APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT

1.8 Instrument Mooring Report: Day 0 to 45

NAMIBIAN MARINE PHOSPHATE

VERIFICATION SURVEY

DATA REPORT
Day 0 to 45

Prepared for:
Namibian Marine Phosphate (Pty) Ltd.

Prepared by:

October 2014

Project: 267

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REVISION HISTORY

Date	Version	Originator	Checked	Approved
21 Aug 2013	0	C. Bloch	B. Spolander	B. Spolander
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1 EXECUTIVE SUMMARY

Metocean Services International (Pty) Limited (MSI) has been awarded a contract by Lwandle Technologies, under sub contract from Namibian Marine Phosphate (Pty) Ltd (NMP), to deploy an oceanographic mooring offshore Namibia. NMP intends dredging marine phosphate reserves at the site and requires verification of previous studies regarding the behaviour of the water column and sediment re-suspension events. Current measurements throughout the water column were undertaken with an ADCP and two single point current meters and water quality measurements were undertaken with a CTD near the seabed.

First order statistics of the data collected during the first measurement period (nominally from 8 June 2013 to 26 July 2013) are presented in this section, together with an indication of the data return achieved. Data return was good, however the upper AQD and CTD stopped logging data shortly before recovery as a result of depleted batteries.

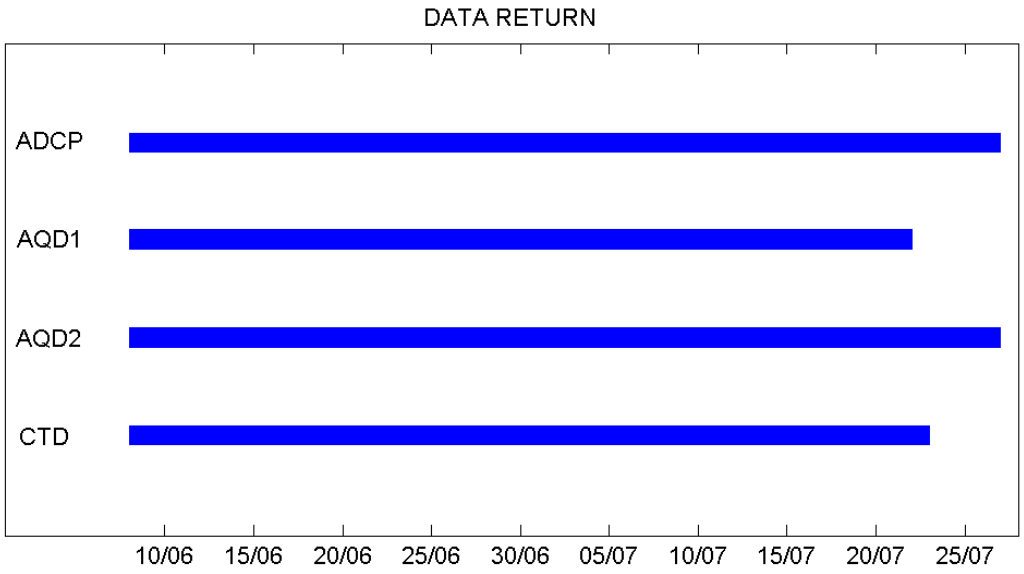


Figure 1: Data return for the measurement period for each instrument.
Every day for which a greater than 50% data return was achieved is marked in colour.

Table 1: Current flow summary

Instrument	Depth	Start	End	DR	Max speed	Max dir	Max date	Mean speed	STD speed	VM speed	VM Dir
	m	dd/mm/yy	dd/mm/yy	%	$cm.s^{-1}$	^{0}	dd/mm/yy	$cm.s^{-1}$	$cm.s^{-1}$	$cm.s^{-1}$	^{0}
ADCP	-5.7	08/06/13	26/07/13	23.38	56.94	316.38	21/07/13	22.06	9.06	14.40	331.38
ADCP	-6.7	08/06/13	26/07/13	95.54	56.73	326.88	15/06/13	17.08	9.30	10.85	327.73
ADCP	-7.7	08/06/13	26/07/13	98.16	54.31	336.80	15/06/13	15.10	9.02	8.90	309.86
ADCP	-8.7	08/06/13	26/07/13	98.90	46.50	345.38	15/06/13	14.77	8.19	8.20	294.70
ADCP	-9.7	08/06/13	26/07/13	99.33	43.80	275.96	16/06/13	14.46	7.67	7.78	289.23
ADCP	-10.7	08/06/13	26/07/13	99.58	42.40	269.02	04/07/13	14.27	7.58	7.61	288.56
ADCP	-11.7	08/06/13	26/07/13	99.68	40.15	275.48	16/06/13	14.11	7.48	7.47	288.73
ADCP	-12.7	08/06/13	26/07/13	99.74	40.80	267.40	04/07/13	13.99	7.40	7.32	288.68
ADCP	-13.7	08/06/13	26/07/13	99.72	39.72	274.18	16/06/13	13.86	7.37	7.18	288.62
ADCP	-14.7	08/06/13	26/07/13	99.72	39.85	271.40	16/06/13	13.74	7.31	7.05	288.92
ADCP	-15.7	08/06/13	26/07/13	99.81	39.83	268.43	16/06/13	13.65	7.24	6.90	289.14
ADCP	-16.7	08/06/13	26/07/13	99.84	39.83	266.37	04/07/13	13.51	7.22	6.77	289.29
ADCP	-17.7	08/06/13	26/07/13	99.88	39.85	272.90	16/06/13	13.38	7.12	6.64	289.14
ADCP	-18.7	08/06/13	26/07/13	99.88	40.29	274.80	16/06/13	13.26	7.06	6.53	289.49
ADCP	-19.7	08/06/13	26/07/13	99.91	39.69	266.86	04/07/13	13.16	7.04	6.38	289.89
ADCP	-20.7	08/06/13	26/07/13	99.97	37.36	272.50	16/06/13	12.98	6.99	6.20	290.19
ADCP	-21.7	08/06/13	26/07/13	99.96	37.56	270.82	16/06/13	12.89	6.94	6.07	290.52
ADCP	-22.7	08/06/13	26/07/13	99.99	39.41	275.10	16/06/13	12.77	6.91	5.91	291.03
ADCP	-23.7	08/06/13	26/07/13	99.99	42.76	303.22	20/06/13	12.65	6.85	5.78	291.19
ADCP	-24.7	08/06/13	26/07/13	99.99	42.48	303.24	20/06/13	12.57	6.81	5.63	292.30
ADCP	-25.7	08/06/13	26/07/13	99.97	43.19	304.79	20/06/13	12.43	6.76	5.49	292.93
ADCP	-26.7	08/06/13	26/07/13	99.97	40.89	305.53	20/06/13	12.28	6.70	5.37	293.75
ADCP	-27.7	08/06/13	26/07/13	99.97	40.14	305.94	20/06/13	12.18	6.68	5.23	295.06

Table 1 – continued...

Instrument	Depth	Start	End	DR	Max speed	Max dir	Max date	Mean speed	STD speed	VM speed	VM Dir
	m	dd/mm/yy	dd/mm/yy	%	$cm.s^{-1}$	^{0}	dd/mm/yy	$cm.s^{-1}$	$cm.s^{-1}$	$cm.s^{-1}$	^{0}
ADCP	-28.7	08/06/13	26/07/13	99.97	37.71	269.34	16/06/13	12.04	6.64	5.15	295.79
ADCP	-29. 7	08/06/13	26/07/13	99.97	37.13	274.40	16/06/13	11.96	6.59	5.03	296.56
ADCP	-30.7	08/06/13	26/07/13	100.00	37.43	281.53	04/07/13	11.85	6.53	4.94	297.83
ADCP	-31.7	08/06/13	26/07/13	100.00	37.03	334.79	21/07/13	11.72	6.51	4.85	299.31
ADCP	-32.7	08/06/13	26/07/13	100.00	35.70	271.48	16/06/13	11.63	6.48	4.78	300.41
ADCP	-33.7	08/06/13	26/07/13	100.00	35.78	271.94	16/06/13	11.51	6.48	4.71	301.65
ADCP	-34.7	08/06/13	26/07/13	100.00	36.00	335.78	10/07/13	11.43	6.41	4.63	302.43
ADCP	-35.7	08/06/13	26/07/13	100.00	35.46	338.41	10/07/13	11.35	6.44	4.61	303.90
ADCP	-36.7	08/06/13	26/07/13	100.00	35.60	339.25	21/07/13	11.24	6.37	4.57	305.46
ADCP	-37.7	08/06/13	26/07/13	100.00	34.79	282.38	16/06/13	11.20	6.32	4.53	306.46
ADCP	-38.7	08/06/13	26/07/13	100.00	35.99	334.97	21/07/13	11.15	6.30	4.49	307.85
ADCP	-39.7	08/06/13	26/07/13	99.97	34.27	336.99	21/07/13	11.08	6.29	4.50	309.16
ADCP	-40.7	08/06/13	26/07/13	99.99	34.52	340.56	21/07/13	11.02	6.26	4.51	310.57
ADCP	-41.7	08/06/13	26/07/13	99.99	34.65	340.08	21/07/13	10.99	6.28	4.49	311.71
ADCP	-42.7	08/06/13	26/07/13	99.94	34.26	339.85	21/07/13	11.01	6.28	4.46	313.04
ADCP	-43.7	08/06/13	26/07/13	99.94	35.57	300.94	20/07/13	10.97	6.28	4.48	313.71
ADCP	-44.7	08/06/13	26/07/13	99.96	34.67	305.99	20/07/13	11.02	6.22	4.49	314.99
ADCP	-45.7	08/06/13	26/07/13	99.94	35.56	26.96	21/06/13	11.00	6.25	4.52	316.26
ADCP	-46.7	08/06/13	26/07/13	99.99	37.62	15.01	21/06/13	11.06	6.25	4.58	316.71
ADCP	-47.7	08/06/13	26/07/13	100.00	38.40	17.29	21/06/13	11.04	6.26	4.62	317.73
ADCP	-48.7	08/06/13	26/07/13	100.00	39.70	22.39	21/06/13	11.06	6.26	4.62	318.34
ADCP	-49.7	08/06/13	26/07/13	100.00	36.09	315.83	21/07/13	11.04	6.28	4.62	319.08
ADCP	-50.7	08/06/13	26/07/13	99.94	37.15	315.15	21/07/13	11.03	6.28	4.62	319.33
ADCP	-51.7	08/06/13	26/07/13	99.94	37.75	314.80	21/07/13	11.04	6.29	4.70	319.51

Table 1 – continued...

