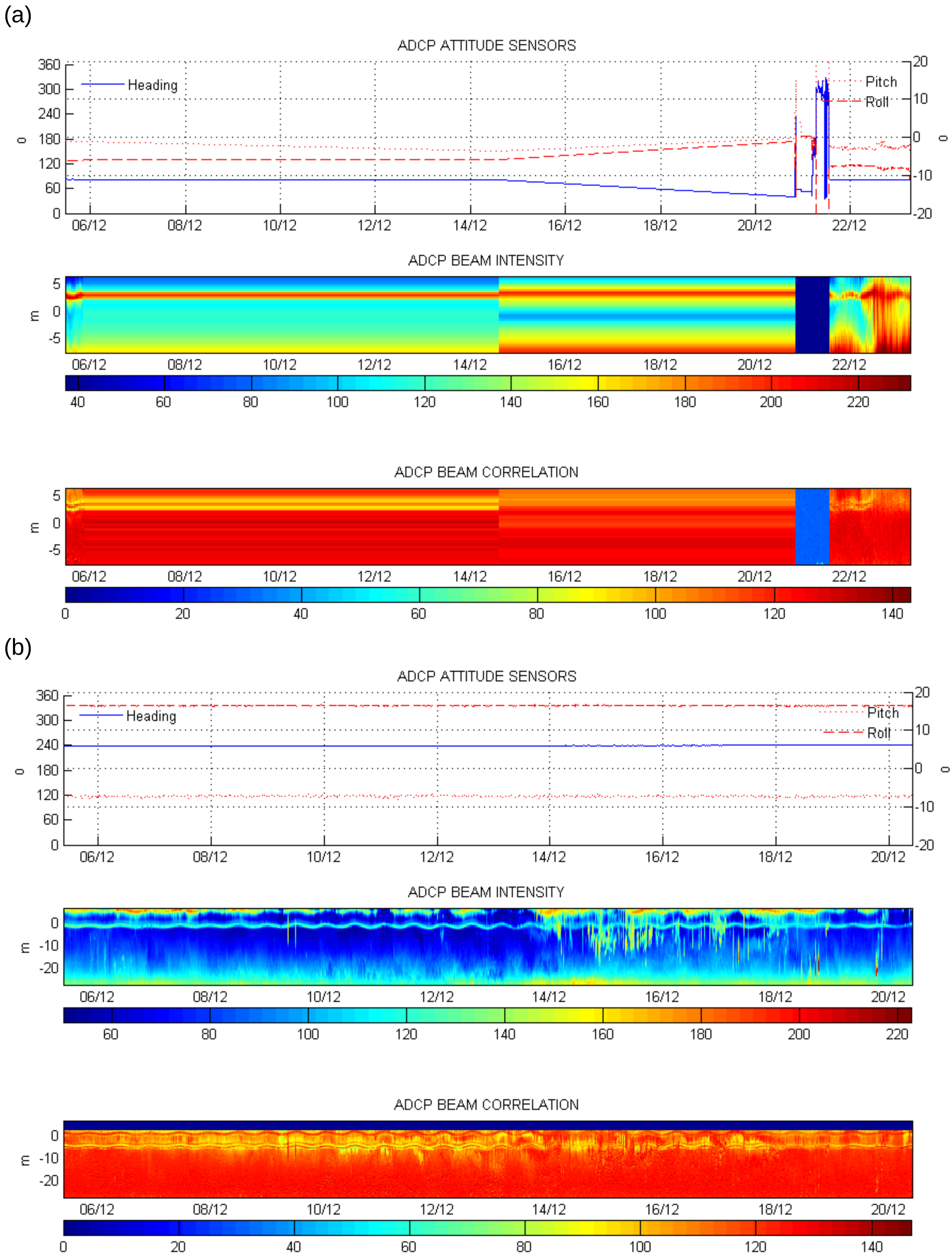


Figure 2: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

4.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment as well for Dec 20 – 21's service visit when the instruments were out of the water.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.

4.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is +0.73m.
- Finally the data was averaged over a 10-minute period.

The tide gauge was found lost during SV5 and was replaced on January 7th 2009.

4.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was not scheduled for service visit 7.

4.5 WATER SAMPLE.

No water samples were collected during this service.

5. DATA PRESENTATION

All data presented have been subject to the quality control procedures detailed in the previous section. Bad data have been excluded from all plots and calculations.

All plots in this section include a stamp that details the location, depth, time period and number of observations that the plot is based upon. Wherever possible, scaling of parameters has been kept constant throughout this section to facilitate comparison between plots and stations.

5.1 10M ADCP

5.1.1 Current Data

5.1.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

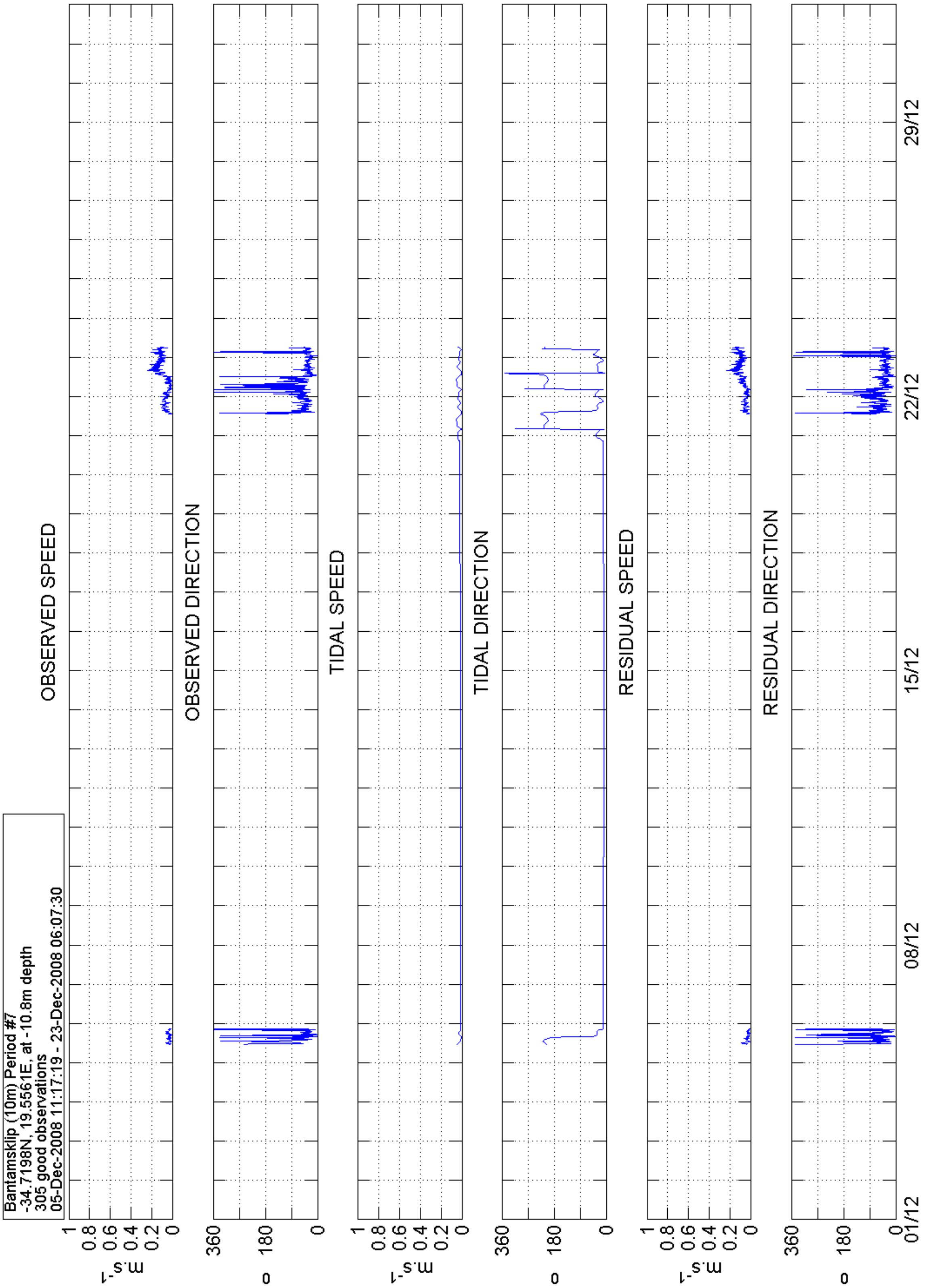


Figure 3: Time series plot for 10m ADCP current data at 10.8m.

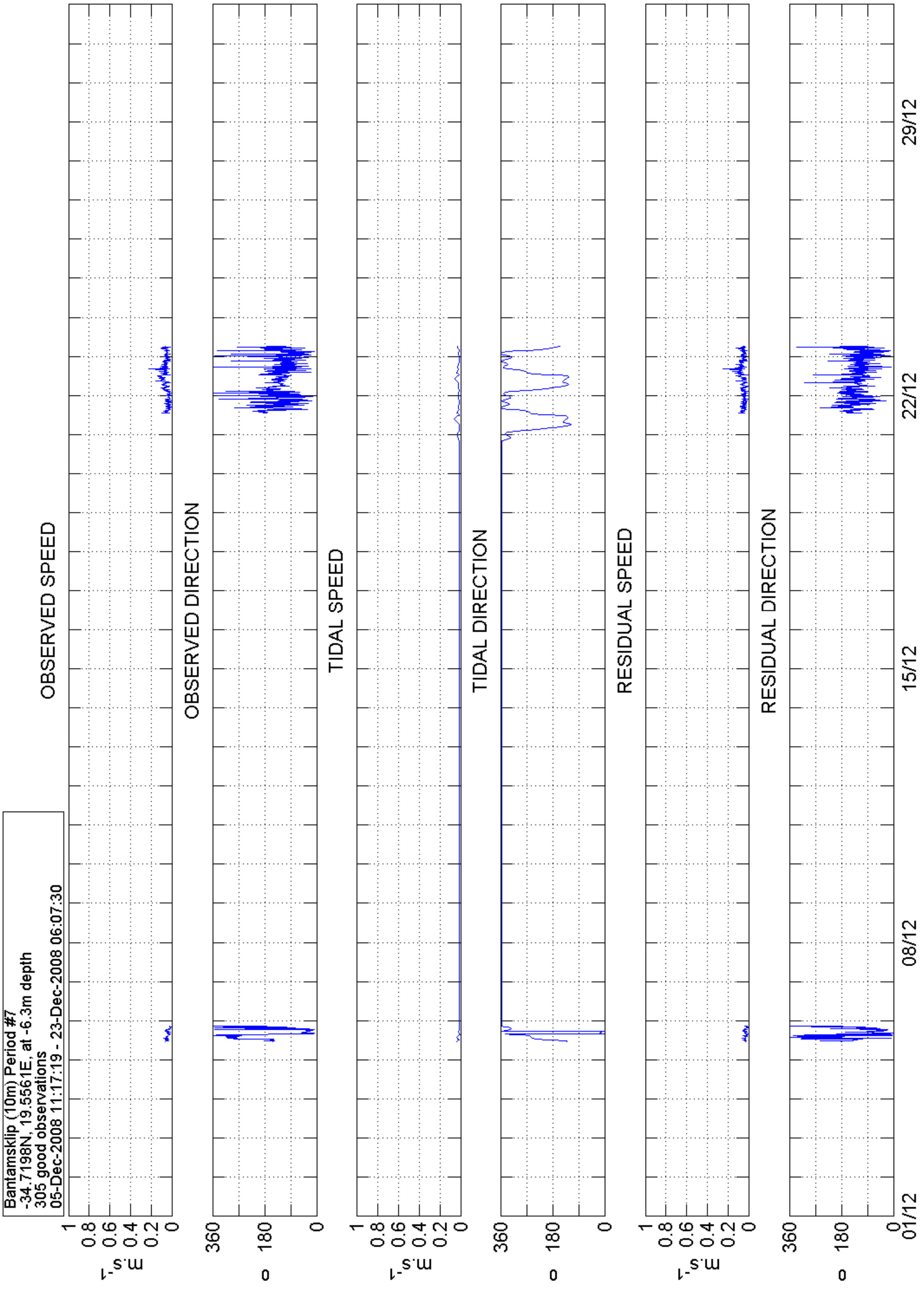


Figure 4: Time series plot for 10m ADCP current data at 6.3m.

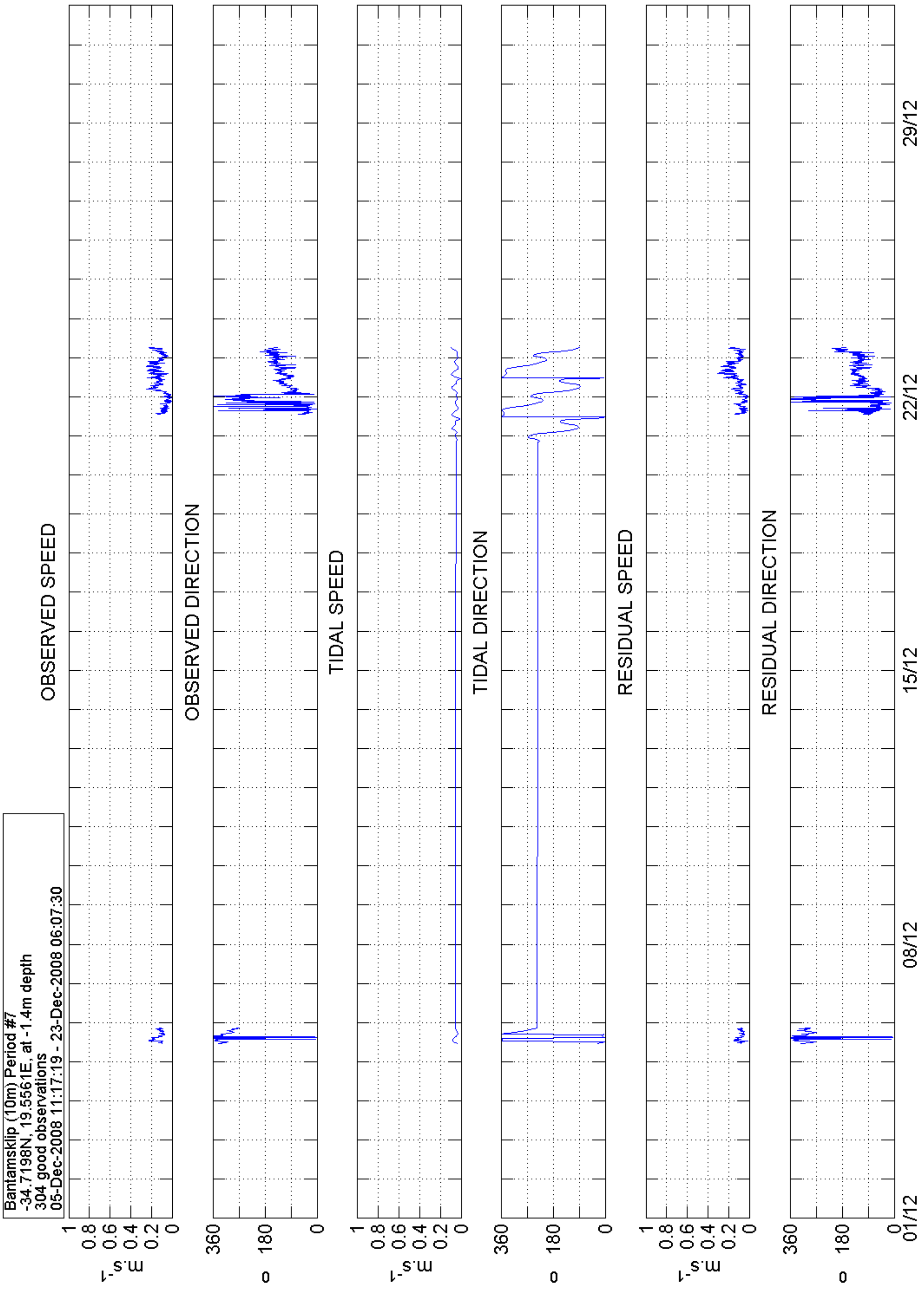


Figure 5: Time series plot for 10m ADCP current data at 1.4m.

5.1.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.1.1.3 Progressive vector plots

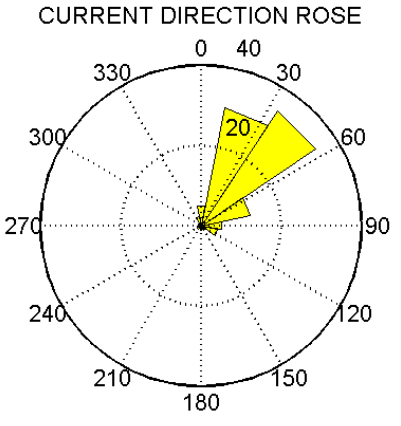
The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at -10.8m depth
305 good observations
05-Dec-2008 11:17:19 - 23-Dec-2008 06:07:30

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	4.59	15.08	22.95	12.46	4.92	4.26	1.31	0.66	1.31	0.33	0.98	0.98		0.33	0.66	2.30	73.11
0.1-0.2	0.33	13.11	11.15		0.33												24.92
0.2-0.3		1.64	0.33														1.97
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	4.92	29.84	34.43	12.46	5.25	4.26	1.31	0.66	1.31	0.33	0.98	0.98	0.00	0.33	0.66	2.30	100.00



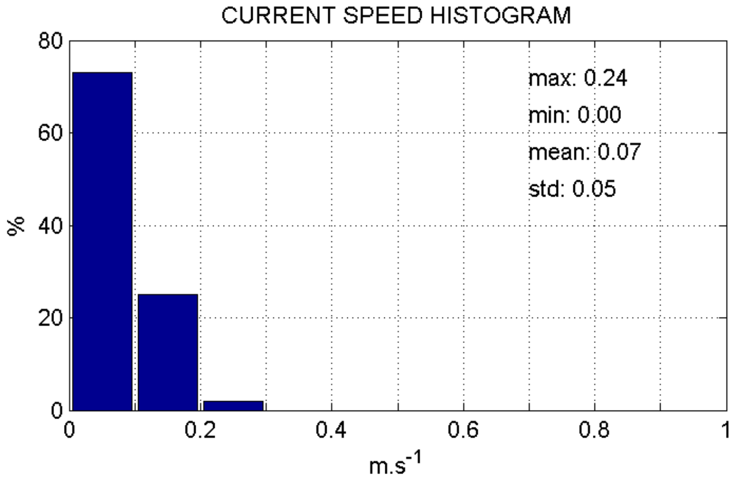


Figure 6: Summary plot for 10m ADCP current data at 10.8m.

Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at -6.3m depth
305 good observations
05-Dec-2008 11:17:19 - 23-Dec-2008 06:07:30

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	3.61	6.89	7.54	8.85	7.21	11.48	13.11	8.85	9.84	3.93	1.97	0.98	1.97	2.95	1.97	1.97	93.11
0.1-0.2		0.33	0.33		1.31	1.97	1.97	0.33	0.33								6.56
0.2-0.3								0.33									0.33
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	3.61	7.21	7.87	8.85	8.52	13.44	15.08	9.51	10.16	3.93	1.97	0.98	1.97	2.95	1.97	1.97	100.00

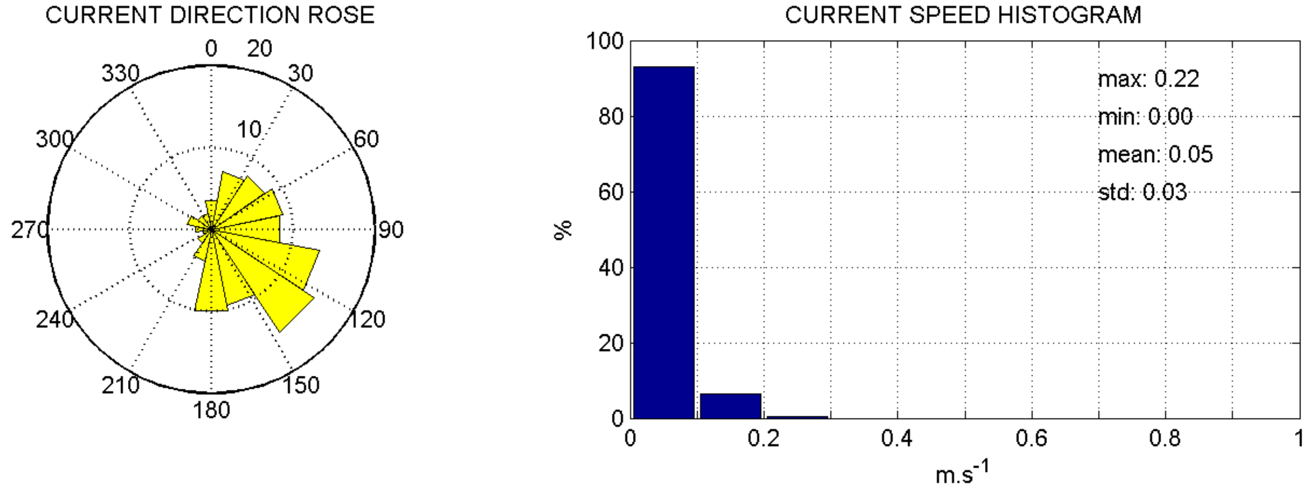


Figure 7: Summary plot for 10m ADCP current data at 6.3m

Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at -1.4m depth
304 good observations
05-Dec-2008 11:17:19 - 23-Dec-2008 06:07:30

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.64	4.61	3.62	2.96	1.64	3.29	4.28	2.96	0.99	0.66	1.32	1.64	1.64	4.61	3.29	2.63	41.78
0.1-0.2	3.29	1.32	1.32	2.63	6.25	8.22	11.18	3.95	1.97	0.33			1.32	1.97	2.30	1.97	48.03
0.2-0.3	1.32			1.32	1.32	0.99	2.96	1.97								0.33	10.20
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	6.25	5.92	4.93	6.91	9.21	12.50	18.42	8.88	2.96	0.99	1.32	1.64	2.96	6.58	5.59	4.93	100.00

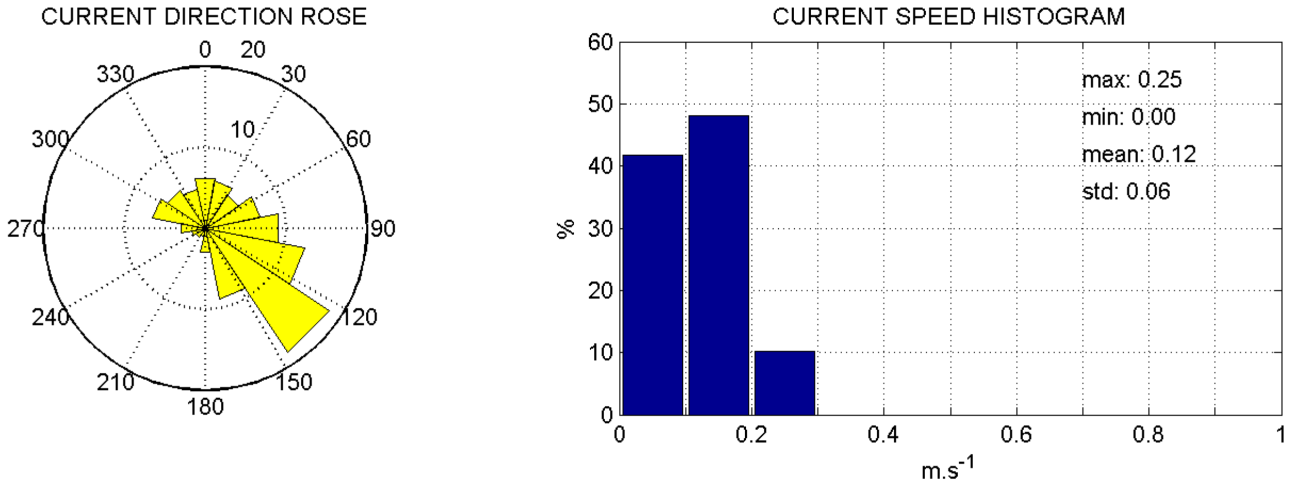


Figure 8: Summary plot for 10m ADCP current data at 1.4m.

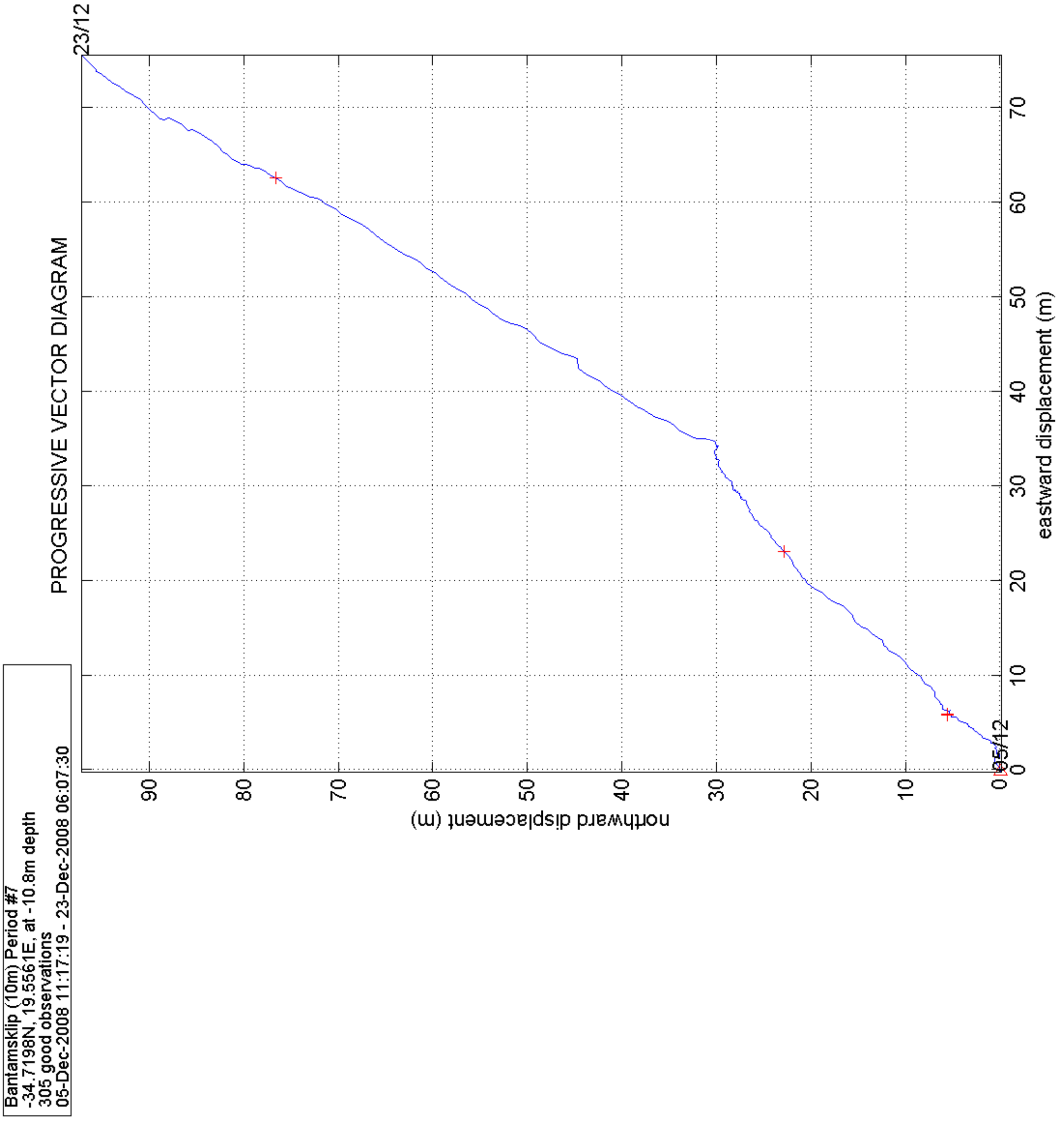


Figure 9: Progressive vector plot for 10m ADCP current data at 10.8m.

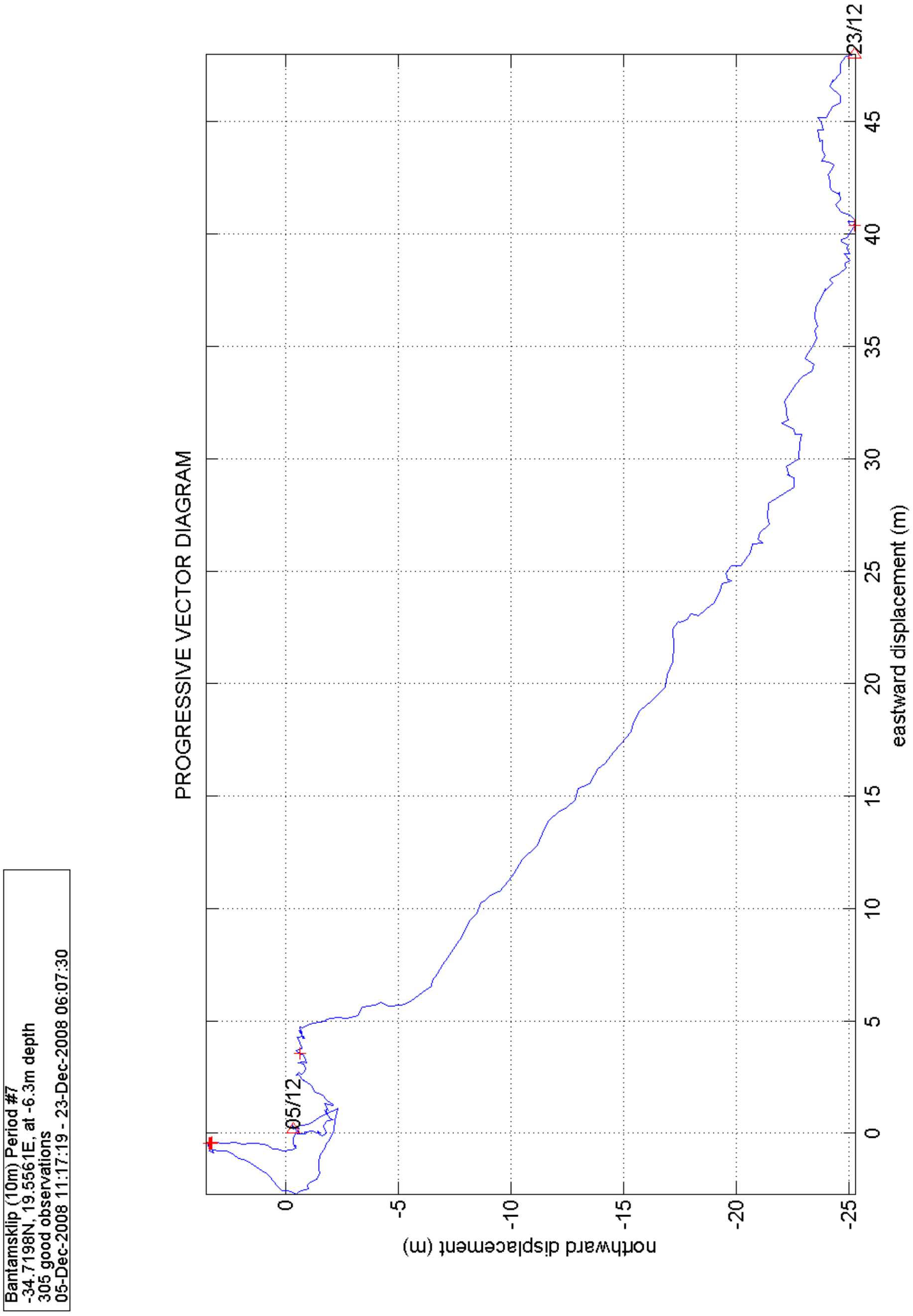


Figure 10: Progressive vector plot for 10m ADCP current data at 6.3m.

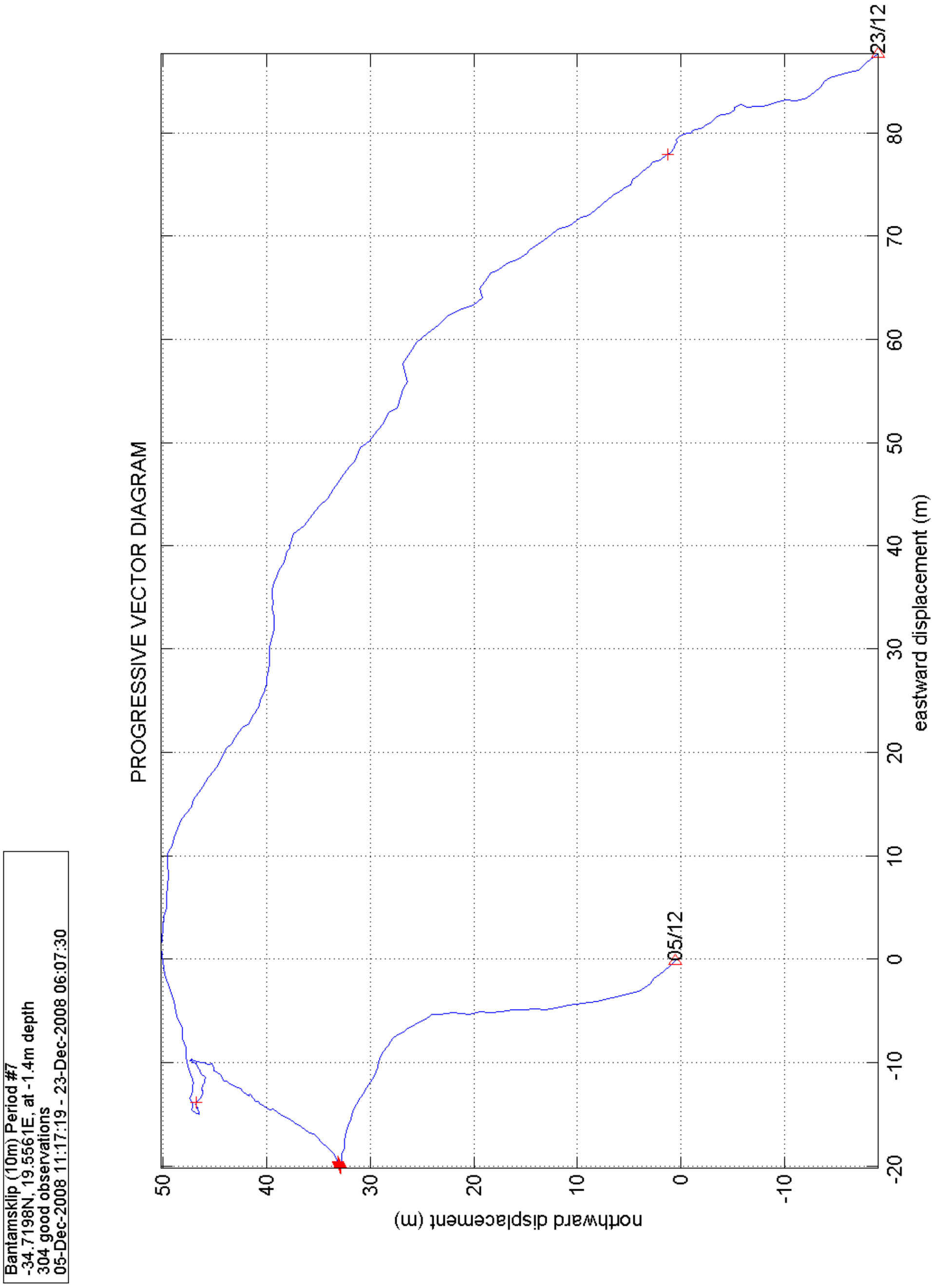


Figure 11: Progressive vector plot for 10m ADCP current data at 1.4m.

5.1.2 Wave Data.

5.1.2.1 Hs and Tp summary plot

Figure 12 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.1.2.2 Hs and Dp summary plot

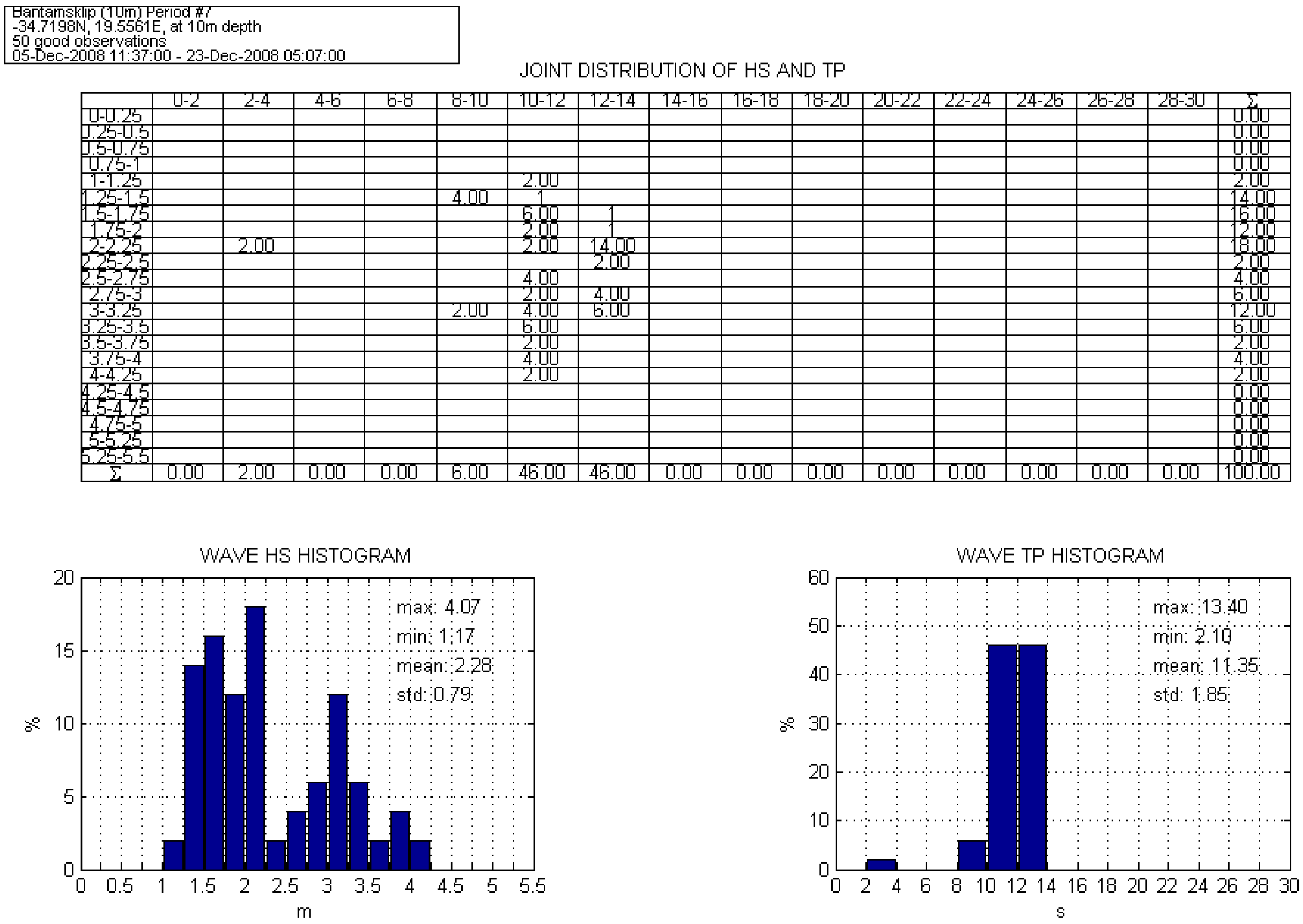
Figure 13 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.1.2.3 Tp and Dp summary plot

Figure 14 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

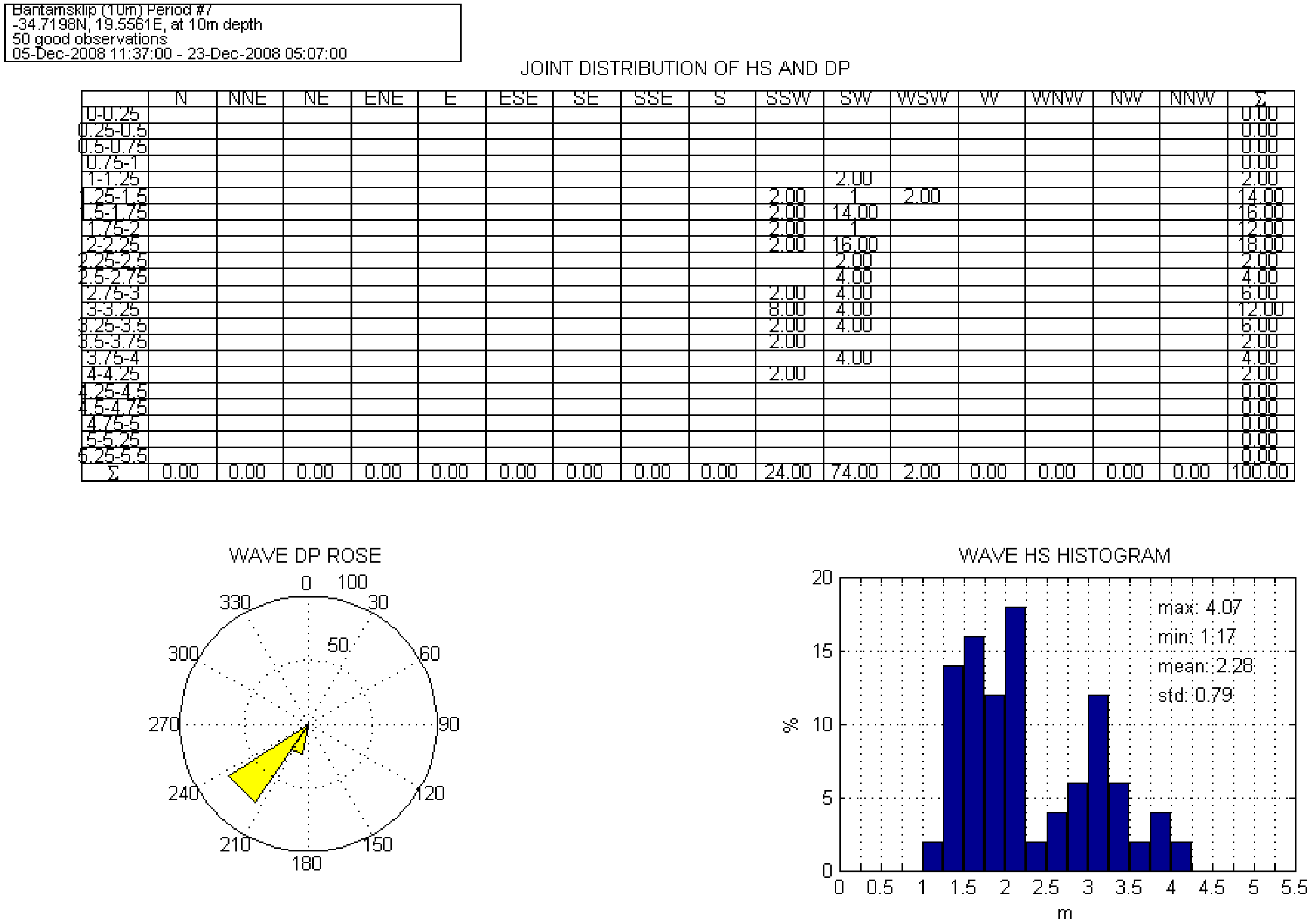


Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at 10m depth
50 good observations
05-Dec-2008 11:37:00 - 23-Dec-2008 05:07:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1																0.00
1-1.25						2.00										2.00
1.25-1.5					4.00	1										14.00
1.5-1.75						6.00	1									16.00
1.75-2						2.00	1									12.00
2-2.25		2.00				2.00	14.00									18.00
2.25-2.5							2.00									2.00
2.5-2.75						4.00										4.00
2.75-3						2.00	4.00									6.00
3-3.25					2.00	4.00	6.00									12.00
3.25-3.5						6.00										6.00
3.5-3.75						2.00										2.00
3.75-4						4.00										4.00
4-4.25						2.00										2.00
4.25-4.5																0.00
4.5-4.75																0.00
4.75-5																0.00
5-5.25																0.00
5.25-5.5																0.00
Σ	0.00	2.00	0.00	0.00	6.00	46.00	46.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Figure 12: Summary plot of H_s and T_p.

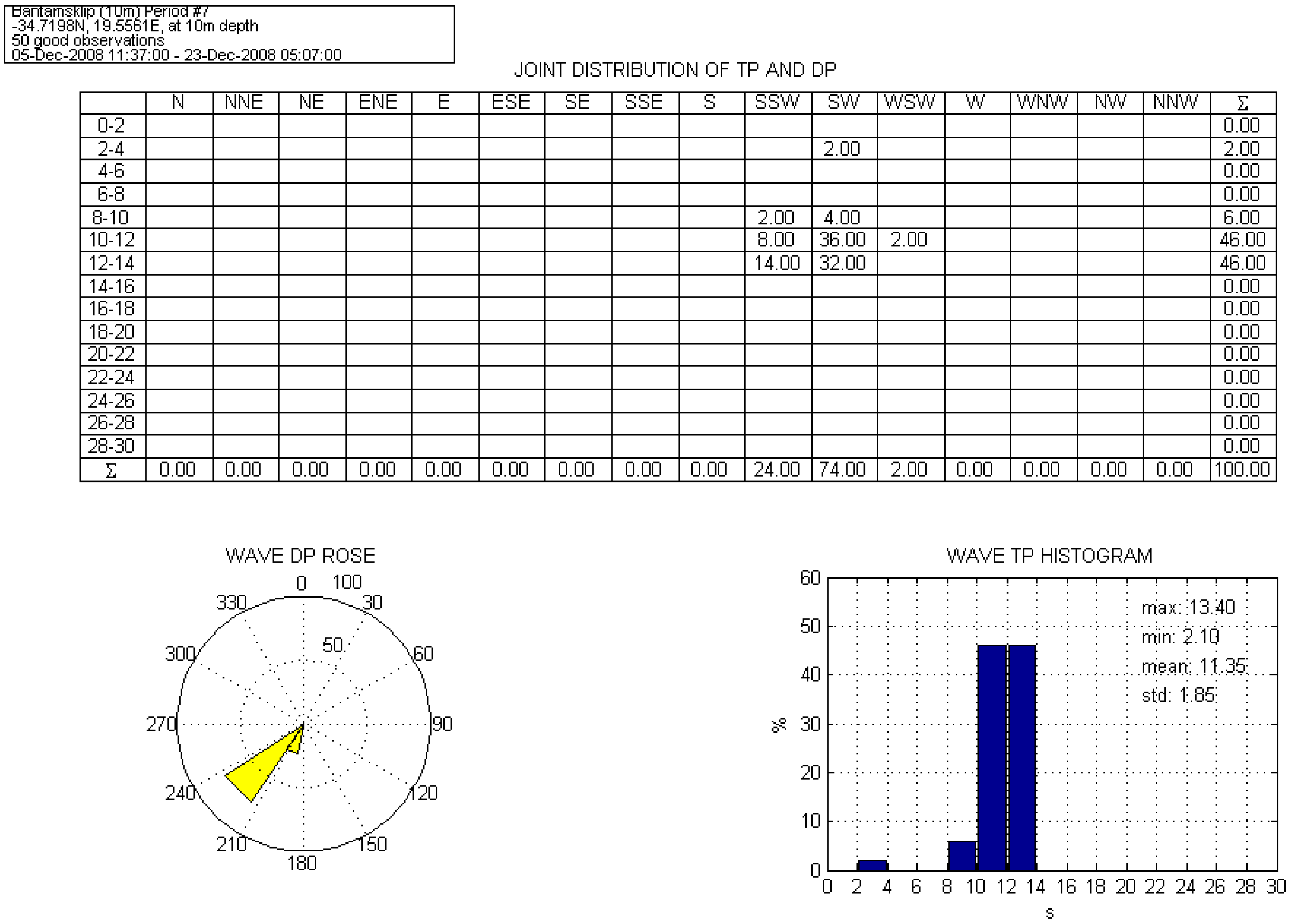


Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at 10m depth
50 good observations
05-Dec-2008 11:37:00 - 23-Dec-2008 05:07:00

JOINT DISTRIBUTION OF HS AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1																	0.00
1-1.25											2.00						2.00
1.25-1.5										2.00	1	2.00					14.00
1.5-1.75										2.00	14.00						16.00
1.75-2										2.00	1						12.00
2-2.25										2.00	16.00						18.00
2.25-2.5											2.00						2.00
2.5-2.75											4.00						4.00
2.75-3										2.00	4.00						6.00
3-3.25										8.00	4.00						12.00
3.25-3.5										2.00	4.00						6.00
3.5-3.75										2.00							2.00
3.75-4											4.00						4.00
4-4.25										2.00							2.00
4.25-4.5																	0.00
4.5-4.75																	0.00
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	74.00	2.00	0.00	0.00	0.00	0.00	100.00

Figure 13: Summary plot of H_s and D_p.



Bantamsklip (10m) Period #7
-34.7198N, 19.5561E, at 10m depth
50 good observations
05-Dec-2008 11:37:00 - 23-Dec-2008 05:07:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4											2.00						2.00
4-6																	0.00
6-8																	0.00
8-10										2.00	4.00						6.00
10-12										8.00	36.00	2.00					46.00
12-14										14.00	32.00						46.00
14-16																	0.00
16-18																	0.00
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.00	74.00	2.00	0.00	0.00	0.00	0.00	100.00

Figure 14: Summary plot of T_p and D_p.

5.2 30M ADCP

5.2.1 Current Data

5.2.1.1 Time series plots

The figures on the following pages display time series plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The first (upper) panel is of the averaged current speed against time.
- The second panel is of the averaged current direction against time.
- The third panel is of the tidal current speed, calculated from the observed current speed and direction, against time. The entire data set of observations is used in the derivation of the tidal component. The tidal calculation follows the method of Foreman and uses the observed complex current vector as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)
- The fourth panel is of the tidal current direction, calculated as above, against time.
- The fifth panel is of the residual current speed against time. The residual has been calculated as north and east components (residual component = observed component – tidal component), which have then been converted into residual speed and direction.
- The sixth panel is of the residual current direction against time, calculated as above.

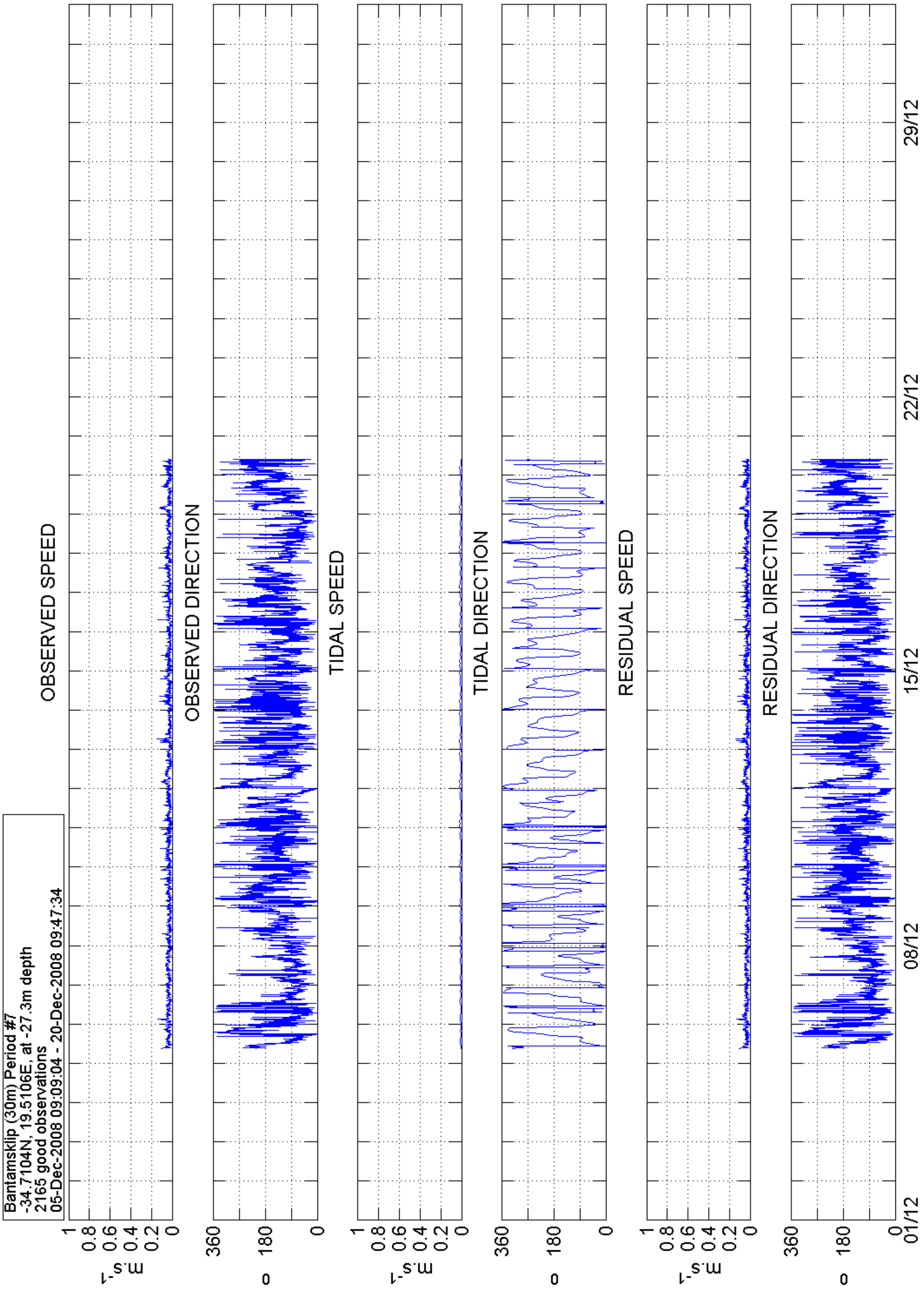


Figure 15: Time series plot for 30m ADCP current data at 27.3m.

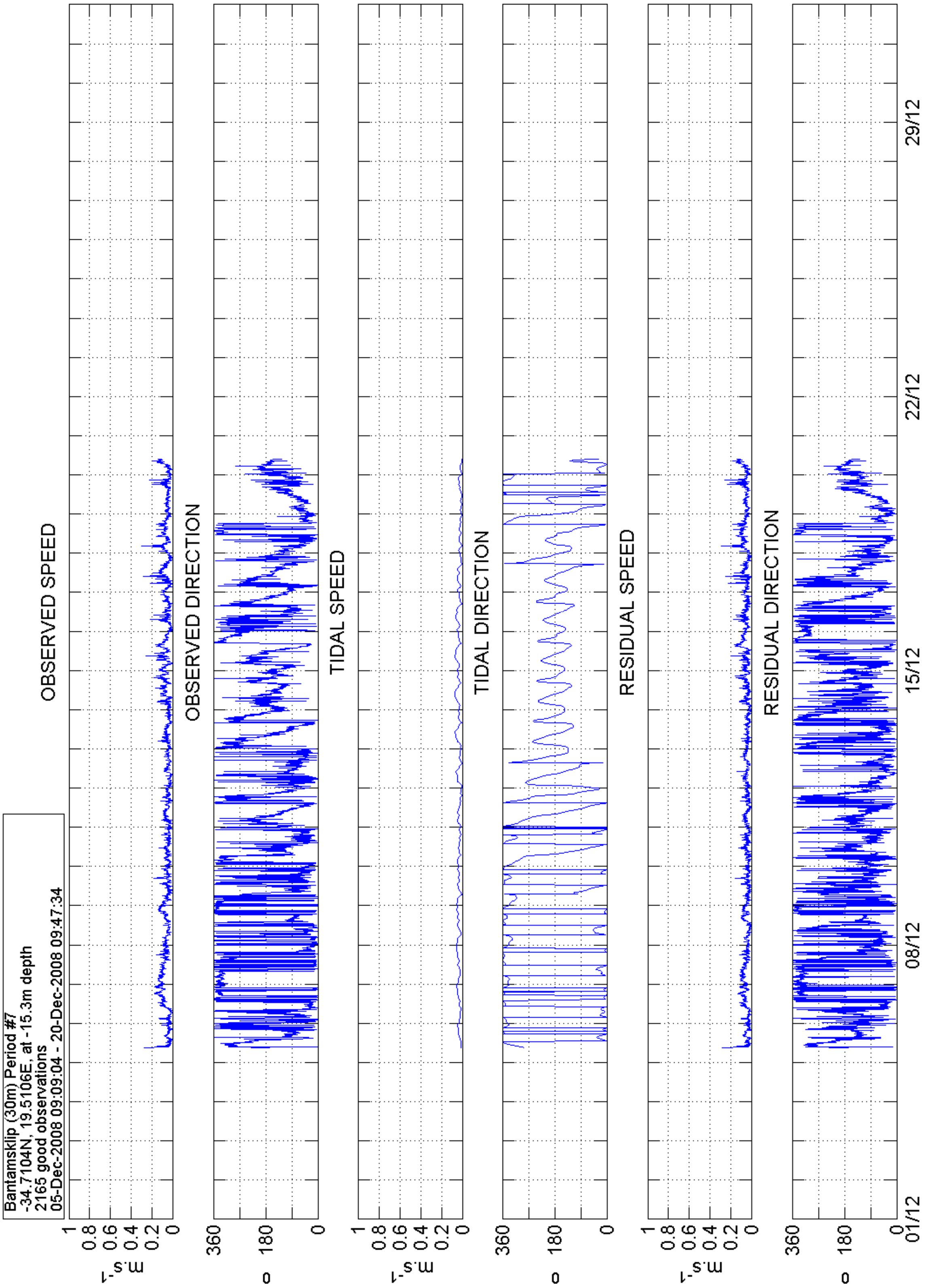


Figure 16: Time series plot for 30m ADCP current data at 15.3m.

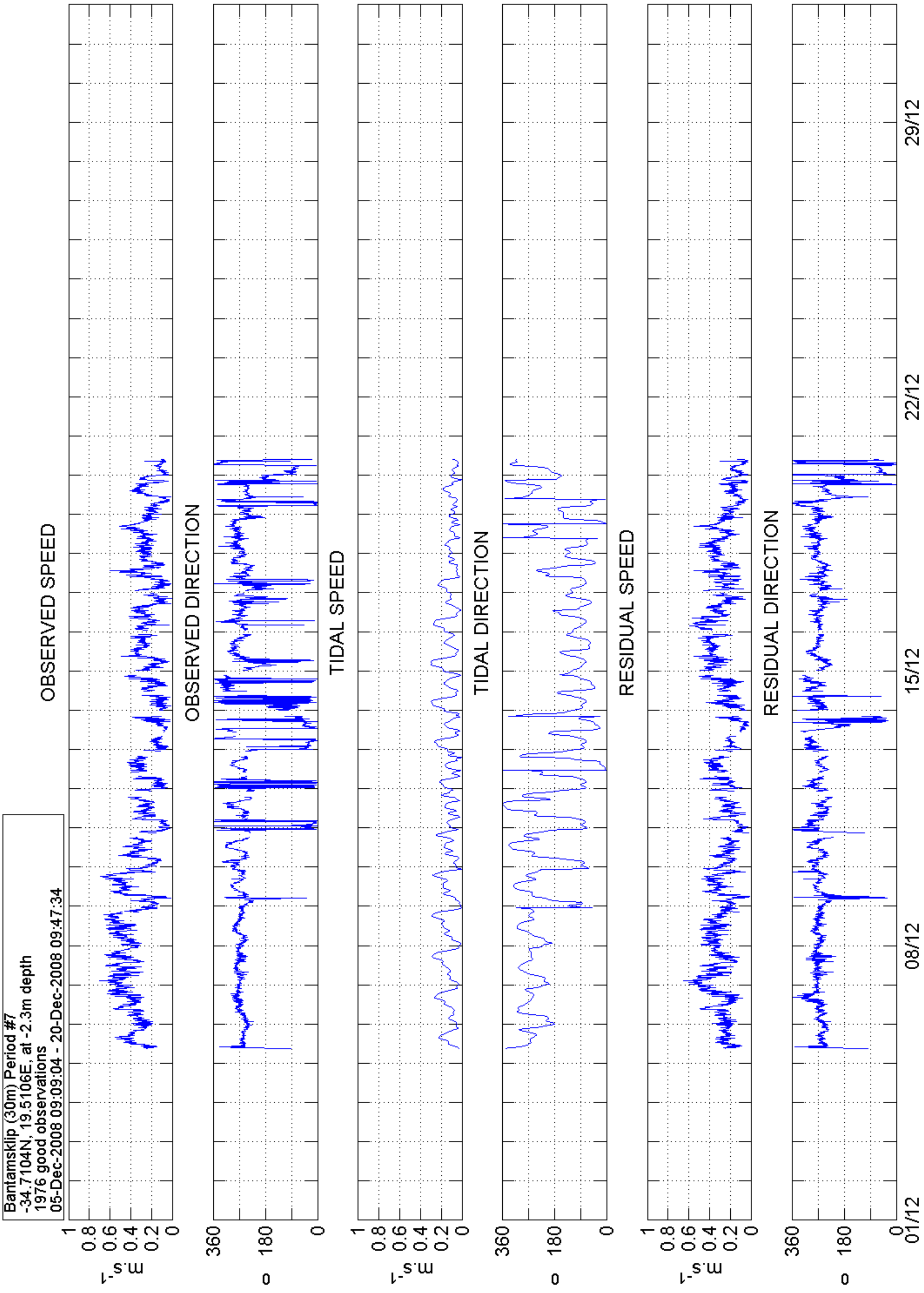


Figure 17: Time series plot for 30m ADCP current data at 2.3m.

5.2.1.2 Summary plots

The figures on the following pages display summary plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The upper panel is a table of the joint distribution of 10 minute averaged current speed against direction. Columns of the table represent direction classes and rows the speed classes. The numbers in the table reflect the percentage of observations that fall within a particular speed interval and direction sector.
- The lower left hand panel is a rose of the 10 minute averaged current direction. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the 10 minute averaged current speeds. This reflects the percentage of observations that fall within each speed interval. Included on the plot are basic statistics for the current speed distribution.

5.2.1.3 Progressive vector plots

The figures on the following pages display progressive vector plots for depths representing near-bottom, mid-depth and near-surface flow respectively. These plots consist of:

- The solid line represents the displacement that a particle of water would undergo when subject to the currents that were observed.
- The start and end points of the observations are labelled.
- Each day is represented by a red cross.

Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at -27.3m depth
2165 good observations
05-Dec-2008 09:09:04 - 20-Dec-2008 09:47:34

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	2.86	5.45	10.02	12.10	10.90	11.32	9.42	6.74	5.64	6.42	6.42	4.53	1.99	1.71	1.25	2.17	98.94
0.1-0.2				0.14						0.32	0.46	0.09	0.05				1.06
0.2-0.3																	0.00
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	2.86	5.45	10.02	12.24	10.90	11.32	9.42	6.74	5.64	6.74	6.88	4.62	2.03	1.71	1.25	2.17	100.00

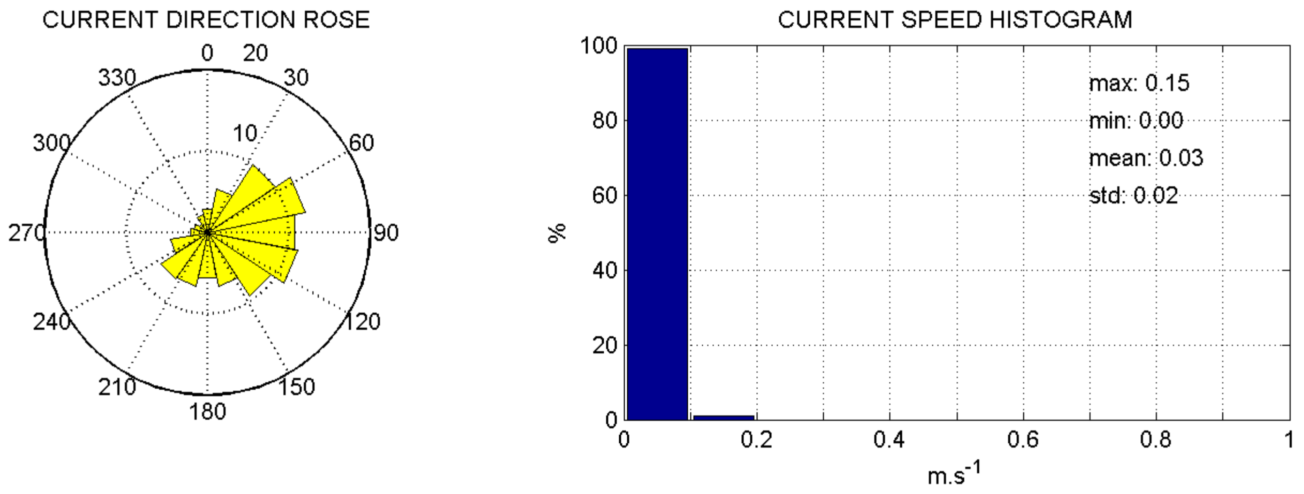


Figure 18: Summary plot for 30m ADCP current data at 27.3m.

Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at -15.3m depth
2165 good observations
05-Dec-2008 09:09:04 - 20-Dec-2008 09:47:34

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	9.56	8.64	8.45	7.99	8.31	7.39	5.40	4.48	3.09	3.23	3.09	2.86	2.96	2.36	4.57	5.64	88.04
0.1-0.2	2.17	0.60	0.51	0.28	0.37	0.37	0.88	1.20	0.55	0.55	0.51	0.09	0.18	0.14	0.46	2.73	11.59
0.2-0.3						0.05	0.09	0.09		0.05	0.05	0.05					0.37
0.3-0.4																	0.00
0.4-0.5																	0.00
0.5-0.6																	0.00
0.6-0.7																	0.00
0.7-0.8																	0.00
0.8-0.9																	0.00
0.9-1																	0.00
Σ	11.73	9.24	8.96	8.27	8.68	7.81	6.37	5.77	3.65	3.83	3.65	3.00	3.14	2.49	5.03	8.36	100.00

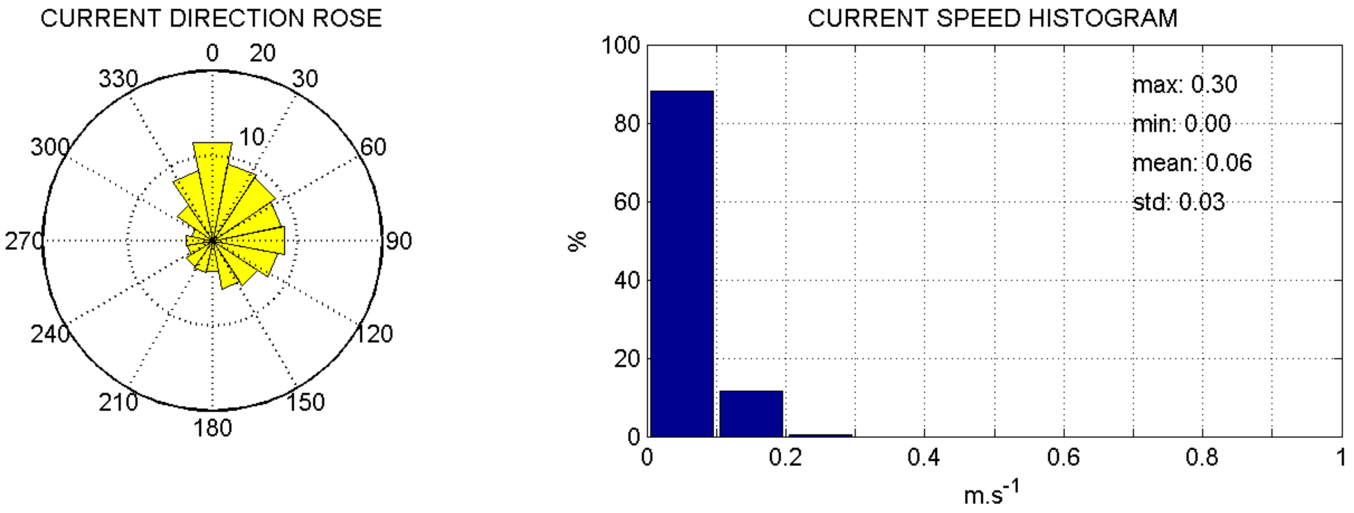


Figure 19: Summary plot for 30m ADCP current data at 15.3m

Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at -2.3m depth
1976 good observations
05-Dec-2008 09:09:04 - 20-Dec-2008 09:47:34

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.1	1.16	1.42	0.71	0.40	0.51	0.51	0.20	0.25	0.25	0.20	0.61	0.71	0.81	0.76	1.21	1.21	10.93
0.1-0.2	1.97	2.33	1.52	0.81	0.56	0.20	0.15	0.25	0.46	0.56	1.67	2.83	2.43	2.13	1.06	0.76	19.69
0.2-0.3	0.20	0.10	0.25	0.20	0.10	0.05	0.05	0.15	0.56	0.30	2.23	9.46	6.68	4.40	1.27	0.25	26.27
0.3-0.4	0.05		0.05	0.05					0.15	0.05	0.86	8.76	6.43	3.59	0.81	0.10	20.90
0.4-0.5											0.05	3.44	5.36	2.43	0.40		11.69
0.5-0.6												1.57	5.72	1.27	0.05		8.60
0.6-0.7												0.30	1.16	0.40			1.87
0.7-0.8													0.05				0.05
0.8-0.9																	0.00
0.9-1																	0.00
Σ	3.39	3.85	2.53	1.47	1.16	0.76	0.40	0.66	1.42	1.11	5.41	27.07	28.64	14.98	4.81	2.33	100.00

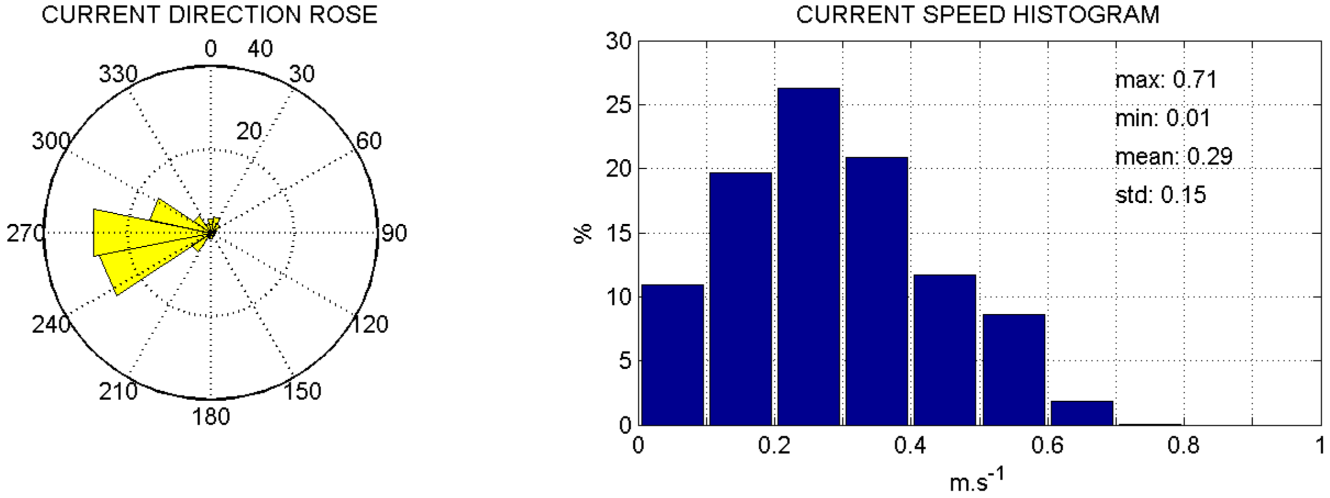


Figure 20: Summary plot for 30m ADCP current data at 2.3m.