Instrument	Depth	Start	End	DR	Max speed	Max dir	Max date	Mean speed	STD speed	VM speed	VM Dir
	m	dd/mm/yy	dd/mm/yy	%	$cm.s^{-1}$	^{0}	dd/mm/yy	$cm.s^{-1}$	$cm.s^{-1}$	$cm.s^{-1}$	^{0}
ADCP	-52.7	08/06/13	26/07/13	99.99	39.04	328.70	21/07/13	10.96	6.27	4.67	320.23
ADCP	-53.7	08/06/13	26/07/13	99.97	42.54	320.20	21/07/13	10.93	6.29	4.72	319.91
ADCP	-54.7	08/06/13	26/07/13	99.97	40.45	320.52	21/07/13	10.92	6.28	4.71	319.59
ADCP	-55.7	08/06/13	26/07/13	99.97	41.61	320.35	21/07/13	10.87	6.28	4.67	320.03
ADCP	-56.7	08/06/13	26/07/13	99.94	39.53	314.14	21/07/13	10.84	6.27	4.66	320.14
ADCP	-57.7	08/06/13	26/07/13	100.00	39.59	315.70	21/07/13	10.73	6.27	4.64	319.75
ADCP	-58.7	08/06/13	26/07/13	99.99	40.12	318.87	21/07/13	10.75	6.26	4.67	319.64
ADCP	-59.7	08/06/13	26/07/13	99.97	39.64	332.85	21/07/13	10.70	6.23	4.66	319.35
ADCP	-60.7	08/06/13	26/07/13	99.93	38.86	330.16	21/07/13	10.65	6.23	4.63	319.11
ADCP	-61.7	08/06/13	26/07/13	99.96	40.01	351.26	21/07/13	10.62	6.24	4.64	319.10
ADCP	-62.7	08/06/13	26/07/13	99.99	40.74	342.98	21/07/13	10.63	6.26	4.68	318.74
ADCP	-63.7	08/06/13	26/07/13	99.97	40.20	344.52	21/07/13	10.60	6.26	4.66	318.03
ADCP	-64.7	08/06/13	26/07/13	99.99	41.52	351.32	21/07/13	10.61	6.27	4.70	318.09
ADCP	-65.7	08/06/13	26/07/13	99.99	41.10	349.42	21/07/13	10.59	6.28	4.73	317.34
ADCP	-66.7	08/06/13	26/07/13	99.99	44.33	347.44	21/07/13	10.54	6.25	4.76	317.09
ADCP	-67.7	08/06/13	26/07/13	99.99	43.90	349.16	21/07/13	10.55	6.24	4.78	316.58
ADCP	-68.7	08/06/13	26/07/13	99.96	42.18	350.68	21/07/13	10.52	6.25	4.79	315.63
ADCP	-69.7	08/06/13	26/07/13	99.97	41.49	350.91	21/07/13	10.51	6.18	4.83	315.36
ADCP	-70.7	08/06/13	26/07/13	100.00	44.20	344.86	21/07/13	10.50	6.16	4.85	314.57
ADCP	-71.7	08/06/13	26/07/13	100.00	44.23	343.17	21/07/13	10.48	6.12	4.85	314.22
ADCP	-72.7	08/06/13	26/07/13	100.00	42.80	345.78	21/07/13	10.50	6.07	4.92	313.00
ADCP	-73.7	08/06/13	26/07/13	99.99	41.50	338.46	21/07/13	10.47	6.04	4.96	312.48
ADCP	-74.7	08/06/13	26/07/13	100.00	40.10	344.80	21/07/13	10.40	6.03	4.98	311.50
ADCP	-75.7	08/06/13	26/07/13	99.99	39.91	339.48	21/07/13	10.41	5.97	4.98	311.18

Table 1 – continued...

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.8 Instrument Mooring Report: Day 0 to 45

Instrument	Depth	Start	End	DR	Max speed	Max dir	Max date	Mean speed	STD speed	VM speed	VM Dir
	m	dd/mm/yy	dd/mm/yy	%	$cm.s^{-1}$	^{0}	dd/mm/yy	$cm.s^{-1}$	$cm.s^{-1}$	$cm.s^{-1}$	^{0}
ADCP	-76.7	08/06/13	26/07/13	99.99	37.74	340.51	21/07/13	10.38	5.93	5.04	310.28
ADCP	-77.7	08/06/13	26/07/13	99.99	37.72	336.84	21/07/13	10.33	5.92	5.05	309.60
ADCP	-78.7	08/06/13	26/07/13	99.99	37.47	336.32	21/07/13	10.32	5.85	5.09	309.09
ADCP	-79.7	08/06/13	26/07/13	100.00	35.67	334.22	21/07/13	10.25	5.79	5.08	308.22
ADCP	-80.7	08/06/13	26/07/13	99.97	35.40	345.38	15/06/13	10.24	5.74	5.15	307.91
ADCP	-81.7	08/06/13	26/07/13	100.00	33.76	334.96	21/07/13	10.21	5.70	5.14	307.11
ADCP	-82.7	08/06/13	26/07/13	99.96	35.96	318.24	15/06/13	10.15	5.63	5.19	306.29
ADCP	-83.7	08/06/13	26/07/13	99.99	34.58	320.22	15/06/13	10.10	5.64	5.17	305.66
ADCP	-84.7	08/06/13	26/07/13	100.00	33.66	321.17	15/06/13	10.03	5.57	5.21	305.22
ADCP	-85.7	08/06/13	26/07/13	100.00	37.88	319.55	15/06/13	10.02	5.59	5.20	304.41
ADCP	-86.7	08/06/13	26/07/13	99.97	34.22	320.31	15/06/13	9.99	5.53	5.27	303.58
ADCP	-87.7	08/06/13	26/07/13	99.99	33.14	319.82	15/06/13	9.98	5.51	5.31	303.23
ADCP	-88.7	08/06/13	26/07/13	99.99	33.36	318.66	15/06/13	9.89	5.49	5.31	302.54
ADCP	-89.7	08/06/13	26/07/13	99.99	30.91	334.94	15/06/13	9.88	5.48	5.31	301.99
ADCP	-90.7	08/06/13	26/07/13	100.00	31.32	333.96	16/06/13	9.85	5.55	5.37	301.60
ADCP	-91.7	08/06/13	26/07/13	100.00	30.86	332.65	16/06/13	9.89	5.56	5.43	301.15
ADCP	-92.7	08/06/13	26/07/13	99.99	30.80	321.22	15/06/13	9.97	5.59	5.54	301.77
ADCP	-93.7	08/06/13	26/07/13	100.00	31.96	321.38	15/06/13	10.07	5.52	5.66	302.88
AQD1	-148.0	08/06/13	24/07/13	97.93	37.01	25.37	16/06/13	10.62	6.12	1.01	77.84
AQD2	-193.0	08/06/13	26/07/13	100.00	42.76	250.63	17/07/13	17.52	5.87	12.97	221.45

Table 2: Temperature summary

Instrument	Mean Depth (m)	Data Return (%)	Max (°C)	Mean (°C)	Min (°C)
ADCP	-97	100.00	13.54	12.31	11.71
AQD1	-148	97.89	12.59	11.77	11.13
AQD2	-193	99.96	11.85	11.20	10.03
CTD	-192	100.00	11.64	11.05	9.81

Table 3 : Pressure summary

Instrument	Mean Depth (m)	Data Return (%)	Max (Bar)	Mean (Bar)	Min (Bar)
ADCP	-97	100.00	9.82	9.72	9.63
AQD1	-148	97.93	14.97	14.86	14.78
AQD2	-193	100.00	19.43	19.34	19.26
CTD	-192	100.00	19.39	19.30	19.22

Table 4: CTD summary

Parameter	Unit	Data Return (%)	Max	Mean	Min
Temperature	˚C	100.00	11.64	11.05	9.81
Conductivity	$S.m^{-1}$	100.00	39.85	39.17	35.31
Salinity	psu	97.06	35.11	35.02	34.86
Depth	m	100.00	-191.53	-192.33	-193.22
Dissolved Oxygen	$\mu mol.l^{-1}$	99.94	34.31	9.15	1.35
Fluorescence	$\mu g.l^{-1}$	99.97	0.42	0.08	0.06
Turbidity	NTU	99.97	408.76	2.86	0.22
Height	m	100.00	0.89	0.00	-0.81

2 INTRODUCTION

2.1 PROJECT DESCRIPTION

Metocean Services International (Pty) Limited (MSI) has been awarded a contract by Lwandle Technologies, under sub contract from Namibian Marine Phosphate (Pty) Ltd (NMP), to deploy an oceanographic mooring offshore Namibia. NMP intends dredging marine phosphate reserves at the site and requires verification of previous studies regarding the behaviour of the water column and sediment re-suspension events. Current measurements throughout the water column were undertaken with an ADCP and two single point current meters and water quality measurements were undertaken with a CTD near the seabed.

This report details the quality control procedures and data presentation (Sections 3 and 4 for the first measurement period (nominally from 8 June 2013 to 26 July 2013).

2.2 CONVENTIONS USED IN THIS REPORT

A list of the conventions used in this report is presented in Table 5.

Table 5: Glossary and conventions used in this report

Term	Explanation
ADCP	Acoustic Doppler Current Profiler
AQD	Aquadopp
Bin	ADCP depth cell within which the measurement of current velocity is spatially averaged. The depth of the bin refers to the centre of the bin.
Bin length	Vertical distance over which ADCP data is spatially averaged into a single current velocity.
Conductivity	Conductivity is measured in Siemens per metre ($S.m^{-1}$)
CTD	Conductivity, temperature and depth meter
Current Speed	The speed of flow with units of centimetres per second ($cm.s^{-1}$)
Current Direction	The direction towards which the vector mean current is flowing and referenced to true north at 0^0 with a right handed convention.
Data Return	The data return reflects the percentage of good data coverage for the time period that the instrument was operational.
Density	Density is expressed as kilograms per cubic metre ($kg.m^{-3}$).
Depth	The water depth below mean sea level, with units of m.
Dissolved Oxygen	Dissolved oxygen is measured in micromoles per litre ($\mu mol.l^{-1}$).
Ensemble	Time interval over which ADCP pings are averaged into a single current velocity for each bin.
Fluorescence	Fluorescence is a measure of chlorophyll in micrograms per litre ($\mu g.l^{-1}$).
Height	Height is measured in meters (m) referenced to mean sea level.
Ping	Single acoustic pulse from the ADCP, which produces measurement of current velocity.
Pressure	Pressure is in Bars.
Salinity	Salinities are expressed in practical salinity units (psu)
Sound velocity	Sound velocity is expressed in meters per second ($m.s^{-1}$).
STD	The standard deviation of the current speed.
Temperatures	Temperatures are in degrees centigrade (°C).
Time	All times are presented in UTC.
VM	Vector mean.

2.3 MEASUREMENT LOCATIONS

The location of the measurements offshore Namibia, is given in Table 6 and indicated in Figure 2 below.

Table 6: As deployed measurement location

Location	Latitude	Longitude	Depth
MP1*	24° 08' 18.96" S	14° 01' 32.88" E	~ 193 m
*(Position calculated using slant-range position and depth information)			

Figure 2: Oceanographic measurement location offshore Namibia.

2.4 MOORING CONFIGURATION

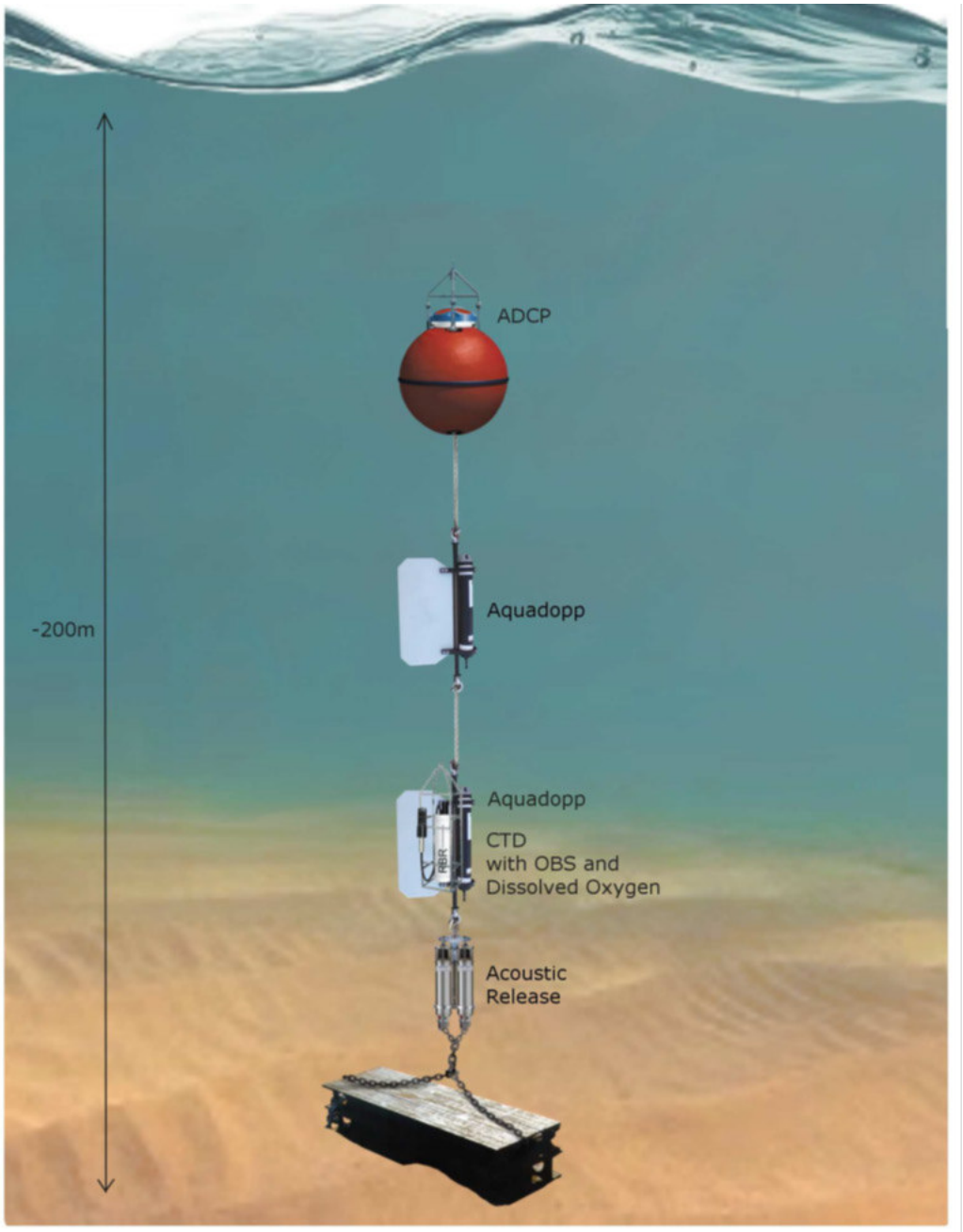


Figure 3: Mooring configuration.

2.5 EQUIPMENT CONFIGURATION

Table 7: TRDI 300 kHz ACDCP configuration

Parameter	Configuration
Planned water depth	~100 m (200 m total)
Assumed duration	90 days (~ 45 service)
Number of battery packs	1 x alkaline
Ensemble interval	10 minutes
Number of pings	110
Number of depth cells	175
Cellsize	1m
General	
Standard deviation	1.29 $cm.s^{-1}$
Battery utilisation	1.0
Memory required	23.46 mb

Table 8: Aquadopp configuration

Parameter	Configuration	
	Mid-water DW Aquadopp (s/n AQD 3011)	**Near-bottom Aquadopp (s/n AQD 2481)**
Planned water depth	~150 m (200 m total)	~195 m (200 m total)
Assumed duration	50 days	50 days
Number of battery packs	1 x alkaline (50Wh)	1 x alkaline (50Wh)
Measurement interval	30 seconds	30 seconds
Average interval	5 seconds	5 seconds
Measurement load	9 %	22 %
Blanking distance	0.50 m	0.35 m
Compass update rate Diagnostics Interval (min) Number of samples	1 second Enabled 60 16	1 second Enabled 60 16
General		
Vertical velocity precision	3.4 $cm.s^{-1}$	3.8 $cm.s^{-1}$
Horizontal velocity precision	2.3 $cm.s^{-1}$	2.3 $cm.s^{-1}$
Battery utilisation	97 %	97 %
Memory required	6.6 mb	6.6 mb

Table 9 : CTD configuration

Parameter	Configuration
Approximate water depth	~195 m (total 200 m)
Sampling period	00:10:00
Averaging period Maximum duration[1]	2 seconds battery
Memory required	3%
Battery required	100%

3 DATA QUALITY CONTROL

3.1 ADCP

The current data were imported from RD Instruments WinSc software into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- The depth of the instrument was determined from the pressure sensor.
- Directions were adjusted from magnetic to true north using a magnetic variation of -14.6247°. Magnetic variation was obtained from the NOAA website at http://www.ngdc.noaa.gov/geomag-web/#declination.
- A flag was imposed on all data within 6% of the ocean surface due to side lobe interference. The distance to the ocean surface was deduced from the pressure data.
- The ADCP attitude data (heading, pitch and roll) were then examined (see Figure 4). These parameters were well within the recommended operating range throughout the deployment.
- The ADCP beam correlation data were then examined. Adopting RDI recommended practice, when the correlation count for any of the 4 beams fell below 64 (RD Instruments recommended value) in a bin, all data from this bin to the end of the profile were flagged.
- Checks were then run on the percentage good data collected by the ADCPs. All ensembles where the number of two beam solutions exceeded 50% were flagged.
- Checks were then run on the error velocities. Examination of the error velocity distribution led to the selection of a cut off of –20 $cm.s^{-1}$ to +20 $cm.s^{-1}$. All data with error velocities beyond this range were flagged. This check mainly affected data in the uppermost valid bins.
- Checks were then run searching for any outliers in the speed data. This was automated within a routine that compared the median of 3 values to the centre point.

A tolerance of 50 $cm.s^{-1}$ was allowed. Outliers identified by this method were then visually examined and flagged. The same check was run on both the northward and eastward velocity components. As a final check, the data were visually examined and any remaining spikes flagged.

- Checks were then run searching for repeated values in the speed and direction data. This was automated within a routine that searched for 3 identical consecutive values.

- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.

- As a result of the quality control measures applied, the data return in the uppermost bins of retained data was reduced. For this reason, the first data bin achieving over 95% data return was presented as representative of the near-surface currents.

- Quality control data from the ACDCP are presented visually in Figure 4.

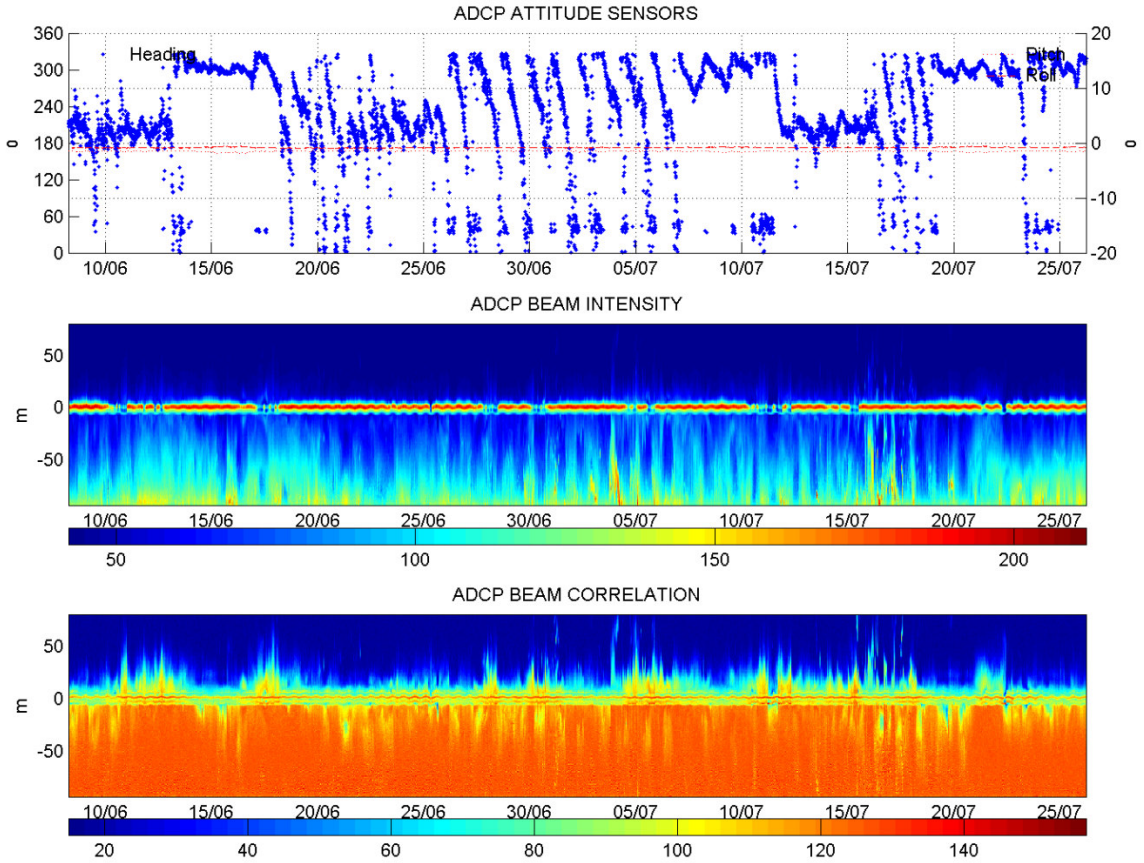


Figure 4 : Quality control data from the ADCP. The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The middle panel shows the time-series of ADCP beam intensity through the water column, while the lower panel shows similar information for the beam correlation.