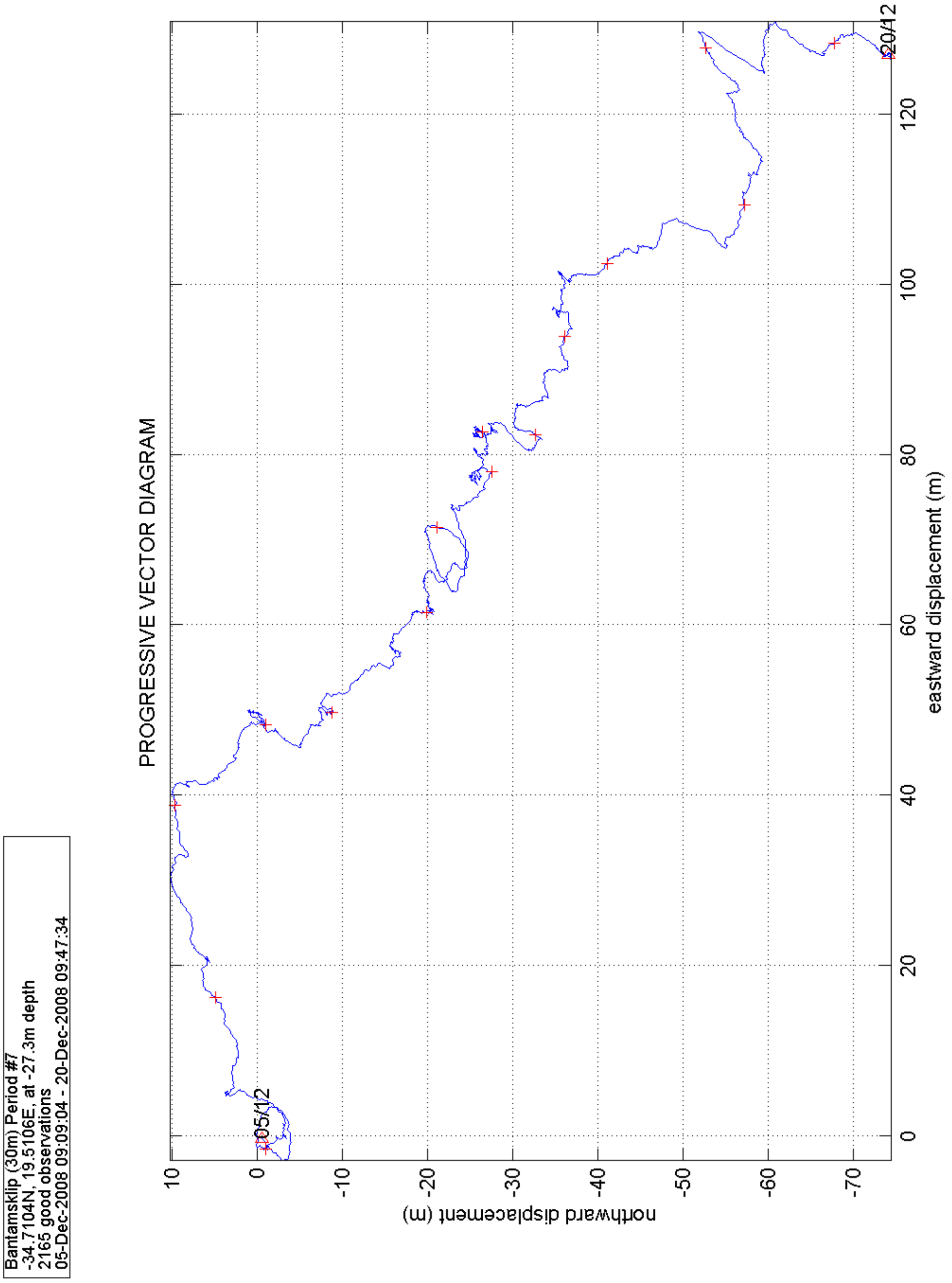


Figure 21: Progressive vector plot for 30m ADCP current data at 27.3m.

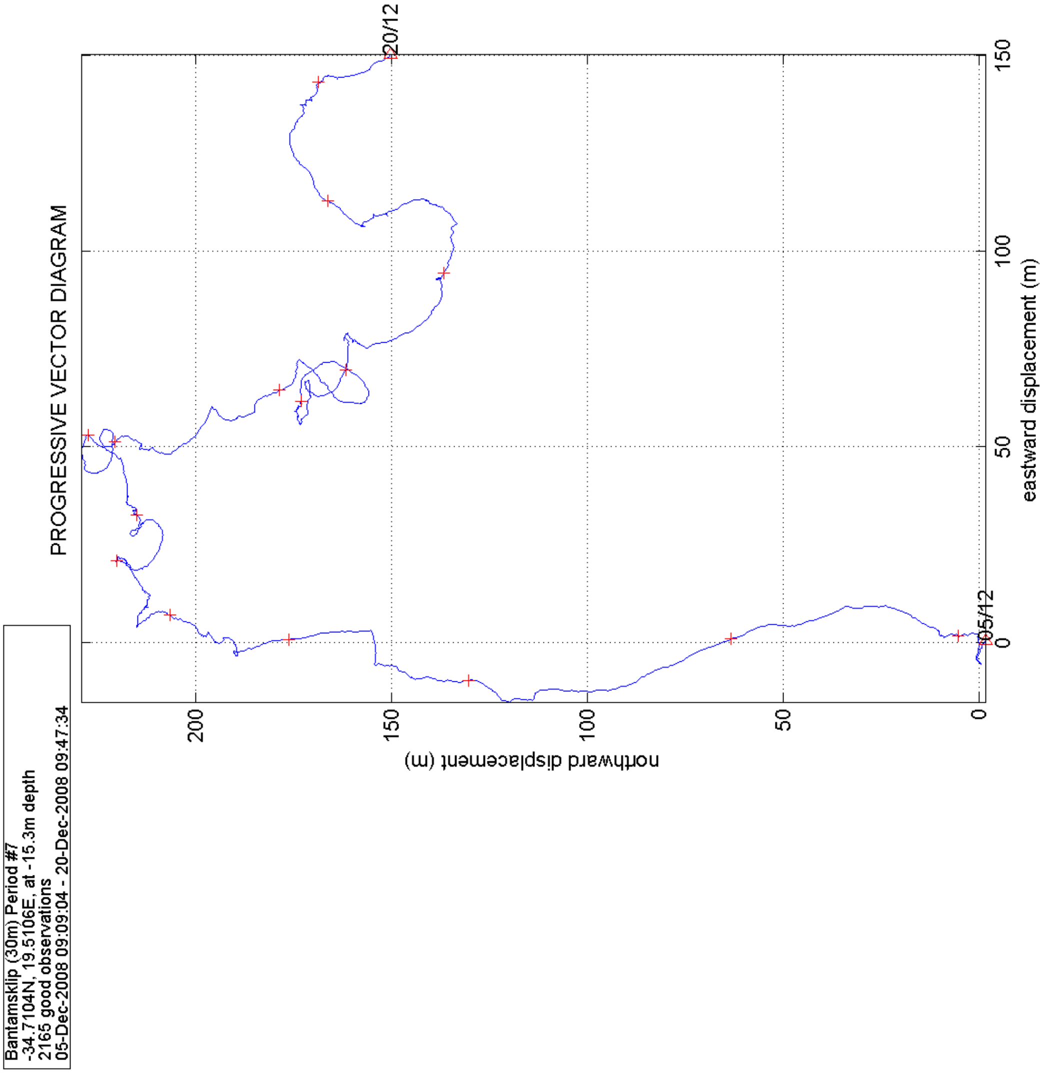


Figure 22: Progressive vector plot for 30m ADCP current data at 15.3m.

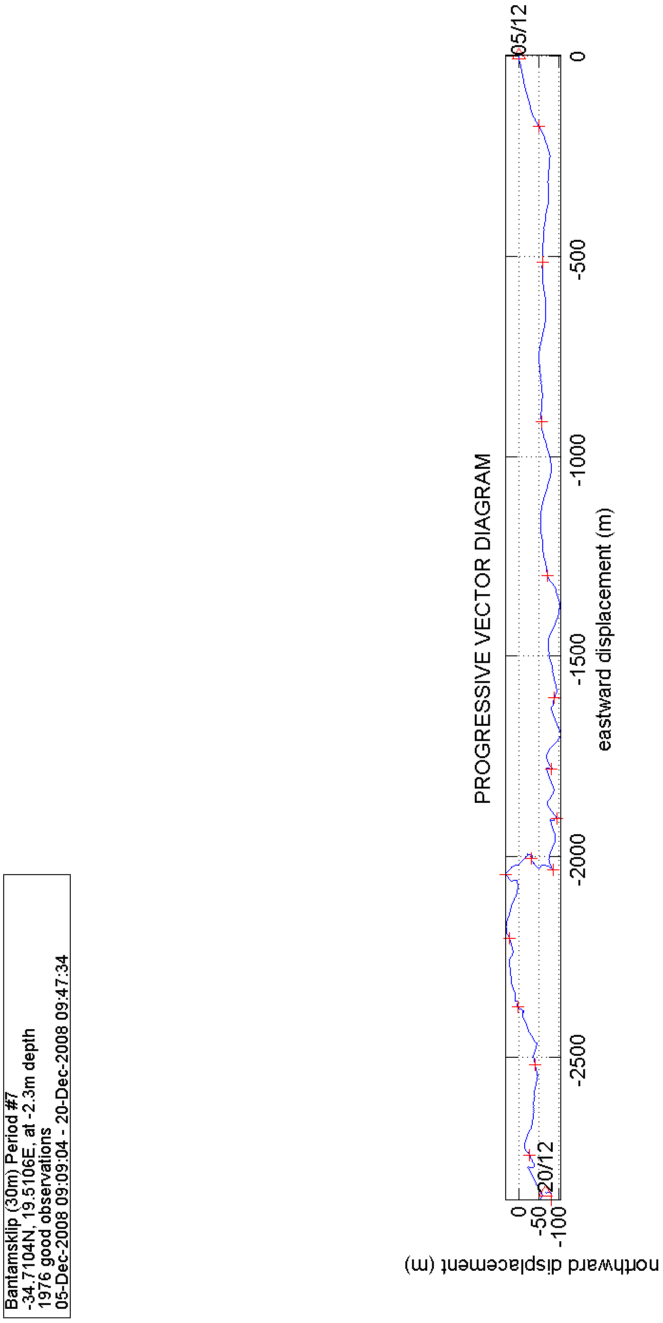


Figure 23: Progressive vector plot for 30m ADCP current data at 2.3m.

5.2.2 Wave Data.

5.2.2.1 Hs and Tp summary plot

Figure 24 displays a summary plot for the wave parameters significant wave height (Hs) and peak period (Tp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Tp. Columns of the table represent Tp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Tp sector.
- The lower left hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

5.2.2.2 Hs and Dp summary plot

Figure 25 displays a summary plot for the wave parameters significant wave height (Hs) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Hs against Dp. Columns of the table represent Dp classes and rows the Hs classes. The numbers in the table reflect the percentage of observations that fall within a particular Hs and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Hs. This reflects the percentage of observations that fall within each Hs interval. Included on the plot are basic statistics for the Hs distribution.

5.2.2.3 Tp and Dp summary plot

Figure 26 displays a summary plot for the wave parameters peak period (Tp) and peak direction (Dp). The plots consist of:

- The upper panel is a table of the joint distribution of Tp against Dp. Columns of the table represent Dp classes and rows the Tp classes. The numbers in the table reflect the percentage of observations that fall within a particular Tp and Dp sector.
- The lower left hand panel is a rose of the observed Dp. This is a histogram of the directional distribution and reflects the percentage of observations that fall within each direction sector.
- The lower right hand panel is a histogram of the observed Tp. This reflects the percentage of observations that fall within each Tp interval. Included on the plot are basic statistics for the Tp distribution.

Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at 30m depth
359 good observations
05-Dec-2008 09:09:00 - 20-Dec-2008 09:09:00

JOINT DISTRIBUTION OF HS AND TP

	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	Σ
0-0.25																0.00
0.25-0.5																0.00
0.5-0.75																0.00
0.75-1																0.00
1-1.25					1.11	1.95	0.28									3.34
1.25-1.5			1.39	1.39	4.46	21.73	5.57									34.54
1.5-1.75			0.84	0.56	2.23	17.27	8.64									29.53
1.75-2		0.28	0.28	0.28	0.84	5.57	4.74	0.28								12.26
2-2.25				2.51	0.56	2.23	2.79									8.08
2.25-2.5				0.28	0.28	2.51	3.34	0.28								6.69
2.5-2.75					0.28	0.84	1.11									2.23
2.75-3						0.84	1.67									2.51
3-3.25						0.84										0.84
3.25-3.5																0.00
3.5-3.75																0.00
3.75-4																0.00
4-4.25																0.00
4.25-4.5																0.00
4.5-4.75																0.00
4.75-5																0.00
5-5.25																0.00
5.25-5.5																0.00
Σ	0.00	0.28	2.51	5.01	9.75	53.76	28.13	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

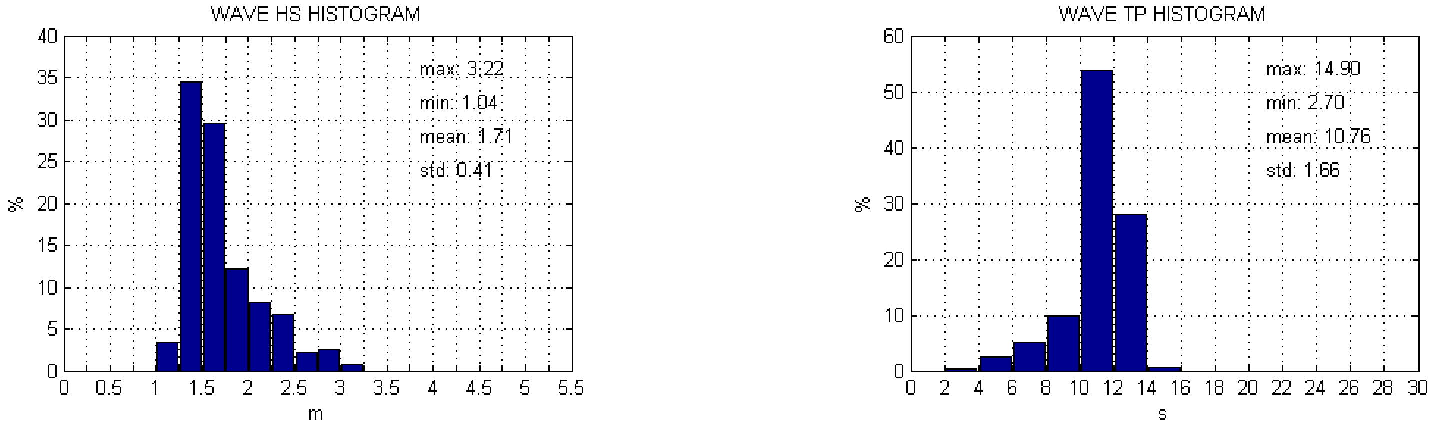
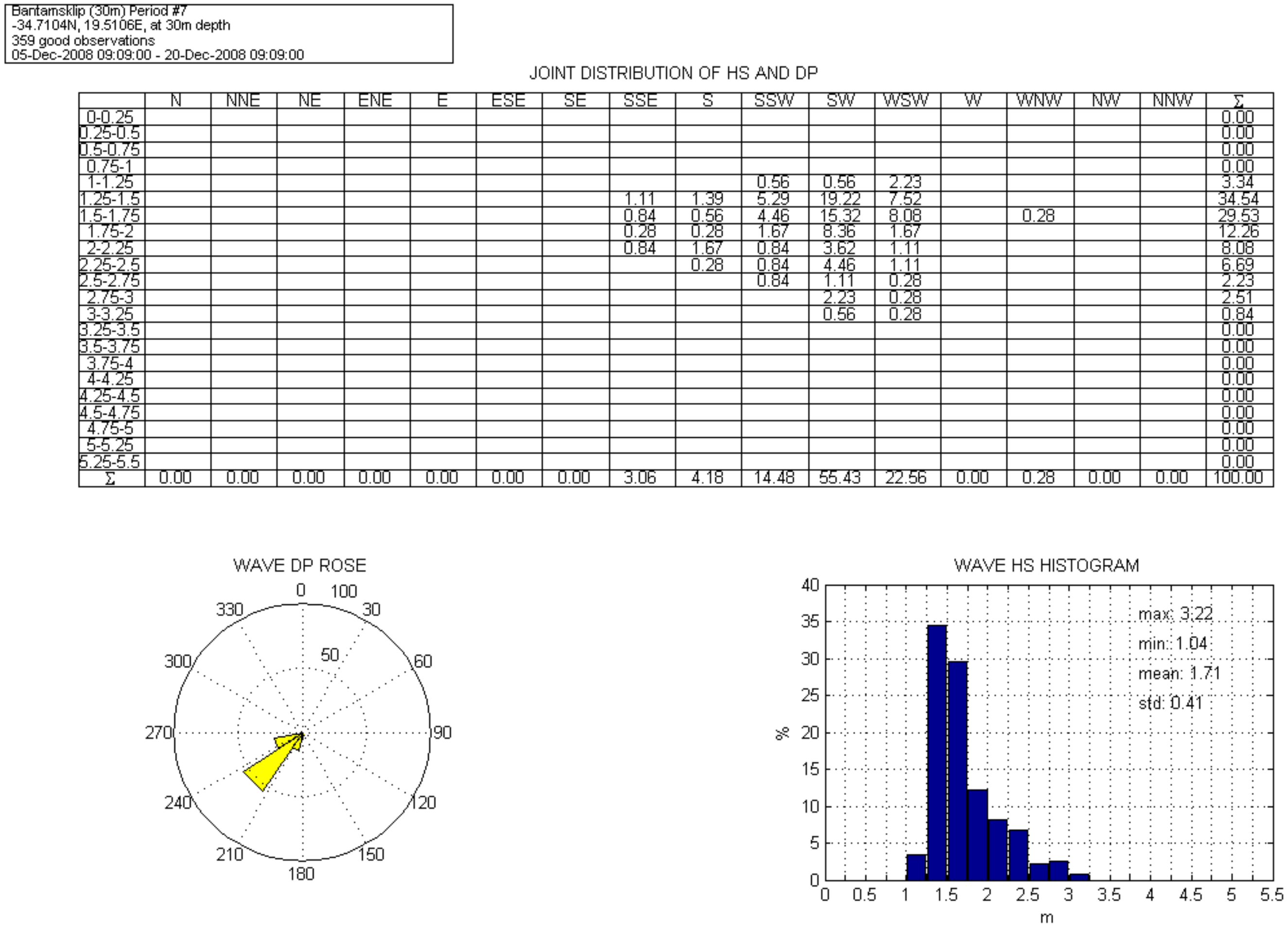


Figure 24: Summary plot of H_s and T_p.



Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at 30m depth
359 good observations
05-Dec-2008 09:09:00 - 20-Dec-2008 09:09:00

JOINT DISTRIBUTION OF HS AND DP

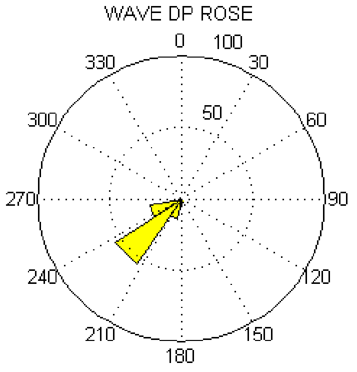
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-0.25																	0.00
0.25-0.5																	0.00
0.5-0.75																	0.00
0.75-1																	0.00
1-1.25										0.56	0.56	2.23					3.34
1.25-1.5								1.11	1.39	5.29	19.22	7.52					34.54
1.5-1.75								0.84	0.56	4.46	15.32	8.08		0.28			29.53
1.75-2								0.28	0.28	1.67	8.36	1.67					12.26
2-2.25								0.84	1.67	0.84	3.62	1.11					8.08
2.25-2.5									0.28	0.84	4.46	1.11					6.69
2.5-2.75										0.84	1.11	0.28					2.23
2.75-3											2.23	0.28					2.51
3-3.25											0.56	0.28					0.84
3.25-3.5																	0.00
3.5-3.75																	0.00
3.75-4																	0.00
4-4.25																	0.00
4.25-4.5																	0.00
4.5-4.75																	0.00
4.75-5																	0.00
5-5.25																	0.00
5.25-5.5																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.06	4.18	14.48	55.43	22.56	0.00	0.28	0.00	0.00	100.00

Figure 25: Summary plot of H_s and D_p.

Bantamsklip (30m) Period #7
-34.7104N, 19.5106E, at 30m depth
359 good observations
05-Dec-2008 09:09:00 - 20-Dec-2008 09:09:00

JOINT DISTRIBUTION OF TP AND DP

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-2																	0.00
2-4											0.28						0.28
4-6								1.67	0.84								2.51
6-8								1.39	2.23	1.11	0.28						5.01
8-10									0.56	2.23	4.46	2.51					9.75
10-12									0.56	8.08	28.97	16.16					53.76
12-14										3.06	20.89	3.90		0.28			28.13
14-16											0.56						0.56
16-18																	0.00
18-20																	0.00
20-22																	0.00
22-24																	0.00
24-26																	0.00
26-28																	0.00
28-30																	0.00
Σ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.06	4.18	14.48	55.43	22.56	0.00	0.28	0.00	0.00	100.00



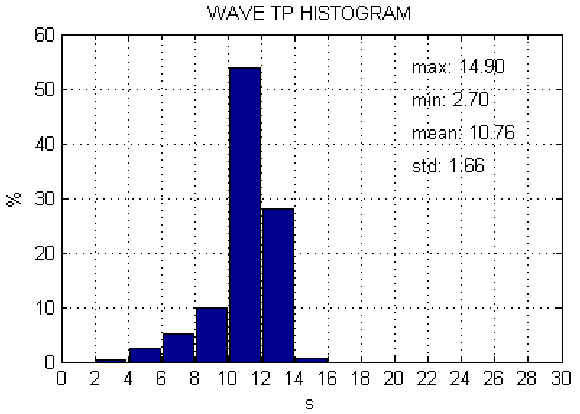


Figure 26: Summary plot of T_p and D_p.

5.2.2.4 Wave spectral plot

Figure 27 displays a wave spectral plot for a significant wave event. The time of the spectra is given in the title of the graph. The plots consist of:

- The spectral energy for each frequency is presented on the left panel.
- The direction spectrum for each frequency is presented on the right panel.

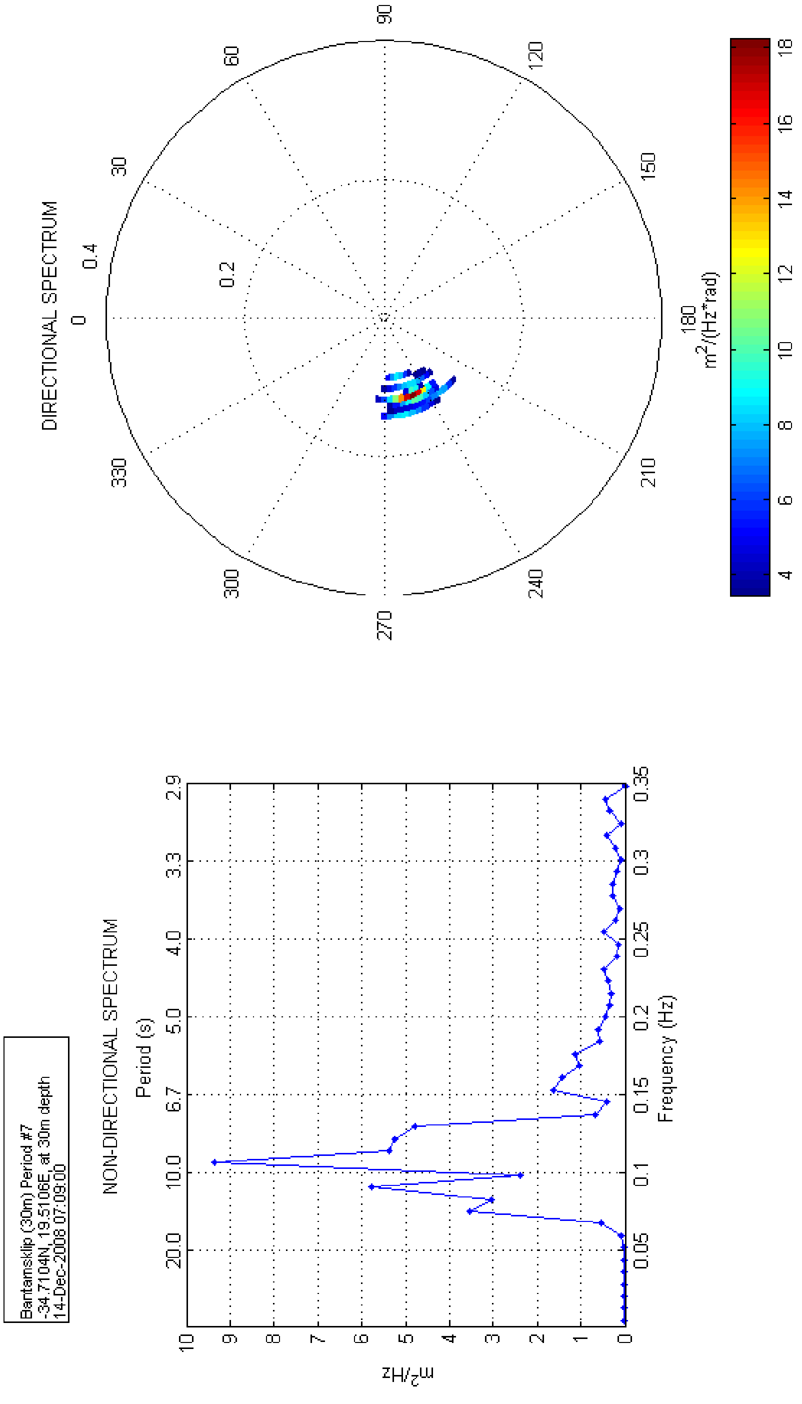


Figure 27: Wave spectra for 14th of December 2008 at 07:09:00.

5.3 COMPARISON PLOTS

5.3.1 Hs, Tp and Dp time series plots for 10m and 30m ADCPs.

Figure 28 displays a time series plot of the main wave parameters:

- The first (upper) panel is of the significant wave height (Hs).
- The second panel is of the peak period (Tp).
- The third panel is of the peak wave direction (Dp).

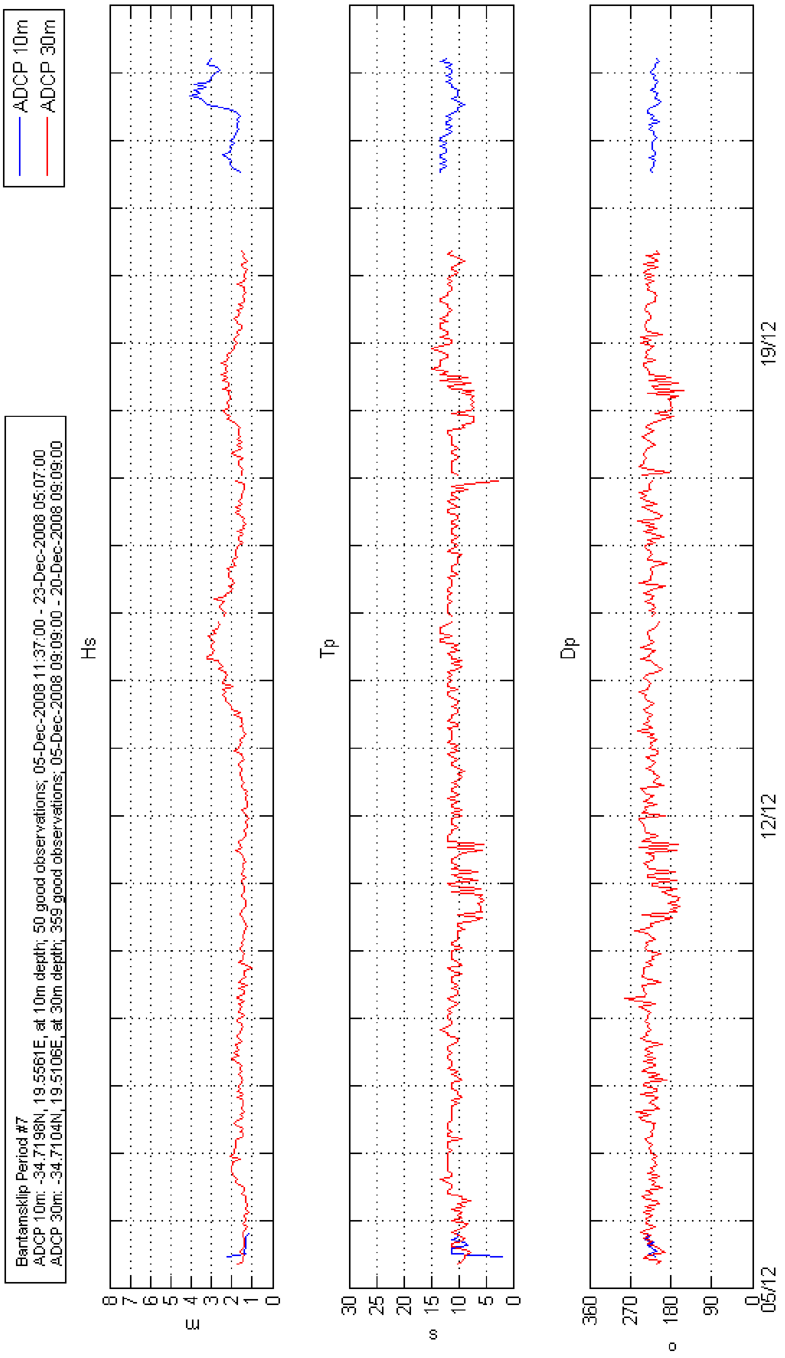


Figure 28: Time series of Hs, Tp and Dp from 10m and 30m ADCPs.

5.3.2 Water properties: RBR-CT loggers and ADCPs’ temperature sensor.

Figure 29 displays a time series plot, which consists of:

- The first panel is of the observed water temperature from surface and bottom RBR loggers as well as ADCPs’ temperature sensor against time.
- The second panel is of the derived salinity from the RBR loggers against time.

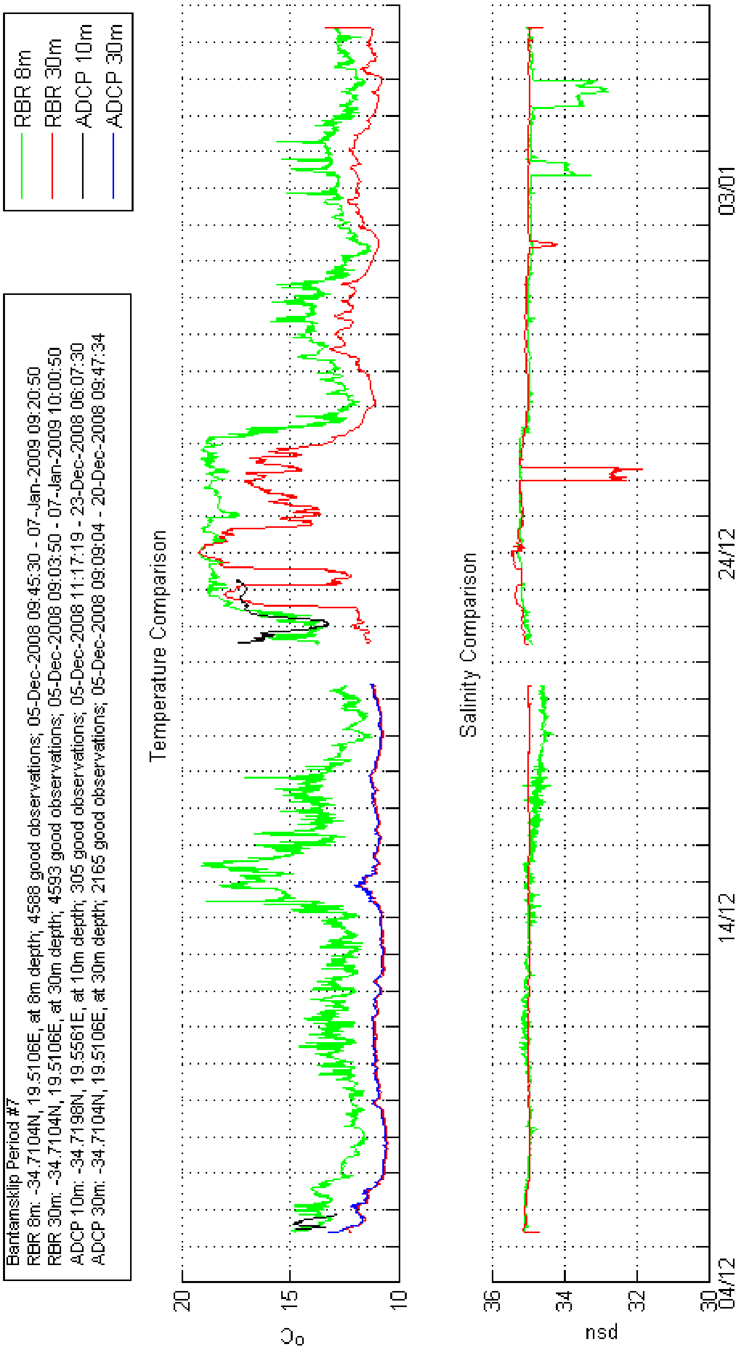


Figure 29: Time series of temperature and salinity from the RBR loggers and ADCPs.