3.2 AQUADOPPS

The current data were exported to ascii text files from Nortek's Aquadopp software and then imported into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- The depth of the instrument was determined from the pressure sensor.
- A 10 minute data set was created from the 30 second data by finding the mean of all data recorded within each ten minute period. The mean u and v velocity components for each ten minute period were then converted to speed and direction. All data presented in this report are derived from the 10 minute data set.
- Directions were adjusted from magnetic to true north using a magnetic variation of -14.6247°. Magnetic variation was obtained from the NOAA website at http://www.ngdc.noaa.gov/geomag-web/#declination.
- The AQD attitude data (heading, pitch and roll) as well as the depth and vertical velocity were then examined (see Figure 5 and Figure 6). All instruments remained within the recommended operating range for pitch and roll (-30° to 30°) throughout the deployment.
- Checks were then run searching for any outliers in the speed data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 30 $cm.s^{-1}$ was allowed. Outliers identified by this method were then visually examined and flagged. The same check was run on both the northward and eastward velocity components. As a final check, the data were visually examined and any remaining spikes flagged.
- Checks were then run searching for repeated values in the speed and direction data. This was automated within a routine that searched for 3 identical consecutive values.
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- AQD 1 stopped logging data before recovery as a result of a depleted battery. Additionally, intermittent data loss occurred towards the end of the dataset as a result of low battery power.
- Quality control data from the Aquadopp 1(AQD 1) and the Aquadopp 2(AQD 2) instruments are presented in Figures 5 and 6 respectively.

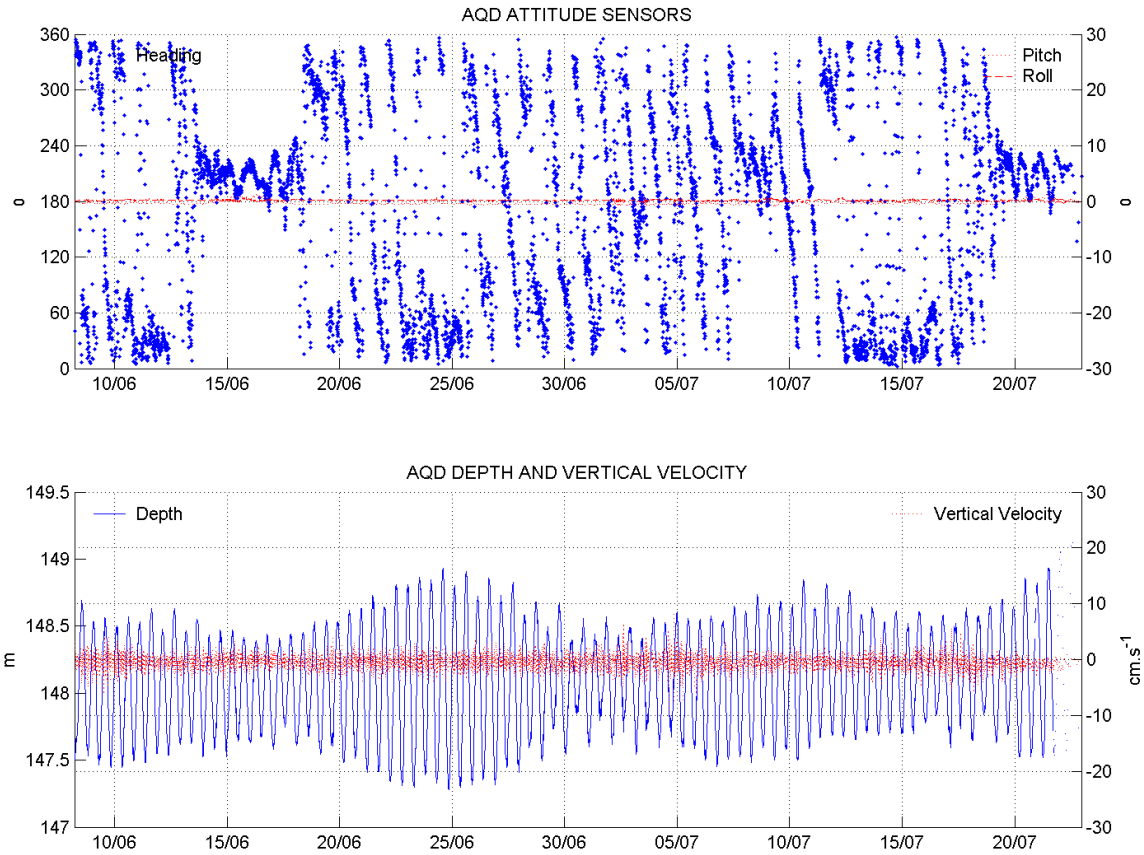


Figure 5: Quality control data from AQD 1. The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The lower panel shows the depth (scaled to the left axis) and the vertical velocity (scaled to the right axis).

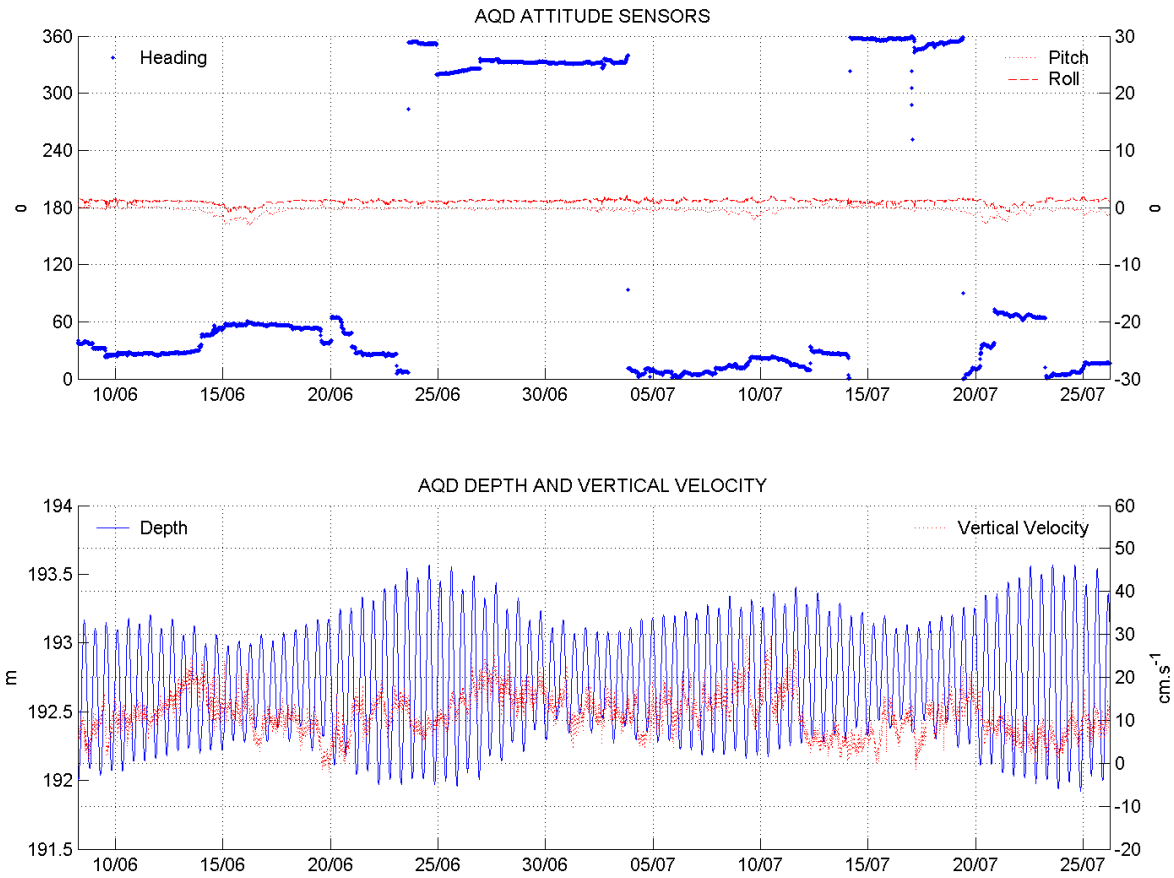


Figure 6: Quality control data from AQD 2.
The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The lower panel shows the depth (scaled to the left axis) and the vertical velocity (scaled to the right axis).

3.3 RBR CTD LOGGER

The data were exported directly from the RBR software into Matlab for further processing:

- The record was truncated to exclude times pre and post deployment.
- Depth was derived using an assumed gravity value of 9.80 $m.s^{-2}$ and mean water density of 1024 $kg.m^{-3}$.
- The conductivity and temperature data were used to derive salinity according to the 1978 UNESCO algorithm.
- Checks were run searching for any outliers in the data. This was automated within a routine that compared the median of 5 values to the centre point. For salinity, a tolerance of 1 psu was allowed. For turbidity, a tolerance of 250 NTU was allowed. For fluorescence and dissolved oxygen, tolerances of 0.5 $\mu mol.l^{-1}$ and 5 $\mu g.l^{-1}$ were allowed respectively.
- Height was determined from the depth. Checks were then run searching for any outliers in the height data. This was automated within a routine that compared the median of 5 values to the centre point. A tolerance of 15 cm was allowed. Outliers identified by this method were then visually examined and flagged. As a final check, the data were examined visually and any remaining spikes flagged.
- 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.
- Finally, all flagged data were replaced with the Matlab NaN symbol, ensuring that they would be excluded from all further processing.
- The CTD stopped logging data prior to recovery as a result of a depleted battery.
- A number of low salinity spikes were noted in the dataset. These spikes were mostly observed during periods of elevated turbidity, which may have affected the conductivity measurements. These spikes were therefore removed from the dataset. An additional low salinity spike was observed when turbidity levels were not elevated, however this may have been the result of particles settling in the sensor. This spike was also removed from the dataset.

4 DATA PRESENTATION

4.1 ADCP

4.1.1 Current Data

4.1.1.1 Time series plots

Figures 7,8 and 9 on the following pages present time series plots for the depths; -7 m, -51 m and -94 m respectively. The time series plots consist of:

- The first (upper) panel is of the observed current speed against time.
- The second panel is of the observed 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.
- The first day of each month is indicated visually by a thin red line on each of the plots.

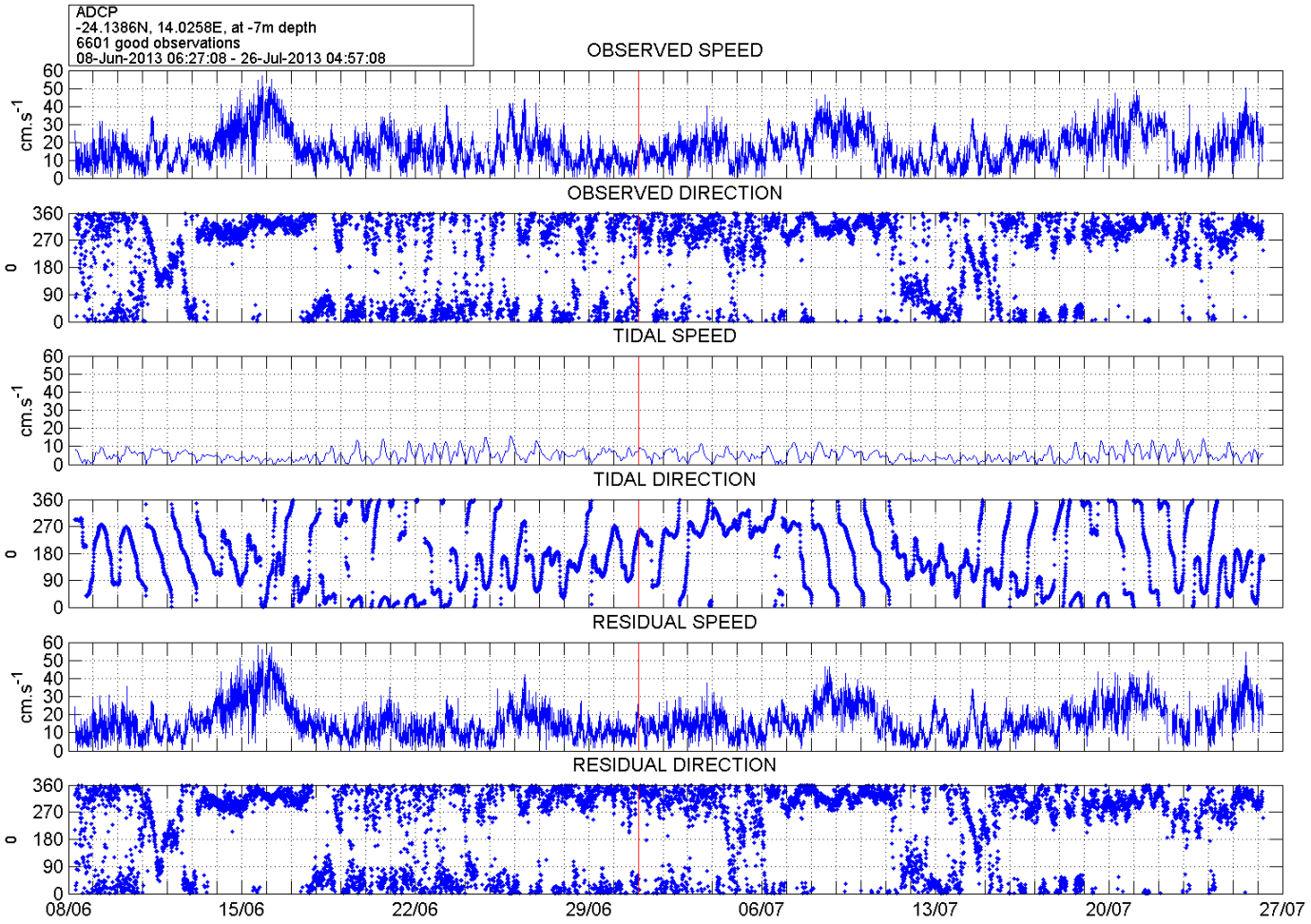


Figure 7: Time series plots of current data at 7 m depth

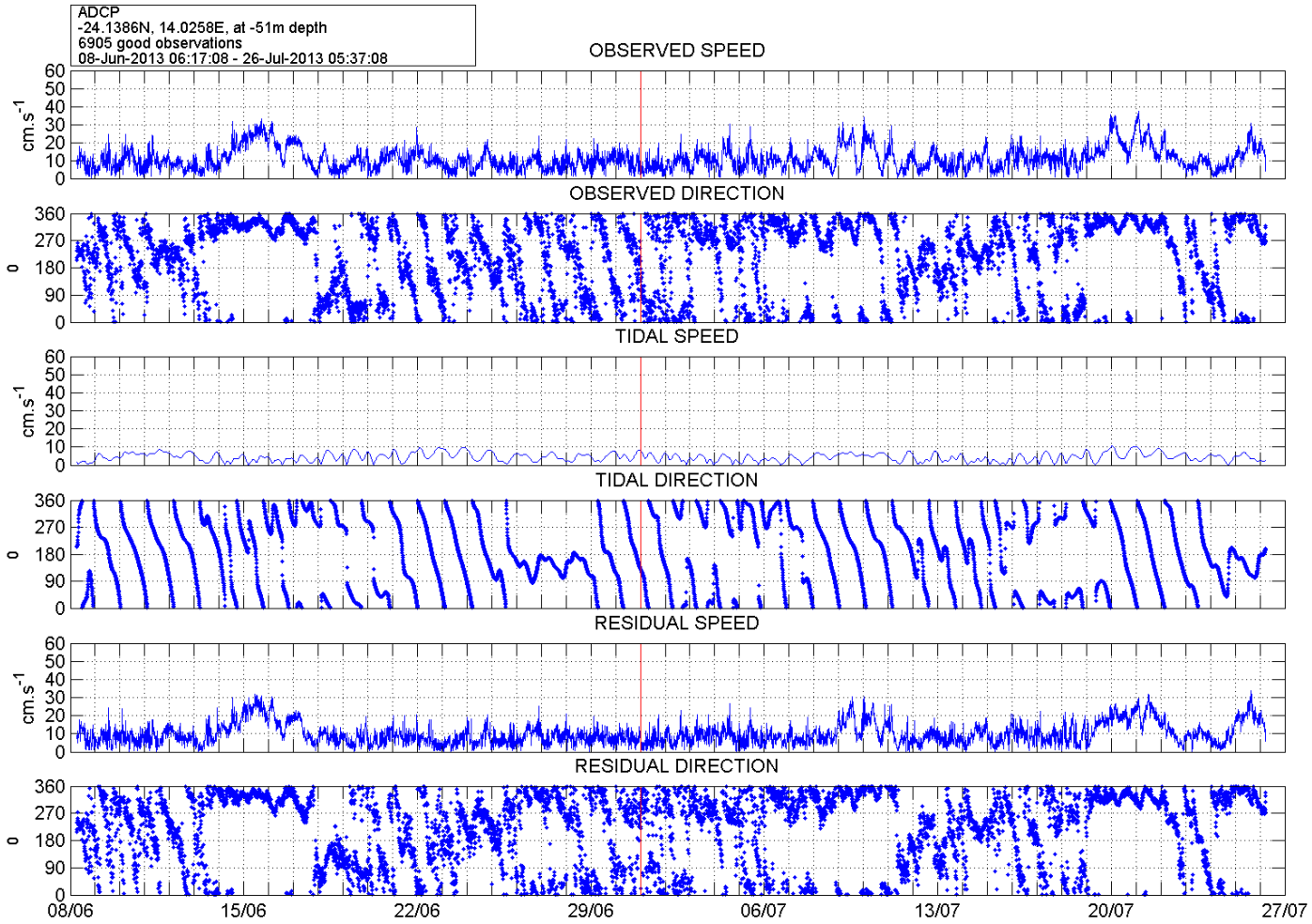


Figure 8: Time series plots of current data at 51 m depth

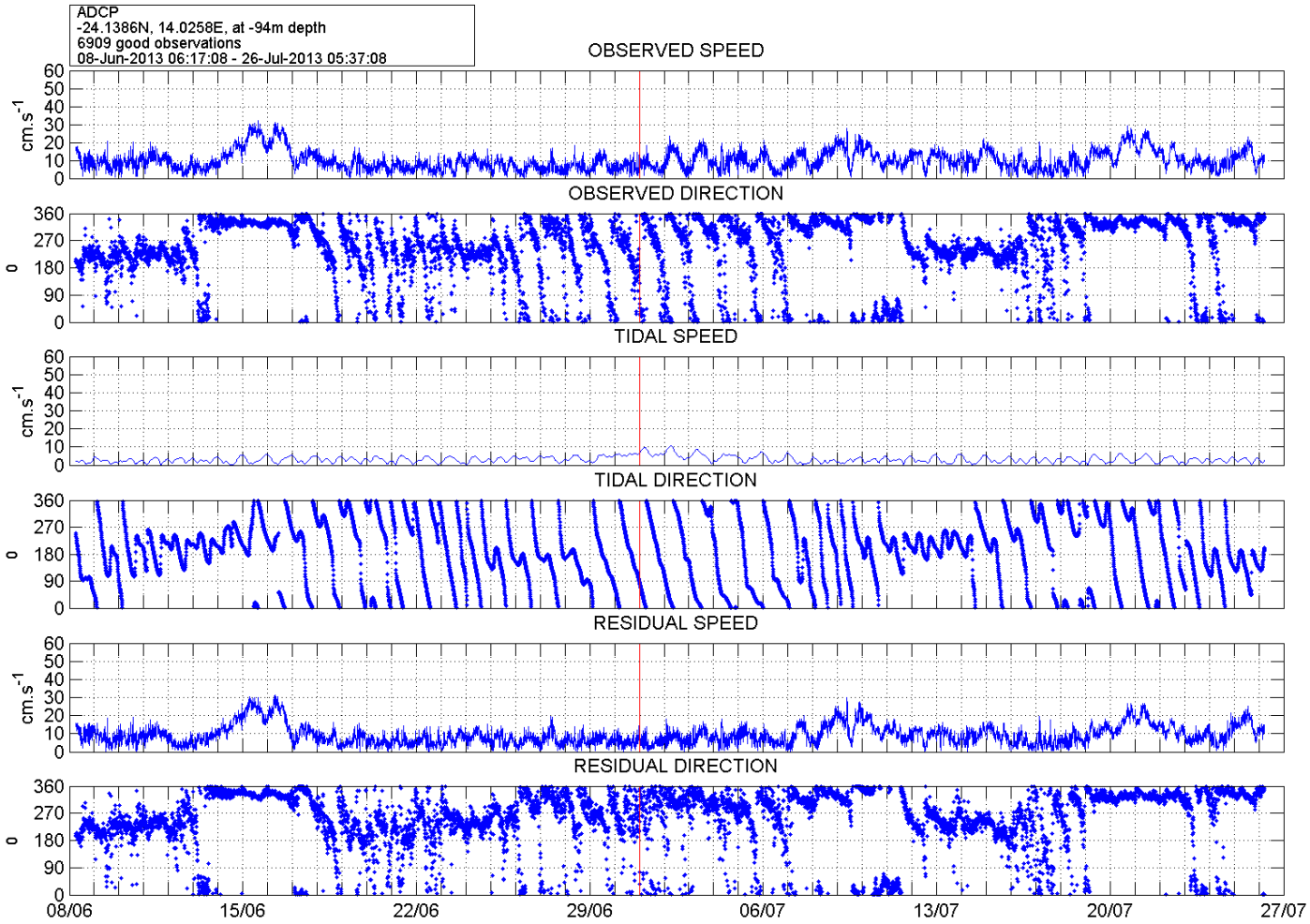


Figure 9: Time series plots of current data at 94 m depth

4.1.1.2 Summary plots

Figures 10, 11 and 12 on the following pages present summary plots for the depths; -7 m, -51 m and -94 m respectively. The summary 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 colour scale indicated the current speeds which are represented.
- 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.