6. DISCUSSION

The seventh set of oceanographic data collected off the coast of Bantamsklip for the period between December 5th 2008 – January 7th 2009 has been presented in this report. The measurements taken fall within a larger dataset being compiled to assist a preliminary safety survey of multiple sites around the South African coast reports for Eskom. This report presents data obtained from the 10m and 30m ADCPs, the surface and bottom RBR-CT loggers.

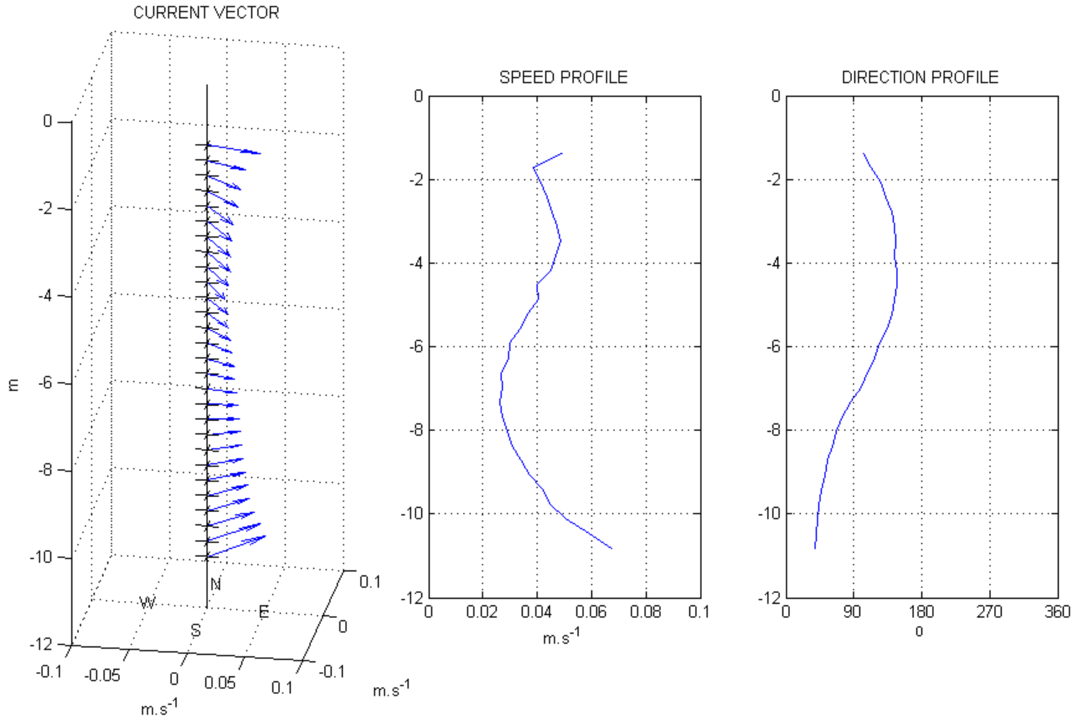


Figure 30: Mean profile plot for 10m ADCP.

The average surface flow for the 10m ADCP was 0.12ms^{-1}, decreasing to ~0.07ms^{-1} at ~10m depth. The flow at the surface was predominantly from the NNE/NE, while at depth it was more variable. Average wave parameters of ~1.2m, ~11.3s and ~200^{o} were recorded for Hs, Tp and Dp respectively.

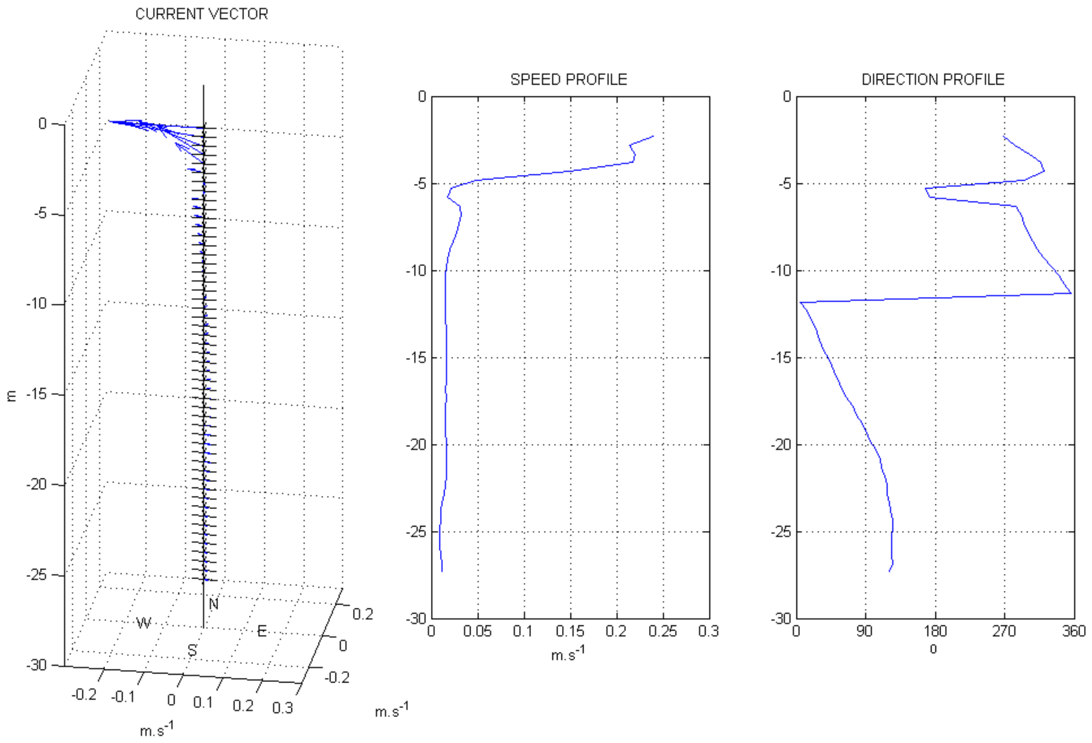


Figure 31: Mean profile plot for 30m ADCP.

The average surface flow for the 30m ADCP was 0.29ms^{-1}, decreasing to ~0.03ms^{-1} at ~27m depth. Surface flow was mainly from the W/WSW. Average wave parameters of ~1.7m, ~10.8s and ~223^{o} were recorded for Hs, Tp and Dp respectively.

Figure 29 shows the temperature sensors on board the 30m ADCP and surface RBR logger recorded reasonably similar values during the deployment period.

7. INSTRUMENT PARTICULARS FOR SERVICE VISIT FIVE

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1. RECOVERY Site Name: Bantams 10 m site Date: 20 Dec 2008

Instrument type and serial number			RDI	10105
Recovery date and time	LT	GMT	**20 Dec 2008 10:35**	
Latitude **(do not ignore – if same, please indicate)**			**34 43.186**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.637**	
Switch off date and time	LT	GMT	20 Dec 2008 20:06	
File size			8MB	
Was the data copied to memory card?			Y*	N

2. **RE-DEPLOYMENT Site Name: Bantams 10 m site Date 21 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**10105**
Install a new battery and/or check the voltage		**1*44.8V**
Frequency of unit being used	**600kHz**	
Depth range	**10m**	
Number of bins (calculated automatically)	**42**	
Bin Size (calculated automatically)	**0.35**	
Wave burst duration	**41min**	
Time between wave bursts	**60min**	
Pings per ensemble	**500**	
Ensemble interval	**10min**	
Deployment duration	**15days**	
Transducer depth	**10m**	
Any other commands	**minTP,RI0**	
Temperature	**5**	
Recorder size	**1256MB**	

Consequences of the sampling parameters

First and last bin range		**1.41**	**15.76**
Battery usage			**440Wh**
Standard deviation			**1.08**
Storage space required			**133MB**
Set the ADCP clock	LT	GMT	**20 Dec 2008 20:05:56**
Run pre-deployment tests			
Name the ADCP deployment			**B1013**

Deployment details

Switch on date and time	LT	GMT	**20 Dec 2008 20:05:56**
Deployment date and time	LT	GMT	**21 Dec 2008 01:07**
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43.186**
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.637**

Site depth	10m	Deployment depth	**10m**
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 20 December 2008/ADCP_newDeployFiles/B1013**

3. RECOVERY Site Name: Bantams 10 m site Date: 7 Jan 2009

Instrument type and serial number		RDI	10105
Recovery date and time	LT	GMT	7 Jan 2009 09:09
Latitude **(do not ignore – if same, please indicate)**			**34 43.186**
Longitude **(do not ignore – if same, please indicate)**			**19 33.637**
Switch off date and time	LT	GMT	7 Jan 2009 21:30
File size			23MB
Was the data copied to memory card?		Y*	N

4. RE-DEPLOYMENT Site Name: Bantams 10 m site Date 2 Feb 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**10105**
Install a new battery and/or check the voltage		**1*44.7V**
Frequency of unit being used		**600kHz**
Depth range		**10m**
Number of bins (calculated automatically)		**42**
Bin Size (calculated automatically)		**0.35**
Wave burst duration		**40min**
Time between wave bursts		**60min**
Pings per ensemble		**500**
Ensemble interval		**10min**
Deployment duration		**13days**
Transducer depth		**10m**
Any other commands		**minTP,RI0**
Temperature		**5**
Recorder size		**1128MB**

Consequences of the sampling parameters

First and last bin range		**1.41**	**15.76**
Battery usage			**376Wh**
Standard deviation			**1.08**
Storage space required			**113MB**
Set the ADCP clock	LT*	GMT	**2 Feb 2009 03:17:00**
Run pre-deployment tests			**Yes**
Name the ADCP deployment			**B1001**

Deployment details

Switch on date and time	LT*	GMT	**2 Feb 2009 12:00:00**
Deployment date and time	LT*	GMT	**2 Feb 2009 08:50:00**
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43.186**

Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.637**
Site depth	10m	Deployment depth	**12.3m**
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 2 February 2009/ADCP_newDeployFiles/B1001**

30m ADCP.

1. **RECOVERY** **Site Name: Bantams 30m site** **Date: 20 Dec 2008**

Instrument type and serial number			RDI	11424
Recovery date and time	LT	GMT	**20 Dec 2008 10:15**	
Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Longitude **(do not ignore – if same, please indicate)**			19 30.696	
Switch off date and time	LT	GMT	20 Dec 2008 18:24	
File size			125Mb	
Was the data copied to memory card?			Y*	N

2. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 21 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)		RDI	**11424**
Install a new battery and/or check the voltage			**1*44.8V**
Frequency of unit being used		**600kHz**	
Depth range		**30m**	
Number of bins (calculated automatically)		**69**	
Bin Size (calculated automatically)		**0.5**	
Wave burst duration		**34min**	
Time between wave bursts		**60min**	
Pings per ensemble		**250**	
Ensemble interval		**10min**	
Deployment duration		**15days**	
Transducer depth		**30m**	
Any other commands		**minTP,RI0**	
Temperature		**5**	
Recorder size		**1256MB**	

Consequences of the sampling parameters

First and last bin range		**1.6**	**35.6**
Battery usage			**447Wh**
Standard deviation			**1.08**
Storage space required			**112MB**
Set the ADCP clock	LT	GMT	**20 Dec 2008 20:11:20**
Run pre-deployment tests			**yes**
Name the ADCP deployment			**B3013**

Deployment details

Switch on date and time	LT	GMT	**20 Dec 2008 20:11:20**
Deployment date and time	LT	GMT	**21 Dec 2008 11:30**
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.696
Site depth	30m	Deployment depth	**30m**
Acoustic release (1) serial number and release code		**32383**	**642016**
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 20 December 2008/ADCP_newDeployFiles/B3013**

3. **RECOVERY** **Site Name: Bantams 30m site** **Date: 7 Jan 2009**

Instrument type and serial number		RDI	11424
Recovery date and time	LT	GMT	**7 Jan 2009 10:03**
Latitude **(do not ignore – if same, please indicate)**			34 42.602
Longitude **(do not ignore – if same, please indicate)**			19 30.676
Switch off date and time	LT	GMT	7 Jan 2009 21:44
File size			6MB
Was the data copied to memory card?		Y*	N

4. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 2 Feb 2009**

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**11424**
Install a new battery and/or check the voltage		**1*44.7V**
Frequency of unit being used		**600kHz**
Depth range		**30m**
Number of bins (calculated automatically)		**69**
Bin Size (calculated automatically)		**0.5**
Wave burst duration		**40min**
Time between wave bursts		**60min**
Pings per ensemble		**250**
Ensemble interval		**10min**
Deployment duration		**13days**
Transducer depth		**30m**
Any other commands		**minTP,RI0**
Temperature		**5**
Recorder size		**1128MB**

Consequences of the sampling parameters

First and last bin range		**1.6**	**35.6**
Battery usage			**453Wh**
Standard deviation			**1.08**
Storage space required			**114MB**
Set the ADCP clock	LT*	GMT	**1 Feb 2009 09:18:00**

Run pre-deployment tests	**yes**
Name the ADCP deployment	**B3001**

Deployment details

Switch on date and time	LT*	GMT	**2 Feb 2009 12:00:00**
Deployment date and time	LT*	GMT	**2 Feb 2009 07:45:00**
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.601
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.691
Site depth	30m	Deployment depth	**28.6m**
Acoustic release (1) serial number and release code		**32383**	**642016**
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 2 February 2009/ADCP_newDeployFiles/B3001**

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

1. **RECOVERY** **Site Name: Bantams 30m site** **Date: 20 Dec 2008**

Instrument type and serial number		RBR 420ct	12994
Recovery date and time	LT	GMT	**20 Dec 2008 08:45**
Latitude **(do not ignore – if same, please indicate)**			34 42.602
Longitude **(do not ignore – if same, please indicate)**			19 30.696
Switch off date and time	LT	GMT	20 Dec 2008 18:42:53
File size			50KB
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 20 December 2008/RBR_RecoveredData

2. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 21 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period		**10min**
Averaging period		**1min**
Expected deployment duration		**30days**
Start of logging (date / time)	20 Dec 2008	19:49:20
End of logging (date / time)	27 Jan 2009	12:00:00
Memory usage		.4%
Battery usage		939mAH

Deployment details

Deployment date and time	LT	GMT	21 Dec 2008 12:15	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.696	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			8m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 20 December 2008/RBR_RecoveredData/012994.log	

3. RECOVERY Site Name: Bantams 30m site Date: 7 Jan 2009

Instrument type and serial number			RBR 420ct	12994
Recovery date and time	LT	GMT	**7 Jan 2009 10:03**	
Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Switch off date and time	LT	GMT	7 Jan 2009 21:30:19	
File size			57KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 7 January 2009/RBR_RecoveredData	

4. RE-DEPLOYMENT Site Name: Bantams 30m site Date: 2 Feb 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	2 Feb 2009	12:00:00
End of logging (date / time)	14 Mar 2009	12:00:00
Memory usage		.4%
Battery usage		997mAH

Deployment details

Deployment date and time	LT*	GMT	2 Feb 2009 07:45:00
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.605
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.667

Site name	Batamsklip	
Site depth	30m	
Deployment depth	13m	
Acoustic release (1) serial number and release code		
Acoustic release (2) serial number and release code		
Argos beacon serial number		
Save *log* file (filename format: ***serialnumber_date***)	Bantams 2 Feb 2009/RBR_RecoveredData/012994.log	

Bottom.

1. **RECOVERY** **Site Name: Bantams 30m site** **Date: 20 Dec 2008**

Instrument type and serial number			RBR 420ct	15248
Recovery date and time	LT	GMT	**20 Dec 2008 08:45**	
Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Switch off date and time	LT	GMT	20 Dec 2008 18:44:30	
File size			50KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 20 December 2008/RBR_RecoveredData	

2. **RE-DEPLOYMENT** **Site Name: Bantams 30m site** **Date: 21 Dec 2008**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.0V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	20 Dec 2008	19:50:50
End of logging (date / time)	27 Jan 2009	12:00:00
Memory usage		.4%
Battery usage		939mAH

Deployment details

Deployment date and time	LT	GMT	21 Dec 2008 12:15	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.602	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.676	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			30m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 20 December 2008/RBR_RecoveredData/**015248.log**	

3. <u>RECOVERY</u> **Site Name: Bantams 30m site** **Date: 7 Jan 2009**

Instrument type and serial number		RBR 420ct	15248
Recovery date and time	LT	GMT	**<u>7 Jan 2009 10:03</u>**
Latitude **(do not ignore – if same, please indicate)**			34 42.602
Longitude **(do not ignore – if same, please indicate)**			19 30.676
Switch off date and time	LT	GMT	7 Jan 2009 21:27:36
File size			57KB
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 7 January 2009/RBR_RecoveredData

4. <u>RE-DEPLOYMENT</u> **Site Name: Bantams 30m site** **Date: 2 Feb 2009**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.2V

Set up the sampling parameters

Sampling period		**10min**
Averaging period		**1min**
Expected deployment duration		**30days**
Start of logging (date / time)	2 Feb 2009	12:00:00
End of logging (date / time)	14 Mar 2009	12:00:00
Memory usage		.4%
Battery usage		997mAH

Deployment details

Deployment date and time	LT	GMT	2 Feb 2009 07:45:00	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.601	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.691	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			28.6m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 2 February 2009/RBR_RecoveredData/**015248.log**	

7.3 RBR TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS

1. DEPLOYMENT Site Name: Bantamsklip Date: 7 Jan 2009

Instrument type and serial number (do not ignore – if same, please indicate)	TGR 2050	13084
Install a new battery and check the voltage		2 * 3.28

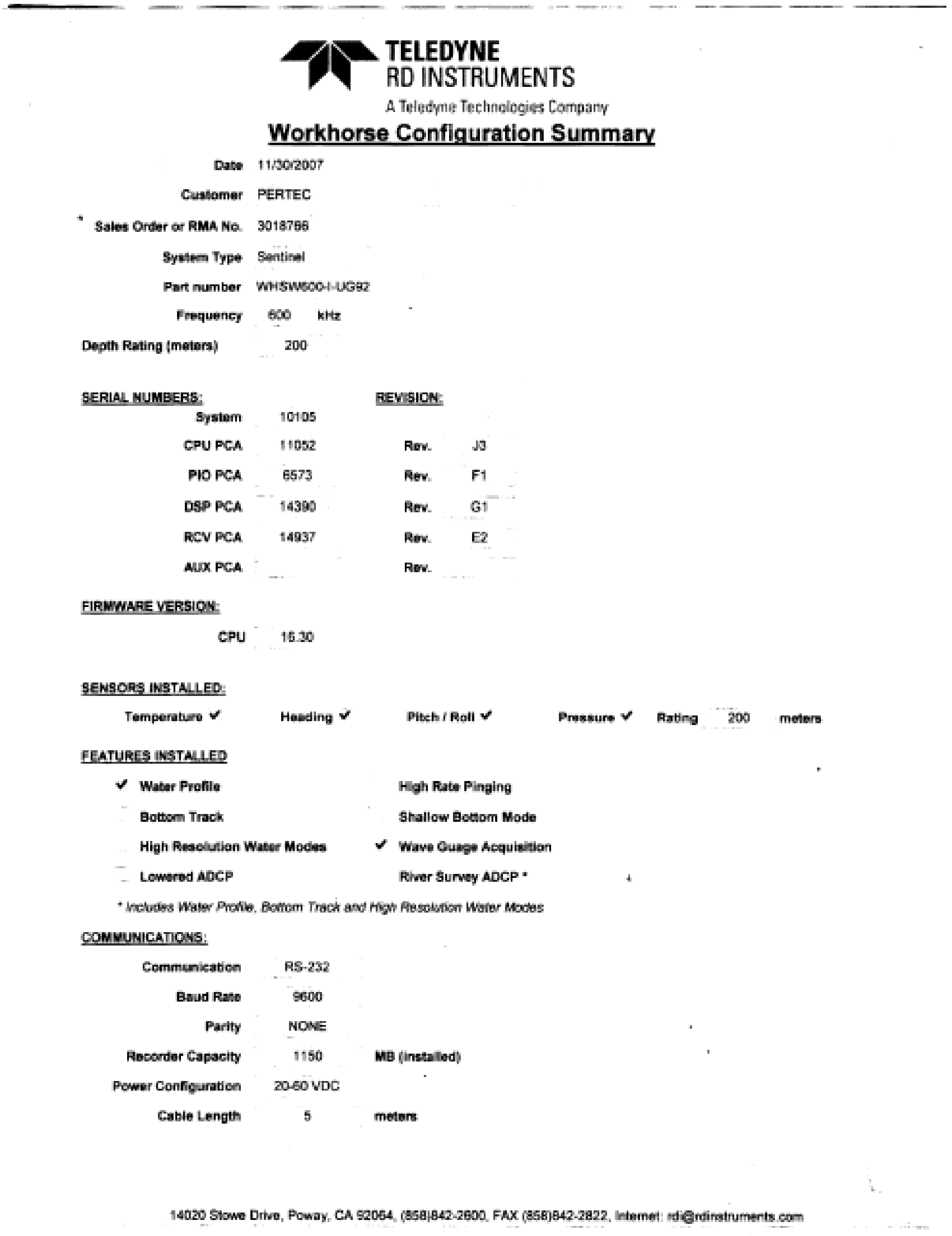
Set up the sampling parameters

Sampling period	**10 sec**	
Averaging period	**1 sec**	
Expected deployment duration	**6 weeks**	
Start of logging (date / time)	7 Jan 2009	04:41:30
End of logging (date / time)	27 Feb 2009	12:00:00
Memory usage		31.7%
Battery usage		177mAH

Deployment details

Deployment date and time	LT	GMT	7 Jan 2009 08:22
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 42.241**
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.101**
Site name			Bantamsklip
Site depth			1.8m
Deployment depth			1.7m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *log* file (filename format: ***serialnumber_date***)			**Bantams 7 January 2009/TideGuage_Data**

7.4 CALIBRATION CERTIFICATES



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date	11/30/2007
Customer	PERTEC
Sales Order or RMA No.	3018786
System Type	Sentinel
Part number	WHSW600-I-UG92
Frequency	600 kHz
Depth Rating (meters)	200

SERIAL NUMBERS:		**REVISION:**	
System	10105		
CPU PCA	11052	**Rev.**	J3
PIO PCA	6573	**Rev.**	F1
DSP PCA	14390	**Rev.**	G1
RCV PCA	14937	**Rev.**	E2
AUX PCA		**Rev.**	

FIRMWARE VERSION:

CPU 16.30

SENSORS INSTALLED:

Temperature ✓ **Heading** ✓ **Pitch / Roll** ✓ **Pressure** ✓ **Rating** 200 **meters**

FEATURES INSTALLED

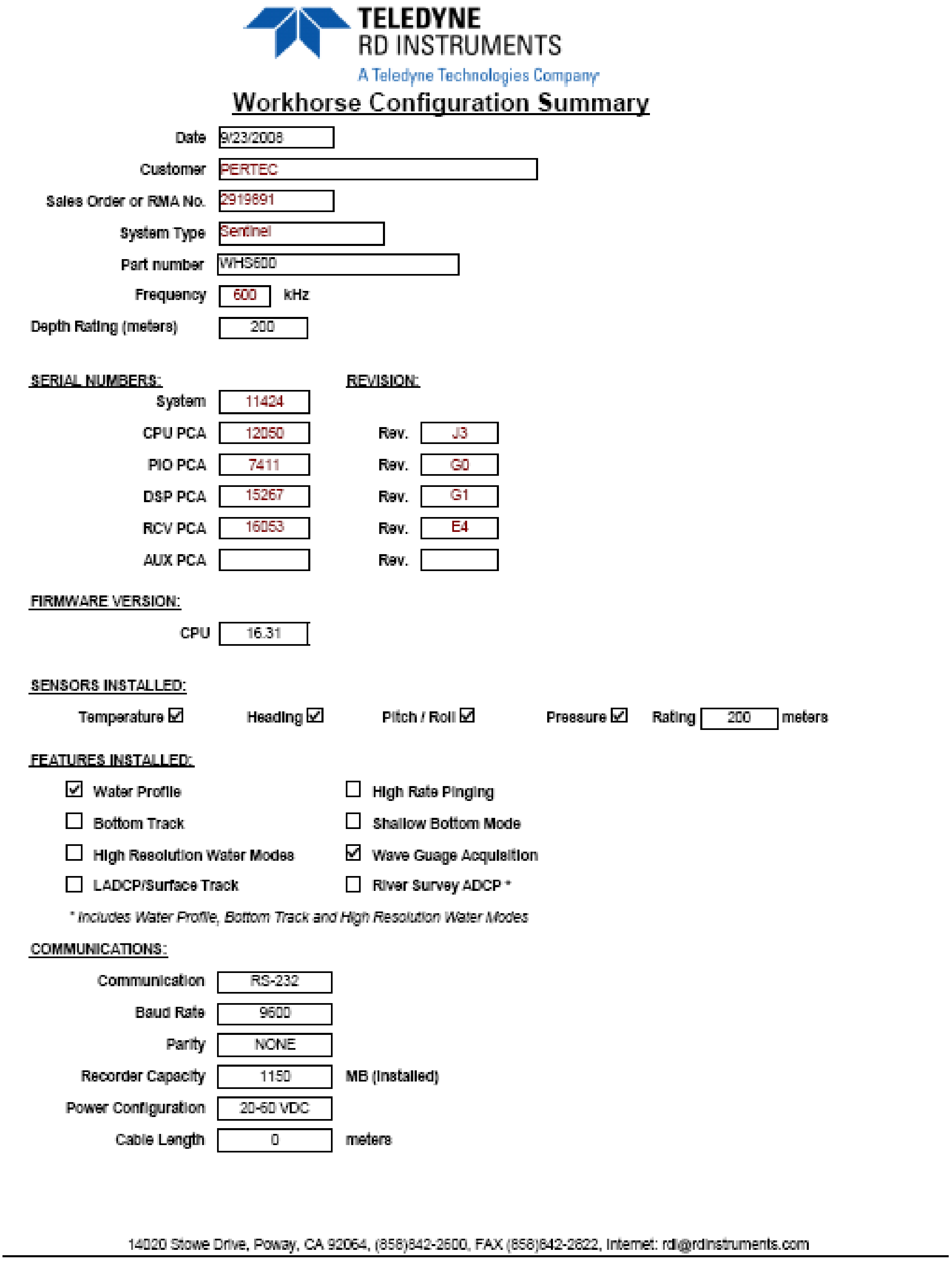
✓ **Water Profile**	**High Rate Pinging**
Bottom Track	**Shallow Bottom Mode**
High Resolution Water Modes	✓ **Wave Guage Acquisition**
Lowered ADCP	**River Survey ADCP ***

* *Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication	RS-232	
Baud Rate	9600	
Parity	NONE	
Recorder Capacity	1150	**MB (installed)**
Power Configuration	20-60 VDC	
Cable Length	5	**meters**

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2822, Internet: rdi@rdinstruments.com



TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Configuration Summary

Date: 9/23/2008
Customer: PERTEC
Sales Order or RMA No. 2919691
System Type: Sentinel
Part number: WHS600
Frequency: 600 kHz
Depth Rating (meters): 200

SERIAL NUMBERS:		REVISION:	
System	11424		
CPU PCA	12050	Rev.	J3
PIO PCA	7411	Rev.	G0
DSP PCA	15267	Rev.	G1
RCV PCA	16053	Rev.	E4
AUX PCA		Rev.	

FIRMWARE VERSION:

CPU: 16.31

SENSORS INSTALLED:

Temperature ☑ Heading ☑ Pitch / Roll ☑ Pressure ☑ Rating 200 meters

FEATURES INSTALLED:

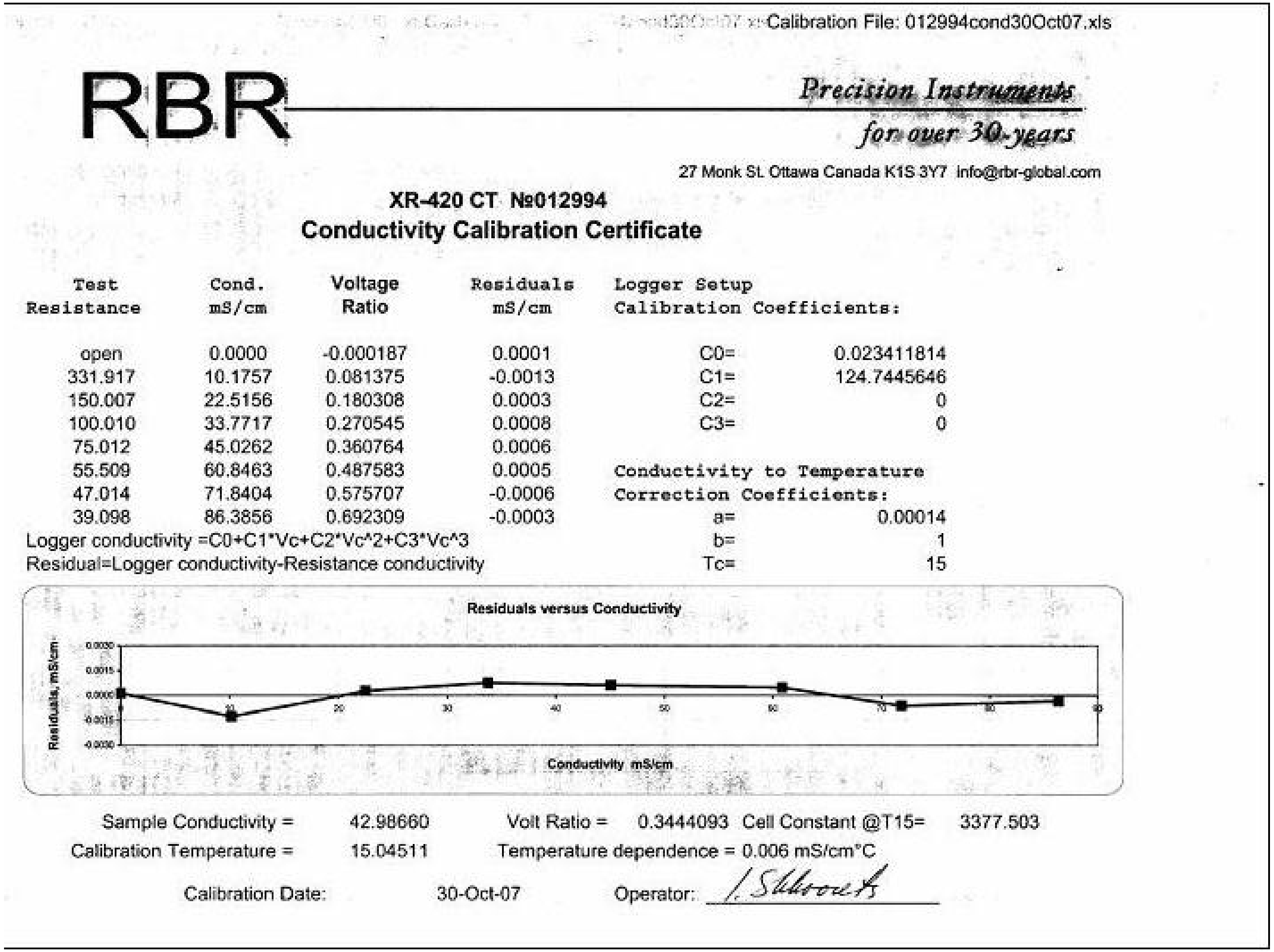
☑ Water Profile
☐ Bottom Track
☐ High Resolution Water Modes
☐ LADCP/Surface Track
☐ High Rate Pinging
☐ Shallow Bottom Mode
☑ Wave Guage Acquisition
☐ River Survey ADCP *

** Includes Water Profile, Bottom Track and High Resolution Water Modes*

COMMUNICATIONS:

Communication: RS-232
Baud Rate: 9600
Parity: NONE
Recorder Capacity: 1150 MB (Installed)
Power Configuration: 20-60 VDC
Cable Length: 0 meters

14020 Stowe Drive, Poway, CA 92064, (858)842-2600, FAX (858)842-2622, Internet: rdi@rdinstruments.com



Calibration File: 012994cond30Oct07.xls

RBR

Precision Instruments for over 30 years

27 Monk St. Ottawa Canada K1S 3Y7 info@rbr-global.com

XR-420 CT №012994
Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000187	0.0001
331.917	10.1757	0.081375	-0.0013
150.007	22.5156	0.180308	0.0003
100.010	33.7717	0.270545	0.0008
75.012	45.0262	0.360764	0.0006
55.509	60.8463	0.487583	0.0005
47.014	71.8404	0.575707	-0.0006
39.098	86.3856	0.692309	-0.0003

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3
Residual=Logger conductivity-Resistance conductivity

Logger Setup
Calibration Coefficients:

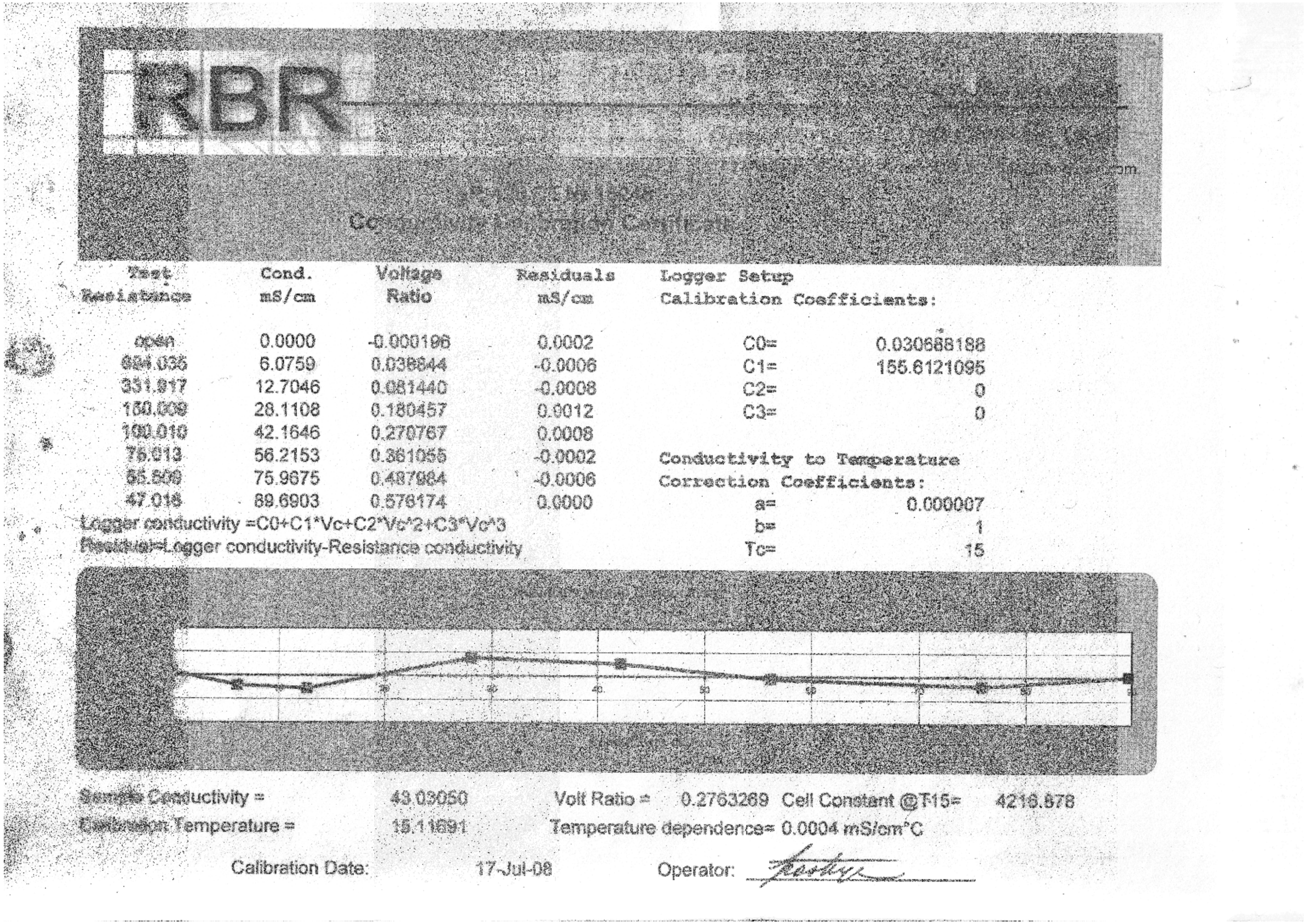
C0= 0.023411814
C1= 124.7445646
C2= 0
C3= 0

Conductivity to Temperature
Correction Coefficients:

a= 0.00014
b= 1
Tc= 15

Sample Conductivity = 42.98660
Volt Ratio = 0.3444093
Cell Constant @T15= 3377.503
Calibration Temperature = 15.04511
Temperature dependence = 0.006 mS/cm°C

Calibration Date: 30-Oct-07
Operator: I. Shkvorets



RBR

Conductivity Calibration Certificate

Test Resistance	Cond. mS/cm	Voltage Ratio	Residuals mS/cm
open	0.0000	-0.000196	0.0002
694.035	6.0759	0.038844	-0.0006
331.917	12.7046	0.081440	-0.0008
150.009	28.1108	0.180457	0.0012
100.010	42.1646	0.270767	0.0008
75.013	56.2153	0.361055	-0.0002
55.509	75.9675	0.487984	-0.0006
47.016	89.6903	0.576174	0.0000

Logger conductivity =C0+C1*Vc+C2*Vc^2+C3*Vc^3

Residual=Logger conductivity-Resistance conductivity

Logger Setup

Calibration Coefficients:

C0= 0.030688188
C1= 155.6121095
C2= 0
C3= 0

Conductivity to Temperature

Correction Coefficients:

a= 0.000007
b= 1
Tc= 15

Sample Conductivity = 43.03050

Volt Ratio = 0.2763269

Cell Constant @T15= 4216.878

Calibration Temperature = 15.11691

Temperature dependence= 0.0004 mS/cm°C

Calibration Date: 17-Jul-08

Operator:

7.5 ADCP CONFIGURATION FILES

10m ADCP.

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4920
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 133.83 MB (140329440 bytes)
;Power usage         = 440.26 Wh
;Battery usage       = 1.0
;Samples / Wv Burst = 4920
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
```

```
;Bytes / Wave Burst = 383840
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.


CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
TF09/02/02 12:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1128
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 113.20 MB (118698528 bytes)
```

```
;Power usage         = 376.92 Wh
;Battery usage       = 0.8
;Samples / Wv Burst = 4800
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP.

```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4080
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 360.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 1
```

```
;
;Consequences generated by PlanADCP version 2.04:
;First cell range   = 1.60 m
;Last cell range    = 35.60 m
;Max range          = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size      = 1534 bytes
;Storage required   = 112.45 MB (117908640 bytes)
;Power usage        = 447.68 Wh
;Battery usage      = 1.0
;Samples / Wv Burst = 4080
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 318320
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.



CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
TF09/02/02 12:00:00
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge         = YES
;Lowered ADCP       = NO
;Beam angle         = 20
```

```
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1128
;Saved Screen        = 2
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.60 m
;Last cell range     = 35.60 m
;Max range           = 38.22 m
;Standard deviation = 0.86 cm/s
;Ensemble size       = 1534 bytes
;Storage required    = 114.16 MB (119709408 bytes)
;Power usage         = 435.03 Wh
;Battery usage       = 1.0
;Samples / Wv Burst = 4800
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT EIGHT

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

28 August 2009

Job No: LT-JOB-50

TABLE OF CONTENTS

1. DISCLAIMER

The data is this report will undergo additional quality control procedures by Prestedge Retief Dresner Wijnberg (PRDW). For this reason no data in this report should be used for design purposes and only quality controlled data provided by PRDW should be used.

2. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 8 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-10.8	0.1135	0.0379	0.0202	0.0301	58.39
-10.4	0.1008	0.0345	0.0185	0.0205	78.23
-10.1	0.0863	0.0350	0.0161	0.0188	99.80
-9.7	0.1010	0.0350	0.0174	0.0133	125.34
-9.4	0.0983	0.0374	0.0185	0.0154	143.37
-9.0	0.1008	0.0424	0.0210	0.0231	160.72
-8.7	0.0993	0.0451	0.0197	0.0273	164.74
-8.3	0.0905	0.0477	0.0212	0.0347	167.13
-8.0	0.1109	0.0550	0.0258	0.0434	167.27
-7.6	0.1280	0.0597	0.0273	0.0498	160.90
-7.3	0.1344	0.0637	0.0275	0.0543	161.50
-6.9	0.1337	0.0714	0.0291	0.0613	160.40
-6.6	0.1448	0.0762	0.0282	0.0659	158.89
-6.2	0.1461	0.0807	0.0285	0.0709	156.59
-5.9	0.1543	0.0866	0.0304	0.0772	151.90
-5.5	0.1691	0.0915	0.0316	0.0820	150.50
-5.2	0.1754	0.0929	0.0312	0.0839	149.68
-4.8	0.1587	0.0937	0.0292	0.0843	150.58
-4.5	0.1904	0.0960	0.0297	0.0863	148.31
-4.1	0.1786	0.0998	0.0308	0.0887	147.22
-3.8	0.1840	0.1069	0.0311	0.0946	146.55
-3.4	0.1864	0.1093	0.0287	0.0963	146.17
-3.1	0.1908	0.1126	0.0277	0.0959	144.98
-2.7	0.1992	0.1166	0.0312	0.0992	144.28
-2.4	0.2011	0.1214	0.0299	0.1038	144.78
-2.0	0.1725	0.1235	0.0276	0.1033	144.32
-1.7	0.1817	0.1292	0.0290	0.1100	142.62
-1.3	0.2152	0.1343	0.0308	0.1166	135.84
-1.0	0.3085	0.1535	0.0466	0.1325	128.62

Table 2 – Waves summary for 10m ADCP

	Max	Min	Mean	Std
Hs (m)	2.22	1.20	1.74	0.30
Tp (s)	12.20	10.20	11.43	0.81
Dp (^{o})	233.52	218.52	224.45	3.53

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-27.3	0.1497	0.0372	0.0218	0.0149	61.16
-26.8	0.1739	0.0408	0.0237	0.0156	57.32
-26.3	0.2233	0.0438	0.0259	0.0164	56.11
-25.8	0.2529	0.0472	0.0277	0.0176	52.76
-25.3	0.2774	0.0495	0.0291	0.0180	49.45
-24.8	0.2581	0.0519	0.0301	0.0187	46.97
-24.3	0.2433	0.0544	0.0314	0.0196	43.98
-23.8	0.2317	0.0563	0.0321	0.0205	41.30
-23.3	0.2400	0.0587	0.0332	0.0209	37.75
-22.8	0.2075	0.0604	0.0339	0.0212	33.18
-22.3	0.2024	0.0621	0.0347	0.0219	31.18
-21.8	0.2196	0.0645	0.0359	0.0224	26.27
-21.3	0.2288	0.0658	0.0369	0.0232	22.22
-20.8	0.2202	0.0671	0.0378	0.0239	17.74
-20.3	0.2227	0.0687	0.0384	0.0253	13.71
-19.8	0.2344	0.0697	0.0392	0.0264	9.53
-19.3	0.2339	0.0704	0.0399	0.0279	6.06
-18.8	0.2241	0.0716	0.0401	0.0286	1.88
-18.3	0.2116	0.0728	0.0402	0.0298	358.04
-17.8	0.2073	0.0737	0.0406	0.0311	355.37
-17.3	0.2441	0.0748	0.0415	0.0320	352.27
-16.8	0.2257	0.0761	0.0418	0.0326	349.71
-16.3	0.2327	0.0778	0.0417	0.0335	347.64
-15.8	0.2271	0.0791	0.0421	0.0339	345.05
-15.3	0.2541	0.0804	0.0430	0.0339	342.33
-14.8	0.3091	0.0811	0.0436	0.0345	338.91
-14.3	0.3165	0.0821	0.0439	0.0346	335.03
-13.8	0.3003	0.0829	0.0440	0.0351	331.26
-13.3	0.2899	0.0829	0.0445	0.0348	327.87
-12.8	0.2751	0.0833	0.0447	0.0360	323.02
-12.3	0.2910	0.0838	0.0444	0.0372	319.82
-11.8	0.3168	0.0845	0.0453	0.0383	315.18
-11.3	0.3379	0.0851	0.0460	0.0402	312.90
-10.8	0.3516	0.0858	0.0467	0.0419	309.44
-10.3	0.3252	0.0869	0.0476	0.0432	307.01
-9.8	0.3272	0.0882	0.0492	0.0450	304.90
-9.3	0.3471	0.0897	0.0500	0.0470	303.25
-8.8	0.3591	0.0916	0.0508	0.0486	301.70
-8.3	0.3403	0.0937	0.0521	0.0503	299.82
-7.8	0.3762	0.0965	0.0539	0.0526	297.86
-7.3	0.3945	0.0985	0.0556	0.0549	296.03
-6.8	0.4132	0.1010	0.0575	0.0576	294.26
-6.3	0.4038	0.1036	0.0595	0.0604	292.72

-5.8	0.4053	0.1064	0.0614	0.0635	290.95
-5.3	0.4090	0.1103	0.0630	0.0674	289.70
-4.8	0.3864	0.1139	0.0646	0.0706	287.84
-4.3	0.3670	0.1175	0.0660	0.0745	287.15
-3.8	0.3880	0.1209	0.0674	0.0771	288.92
-3.3	0.3766	0.1283	0.0667	0.0815	300.49
-2.8	0.3776	0.1419	0.0667	0.0921	311.08
-2.3	0.4396	0.1637	0.0736	0.1109	310.85

Table 4 – Waves summary for 30m ADCP

	Max	Min	Mean	Std
Hs (m)	3.26	1.00	1.67	0.50
Tp (s)	15.00	5.40	11.17	1.88
Dp (^{o})	253.53	156.53	219.40	15.67

Table 5 – Water temperature and salinity summary (surface, 13m)

Parameter	Mean	Max	Min
Temperature (^{o}C)	12.20	17.89	10.23
Conductivity	40.04	45.84	37.42
Salinity (psu)	34.83	35.11	33.32

Table 6 – Water temperature and salinity summary (bottom, 30m)

Parameter	Mean	Max	Min
Temperature (^{o}C)	10.69	13.72	9.93
Conductivity	38.71	41.73	34.72
Salinity (psu)	34.96	35.08	30.64

2.1 DATA RETURN FOR BANTAMSKLIP SITE.

Table 7 – Data Return (%).

Bantams P08	29 January 2008 – 15 January 2009	15 January 2009 – 3 March 2009	2 February 2009 – 3 March 2009
Btm RBR Salinity	54	63	100
Surf RBR Salinity	70	63	100
10m ADCP Current	33	4	7
10m ADCP Wave	33	4	7
30m ADCP Current	28	33	53
30m ADCP Wave	25	33	53
Tide	35	92	87
Temp-Btm RBR,	62	63	100
Temp-Surf RBR	77	63	100
Temp-10m ADCP	33	4	7
Temp-30m ADCP	34	33	53
Tide Temperature	10	92	87
30m Temperature	76	63	100
10m Temperature	86	63	100

3. INTRODUCTION

3.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents waves, currents, temperature and salinity data collected at Bantamsklip station for the period February 2nd – March 3rd 2009 (Period 8). Service of the instruments was undertaken during March 3rd – 7th 2009.

3.2 MEASUREMENT LOCATION

The deployment location of the instruments is given in Table 8 and a location of waters samples taken on March 7th is given in Table 9.

Table 8 – Measurement locations.

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34.7040	19.5517
10m ADCP	34.7198	19.5606
Biofouling	34.7198	19.5614
30m ADCP	34.7101	19.5111
T&C mooring	34.7101	19.5111

Table 9 – Measurement locations – water samples.

Bottle #	STN #	Lat	Long	Exact Time HH:MM:SS	COMMENTS (if RBR profile is taken etc..)
1	30m	34 42.603	19 30.668	10.10	Depth: 4m
2	30m	34 42.603	19 30.668	10.13	Depth: 12m
3	30m	34 42.603	19 30.668	10.15	Depth: 20m
4	30m	34 42.603	19 30.668	10.19	Depth: 28m
5	10m	34 43.186	19 33.637	10.54	Depth: 4m
6	10m	34 43.186	19 33.637	10.56	Depth: 8m
7	1	34 43.190	19 33.611	10.58	Depth: 4m
8	2	34 43.161	19 33.591	11.01	Depth: 4m
9	3	34 43.124	10 33.584	11.04	Depth: 4m
10	4	34 43.097	19 33.577	11.06	Depth: 4m
11	5	34 43.081	19 33.541	11.08	Depth: 4m

4. OPERATIONS

4.1 SUMMARY OF EVENTS

Recovery of the instruments were undertaken on March 3rd 2009 and redeployment on March 7th 2009.

4.2 INSTRUMENT CONFIGURATIONS

Configurations were as per specifications.

Note: Biofouling plates have been installed on frame to avoid third party interference (as of May 2009).

5. DATA QUALITY CONTROL

5.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

5.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 29’ W for the 10m ADCP and 25° 28’ W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 1).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

5.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 29’ W for the 10m ADCP and 25° 28’ W for the 30m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

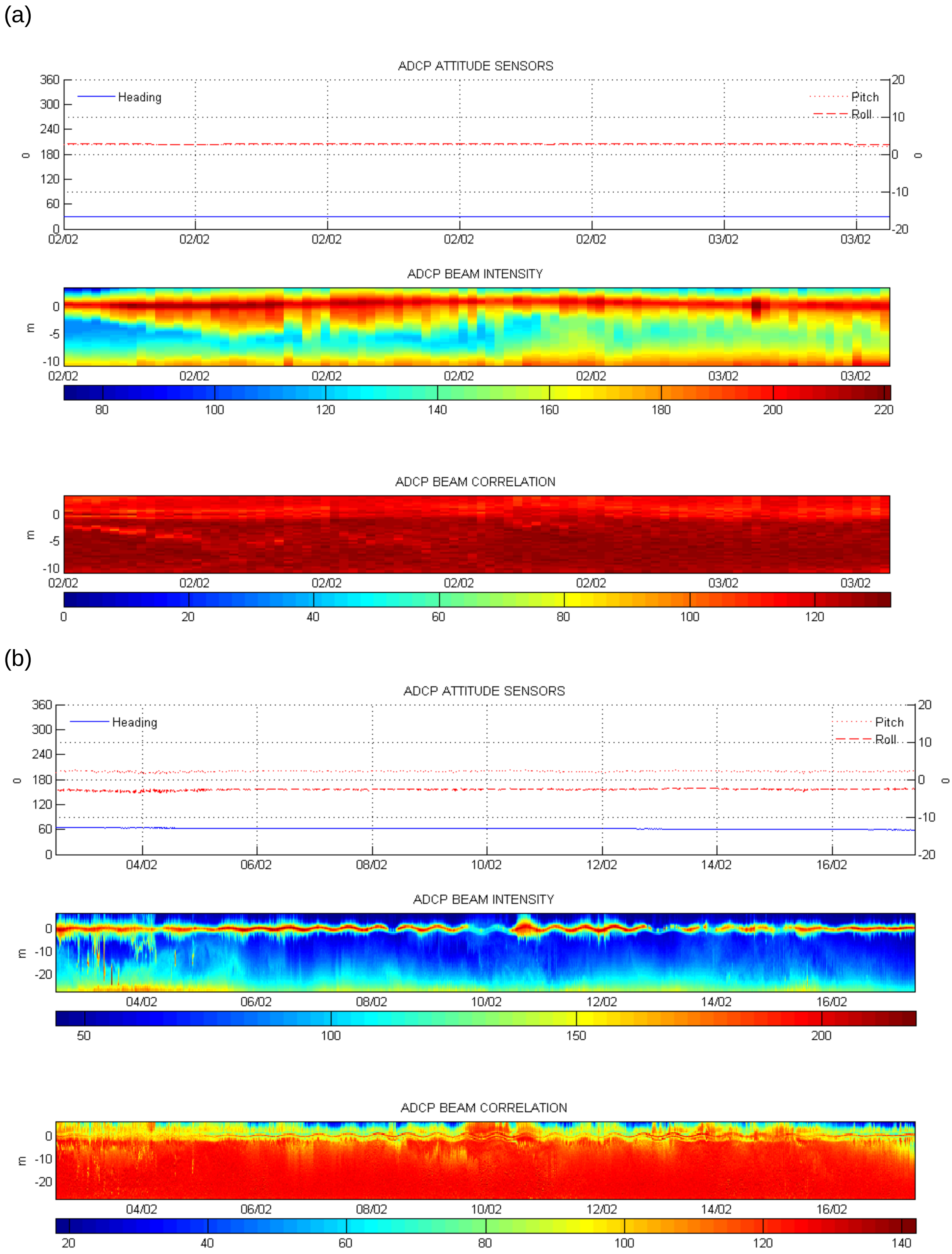


Figure 1: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

5.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.

5.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is -1.649m.
- Finally the data was averaged over a 10-minute period.

5.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the plates was not scheduled for service visit 8.

5.5 WATER SAMPLE.

Water samples were collected during this service and sent to the CSIR for analysis.

6. DATA PRESENTATION AND DISCUSSION

The eighth set of oceanographic data collected off the coast of Bantamsklip for the period between February 2nd and March 3rd 2009 has been presented in this report. Data obtained from the 10m and 30m ADCPs, the surface and bottom RBR-CT loggers and the tide gauge have been supplied to PRDW and are briefly presented here.

The average surface flow for the 10m ADCP was 0.15ms^{-1}, decreasing to ~0.04ms^{-1} at ~10m depth. Average wave parameters of ~1.74m, ~11.4s and ~224^{o} were recorded for Hs, Tp and Dp respectively. However, only one day worth of data was measured.

The average surface flow for the 30m ADCP was 0.16ms^{-1}, decreasing to ~0.04ms^{-1} at ~27m depth. Average wave parameters of ~1.7m, ~11.2s and ~220^{o} were recorded for Hs, Tp and Dp respectively.

The temperature sensors on board the ADCPs and RBR loggers recorded reasonably similar values during the deployment period.

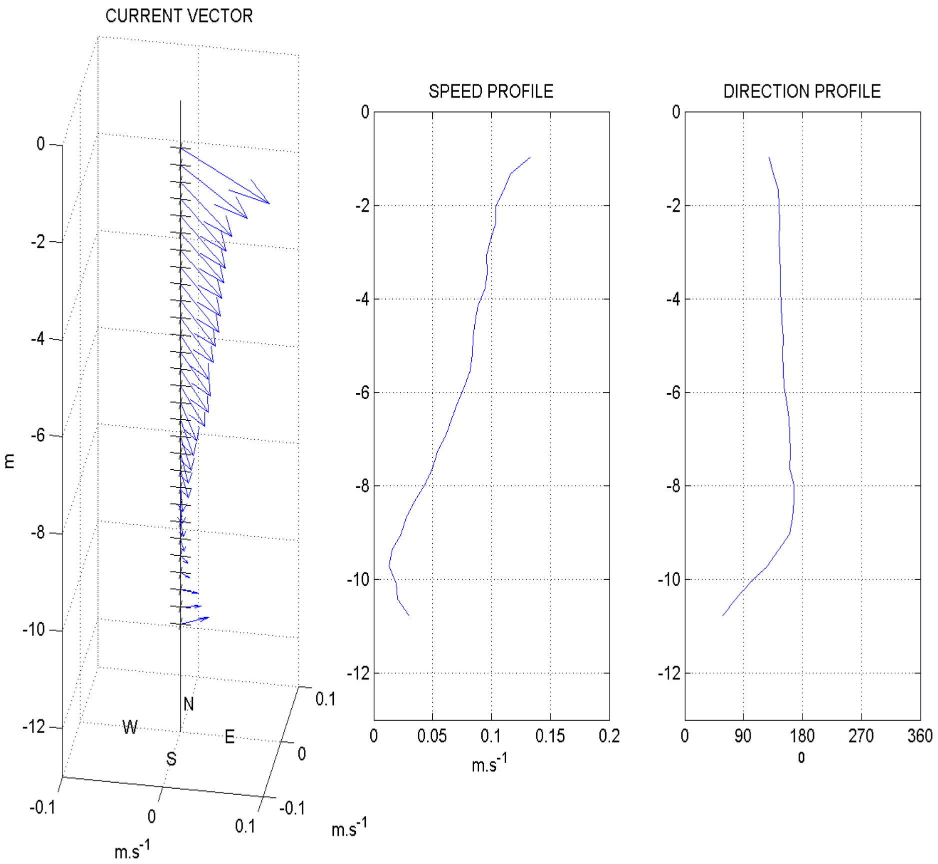


Figure 2: Mean profile plot for 10m ADCP.

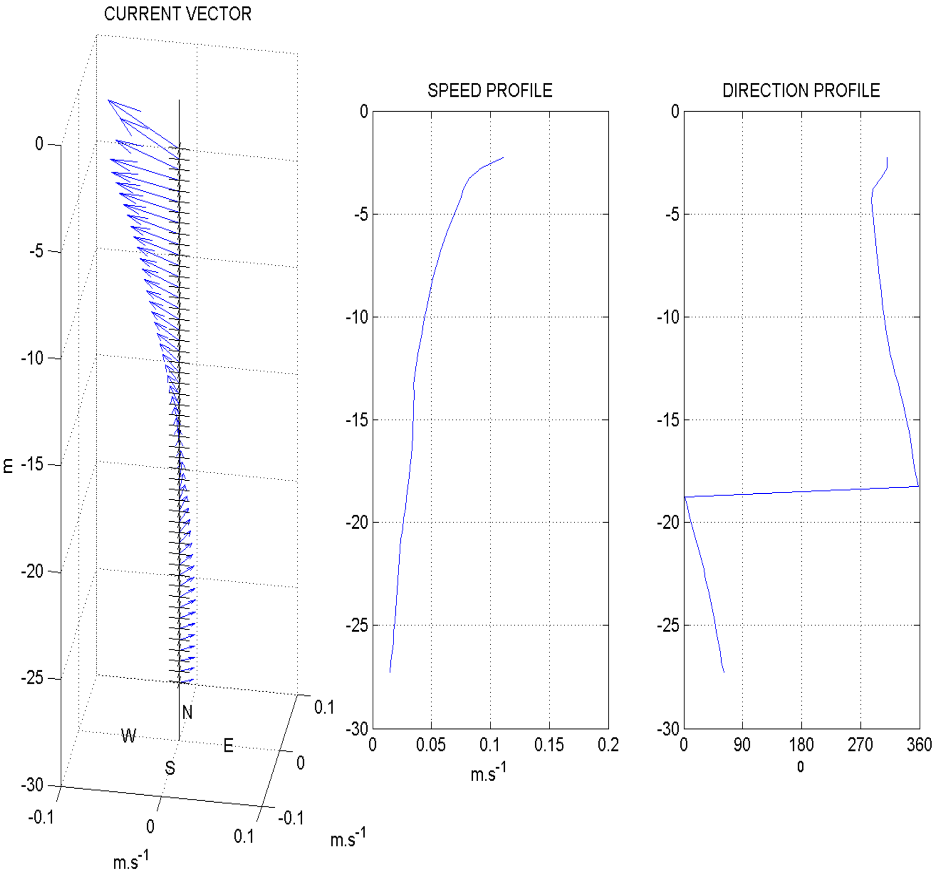


Figure 3: Mean profile plot for 30m ADCP.

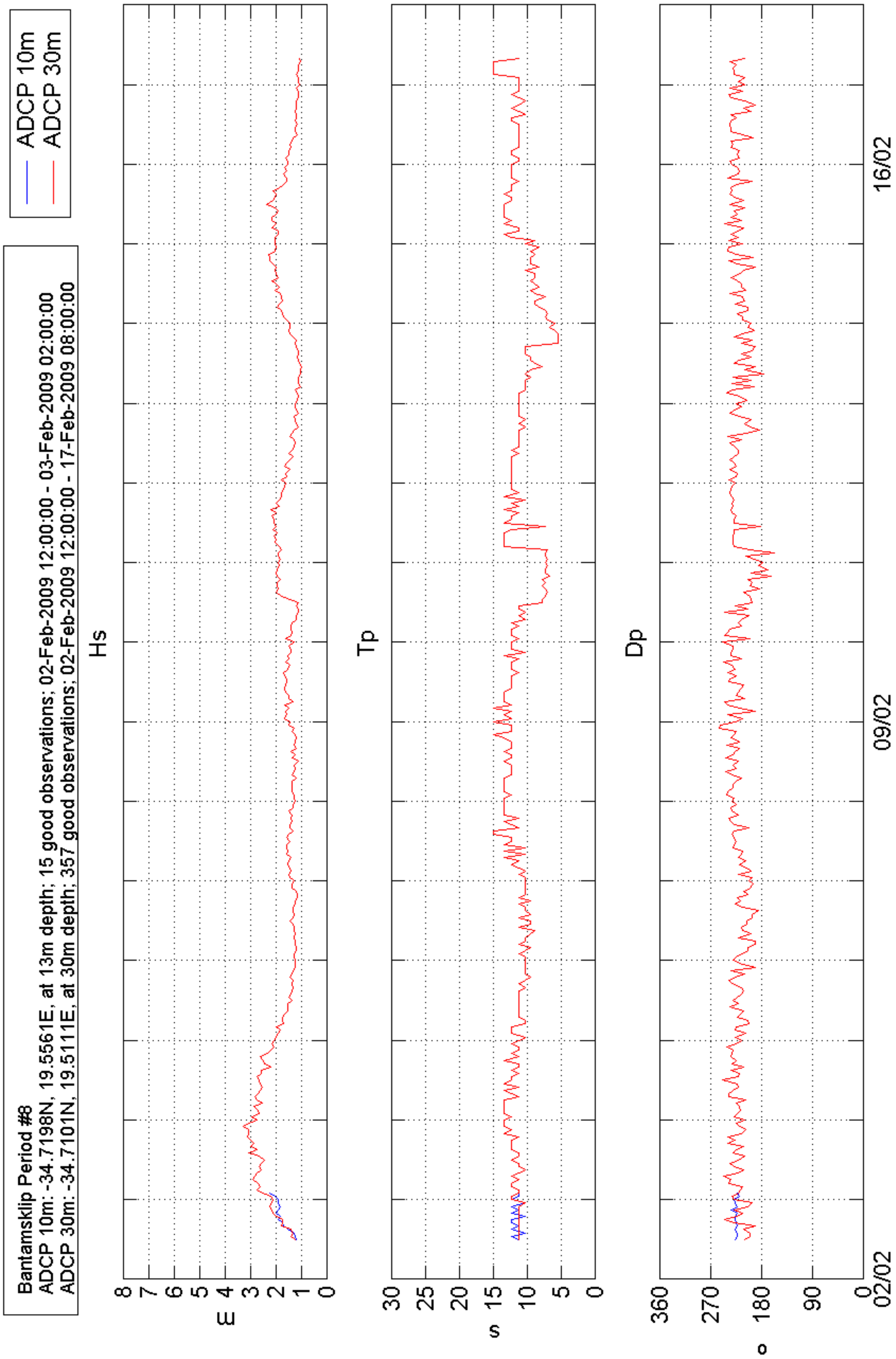


Figure 4: Time series of Hs, Tp (peak period) and Dp (Direction at Tp) from 10m and 30m ADCPs.

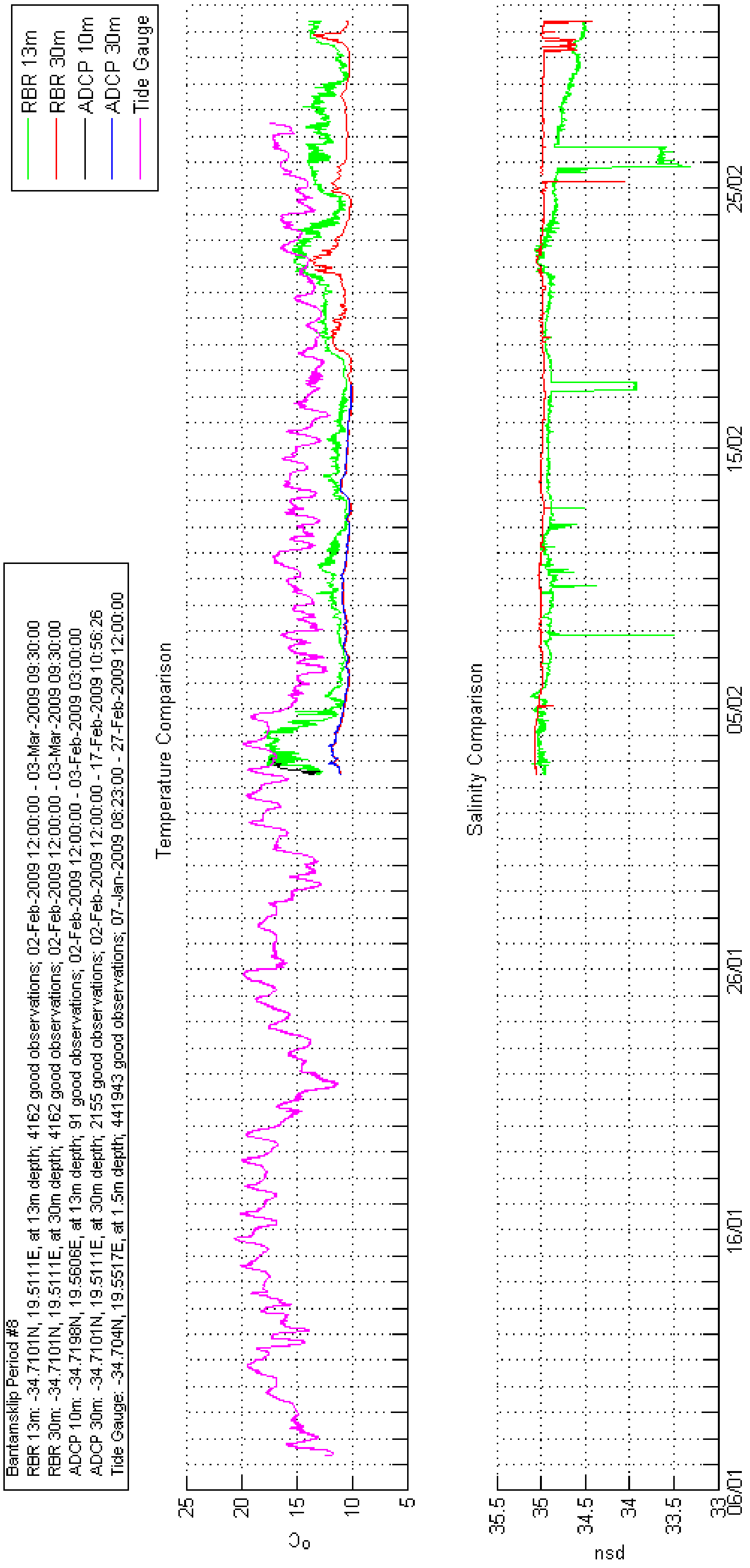


Figure 5: Time series of temperature and salinity from the RBR loggers and ADCPs.

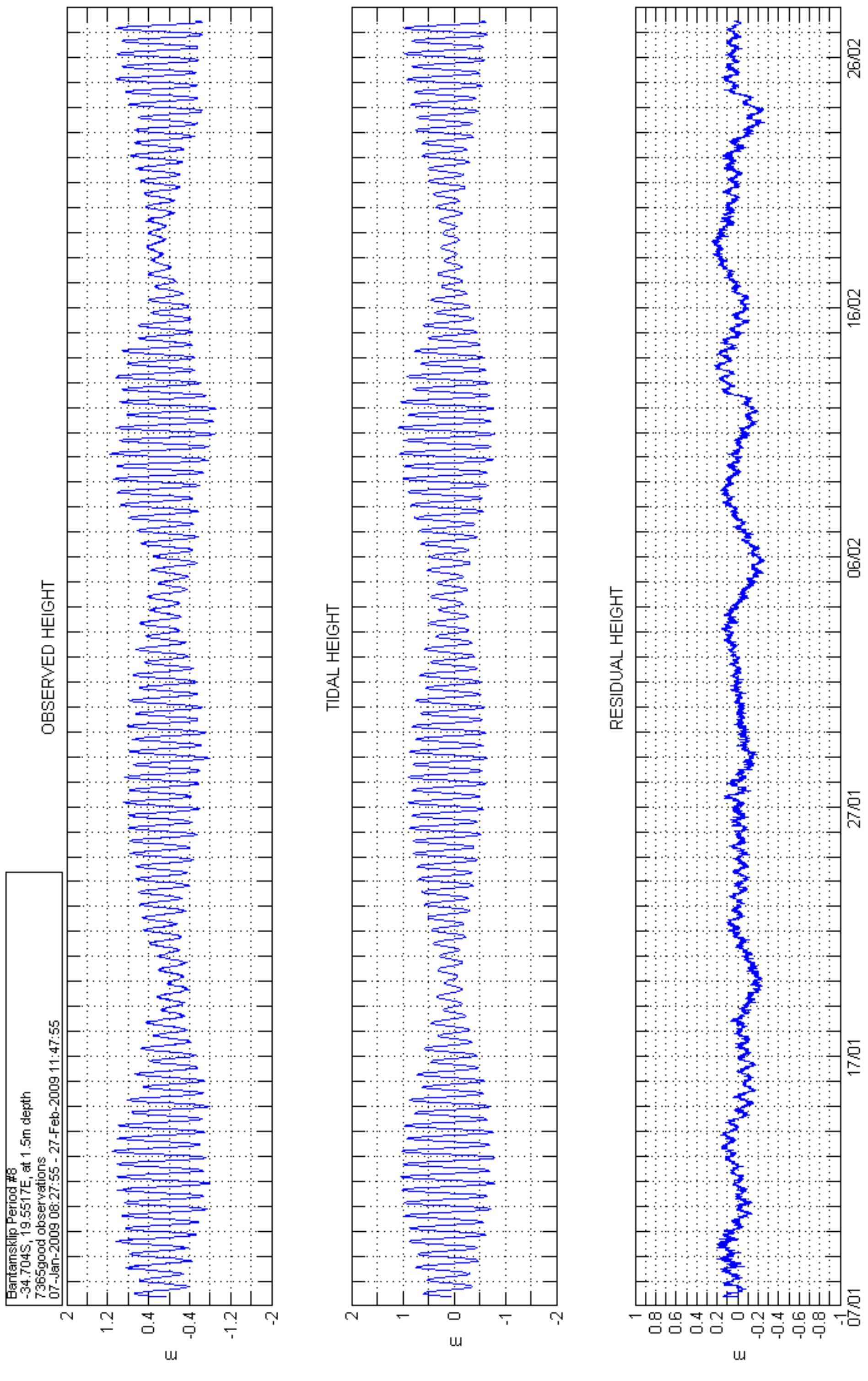


Figure 6: Tidal time series (a) observed height, (b) tidal height (tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)), (c) residual height.

7. INSTRUMENT PARTICULARS

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1 RECOVERY Site Name: Bantamsklip 10 m site Date: 3 March 2009

Instrument type and serial number			RDI	10105
Recovery date and time	LT	GMT	3 March 2009 11:29	
Latitude **(do not ignore – if same, please indicate)**			**34 43.186**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.637**	
Switch off date and time	LT	GMT	3 March 2009 18:56	
File size			6MB	
Was the data copied to memory card?			Y*	N

2 RE-DEPLOYMENT Site Name: Bantams 10 m site. Date 7 March 2009

Instrument type and serial number (do not ignore – if same, please indicate)			RDI	**10105**
Install a new battery and/or check the voltage				**1*44.7V**
Frequency of unit being used			**600kHz**	
Depth range			**10m**	
Number of bins (calculated automatically)			**42**	
Bin Size (calculated automatically)			**0.35**	
Wave burst duration			**40min**	
Time between wave bursts			**60min**	
Pings per ensemble			**500**	
Ensemble interval			**10min**	
Deployment duration			**13days**	
Transducer depth			**10m**	
Any other commands			**minTP,RI0**	
Temperature			**5**	
Recorder size	**2000MB**			

Consequences of the sampling parameters

First and last bin range		**1.41**	**15.76**
Battery usage			**376Wh**
Standard deviation			**1.08**
Storage space required			**113MB**
Set the ADCP clock	LT*	GMT	**6 March 2009 21:30**
Run pre-deployment tests			**Yes**
Name the ADCP deployment			**B1003**

Deployment details

Switch on date and time	LT*	GMT	**7 March 2009 08:00**
Deployment date and time	LT*	GMT	**7 March 2009 10:50**
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43.186**
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.637**
Site depth	10m	Deployment depth	**12.3m**
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 3 March 2009/ADCP_newDeployFiles/B1003**

30m ADCP.

1 RECOVERY Site Name: Bantamsklip 30m site Date: 3 march 2009

Instrument type and serial number		RDI	11424
Recovery date and time	LT	GMT	**3 March 2009 09:17**
Latitude **(do not ignore – if same, please indicate)**			34 42.601
Longitude **(do not ignore – if same, please indicate)**			19 30.691
Switch off date and time	LT	GMT	3 March 2009 19:17
File size			141MB
Was the data copied to memory card?		Y*	N

2 RE-DEPLOYMENT Site Name: Bantams 30m site Date: 7 Mar 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RDI	**11424**
Install a new battery and/or check the voltage		**1*44.7V**
Frequency of unit being used	**600kHz**	
Depth range	**30m**	
Number of bins (calculated automatically)	**69**	
Bin Size (calculated automatically)	**0.5**	
Wave burst duration	**40min**	
Time between wave bursts	**60min**	
Pings per ensemble	**250**	
Ensemble interval	**10min**	
Deployment duration	**13days**	
Transducer depth	**30m**	
Any other commands	**minTP,RI0**	
Temperature	**5**	
Recorder size	**2000MB**	

Consequences of the sampling parameters

First and last bin range	**1.6**	**35.6**
Battery usage		**453Wh**
Standard deviation		**1.08**

Storage space required			**114MB**
Set the ADCP clock	LT*	GMT	**6 March 2009 21:40**
Run pre-deployment tests			**yes**
Name the ADCP deployment			**B3003**

Deployment details

Switch on date and time	LT*	GMT	**7 March 2009 08:00**	
Deployment date and time	LT*	GMT	**7 March 2009 10:00**	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.603	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.668	
Site depth	30m	Deployment depth	**31.6**	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)			**Bantams 2 February 2009/ADCP_newDeployFiles/B3001**	

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

RECOVERY **Site Name: Bantamsklip 30m site** **Date: 3 March 2009**

Instrument type and serial number			RBR 420ct	12994
Recovery date and time	LT	GMT	**3 March 2009 09:17**	
Latitude **(do not ignore – if same, please indicate)**			34 42.605	
Longitude **(do not ignore – if same, please indicate)**			19 30.667	
Switch off date and time	LT	GMT	6 March 2009 20:01	
File size			5KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 3 March 2009/RBR_RecoveredData	

RE-DEPLOYMENT **Site Name: Bantamsklip 30m site Date: 7 March 2009**

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	7 March 2009	08:00:00
End of logging (date / time)	15 April 2009	12:00:00
Memory usage		.4%
Battery usage		976mAH

Deployment details

Deployment date and time	LT*	GMT	7 March 2009 10:00
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.603
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.668
Site name			Batamsklip
Site depth			30m
Deployment depth			13m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *log* file (filename format: ***serialnumber_date***)			Bantams 3 March 2009/RBR_RecoveredData/012994.log

Bottom.

RE-DEPLOYMENT Site Name: Bantamsklip 30m site Date: 7 March 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.2V

Set up the sampling parameters

Sampling period		**10min**
Averaging period		**1min**
Expected deployment duration		**30days**
Start of logging (date / time)	7 March 2009	08:00:00
End of logging (date / time)	15 April 2009	12:00:00
Memory usage		.4%
Battery usage		976mAH

Deployment details

Deployment date and time	LT	GMT	7 March 2009 10:00
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.603
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.668
Site name			Batamsklip
Site depth			30m
Deployment depth			31.6m
Acoustic release (1) serial number and release code			
Acoustic release (2) serial number and release code			
Argos beacon serial number			
Save *log* file (filename format: ***serialnumber_date***)			Bantams 3 March 2009/RBR_RecoveredData/**015248.log**

7.3 RBR TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS

1. RECOVERY Site Name: Bantamsklip Tidegauge Date: 3 March 2009

Instrument type and serial number			TGR 2050	13084
Recovery date and time	LT	GMT	**3 March 2009 11:43**	
Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Switch off date and time	LT	GMT	6 March 2009 20:06	
File size			443KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams_TideGauge_013084_06032009	

2. RE-DEPLOYMENT Site Name: Bantamsklip Tide Gauge Date: 3 March 2009

Instrument type and serial number (do not ignore – if same, please indicate)	TGR 2050	13084
Install a new battery and check the voltage		2 * 3.28

Set up the sampling parameters

Sampling period	**10 sec**	
Averaging period	**1 sec**	
Expected deployment duration	**6 weeks**	
Start of logging (date / time)	7 March 2009	08:00:00
End of logging (date / time)	30 April 2009	12:00:00
Memory usage		33.5%
Battery usage		187mAH

Deployment details

Deployment date and time	LT	GMT	7 March 2009 12:00	
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Site name			Bantamsklip	
Site depth			1.8m	
Deployment depth			1.7m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			**Bantams 3 March 2009/TideGuage_Data**	

7.4 ADCP CONFIGURATION FILES

10m ADCP.

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
TF09/03/07 08:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 2000
;Saved Screen        = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 113.20 MB (118698528 bytes)
;Power usage         = 376.92 Wh
;Battery usage       = 0.8
;Samples / Wv Burst = 4800
;Min NonDir Wave Per= 1.85 s
```

```
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP.