ADCP
-24.1386N, 14.0258E, at -7m depth
6601 good observations
08-Jun-2013 06:27:08 - 26-Jul-2013 04:57:08

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-5	0.65	0.50	0.52	0.41	0.52	0.39	0.42	0.41	0.35	0.48	0.42	0.32	0.47	0.44	0.59	0.76	7.65
5-10	2.00	1.62	1.12	1.26	0.79	0.67	0.52	0.47	0.26	0.45	0.73	1.14	1.12	1.44	1.77	1.83	17.18
10-15	2.89	2.41	1.55	0.88	0.61	0.33	0.44	0.38	0.24	0.39	0.70	1.05	1.97	2.23	2.53	2.86	21.45
15-20	2.29	2.20	1.62	0.61	0.30	0.11	0.18	0.27	0.29	0.32	0.32	0.73	1.82	2.67	3.15	2.61	19.47
20-25	1.70	1.76	1.39	0.35	0.02	0.03	0.06	0.14	0.09	0.27	0.21	0.44	1.35	2.26	2.71	2.09	14.86
25-30	0.73	0.73	0.71	0.09					0.02	0.14	0.23	0.23	0.73	1.48	2.24	1.95	9.27
30-35	0.44	0.29	0.18	0.03					0.02	0.02	0.08	0.11	0.33	1.12	1.55	1.39	5.54
35-40	0.14	0.21										0.03	0.14	0.71	1.08	0.56	2.86
40-45	0.03	0.06	0.02										0.02	0.24	0.39	0.47	1.23
45-50	0.02													0.09	0.18	0.06	0.35
50-55														0.02	0.06	0.05	0.12
55-60																0.02	0.02
Σ	10.88	9.77	7.10	3.62	2.23	1.53	1.62	1.67	1.26	2.08	2.68	4.03	7.94	12.70	16.26	14.65	100.00

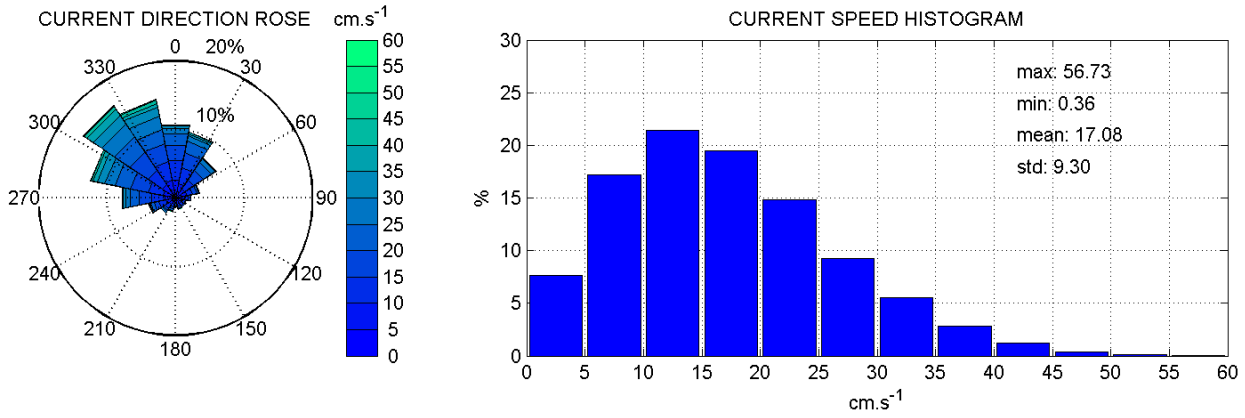


Figure 10: Current data summary plots for 7 m depth

ADCP
-24.1386N, 14.0258E, at -51m depth
6905 good observations
08-Jun-2013 06:17:08 - 26-Jul-2013 05:37:08

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-5	0.96	0.85	0.93	0.91	0.98	0.83	0.84	0.77	0.88	0.88	0.90	0.98	1.01	1.40	1.32	1.58	16.03
5-10	2.10	1.71	1.52	1.68	1.68	1.38	1.96	1.51	1.80	2.11	2.06	2.30	2.42	3.50	2.91	2.88	33.51
10-15	2.49	1.65	1.59	1.07	1.00	0.98	0.97	1.01	1.22	1.49	1.58	2.22	2.48	2.68	3.13	2.97	28.53
15-20	1.25	0.74	0.52	0.43	0.23	0.17	0.32	0.04	0.29	0.23	0.39	1.04	0.91	1.14	2.32	2.04	12.08
20-25	1.06	0.28	0.07	0.06	0.01	0.03		0.01		0.01	0.01	0.22	0.25	0.61	1.56	1.98	6.17
25-30	0.30	0.12											0.03	0.41	0.65	1.23	2.74
30-35	0.04	0.01											0.01	0.06	0.32	0.43	0.88
35-40															0.04	0.01	0.06
40-45																	0.00
45-50																	0.00
50-55																	0.00
55-60																	0.00
Σ	8.20	5.36	4.63	4.16	3.91	3.39	4.08	3.35	4.19	4.74	4.94	6.76	7.11	9.80	12.25	13.14	100.00

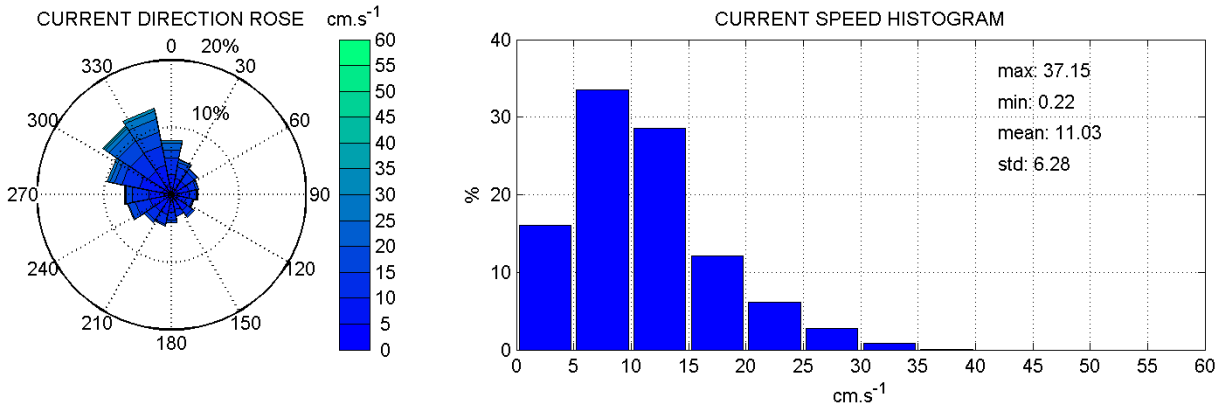


Figure 11: Current data summary plots for 51 m depth

ADCP
-24.1386N, 14.0258E, at -94m depth
6909 good observations
08-Jun-2013 06:17:08 - 26-Jul-2013 05:37:08

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-5	0.85	0.90	0.64	0.58	0.54	0.61	0.74	0.65	1.00	1.36	1.49	1.68	1.38	1.65	1.24	1.40	16.70
5-10	3.17	1.94	1.10	0.88	0.48	0.32	0.52	0.98	2.06	3.43	5.09	4.96	3.84	3.79	3.65	3.78	39.99
10-15	2.40	1.14	0.41	0.12	0.03	0.04	0.09	0.14	0.61	1.77	4.13	3.04	1.62	1.94	3.79	4.60	25.86
15-20	1.23	0.16	0.07	0.01	0.01			0.03	0.03	0.42	0.61	0.97	0.20	0.33	3.01	4.50	11.59
20-25	0.07	0.03		0.01					0.01		0.01	0.04	0.01	0.03	1.10	2.69	4.02
25-30															0.48	1.22	1.69
30-35															0.01	0.12	0.13
35-40																	0.00
40-45																	0.00
45-50																	0.00
50-55																	0.00
55-60																	0.00
Σ	7.73	4.17	2.21	1.61	1.06	0.97	1.35	1.81	3.71	6.98	11.33	10.70	7.05	7.74	13.29	18.31	100.00

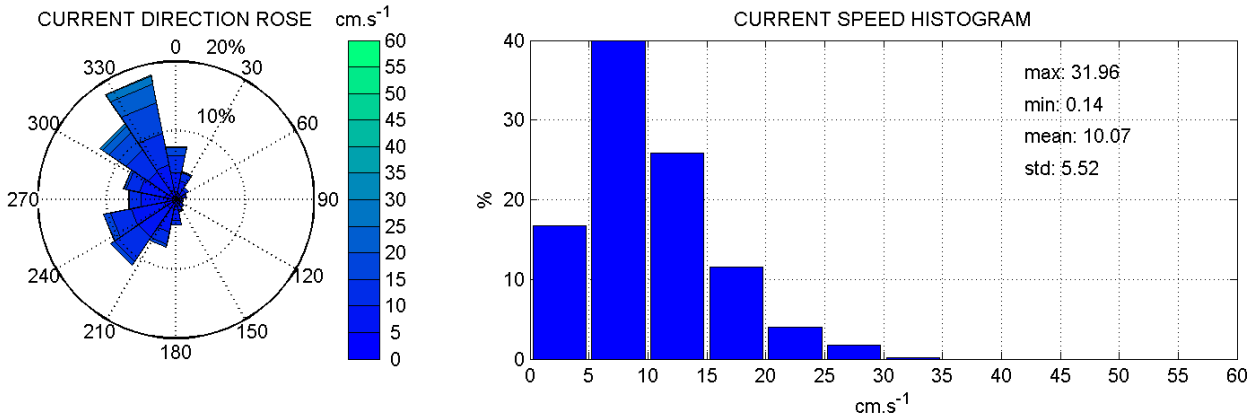


Figure 12: Current data summary plots for 94 m depth

4.1.1.3 Progressive vector plots

Figures 13, 15 and 15 on the following pages present progressive vector plots for the depths; -7 m, -51 m and -94 m respectively. The 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.