```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
TF09/03/07 08:00:00
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 2000
;Saved Screen        = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.60 m
;Last cell range     = 35.60 m
;Max range           = 38.22 m
```

```
;Standard deviation = 0.86 cm/s
;Ensemble size      = 1534 bytes
;Storage required   = 114.16 MB (119709408 bytes)
;Power usage        = 435.03 Wh
;Battery usage      = 1.0
;Samples / Wv Burst = 4800
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2948
Report Number: MALR2948
27 March 2009

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Dr Robin Carter
CHEMICAL ANALYSIS: seawater samples (Order No.: Ben Schoeman)
Samples received: 17/03/09
Analysis completed: 23/03/09
Sample description: Seawater samples in sealed plastic bottles.

Lab No	**Sample Id**	***Total Suspended Solids in mg/L**
35799	**B 1**	***2.3***
35800	**B2**	***2.6***
35801	**B 3**	***2.0***
35802	**B 4**	***0.5***
35803	**B 5**	***2.6***
35804	**B 6**	***2.8***
35805	**B 7**	***3.0***
35806	**B 8**	***1.3***
35807	**B 9**	***4.2***
35808	**B 10**	***5.7***
35809	**B 11**	***2.4***

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

LWANDLE DATA REPORT

BANTAMSKLIP SITE – TURBIDITY DATA

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

28 August 2009

Job No: LT-JOB-50

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1. INTRODUCTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents the turbidity data calculated for the Bantamsklip site for the period 27th March 2008 – 3rd March 2009.

2. DATA AND METHOD.

The turbidity values were derived using the ADCP data collected at the Bantamsklip 10m site as well as the water samples collected during the service visits. The *ViSea Plume Detection Toolbox* enables one to quantify suspended sediment from ADCP backscatter data. The reflections of the acoustic signals from particles in the water column provide an indication about the presence of suspended sediment concentration (SSC). Calibration measurements are provided from water samples collected. The conversion method takes into account the influences on sound absorption by variable sediment concentrations in different layers. The accuracy of the output is strongly influenced by the quality and number of the calibration measurements available.

Methods:

1. Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves.

2. Current data were then loaded into the ViSea toolbox.

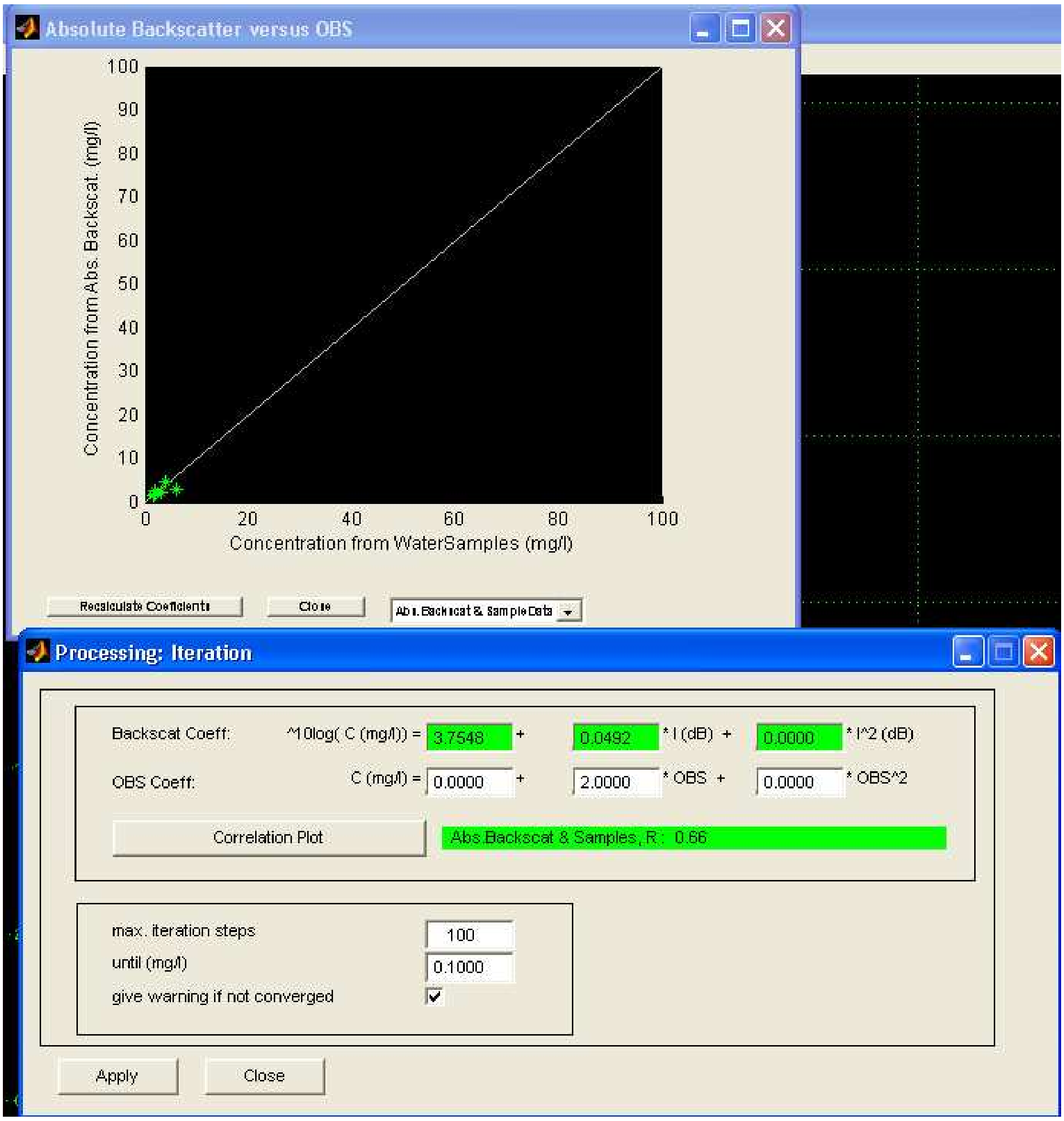
3. Water sample collected during service visits were used for calibration.

Table 1: Water samples, analysed at the CSIR, were collected during service visits 4a, 4b, and 7a. These values were used for calibration.

Lab No	Sample Id	Date	Total Suspended Solids in mg/L	Lat	Long
37078	BTMS-S5-4m	12/07/08	1.99	34.43.187	19.33.635
37079	BTMS-S5-8m	12/07/08	6	34.43.187	19.33.635
34237	BTMS-S5-2m	05/08/08	1.8	34.43.187	19.33.635
34238	BTMS-S6-4m	05/08/08	1.5	34.43.187	19.33.635
34239	BTMS-S7-6m	05/08/08	1.98	34.43.187	19.33.635
34240	BTMS-S8-8m	05/08/08	2	34.43.187	19.33.635
35248	B5-4m	05/12/08	3	34.43.190	19.33.611
35249	B6-8m	05/12/08	4	34.43.161	19.33.591

3. DATA PRESENTATION AND DISCUSSION.

The backscatter coefficients are calculated by means of calibration with reference measurements.



Backscat Coeff: ^10log(C (mg/l)) = 3.7548 + 0.0492 * I (dB) + 0.0000 * I^2 (dB)

OBS Coeff: C (mg/l) = 0.0000 + 2.0000 * OBS + 0.0000 * OBS^2

Abs.Backscat & Samples, R : 0.66

max. iteration steps 100

until (mg/l) 0.1000

give warning if not converged ☑

Figure 1: (a) the relation between the SSC reference measurements and SSC calculated from the absolute backscatter from the selected beam 1. (b) The optimisation of the calculated SSC is achieved after a maximum of 100 iterations within 0.01 mg/L accuracy.

The resulting correlation coefficient is 0.66. The following figures show the suspended sediment concentrations (*mg/L*) for the period 27th March 2008 – 3rd March 2009.

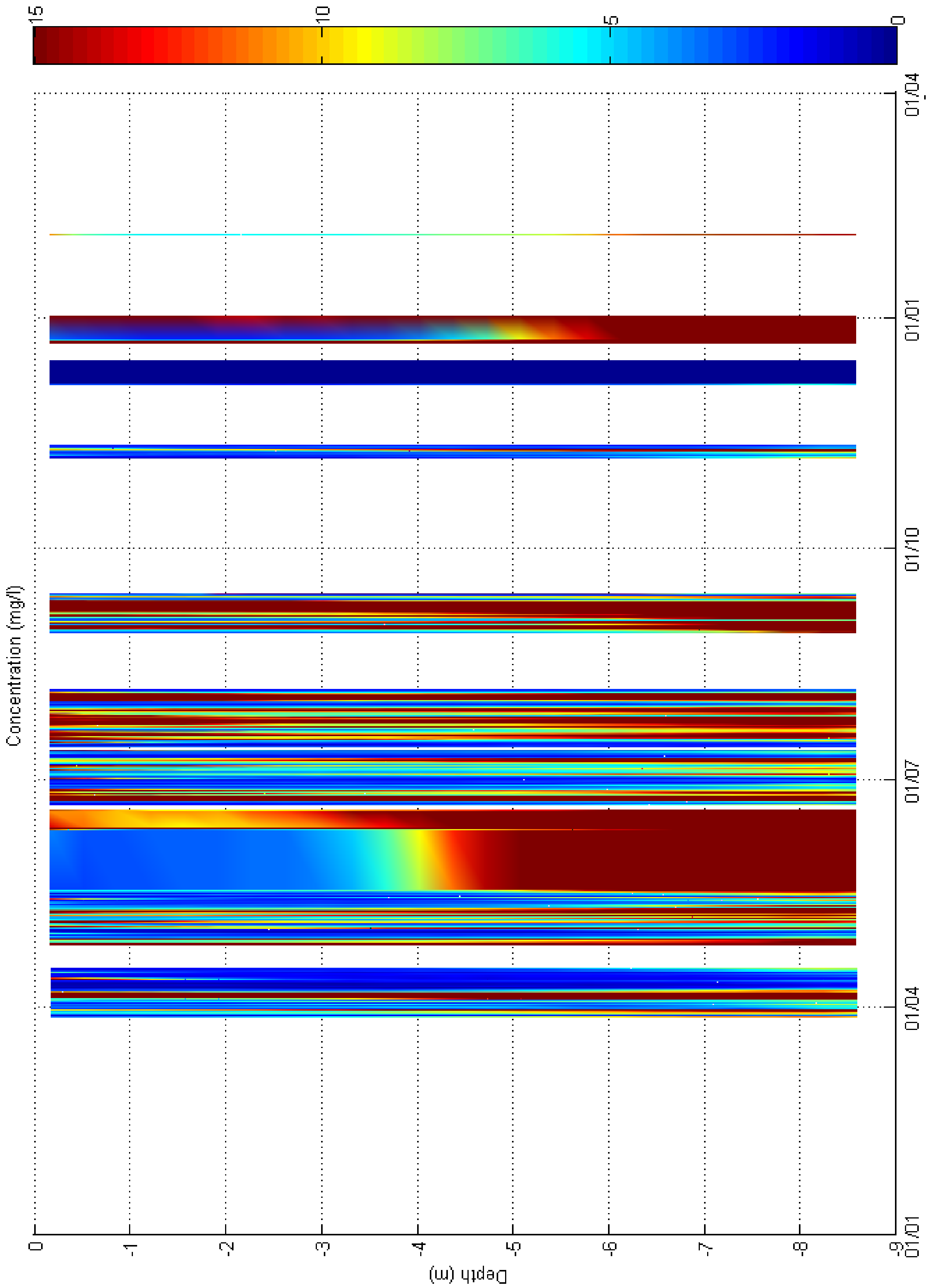


Figure 2: Turbidity concentrations (mg/l) at the Bantamsklip 10m ADCP site from March 2008 to March 2009.

Over a period 27th March 2008 – 3rd March 2009, 14 water samples were taken at the 10m ADCP site. Some of these samples could not be used for the correlation. These include 4 samples taken with no ADCP correspondence and 2 samples deemed wrong as a result of laboratory errors. The higher the number of usable water samples the better the correlation.

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT NINE

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

28 August 2009

Job No: LT-JOB-50

LWANDLE TECHNOLOGIES (PTY) LTD

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

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Cape Town, South Africa

Co Reg. No. 2003/015524/07

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1. DISCLAIMER

The data is this report will undergo additional quality control procedures by Prestedge Retief Dresner Wijnberg (PRDW). For this reason no data in this report should be used for design purposes and only quality controlled data provided by PRDW should be used.

2. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 9 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-11.1	0.1073	0.0402	0.0219	0.0346	57.12
-10.7	0.1066	0.0354	0.0196	0.0284	62.56
-10.4	0.0946	0.0335	0.0174	0.0253	57.66
-10.0	0.0757	0.0323	0.0157	0.0195	53.94
-9.7	0.0956	0.0327	0.0167	0.0163	58.96
-9.3	0.1015	0.0332	0.0198	0.0136	53.78
-9.0	0.1173	0.0353	0.0215	0.0112	52.51
-8.6	0.1256	0.0356	0.0226	0.0087	70.11
-8.3	0.1139	0.0376	0.0231	0.0086	83.45
-7.9	0.1118	0.0396	0.0216	0.0077	94.71
-7.6	0.1112	0.0397	0.0221	0.0081	102.39
-7.2	0.1034	0.0398	0.0221	0.0085	105.52
-6.9	0.1131	0.0383	0.0222	0.0098	114.79
-6.5	0.0981	0.0378	0.0213	0.0098	118.55
-6.2	0.0949	0.0377	0.0201	0.0118	112.18
-5.8	0.1018	0.0359	0.0208	0.012	120.11
-5.5	0.0943	0.0362	0.0209	0.0113	136.48
-5.1	0.1079	0.0358	0.0198	0.0118	151.68
-4.8	0.1128	0.0385	0.0214	0.0132	165.27
-4.4	0.1028	0.042	0.0234	0.0128	187.51
-4.1	0.1178	0.0475	0.0249	0.0151	207.48
-3.7	0.1284	0.0515	0.0266	0.0178	225.84
-3.4	0.1386	0.0562	0.0304	0.0223	241.99
-3.0	0.1426	0.059	0.0334	0.0252	249.22
-2.7	0.1501	0.0658	0.0353	0.0311	252.78
-2.3	0.1804	0.0726	0.0405	0.0289	261.38
-2.0	0.2267	0.0825	0.0497	0.028	296.43
-1.6	0.2909	0.1068	0.0613	0.0423	339.73
-1.3	0.3846	0.1175	0.0692	0.0479	352.84

Table 2 – Waves summary for 10m ADCP

	Max	Min	Mean	Std
Hs (m)	2.49	1.55	0.78	0.59
Tp (s)	17.00	10.05	4.50	2.92
Dp (^{o})	238.50	218.94	184.50	10.56

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (^{o})
-28.1	0.2032	0.0274	0.0176	0.0022	312.01
-27.6	0.1490	0.0286	0.0178	0.0028	323.18
-27.1	0.1539	0.0307	0.0192	0.0031	327.65
-26.6	0.2511	0.0321	0.0214	0.0038	323.45
-26.1	0.2301	0.0344	0.0222	0.0038	320.21
-25.6	0.2418	0.0365	0.0228	0.0041	312.72
-25.1	0.2147	0.0383	0.0240	0.0038	294.94
-24.6	0.2275	0.0405	0.0246	0.0034	302.45
-24.1	0.2197	0.0416	0.0250	0.0034	288.33
-23.6	0.2473	0.0430	0.0268	0.0029	268.01
-23.1	0.2519	0.0444	0.0271	0.0033	249.49
-22.6	0.2383	0.0453	0.0271	0.0030	235.12
-22.1	0.2543	0.0463	0.0269	0.0028	227.72
-21.6	0.2820	0.0473	0.0274	0.0024	202.59
-21.1	0.2883	0.0479	0.0264	0.0020	164.72
-20.6	0.2992	0.0490	0.0266	0.0023	160.26
-20.1	0.2872	0.0489	0.0268	0.0028	153.74
-19.6	0.2869	0.0488	0.0270	0.0031	146.70
-19.1	0.2613	0.0490	0.0264	0.0034	129.81
-18.6	0.2523	0.0494	0.0263	0.0036	113.54
-18.1	0.2318	0.0493	0.0262	0.0033	100.35
-17.6	0.2102	0.0488	0.0264	0.0039	88.58
-17.1	0.2134	0.0490	0.0259	0.0054	71.68
-16.6	0.1956	0.0493	0.0268	0.0067	60.38
-16.1	0.1993	0.0497	0.0268	0.0071	54.77
-15.6	0.2001	0.0504	0.0272	0.0088	46.17
-15.1	0.2179	0.0512	0.0279	0.0094	44.99
-14.6	0.2377	0.0513	0.0287	0.0106	44.71
-14.1	0.2372	0.0516	0.0287	0.0116	42.61
-13.6	0.2588	0.0527	0.0297	0.0120	39.95
-13.1	0.2458	0.0528	0.0305	0.0121	38.15
-12.6	0.2348	0.0531	0.0311	0.0116	36.11
-12.1	0.2447	0.0542	0.0327	0.0106	28.13
-11.6	0.2644	0.0546	0.0333	0.0105	20.84
-11.1	0.2691	0.0552	0.0330	0.0104	12.73
-10.6	0.2945	0.0558	0.0334	0.0100	5.72
-10.1	0.2979	0.0562	0.0337	0.0093	349.63
-9.6	0.2900	0.0580	0.0344	0.0090	337.26
-9.1	0.2715	0.0608	0.0358	0.0093	313.86
-8.6	0.2710	0.0628	0.0376	0.0108	298.47
-8.1	0.2574	0.0655	0.0390	0.0129	283.48
-7.6	0.2518	0.0686	0.0408	0.0150	276.91
-7.1	0.2717	0.0716	0.0438	0.0171	269.61

-6.6	0.2969	0.0758	0.0474	0.0202	263.98
-6.1	0.3094	0.0810	0.0505	0.0232	260.77
-5.6	0.3256	0.0873	0.0543	0.0265	260.53
-5.1	0.3525	0.0943	0.0591	0.0281	263.54
-4.6	0.3372	0.1007	0.0623	0.0312	268.70
-4.1	0.3592	0.1071	0.0649	0.0336	275.24
-3.6	0.3482	0.1113	0.0673	0.0386	285.23
-3.1	0.4004	0.1211	0.0702	0.0462	305.96
-2.6	0.3920	0.1393	0.0702	0.0612	319.81

Table 4 – Waves summary for 30m ADCP

	Max	Min	Mean	Std
Hs (m)	3.48	1.71	0.80	0.57
Tp (s)	15.00	10.90	4.80	2.32
Dp (^{o})	240.53	207.45	157.53	16.35

Table 5 – Water temperature and salinity summary (surface, 13m)

Parameter	Mean	Max	Min
Temperature (^{o}C)	12.17	16.34	9.95
Conductivity	39.89	44.11	37.51
Salinity (psu)	34.73	35.01	33.76

Table 6 – Water temperature and salinity summary (bottom, 30m)

Parameter	Mean	Max	Min
Temperature (^{o}C)	10.48	14.90	9.81
Conductivity	38.47	42.81	37.81
Salinity (psu)	34.91	35.00	34.65

2.1 DATA RETURN FOR BANTAMSKLIP SITE.

Table 7 – Data Return (%).

Bantams P09	29 January 2008 – 15 January 2009	15 January 2009 – 3 April 2009	7 March 2009 – 3 April 2009
Btm RBR Salinity	54	73	100
Surf RBR Salinity	70	73	100
10m ADCP Current	33	6	11
10m ADCP Wave	33	6	11
30m ADCP Current	28	30	29
30m ADCP Wave	25	30	29
Tide	35	91	100
Temp-Btm RBR	62	73	100
Temp-Surf RBR	77	73	100
Temp-10m ADCP	33	6	11
Temp-30m ADCP	34	30	29
Tide Temperature	10	91	100
30m Temperature	76	73	100
10m Temperature	86	73	100

3. INTRODUCTION

3.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents waves, currents, temperature and salinity data collected at Bantamsklip station for the period March 7th – April 3rd 2009 (Period 8). Service of the instruments was undertaken during April 3rd – 4th 2009.

3.2 MEASUREMENT LOCATION

The deployment location of the instruments is given in Table 8 and a location of waters samples taken on April 4th is given in Table 9.

Table 8 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34.7040	19.5517
10m ADCP	34.7198	19.5606
Biofouling	34.7198	19.5614
30m ADCP	34.7101	19.5111
T&C mooring	34.7101	19.5111

Table 9 – Measurement locations – water samples.

Bottle #	STN #	Lat	Long	Exact Time HH:MM:SS	COMMENTS (if RBR profile is taken etc..)
1	30m	34 42.603	19 30.668	13:38	Depth: 4m
2	30m	34 42.603	19 30.668	13:43	Depth: 12m
3	30m	34 42.603	19 30.668	13:46	Depth: 20m
4	30m	34 42.603	19 30.668	13:49	Depth: 28m
5	10m	34 43.186	19 33.637	14:23	Depth: 4m
6	10m	34 43.186	19 33.637	14:25	Depth: 8m
7	1	34 43.190	19 33.611	14:34	Depth: 4m
8	2	34 43.161	19 33.591	14:37	Depth: 4m
9	3	34 43.124	10 33.584	14:41	Depth: 4m
10	4	34 43.097	19 33.577	14:44	Depth: 4m
11	5	34 43.081	19 33.541	14:46	Depth: 4m

4. OPERATIONS

4.1 SUMMARY OF EVENTS

Recovery of the instruments were undertaken on April 3rd 2009 and redeployment on April 4th 2009. The 30m ADCP frame was moved to 34.71005°S, 19.51113°E

An attempt to recover the biofouling was made on April 3rd 2009. They were installed 6 months earlier.

4.2 INSTRUMENT CONFIGURATIONS

Configurations were as per specifications.

Note: Biofouling plates have been installed on frame to avoid third party interference (as of May 2009).

5. DATA QUALITY CONTROL

5.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

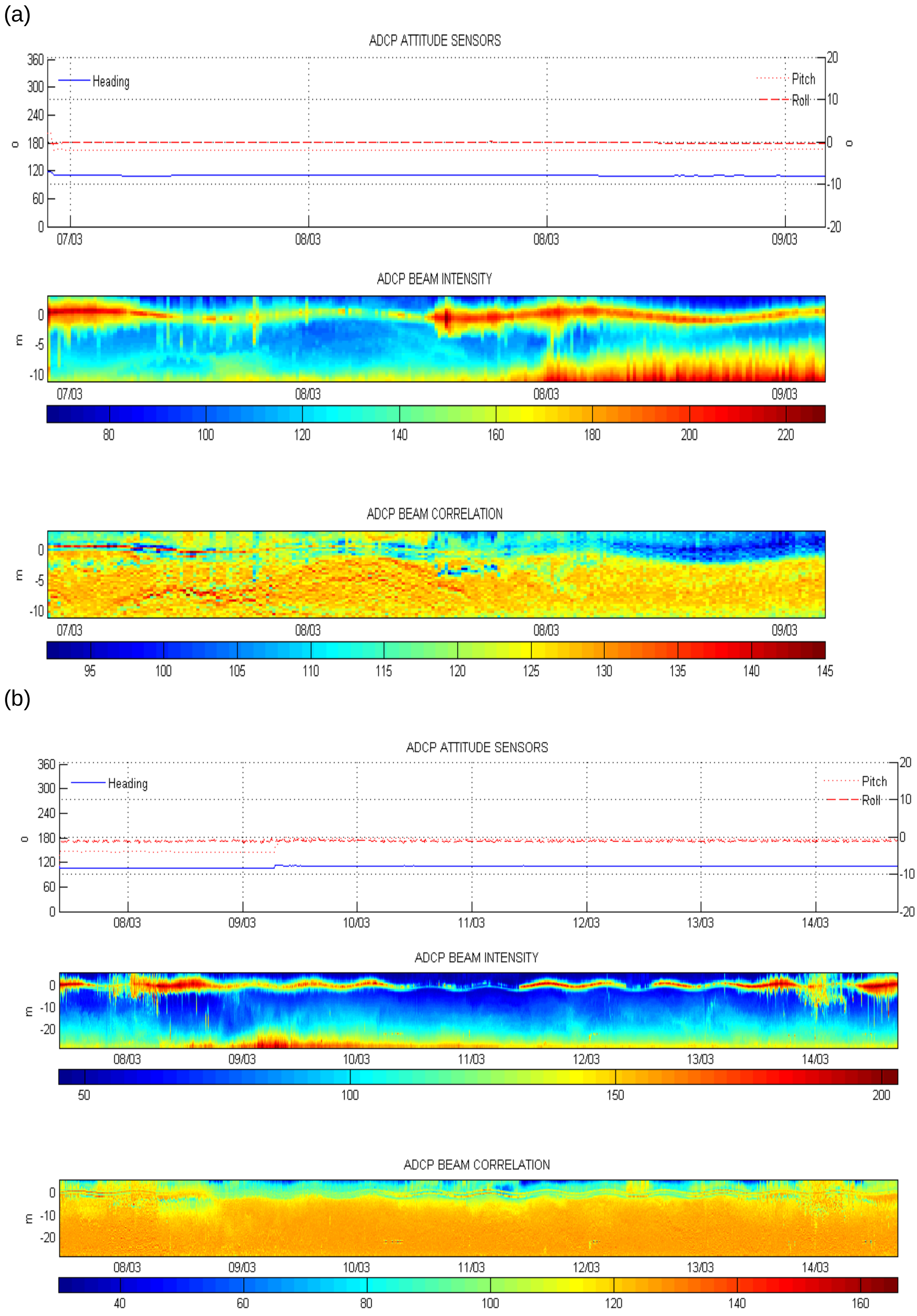
5.1.1 Current processing

- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 30’ W for the 10m ADCP and 25° 28’ W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 0.2ms^{-1} was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 1).
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

5.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 30’ W for the 10m ADCP and 25° 28’ W for the 30m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.



(a)

(b)

Figure 1: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.

5.2 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is -1.649m.
- Finally the data was averaged over a 10-minute period.

5.3 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of the biofouling plates was undertaken on April 3rd 2009.

5.4 WATER SAMPLE.

Water samples were collected during this service and sent to the CSIR for analysis.

6. DATA PRESENTATION AND DISCUSSION

Biofouling recovery:

The line attaching the buoy to the biofouling plates was severed and the buoy was missing. It is suspected that the buoy was stolen by fishermen. The divers were able to locate one set of biofouling plates (consisting of 3 plates) which were lying on the sea bed. The plates were covered with sand resulting in an inaccurate description of the plates. Most of the biomass that had accumulated on the plates had disappeared and only one of the plates had a small quantity of shells attached to the PVC. A sample of the shells was detached from the PVC and placed in a specimen jar filled with seawater, 5ml Formaldehyde and a teaspoon of Calcium Carbonate (labelled 1B). There was very little in terms of Fauna and one type of worm specie was identified and placed in a specimen jar filled with seawater, 5ml Formaldehyde and a teaspoon of Calcium Carbonate (labelled 2B). No Flora was identified on the plate. Pictures were taken of the individual plates and measurements of the growth were done. The growth was insignificant due to the location of the plates on the ocean floor and the greatest amount of growth was <1mm in certain areas (see photographs).

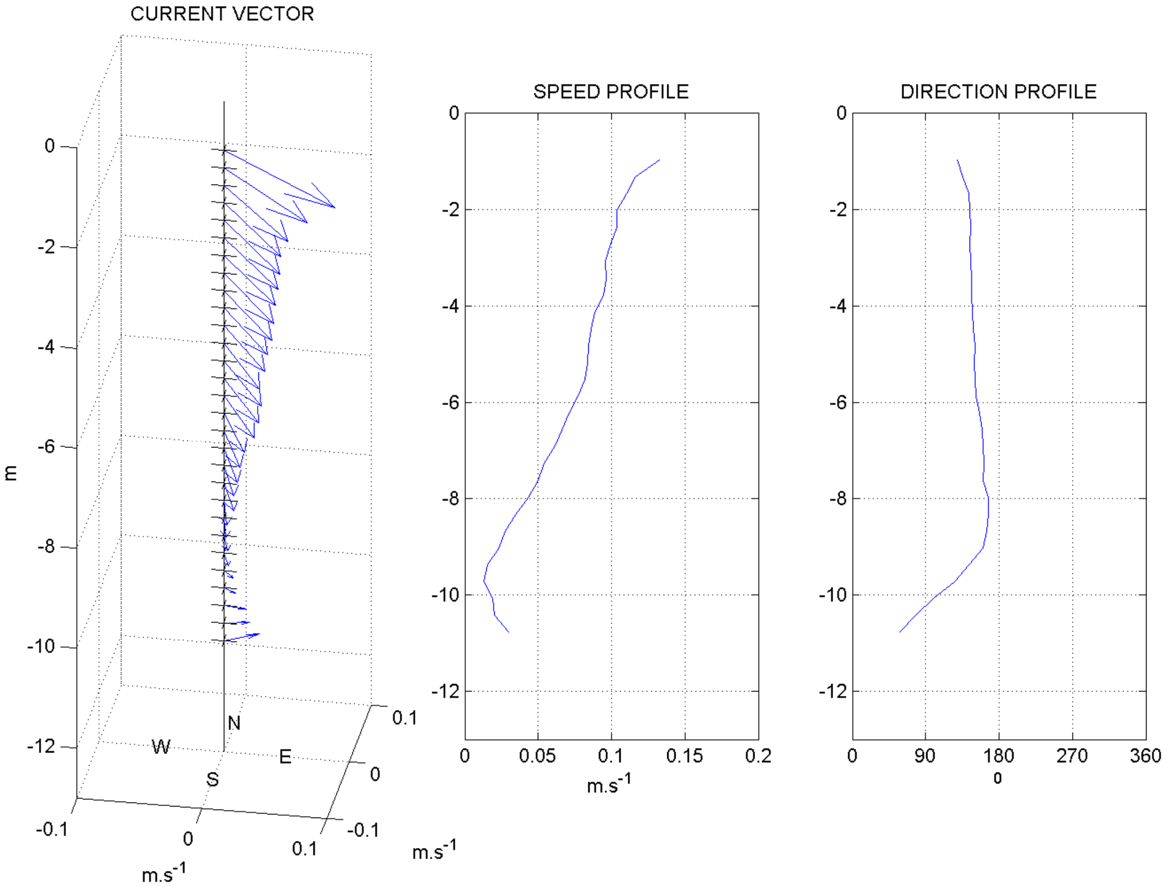


Figure 2: Mean profile plot for 10m ADCP.

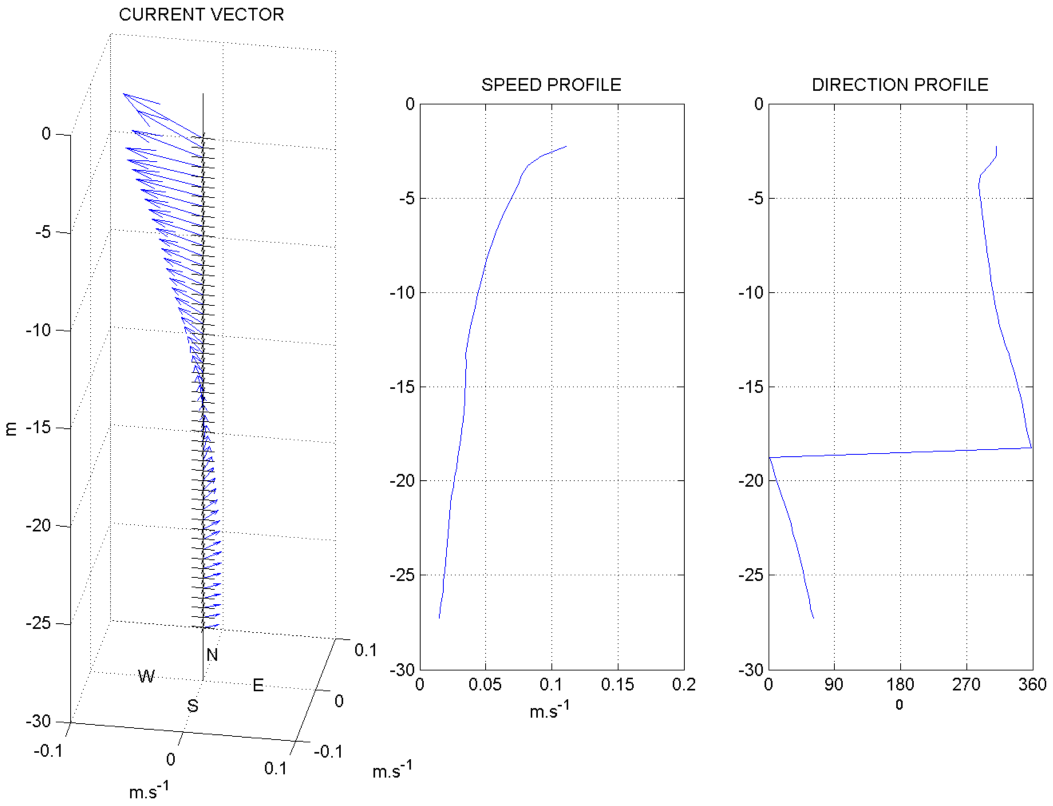


Figure 3: Mean profile plot for 30m ADCP.

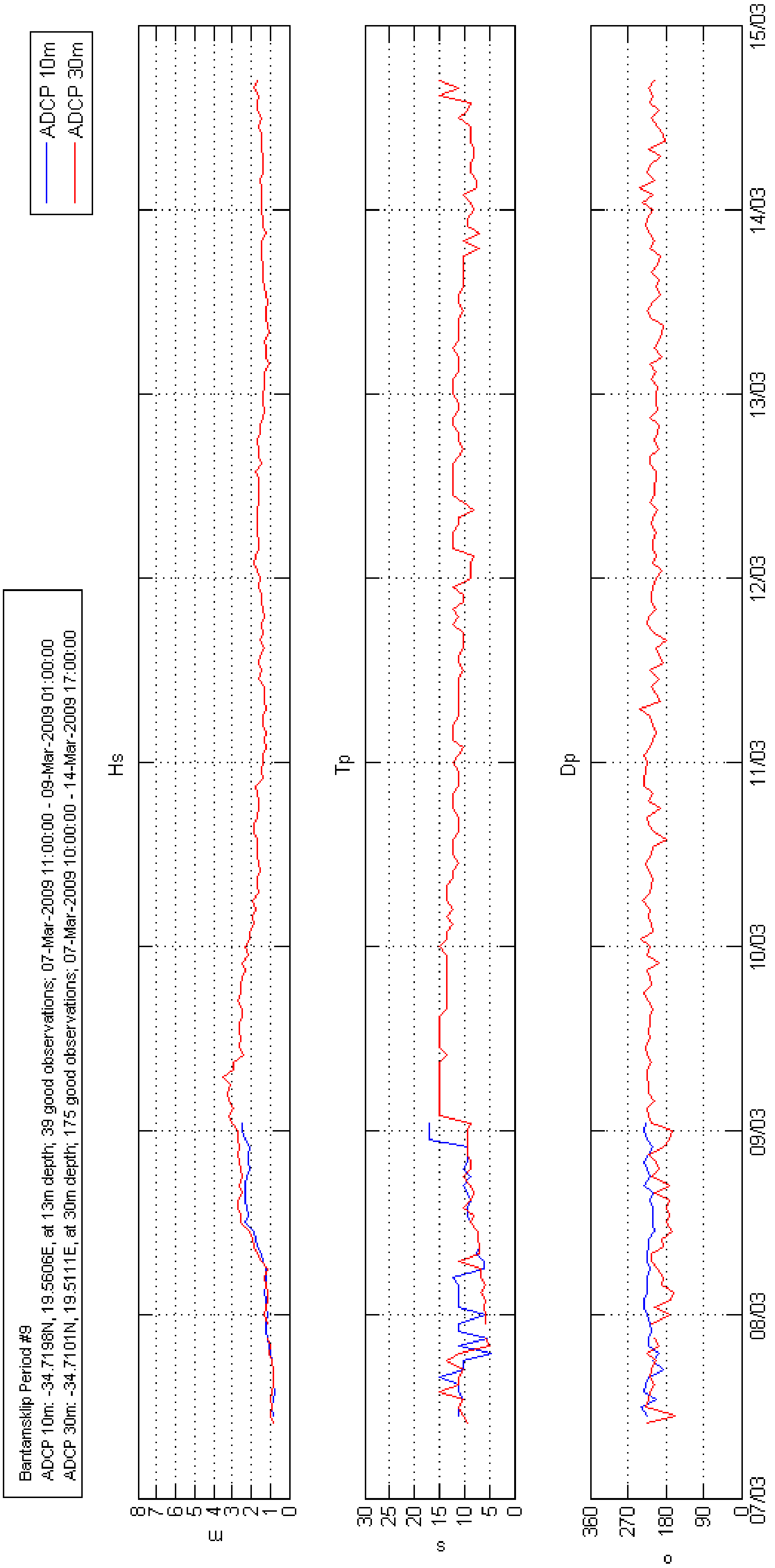


Figure 4: Time series of Hs, Tp and Dp from 10m and 30m ADCPs.

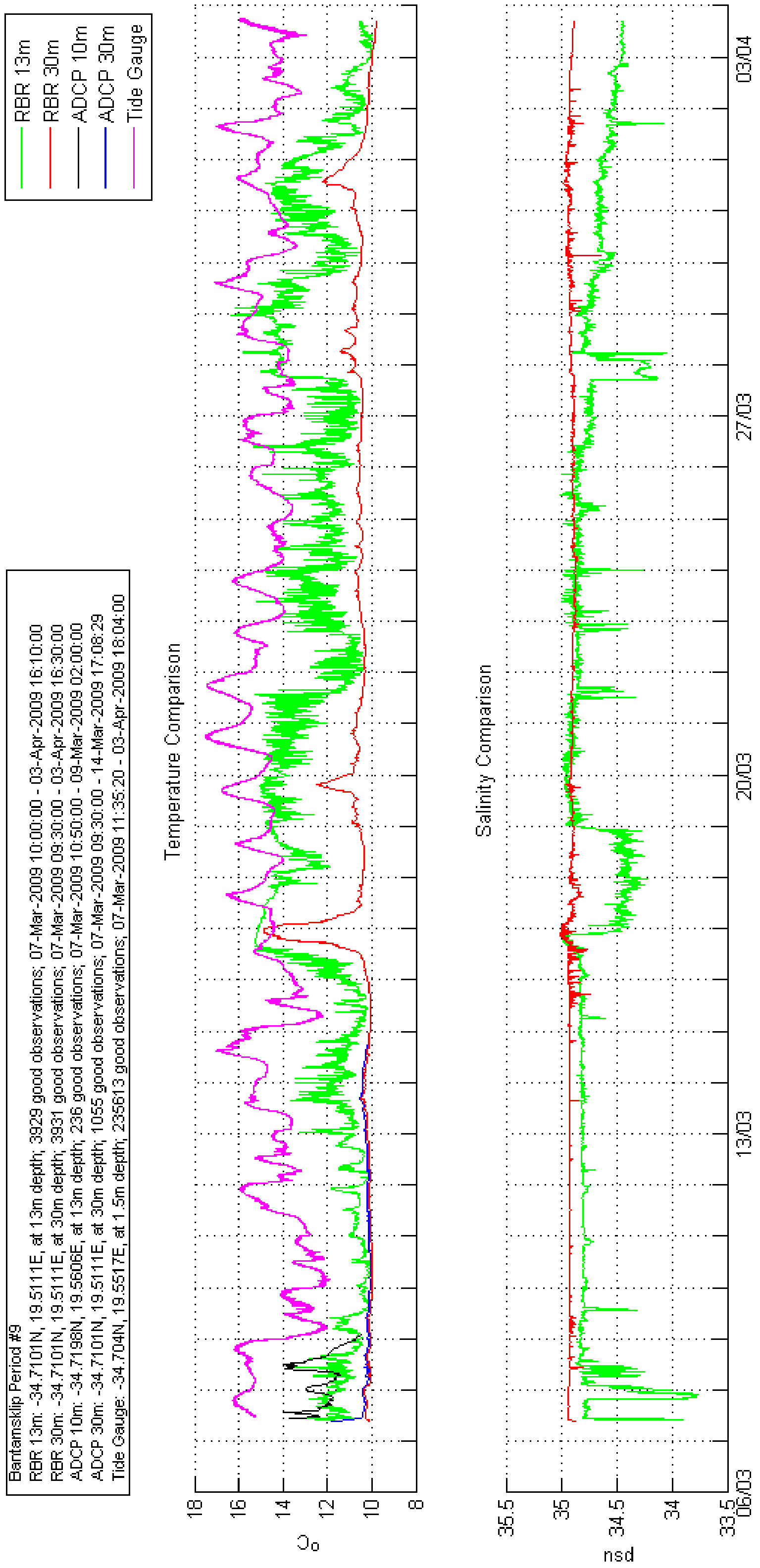


Figure 5: Time series of temperature and salinity from the RBR loggers and ADCPs.

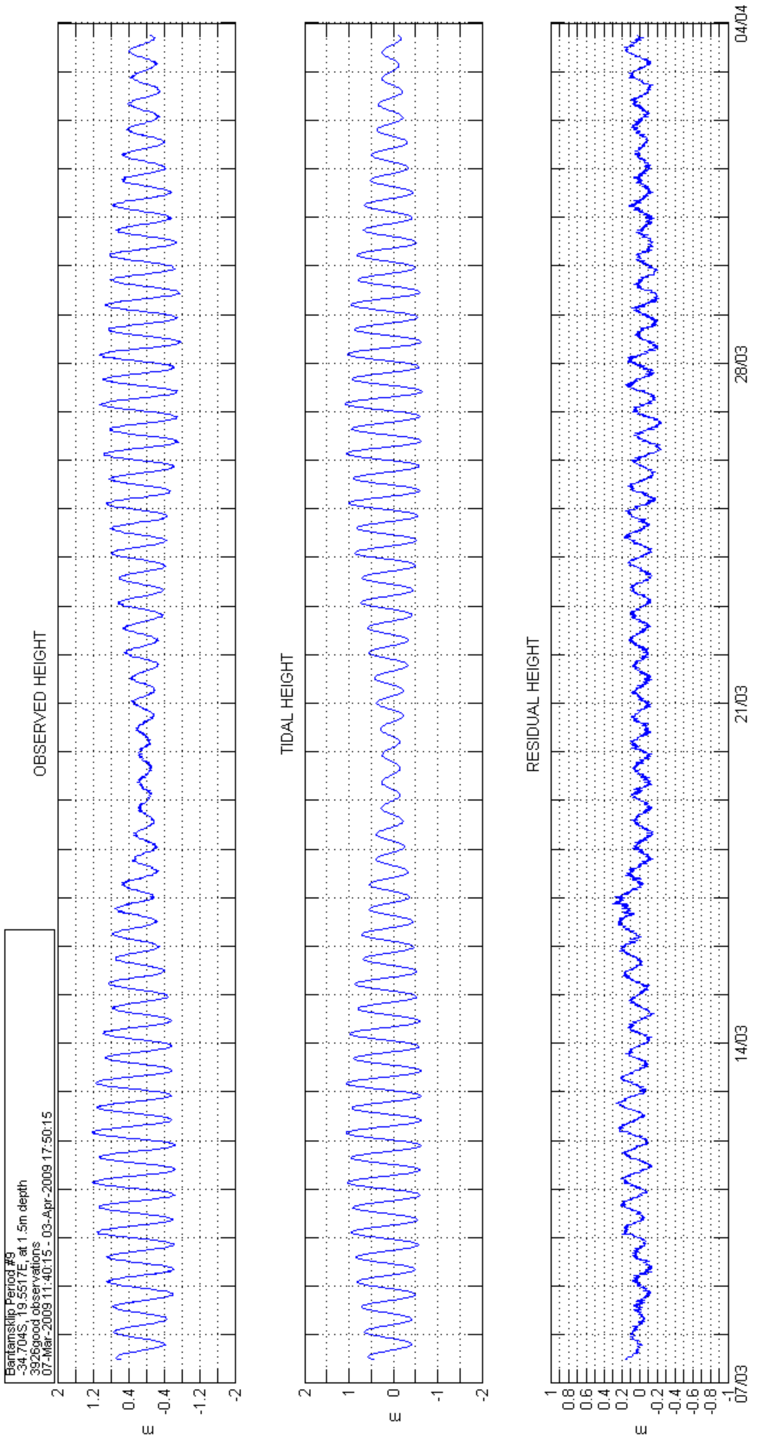


Figure 6: Tidal time series (a) observed height, (b) tidal height (tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)), (c) residual height.

Figure 7

Figure 8

7. INSTRUMENT PARTICULARS

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1 RECOVERY Site Name: Bantamsklip 10 m site Date: 3 April 2009

Instrument type and serial number			RDI	10105
Recovery date and time	LT	GMT	**3 April 2009 17:15**	
Latitude **(do not ignore – if same, please indicate)**			**34 43.186**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.637**	
Switch off date and time	LT	GMT	4 April 2009 07:15	
File size			15.6MB (B1003)	
Was the data copied to memory card?			Y*	N

2 RE-DEPLOYMENT Site Name: Bantams 10m site Date: 4 April 2009

Instrument type and serial number (do not ignore – if same, please indicate)			RDI	**11424**
Install a new battery and/or check the voltage				**1*44.7V**
Frequency of unit being used			**600kHz**	
Depth range			**30m**	
Number of bins (calculated automatically)			**69**	
Bin Size (calculated automatically)			**0.5**	
Wave burst duration			**40min**	
Time between wave bursts			**60min**	
Pings per ensemble			**250**	
Ensemble interval			**10min**	
Deployment duration			**13days**	
Transducer depth			**30m**	
Any other commands			**minTP,RI0**	
Temperature			**5**	
Recorder size			**1000MB Sn#9**	

Consequences of the sampling parameters

First and last bin range			**1.6**	**35.6**
Battery usage				**435Wh**
Standard deviation				**1.08**
Storage space required				**114MB**
Set the ADCP clock	LT*	GMT	**4 April 2009 09:25**	
Run pre-deployment tests				**yes**
Name the ADCP deployment			**B3004**	

Deployment details

Switch on date and time	LT*	GMT	**4 April 2009 09:25**	
Deployment date and time	LT*	GMT	**4 April 2009 13:00**	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.603	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.668	
Site depth	30m	Deployment depth	**31.6**	
Acoustic release (1) serial number and release code				

Acoustic release (2) serial number and release code		
Argos beacon serial number		
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)	**Bantams 4 April 2009 dep/ADCP_newDeploy Files/B3004**	

30m ADCP.

1 RECOVERY Site Name: Bantamsklip 30m site Date: 3 April 2009

Instrument type and serial number			RDI	11424
Recovery date and time	LT	GMT	**3 April 2009 16:34**	
Latitude **(do not ignore – if same, please indicate)**			34 42.603	
Longitude **(do not ignore – if same, please indicate)**			19 30.668	
Switch off date and time	LT	GMT	4 April 2009 07:00	
File size			159MB (B3003)	
Was the data copied to memory card?			Y*	N

2 RE-DEPLOYMENT Site Name: Bantams 30 m site. Date 4 April 2009

Instrument type and serial number (do not ignore – if same, please indicate)			RDI	**10105**
Install a new battery and/or check the voltage				**1*44.7V**
Frequency of unit being used			**600kHz**	
Depth range			**10m**	
Number of bins (calculated automatically)			**42**	
Bin Size (calculated automatically)			**0.35**	
Wave burst duration			**40min**	
Time between wave bursts			**60min**	
Pings per ensemble			**500**	
Ensemble interval			**10min**	
Deployment duration			**13days**	
Transducer depth			**10m**	
Any other commands			**minTP,RI0**	
Temperature			**5**	
Recorder size			**1000MB Sn#10**	

Consequences of the sampling parameters

First and last bin range			**1.41**	**15.76**
Battery usage				**376Wh**
Standard deviation				**1.08**
Storage space required				**113MB**
Set the ADCP clock	LT*	GMT	**4 April 2009 09:20**	
Run pre-deployment tests				**Yes**
Name the ADCP deployment			**B1004**	

Deployment details

Switch on date and time	LT*	GMT	**4 April 2009 09:20**	
Deployment date and time	LT*	GMT	**4 April 2009 14:20**	
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 43.186**	
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.637**	
Site depth	10m	Deployment depth	**12.3m**	
Acoustic release (1) serial number and release code				

Acoustic release (2) serial number and release code		
Argos beacon serial number		
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)	**Bantams 4 April 2009 dep/ADCP_newDeploy Files/B1004**	

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

2 RECOVERY Site Name: Bantamsklip 30m site Date: 3 April 2009

Instrument type and serial number			RBR 420ct	12994
Recovery date and time	LT	GMT	**3 April 2009 16:34**	
Latitude **(do not ignore – if same, please indicate)**			34 42.605	
Longitude **(do not ignore – if same, please indicate)**			19 30.667	
Switch off date and time	LT	GMT	4 April 2009 08:57	
File size			88KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 3 April 2009/RBR_RecoveredData	

2 RE-DEPLOYMENT Site Name: Bantamsklip 30m site Date: 4 April 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	12994
Install a new battery and check the voltage		4* 3.2V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	4 April 2009	09:14:20
End of logging (date / time)	2 June 2009	12:00:00
Memory usage		.4%
Battery usage		950mAH

Deployment details

Deployment date and time	LT*	GMT	4 April 2009 13:00	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.605	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.667	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			13m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				

Save *log* file (filename format: ***serialnumber_date***)	Bantams 4 April 2009 dep/RBR_TideGauge_newDeployLogs/**20090404.log**

Bottom.

1. **RECOVERY** Site Name: Bantamsklip 30m site Date: 3 April 2009

Instrument type and serial number			RBR 420ct	15248
Recovery date and time	LT	GMT	**3 April 2009 16:34**	
Latitude **(do not ignore – if same, please indicate)**			34 42.601	
Longitude **(do not ignore – if same, please indicate)**			19 30.691	
Switch off date and time	LT	GMT	4 April 2009 08:59	
File size			88KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 3 April 2009/RBR_RecoveredData	

2. **RE-DEPLOYMENT** Site Name: Bantamsklip 30m site Date: 4 April 2009

Instrument type and serial number (do not ignore – if same, please indicate)	RBR 420ct	15248
Install a new battery and check the voltage		3 * 3.2V

Set up the sampling parameters

Sampling period	**10min**	
Averaging period	**1min**	
Expected deployment duration	**30days**	
Start of logging (date / time)	4 April 2009	09:15:30
End of logging (date / time)	2 June 2009	12:00:00
Memory usage		.4%
Battery usage		950mAH

Deployment details

Deployment date and time	LT	GMT	4 April 2009 13:00	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 42.603	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 30.668	
Site name			Batamsklip	
Site depth			30m	
Deployment depth			31.6m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 4 April 2009 dep/RBR_TideGauge_newDeployLogs/**20090404.log**	

7.3 RBR TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS

1. **RECOVERY** **Site Name: Bantamsklip Tidegauge** **Date: 3 April 2009**

Instrument type and serial number			TGR 2050	13084
Recovery date and time	LT	GMT	**3 April 2009 18:00**	
Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Switch off date and time	LT	GMT	4 April 2009 09:03	
File size			5207KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 3 April 2009 rec/TideGuage_Data	

2. RE-DEPLOYMENT **Site Name: Bantamsklip Tide Gauge Date: 4 April 2009**

Instrument type and serial number (do not ignore – if same, please indicate)	TGR 2050	13084
Install a new battery and check the voltage		2 * 3.28

Set up the sampling parameters

Sampling period		**10 sec**
Averaging period		**1 sec**
Expected deployment duration		**6 weeks**
Start of logging (date / time)	4 April 2009	09:12:40
End of logging (date / time)	2 June 2009	12:00:00
Memory usage		36%
Battery usage		204mAH

Deployment details

Deployment date and time	LT	GMT	4 April 2009 15:00	
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Site name			Bantamsklip	
Site depth			1.8m	
Deployment depth			1.7m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 4 April 2009 dep/RBR_TideGauge_newDeployLogs/**20090404.log**	

7.4 ADCP CONFIGURATION FILES

10m ADCP

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 113.20 MB (118698528 bytes)
;Power usage         = 376.92 Wh
;Battery usage       = 0.8
;Samples / Wv Burst = 4800
```