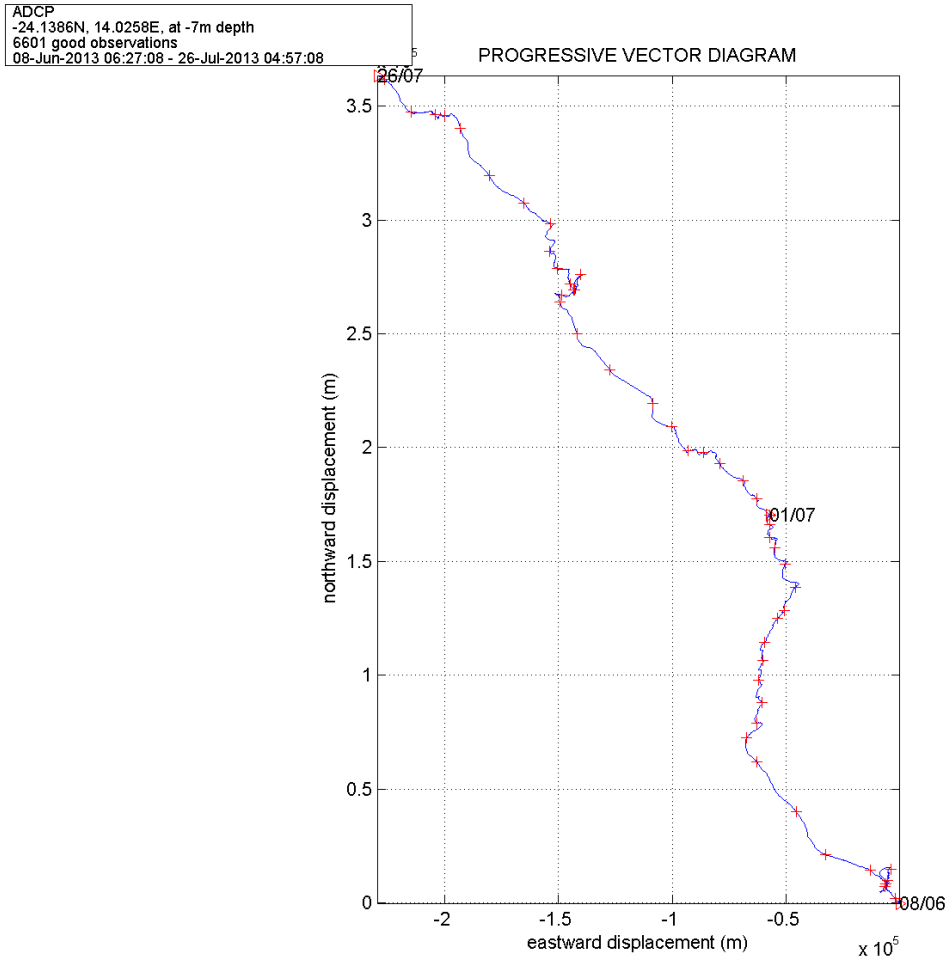


Figure 13: Current progressive vector plot for 7 m depth

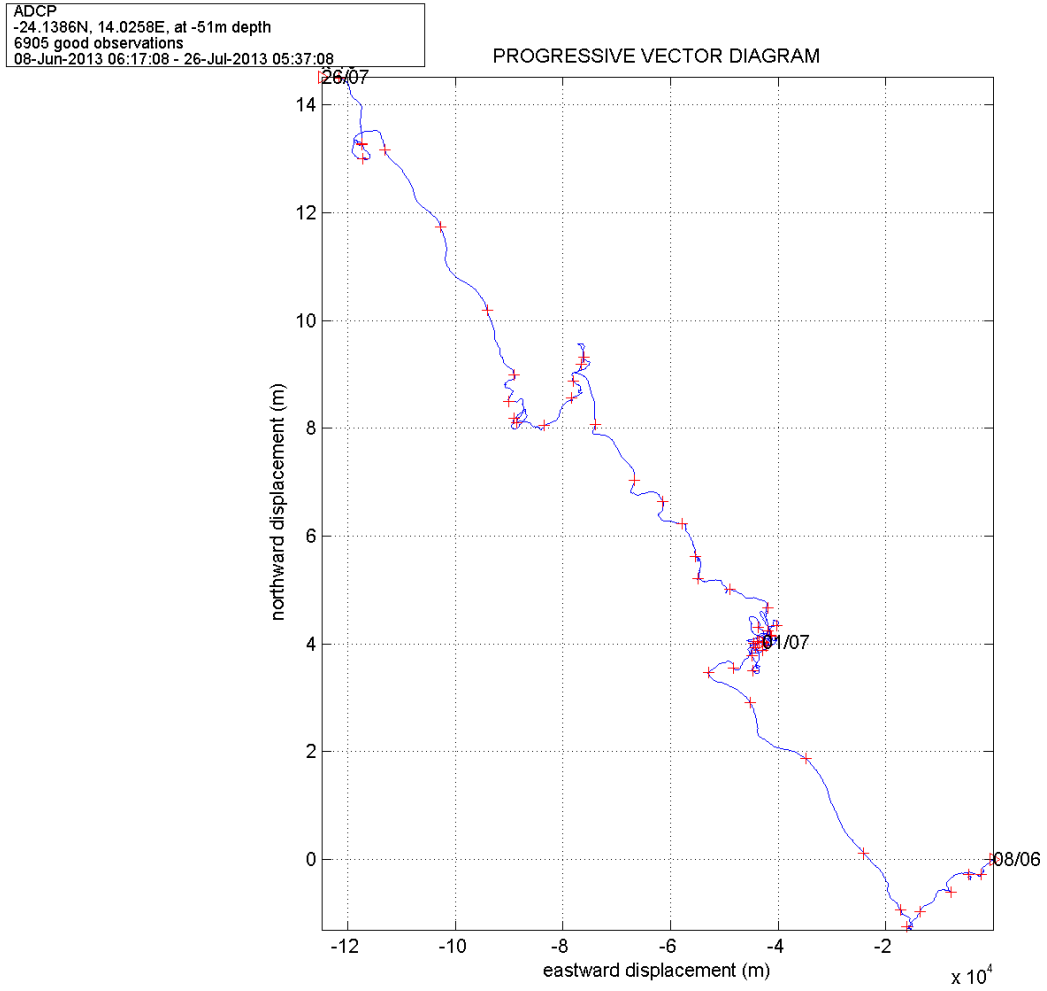


Figure 14: Current progressive vector plot for 51 m depth

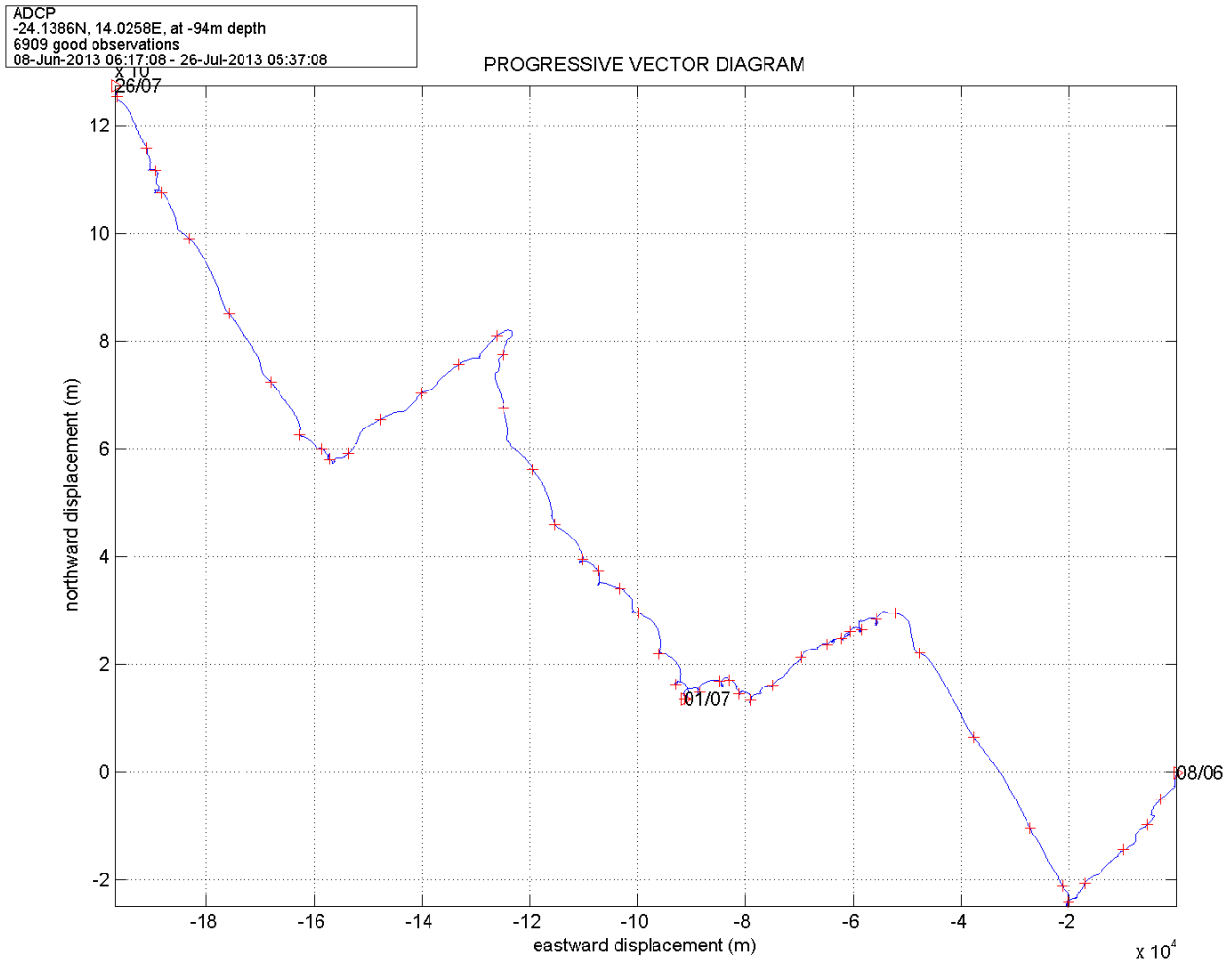


Figure 15: Current progressive vector plot for 94 m depth

4.1.1.4 Tidal harmonic plots

Tables 10, 11 and 12 on the following pages present current harmonic data for the depths; -7 m, -51 m and -94 m respectively. The harmonics consist of:

- 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 major and minor axis amplitudes are given in $cm.s^{-1}$.
- The ellipse orientation and Greenwich phase are given in degrees.

Table 10 : Current harmonic data for 7 m depth

ADCP
-24.1386N, 14.0258E, in -7m depth
6601 good observations
08-Jun-2013 06:27:08 - 26-Jul-2013 04:57:08

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	3.16	-0.33	34.23	338.96
MSF	3.07	-0.73	126.04	293.69
ALP1	3.26	-0.96	43.29	263.41
2Q1	2.22	-0.52	1.14	20.44
Q1	1.71	0.58	14.69	147.97
O1	2.48	0.80	22.98	118.61
NO1	1.51	0.35	156.48	179.70
K1	2.81	1.56	178.24	299.04
J1	0.61	-0.25	147.90	145.15
OO1	3.15	2.37	172.01	221.48
UPS1	1.01	-0.04	58.72	55.19
EPS2	0.32	0.13	2.42	117.06
MU2	0.94	0.11	61.89	190.36
N2	1.87	-0.95	70.27	193.31
M2	2.23	-0.73	66.08	226.50
L2	0.81	0.05	22.65	27.51
S2	0.81	0.04	86.47	236.60
ETA2	0.27	-0.18	72.10	226.23
MO3	0.43	0.01	86.30	208.22
M3	0.59	0.28	89.61	155.82
MK3	0.73	-0.01	59.35	359.57
SK3	0.34	0.17	91.36	46.48
MN4	0.33	-0.09	80.23	3.67
M4	0.54	0.13	101.76	46.01
SN4	0.26	-0.04	3.42	48.15
MS4	0.71	-0.13	31.92	358.14
S4	0.26	0.14	50.62	242.03
2MK5	0.57	-0.29	26.67	157.50
2SK5	0.41	0.11	29.82	341.67
2MN6	0.18	0.02	35.64	263.26
M6	0.22	-0.06	146.32	157.42
2MS6	0.07	-0.04	120.79	191.96
2SM6	0.24	-0.04	156.03	296.35
3MK7	0.32	0.11	36.77	92.94
M8	0.36	0.15	36.98	192.53