```
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP

```
CR1
CF11101
EA0
EB0
ED300
ES35
EX11111
EZ1111111
RI0
WA255
WB0
WD111100000
WF88
WN69
WP250
WS50
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument         = Workhorse Sentinel
;Frequency          = 614400
;Water Profile      = YES
;Bottom Track       = NO
;High Res. Modes    = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge         = YES
;Lowered ADCP       = NO
;Beam angle         = 20
;Temperature        = 5.00
;Deployment hours   = 312.00
;Battery packs      = 1
;Automatic TP       = NO
;Memory size [MB]   = 1000
;Saved Screen       = 1
;
;Consequences generated by PlanADCP version 2.04:
;First cell range   = 1.60 m
;Last cell range    = 35.60 m
;Max range          = 38.22 m
;Standard deviation = 0.86 cm/s
```

```
;Ensemble size      = 1534 bytes
;Storage required   = 114.16 MB (119709408 bytes)
;Power usage        = 435.03 Wh
;Battery usage      = 1.0
;Samples / Wv Burst = 4800
;Min NonDir Wave Per= 2.59 s
;Min Dir Wave Period= 4.31 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

CERTIFICATE OF ANALYSIS

Our ref: H:\USERS\MARLAB\REPORTS\Malr2971
Report Number: MALR2971
17 April 2009

Lwandle Technologies
Gabriel Place
1 Gabriel Road
Plumstead
7800

Attention Dr Robin Carter
CHEMICAL ANALYSIS: seawater samples (Order No.: PRDW)
Samples received: 15/04/09
Analysis completed: 16/04/09
Sample description: Seawater samples in sealed plastic bottles.

Lab No	Sample Id	Total Suspended Solids in mg/L
35976	**B1**	*9*
35977	**B2**	*2*
35978	**B3**	*2*
35979	**B4**	*3*
35980	**B5**	*16*
35981	**B6**	*10*
35982	**B7**	*9*
35983	**B8**	*2*
35984	**B9**	*12*
35985	**B10**	*11*
35986	**B11**	*3*

Andrew Pascall
MARINE ANALYTICAL SERVICES
Laboratory Manager

Sebastian Brown
MARINE ANALYTICAL SERVICES
Deputy Laboratory Manager

- Method not included in the scope of accreditation.

LWANDLE TECHNOLOGIES (PTY) LTD

LWANDLE DATA REPORT

BANTAMSKLIP SITE – DEPLOYMENT TEN

PREPARED FOR
PRESTEDGE RETIEF DRESNER WIJNBERG (PTY) LTD

PREPARED BY
LWANDLE TECHNOLOGIES (PTY) LTD

28 August 2009

Job No: LT-JOB-50

LWANDLE TECHNOLOGIES (PTY) LTD

Directors: C.P. Matthysen, M. Majodina, B.J. Spolander

Unit 13 Constantiaberg Business Park, 31 Princess Vlei Road, Diep River, 7800,
Cape Town, South Africa

Co Reg. No. 2003/015524/07

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1. DISCLAIMER

The data is this report will undergo additional quality control procedures by Prestedge Retief Dresner Wijnberg (PRDW). For this reason no data in this report should be used for design purposes and only quality controlled data provided by PRDW should be used.

2. EXECUTIVE SUMMARY

First order statistics of the data collected at Bantamsklip during deployment 10 are presented in this section together with an indication of the data return achieved.

Table 1 – Current flow summary for 10m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (°)
-10.8	0.3152	0.0563	0.0378	0.0470	19.85
-10.4	0.2730	0.0523	0.0355	0.0425	17.73
-10.1	0.2743	0.0502	0.0340	0.0388	13.25
-9.7	0.2806	0.0481	0.0335	0.0359	10.01
-9.4	0.2938	0.0469	0.0326	0.0333	9.14
-9.0	0.2935	0.0466	0.0327	0.0307	6.11
-8.7	0.3294	0.0460	0.0335	0.0283	5.40
-8.3	0.3183	0.0458	0.0331	0.0263	4.93
-8.0	0.3245	0.0465	0.0331	0.0252	2.64
-7.6	0.2872	0.0459	0.0328	0.0218	359.81
-7.3	0.2830	0.0461	0.0329	0.0197	355.68
-6.9	0.2853	0.0459	0.0326	0.0177	351.70
-6.6	0.2868	0.0466	0.0324	0.0152	349.80
-6.2	0.2648	0.0469	0.0329	0.0138	339.83
-5.9	0.2825	0.0475	0.0332	0.0118	324.45
-5.5	0.2734	0.0491	0.0333	0.0106	312.33
-5.2	0.2668	0.0502	0.0336	0.0096	297.27
-4.8	0.2710	0.0514	0.0345	0.0104	274.39
-4.5	0.2923	0.0532	0.0350	0.0108	258.58
-4.1	0.2822	0.0560	0.0353	0.0122	244.24
-3.8	0.2616	0.0593	0.0362	0.0140	237.07
-3.4	0.2524	0.0628	0.0365	0.0154	242.91
-3.1	0.2655	0.0700	0.0412	0.0175	256.74
-2.7	0.2778	0.0731	0.0426	0.0161	268.04
-2.4	0.2938	0.0749	0.0435	0.0168	288.33
-2.0	0.2823	0.0743	0.0426	0.0167	304.47
-1.7	0.2524	0.0782	0.0444	0.0140	313.70
-1.3	0.2495	0.0890	0.0473	0.0190	359.25

Table 2 – Waves summary for 10m ADCP

	Max	Min	Mean	Std
Hs (m)	2.82	0.81	1.64	0.57
Tp (s)	19.60	6.90	11.79	2.02
Dp (^{o})	248.48	184.48	214.91	8.47

Table 3 – Current flow summary for 30m ADCP

Depth (m)	Max speed (ms^{-1})	Mean speed (ms^{-1})	Std speed (ms^{-1})	Vector mean speed (ms^{-1})	Vector mean direction (^{o})
-28.1	0.1677	0.0253	0.0231	0.0046	144.42
-27.6	0.1867	0.0273	0.0251	0.0056	145.84
-27.1	0.1946	0.0293	0.0265	0.0085	153.27
-26.6	0.1993	0.0317	0.0296	0.0085	164.05
-26.1	0.2147	0.0320	0.0305	0.0095	168.31
-25.6	0.2403	0.0332	0.0303	0.0099	163.00
-25.1	0.2557	0.0344	0.0292	0.0111	161.76
-24.6	0.2549	0.0365	0.0289	0.0126	160.08
-24.1	0.2383	0.0366	0.0286	0.0136	155.06
-23.6	0.2551	0.0373	0.0289	0.0143	151.30
-23.1	0.3236	0.0380	0.0320	0.0154	150.12
-22.6	0.3880	0.0391	0.0346	0.0167	148.42
-22.1	0.4207	0.0390	0.0361	0.0159	144.80
-21.6	0.4559	0.0392	0.0365	0.0158	142.96
-21.1	0.4891	0.0403	0.0396	0.0155	135.72
-20.6	0.5272	0.0408	0.0430	0.0165	133.10
-20.1	0.5700	0.0420	0.0447	0.0168	124.90
-19.6	0.5675	0.0437	0.0448	0.0183	115.84
-19.1	0.5739	0.0455	0.0456	0.0183	105.07
-18.6	0.5824	0.0485	0.0458	0.0209	95.59
-18.1	0.5767	0.0521	0.0462	0.0234	90.07
-17.6	0.5652	0.0537	0.0475	0.0281	84.70
-17.1	0.5533	0.0565	0.0486	0.0322	83.45
-16.6	0.5374	0.0587	0.0485	0.0353	79.55
-16.1	0.5127	0.0610	0.0473	0.0369	80.24
-15.6	0.4832	0.0639	0.0466	0.0400	77.75
-15.1	0.4719	0.0673	0.0485	0.0426	79.66
-14.6	0.4609	0.0688	0.0475	0.0438	79.80
-14.1	0.4466	0.0710	0.0474	0.0465	80.24
-13.6	0.4508	0.0721	0.0481	0.0485	82.62
-13.1	0.4125	0.0734	0.0474	0.0502	83.95
-12.6	0.4275	0.0721	0.0494	0.0507	85.17
-12.1	0.4153	0.0736	0.0501	0.0534	90.14
-11.6	0.3717	0.0727	0.0487	0.0542	92.20
-11.1	0.3724	0.0729	0.0488	0.0555	94.80
-10.6	0.3338	0.0727	0.0480	0.0559	96.30
-10.1	0.3206	0.0731	0.0482	0.0574	96.59
-9.6	0.3274	0.0722	0.0457	0.0568	98.64
-9.1	0.3344	0.0745	0.0461	0.0586	97.17
-8.6	0.3229	0.0739	0.0448	0.0601	96.65
-8.1	0.3029	0.0736	0.0423	0.0613	91.92
-7.6	0.2959	0.0732	0.0424	0.0605	89.64
-7.1	0.2814	0.0754	0.0396	0.0614	88.01

-6.6	0.2850	0.0786	0.0431	0.0615	86.94
-6.1	0.2920	0.0826	0.0467	0.0637	83.65
-5.6	0.2922	0.0861	0.0481	0.0677	82.03
-5.1	0.2982	0.0898	0.0478	0.0716	80.71
-4.6	0.2704	0.0913	0.0437	0.0743	76.87
-4.1	0.2712	0.0937	0.0467	0.0777	75.08
-3.6	0.2733	0.1001	0.0459	0.0838	72.23
-3.1	0.3700	0.1117	0.0491	0.0955	66.68
-2.6	0.3729	0.1469	0.0641	0.1320	56.26
-2.1	0.3989	0.1651	0.0646	0.1513	59.00

Table 4 – Waves summary for 30m ADCP

	Max	Min	Mean	Std
Hs (m)	1.43	0.90	1.09	0.12
Tp (s)	15.00	6.20	11.65	1.63
Dp (^{o})	237.52	167.52	204.62	21.36

Table 5 – Water temperature and salinity summary (bottom, 30m)

Parameter	Mean	Max	Min
Temperature (^{o}C)	11.19	15.52	9.86
Conductivity	39.16	43.66	37.87
Salinity (psu)	34.92	35.21	34.50

2.1 DATA RETURN FOR BANTAMSKLIP SITE.

Table 6 – Data Return (%).

Bantams P10	29 January 2008 – 15 January 2009	15 January 2009 – 6 May 2009	4 April 2009 – 6 May 2009
Btm RBR Salinity	54	81	100
Surf RBR Salinity	70	52	0
10m ADCP Current	33	13	30
10m ADCP Wave	33	13	30
30m ADCP Current	28	24	9
30m ADCP Wave	25	24	9
Tide	35	94	100
Temp-Btm RBR	62	81	100
Temp-Surf RBR	77	52	0
Temp-10m ADCP	33	13	30
Temp-30m ADCP	34	24	9
Tide Temperature	10	94	100
30m Temperature	76	81	100
10m Temperature	86	61	30

3. INTRODUCTION

3.1 PROJECT DESCRIPTION

Lwandle Technologies (Pty) Ltd has been contracted by Prestedge Retief Dresner Wijnberg (PRDW) for oceanographic measurements in connection with the Eskom preliminary site safety report. Oceanographic data is required as input to the coastal engineering studies for a proposed new nuclear power station at three potential sites, Koeberg, Bantamsklip and Thyspunt. This data will be measured for a period of 31 months.

This report presents waves, currents, temperature, salinity and tide data collected at Bantamsklip station for the period April 4th – May 6rd 2009 (Period 10). Service of the instruments was undertaken during May 6th and 23rd 2009.

3.2 MEASUREMENT LOCATION

Table 7 – Measurement locations

Instrument	Latitude (°S)	Longitude (°E)
Tide Gauge	34.7040	19.5517
10m ADCP	34.7198	19.5606
Biofouling	34.7198	19.5614
30m ADCP	34.7101	19.5111
T&C mooring	34.7101	19.5111

4. OPERATIONS

4.1 SUMMARY OF EVENTS

Recovery of the instruments was undertaken on May 6th 2009. The 10 m RBR was not recovered (s/n 12994). Redeployment of 10 m ADCP (s/n 10117) and tide gauge was done on May 23rd 2009.

4.2 INSTRUMENT CONFIGURATIONS

Configurations were as per specifications.

5. DATA QUALITY CONTROL

5.1 ADCP

Raw binary files were processed using the WavesMon software to separate the data into two components: currents and waves. Matlab was then used to process the data further.

5.1.1 Current processing

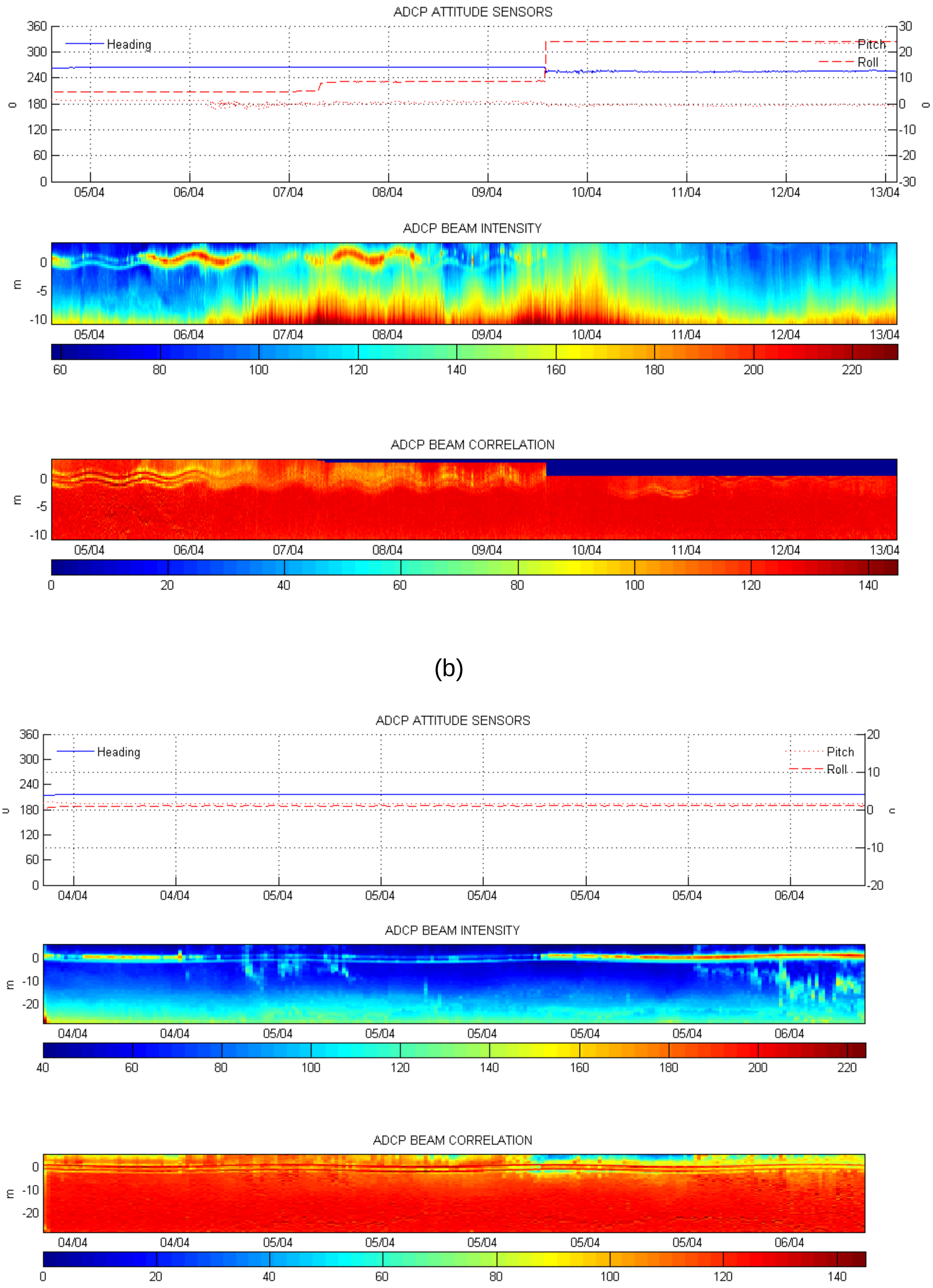
- The record was truncated to exclude times pre and post deployment.
- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 31’ W for the 10m ADCP and 25° 29’ W for the 30m ADCP.
- A flag was imposed on all data within 6% of the waters surface due to side lobe interference. The distance to the water surface was based on the ADCP’s pressure sensor.
- Checks were then run searching for any outliers in the velocity data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of $0.2ms^{-1}$ was allowed. Outliers identified by this method were then visually examined and flagged.
- Checks were then run searching for repeated values in the velocity and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- The ADCP attitude data (heading, pitch and roll) were examined (Figure 1). For the 10m ADCP, the roll sensor jumped to above 20^{o} on the 9th April and remained at that new level. The roll cut off was relaxed from 22^{o} to 30^{o} for the 10m ADCP to account for this jump.
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

5.1.2 Wave processing

Wave parameters Hs (significant wave height), Tp (period of peak energy) and Dp (direction with peak energy at Tp) as well as the full wave directional spectra were then imported into Matlab for further processing:

- Directions were adjusted from magnetic to true north using a magnetic variation of 25° 31’ W for the 10m ADCP and 25° 29’ W for the 30m ADCP.
- Significant wave height data below 0m were removed and replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

(a)



(b)

Figure 1: Attitude data for (a) 10m ADCP and (b) 30m ADCP.

5.2 RBR-CT LOGGER

The conductivity and temperature data were exported directly from the RBR software into Matlab for further processing.

- The record was truncated to exclude times pre and post deployment.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.

5.3 TIDE GAUGE

The RBR software was used to convert and export water level data to a Matlab format. The data were then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Atmospheric sea level pressure correction was applied.
- Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 3 values to the centre point. A tolerance of 0.3m was allowed.
- Checks were then run searching for repeated values in the height data. This was automated within a routine that searched for 3 identical consecutive values.
- Data below 0m and above 10m (operating range of sensor) were flagged.
- All flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The data was then adjusted referenced to the Land Levelling Datum. The distance between top of the stilling well and the LLD is -1.649m.
- Finally the data was averaged over a 10-minute period.

5.4 BIOFOULING.

The following standard procedure is followed:

- The biofouling plates are retrieved.
- Photographs of the plate and prominent features are taken.
- Biofouling 'thickness' at 3 or 4 locations on the plates are measured.
- The Biofouling organisms present on the plates are gently scraped into plastic bag and transferred in water to the sample bottle.
- Formaldehyde is used to get a final 2-4% strength solution and 1 or 2 CaC03 chips are added.
- Sample bottles are stored upright in the dark.

Recovery of plates was not undertaken during this service visit

5.5 WATER SAMPLE.

No water samples were taken

6. DATA PRESENTATION AND DISCUSSION

The 10m ADCP attitude sensor showed a roll exceeding the acceptable 20^{o} threshold starting from around mid-day on April 9th until the 13th. This threshold has been relaxed to 30^{o} and data is presented here but flagged as potentially doubtful.

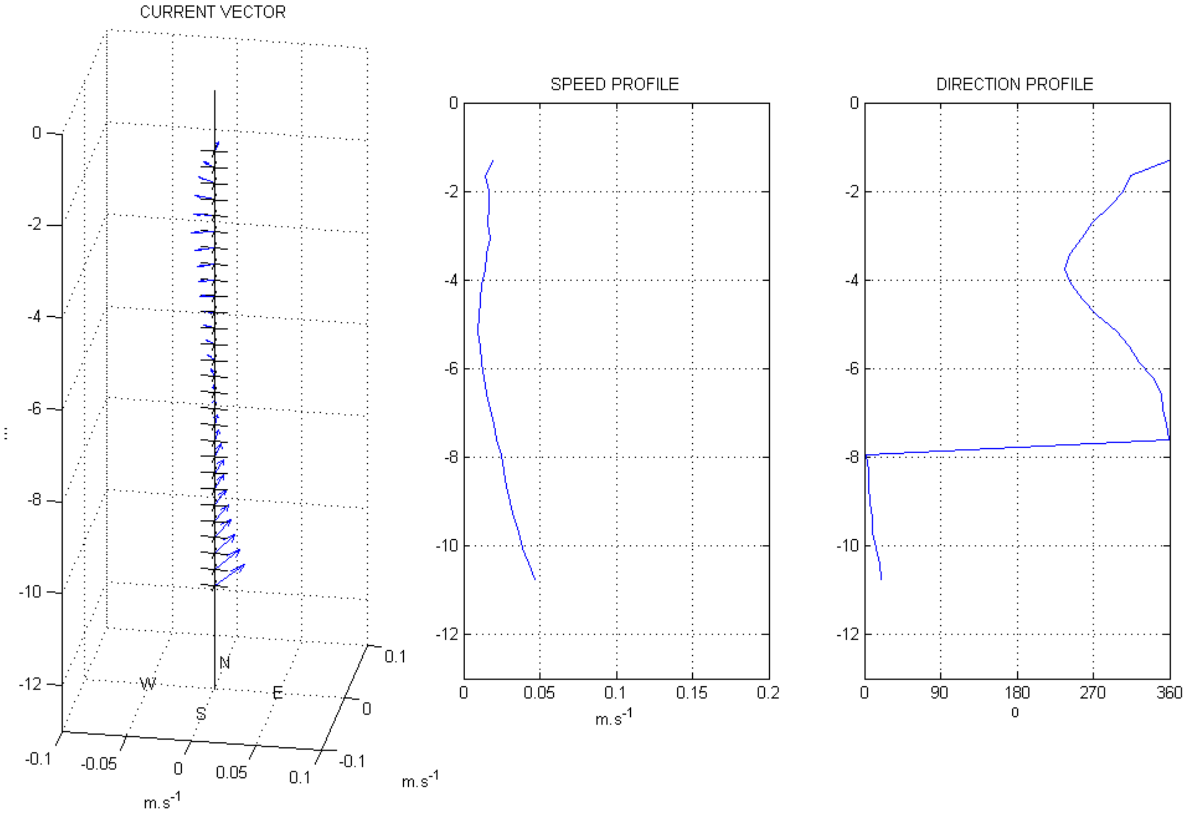


Figure 2: Mean profile plot for 10m ADCP.

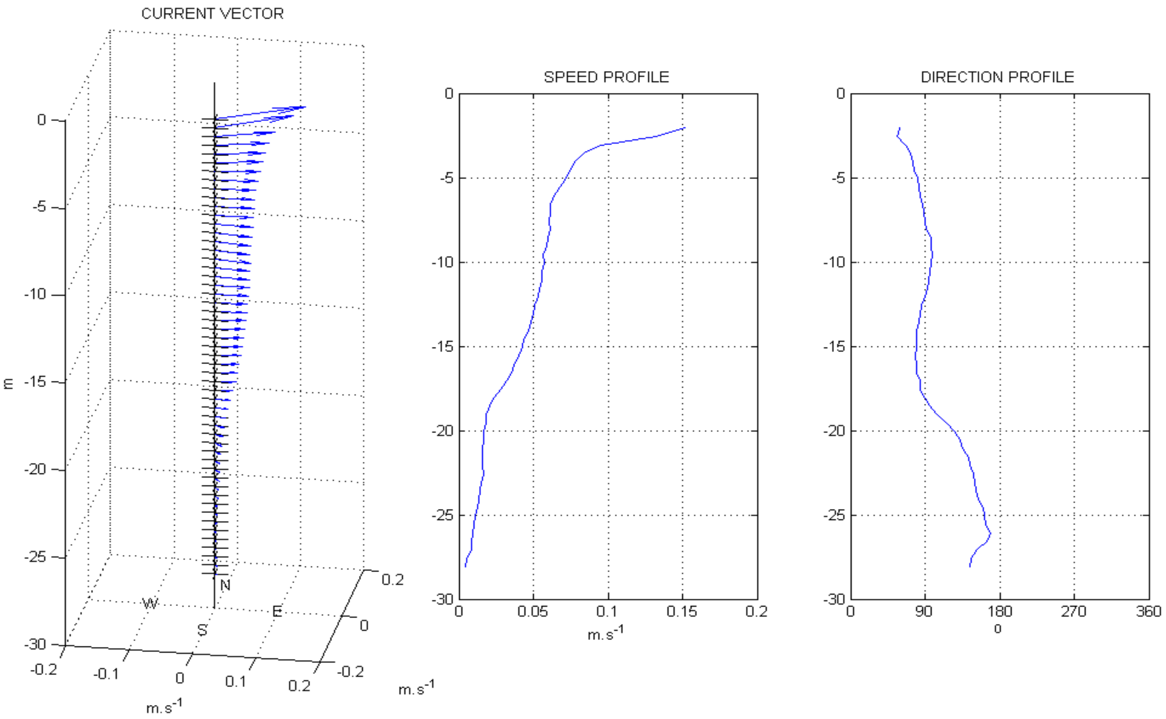


Figure 3: Mean profile plot for 30m ADCP.

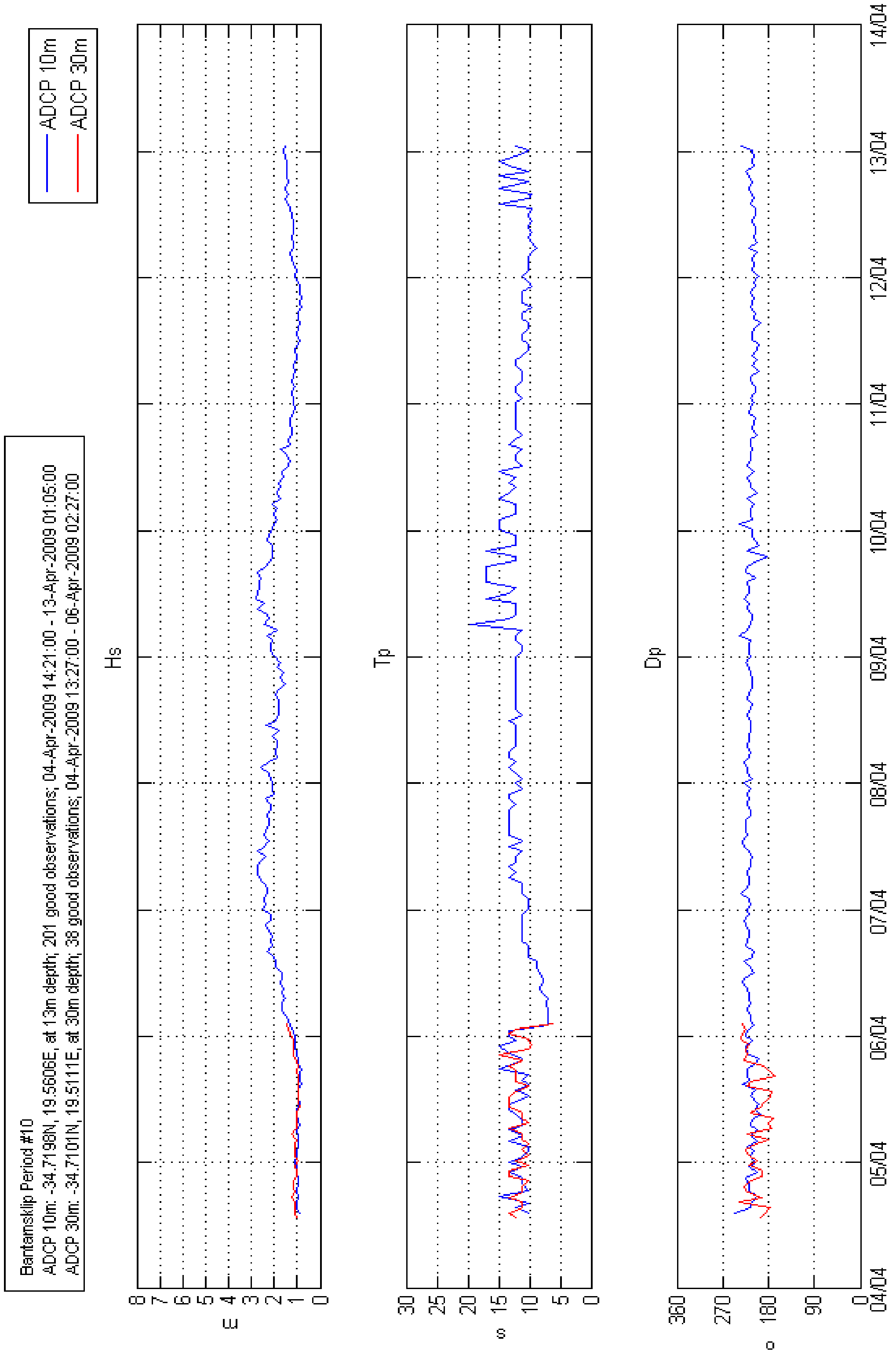


Figure 4: Time series of Hs, Tp and Dp from 10m and 30m ADCPs.

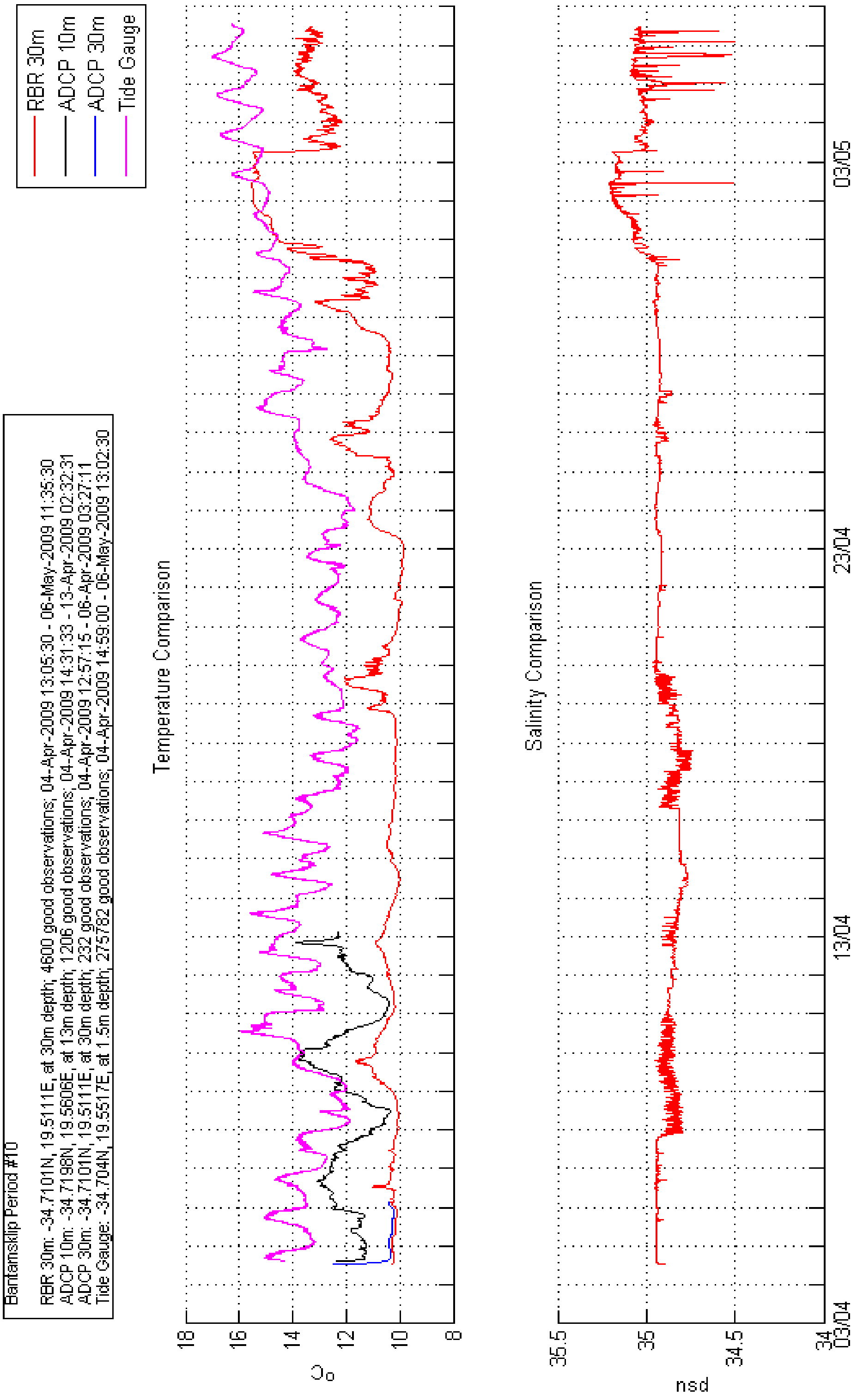


Figure 5: Time series of temperature and salinity from the RBR loggers and ADCPs.

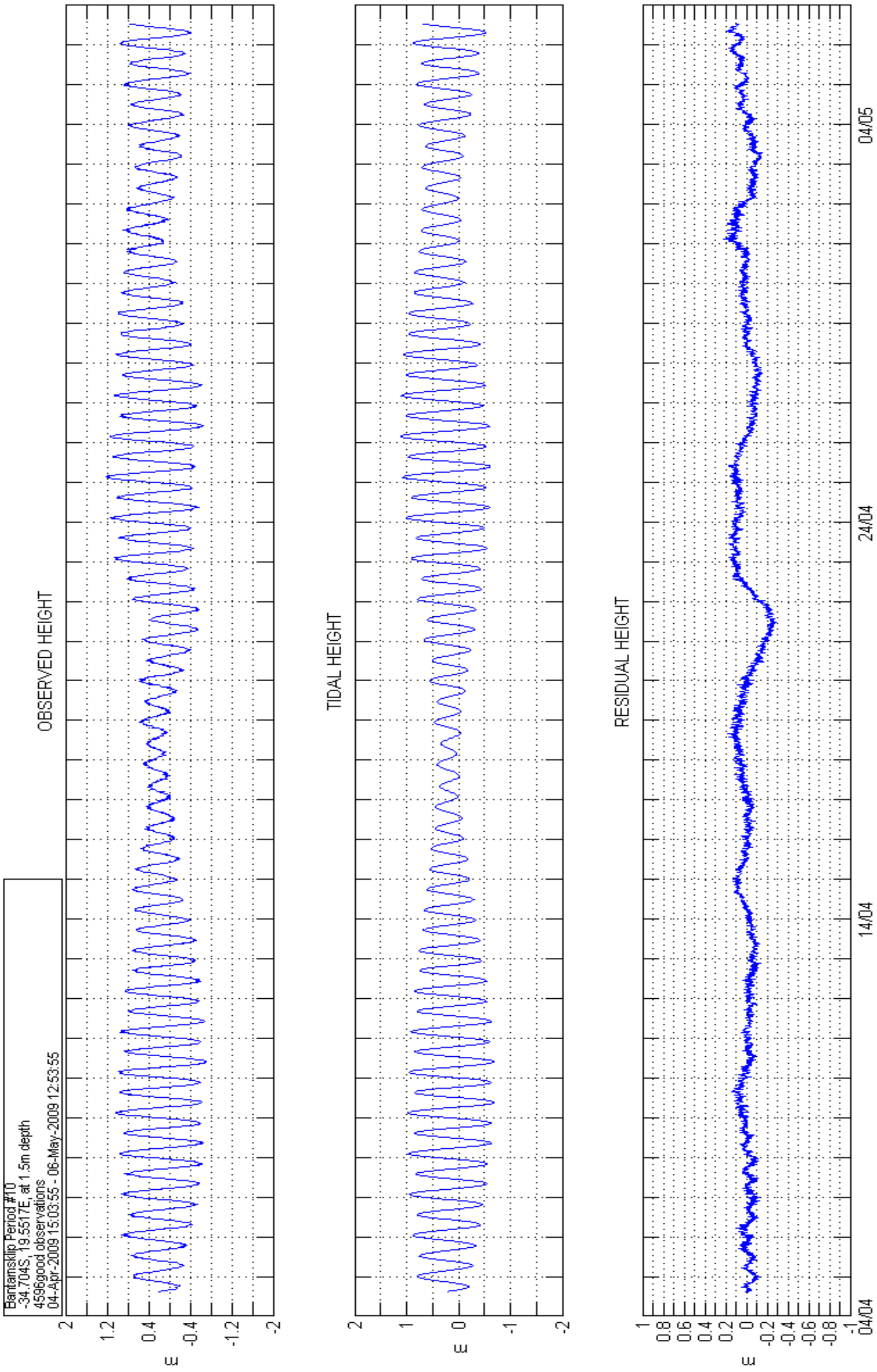


Figure 6: Tidal time series (a) observed height, (b) tidal height (tidal calculation follows the method of Foreman and uses the observed height as input (*R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE", Computers and Geosciences 28 (2002), 929-937*)), (c) residual height.

7. INSTRUMENT PARTICULARS

7.1 ADCPS RECOVERY AND RE-DEPLOYMENT SHEETS

10m ADCP.

1 RECOVERY Site Name: Bantamsklip 10 m site Date: 6 May 2009

Instrument type and serial number			RDI	11424
Recovery date and time	LT	GMT	**6 May 2009 12:40**	
Latitude **(do not ignore – if same, please indicate)**			**34 43.186**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.637**	
Switch off date and time	LT	GMT	7 May 2009 08:02	
File size			82 (B1004)	
Was the data copied to memory card?			Y*	N

2 RE-DEPLOYMENT Site Name: Bantams 10m site Date: 23 May 2009

Instrument type and serial number (do not ignore – if same, please indicate)			RDI	**10117**
Install a new battery and/or check the voltage				**1*44.7V**
Frequency of unit being used			**600kHz**	
Depth range			**42m**	
Number of bins (calculated automatically)			**42**	
Bin Size (calculated automatically)			**0.35**	
Wave burst duration			**40min**	
Time between wave bursts			**60min**	
Pings per ensemble			**500**	
Ensemble interval			**10min**	
Deployment duration			**13days**	
Transducer depth			**10m**	
Any other commands			**minTP,RI0**	
Temperature			**5**	
Recorder size	**1 * !GB Sn#8**			

Consequences of the sampling parameters

First and last bin range			**1.41**	**15.76**
Battery usage				**376Wh**
Standard deviation				**1.08**
Storage space required				**113MB**
Set the ADCP clock	LT*	GMT	**22 May 2009 21:20**	
Run pre-deployment tests				**yes**
Name the ADCP deployment			**B1005**	

Deployment details

Switch on date and time	LT*	GMT	**22 May 2009 21:20**	
Deployment date and time	LT*	GMT	**23 May 2009 11:10**	
Deployment Latitude **(do not ignore – if same, please indicate)**			34 43.186	
Deployment Longitude **(do not ignore – if same, please indicate)**			19 33.637	
Site depth	30m	Deployment depth	**12.3**	
Acoustic release (1) serial number and release code				

Acoustic release (2) serial number and release code		
Argos beacon serial number		
Save *whp*, *dpl* and *scl* files in one folder (filename format: ***serialnumber_date***)	**Bantams 23 May 2009 dep/ADCP_newDeploy Files/B1005**	

30m ADCP.

1 RECOVERY Site Name: Bantamsklip 30m site Date: 6 May 2009

Instrument type and serial number			RDI	10105
Recovery date and time	LT	GMT	**6 May 2009 12:00**	
Latitude **(do not ignore – if same, please indicate)**			34 42.601	
Longitude **(do not ignore – if same, please indicate)**			19 30.691	
Switch off date and time	LT	GMT	7 May 2009 07:54	
File size			16MB (B3004)	
Was the data copied to memory card?			Y*	N

May 23rd: Stainless steel frame at the 30m Site was found with 3 of the 6 legs broken – No re-deployment of the ADCP or the RBR loggers.

7.2 RBR-CT LOGGERS RECOVERY AND RE-DEPLOYMENT SHEETS

Surface.

May 6th: During recovery, the RBR on the mooring line (s/n 12994) was missing.

May 23rd: Stainless steel frame at the 30m Site was found with 3 of the 6 legs broken – No re-deployment of the ADCP or the RBR loggers.

Bottom.

1 <u>RECOVERY</u> Site Name: Bantamsklip 30m site Date 6 May2009

Instrument type and serial number			RBR 420ct	15248
Recovery date and time	LT	GMT	**<u>6 May 2009 12:00</u>**	
Latitude **(do not ignore – if same, please indicate)**			34 42.601	
Longitude **(do not ignore – if same, please indicate)**			19 30.691	
Switch off date and time	LT	GMT	19 May 2009 19:22	
File size			119KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 6 May 2009 rec/RBR_RecoveredData	

May 23rd: Stainless steel frame at the 30m Site was found with 3 of the 6 legs broken – No re-deployment of the ADCP or the RBR loggers.

7.3 RBR TIDE GAUGE RECOVERY AND RE-DEPLOYMENT SHEETS

1. **RECOVERY** **Site Name: Bantamsklip Tidegauge** **Date 6 May 2009**

Instrument type and serial number			TGR 2050	13084
Recovery date and time	LT	GMT	**6 May 2009 13:00**	
Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Switch off date and time	LT	GMT	19 May 2009 19:26	
File size			8433KB	
Save *log*, *hex* and *dat* files in one folder (filename format: ***serialnumber_date***)			Bantams 6 May 2009 rec/TideGuage_Data	

2. **RE-DEPLOYMENT** **Site Name: Bantamsklip Tide Gauge Date: 23 May 2009**

Instrument type and serial number (do not ignore – if same, please indicate)	TGR 2050	13084
Install a new battery and check the voltage		2 * 3.28

Set up the sampling parameters

Sampling period		**10 sec**
Averaging period		**1 sec**
Expected deployment duration		**6 weeks**
Start of logging (date / time)	22 May 2009	21:53:50
End of logging (date / time)	5 Aug 2009	12:00:00
Memory usage		46%
Battery usage		258mAH

Deployment details

Deployment date and time	LT	GMT	23 May 2009 11:35	
Deployment Latitude **(do not ignore – if same, please indicate)**			**34 42.241**	
Deployment Longitude **(do not ignore – if same, please indicate)**			**19 33.101**	
Site name			Bantamsklip	
Site depth			1.8m	
Deployment depth			1.7m	
Acoustic release (1) serial number and release code				
Acoustic release (2) serial number and release code				
Argos beacon serial number				
Save *log* file (filename format: ***serialnumber_date***)			Bantams 23 May 2009 dep/RBR_TideGauge_newDeployLogs/**20090522.log**	

7.4 ADCP CONFIGURATION FILES

10m ADCP

```
CR1
CF11101
EA0
EB0
ED100
ES35
EX11111
EZ1111111
RI0
FD
WA255
WB0
WD111100000
WF88
WN42
WP500
WS35
WV175
HD111000000
HB5
HP4800
HR01:00:00.00
HT00:00:00.50
TE00:10:00.00
TP00:00.50
CK
CS
;
;Instrument          = Workhorse Sentinel
;Frequency           = 614400
;Water Profile       = YES
;Bottom Track        = NO
;High Res. Modes     = NO
;High Rate Pinging   = NO
;Shallow Bottom Mode= NO
;Wave Gauge          = YES
;Lowered ADCP        = NO
;Beam angle          = 20
;Temperature         = 5.00
;Deployment hours    = 312.00
;Battery packs       = 1
;Automatic TP        = NO
;Memory size [MB]    = 1000
;Saved Screen        = 3
;
;Consequences generated by PlanADCP version 2.04:
;First cell range    = 1.41 m
;Last cell range     = 15.76 m
;Max range           = 35.28 m
;Standard deviation = 1.08 cm/s
;Ensemble size       = 994 bytes
;Storage required    = 113.20 MB (118698528 bytes)
;Power usage         = 376.92 Wh
;Battery usage       = 0.8
;Samples / Wv Burst = 4800
```

```
;Min NonDir Wave Per= 1.85 s
;Min Dir Wave Period= 2.49 s
;Bytes / Wave Burst = 374480
;
; WARNINGS AND CAUTIONS:
; Waves Gauge feature has to be installed in Workhorse to use
selected option.
; Advanced settings have been changed.
```

30m ADCP

May 23rd: Stainless steel frame at the 30m Site was found with 3 of the 6 legs broken – No re-deployment of the ADCP or the RBR loggers.