Table 11 : Current harmonic data for 51 m depth

ADCP
-24.1386N, 14.0258E, in -51m depth
6905 good observations
08-Jun-2013 06:17:08 - 26-Jul-2013 05:37:08

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	1.75	-0.61	159.02	223.51
MSF	2.73	0.14	100.06	266.50
ALP1	3.17	2.05	61.47	222.30
2Q1	1.89	1.21	161.70	279.85
Q1	2.11	1.54	145.51	343.48
O1	1.85	1.22	22.40	105.45
NO1	1.79	0.56	152.65	279.45
K1	1.95	0.72	122.73	309.73
J1	1.21	0.22	169.34	132.43
OO1	2.49	1.33	92.35	85.47
UPS1	0.99	0.42	36.26	24.98
EPS2	0.55	-0.07	40.32	294.30
MU2	0.33	0.09	112.33	78.69
N2	0.63	0.59	155.73	197.79
M2	1.24	1.12	172.52	102.49
L2	0.32	-0.19	140.65	258.35
S2	0.23	0.14	60.24	2.72
ETA2	0.59	0.00	77.25	228.73
MO3	0.40	0.17	29.78	134.87
M3	0.43	0.33	56.60	115.47
MK3	0.33	-0.03	89.13	357.22
SK3	0.35	0.03	50.34	285.77
MN4	0.16	0.00	40.99	159.71
M4	0.29	-0.06	124.66	358.65
SN4	0.28	-0.05	175.22	75.22
MS4	0.29	-0.15	16.19	343.93
S4	0.29	0.20	167.72	279.26
2MK5	0.27	0.06	99.92	103.56
2SK5	0.38	0.05	93.08	183.79
2MN6	0.14	-0.03	62.92	141.20
M6	0.16	0.04	53.80	292.02
2MS6	0.13	0.07	164.46	334.50
2SM6	0.12	0.11	71.13	342.55
3MK7	0.06	0.04	124.22	40.60
M8	0.27	0.10	74.57	182.49

Table 12 : Current harmonic data for 94 m depth

ADCP
-24.1386N, 14.0258E, in -94m depth
6909 good observations
08-Jun-2013 06:17:08 - 26-Jul-2013 05:37:08

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	1.30	0.46	12.66	97.06
MSF	2.36	-0.37	90.09	273.74
ALP1	2.07	1.71	74.13	92.13
2Q1	1.14	0.94	79.05	190.87
Q1	2.56	1.65	76.22	321.19
O1	1.05	0.89	172.55	137.11
NO1	1.20	0.53	43.46	142.67
K1	0.53	0.22	58.86	348.70
J1	1.03	0.67	150.94	89.63
OO1	1.46	0.80	94.65	4.82
UPS1	0.32	-0.08	90.53	248.60
EPS2	0.30	0.03	131.95	284.13
MU2	0.51	0.32	79.26	54.19
N2	0.30	0.16	15.41	275.67
M2	1.41	1.15	36.63	339.07
L2	0.44	0.24	157.03	235.22
S2	0.50	0.23	156.72	170.84
ETA2	0.41	0.10	96.30	286.54
MO3	0.34	0.22	162.67	44.65
M3	0.13	-0.02	28.08	165.50
MK3	0.29	0.13	21.89	209.81
SK3	0.31	0.05	174.07	220.64
MN4	0.13	0.05	48.81	312.35
M4	0.23	-0.05	29.87	40.55
SN4	0.25	-0.07	5.95	187.65
MS4	0.27	-0.03	82.83	246.57
S4	0.10	-0.01	71.27	55.29
2MK5	0.24	0.01	50.10	308.57
2SK5	0.06	-0.00	73.84	252.08
2MN6	0.23	0.09	72.52	198.15
M6	0.17	0.02	33.12	172.41
2MS6	0.10	0.06	43.82	350.66
2SM6	0.12	-0.06	138.98	10.61
3MK7	0.07	0.03	46.48	225.70
M8	0.07	0.03	22.94	308.85

4.1.1.5 Profile plots

Figures 16, 17, 18 and 19 on the following pages display profile plots of the currents through the water column. The first plot displays the mean profile plot over the duration of measurements, while the following three plots display profile plots at selected times. The times selected were time of maximum current speed for bins 88, 44 and 1. These represent the flow for the depths -7 m, -51 m and -94 m respectively. These plots consist of:

- The left hand panel is a 3-dimensional illustration of the current vector through the water column, with depth on the vertical axis. The vector arrow indicates the direction towards which the current is flowing, with the length of the arrow proportional to the current speed.
- The middle panel is a plot of the current speed (x-axis) with depth (y-axis).
- The right hand panel is a plot of current direction (x-axis) with depth (y-axis).

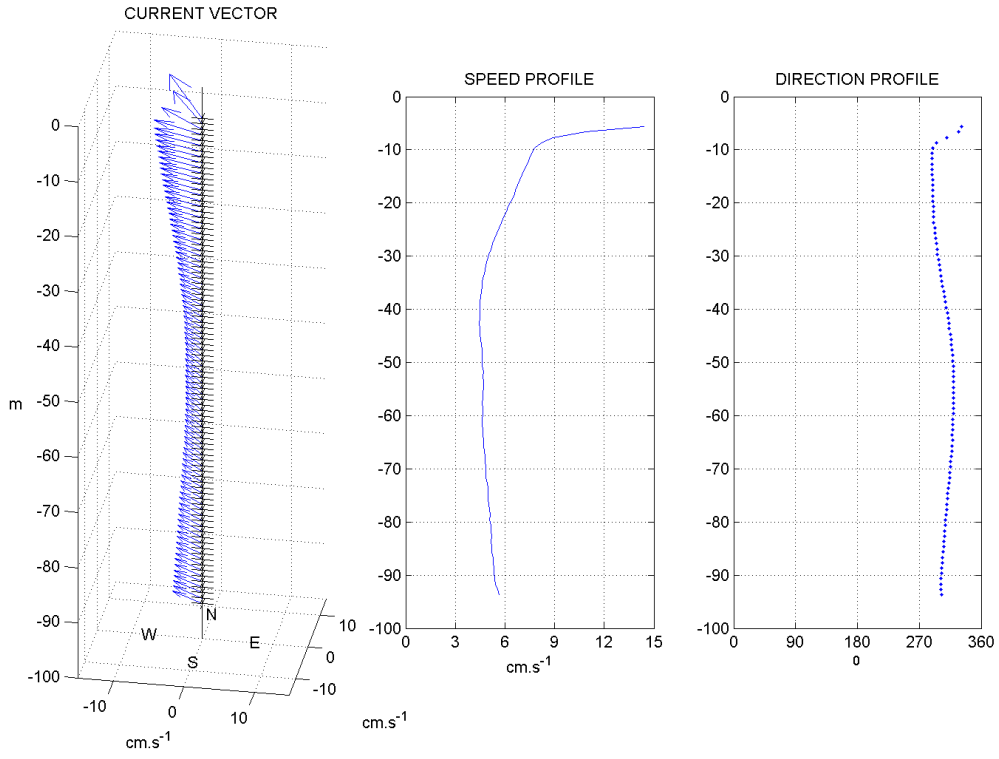


Figure 16: Mean profile plot

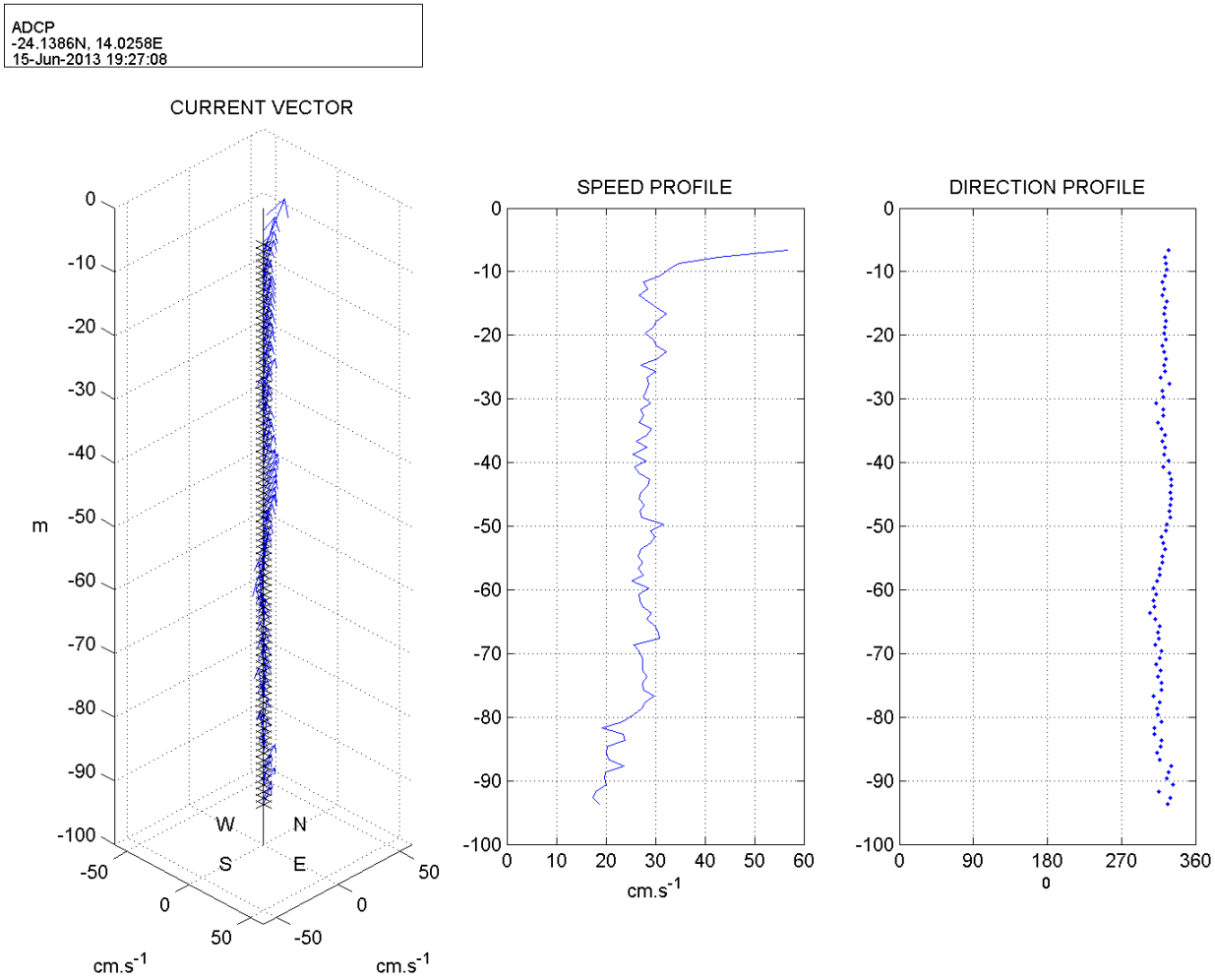


Figure 17: Profile plot at the time of maximum current speed in the upper water column

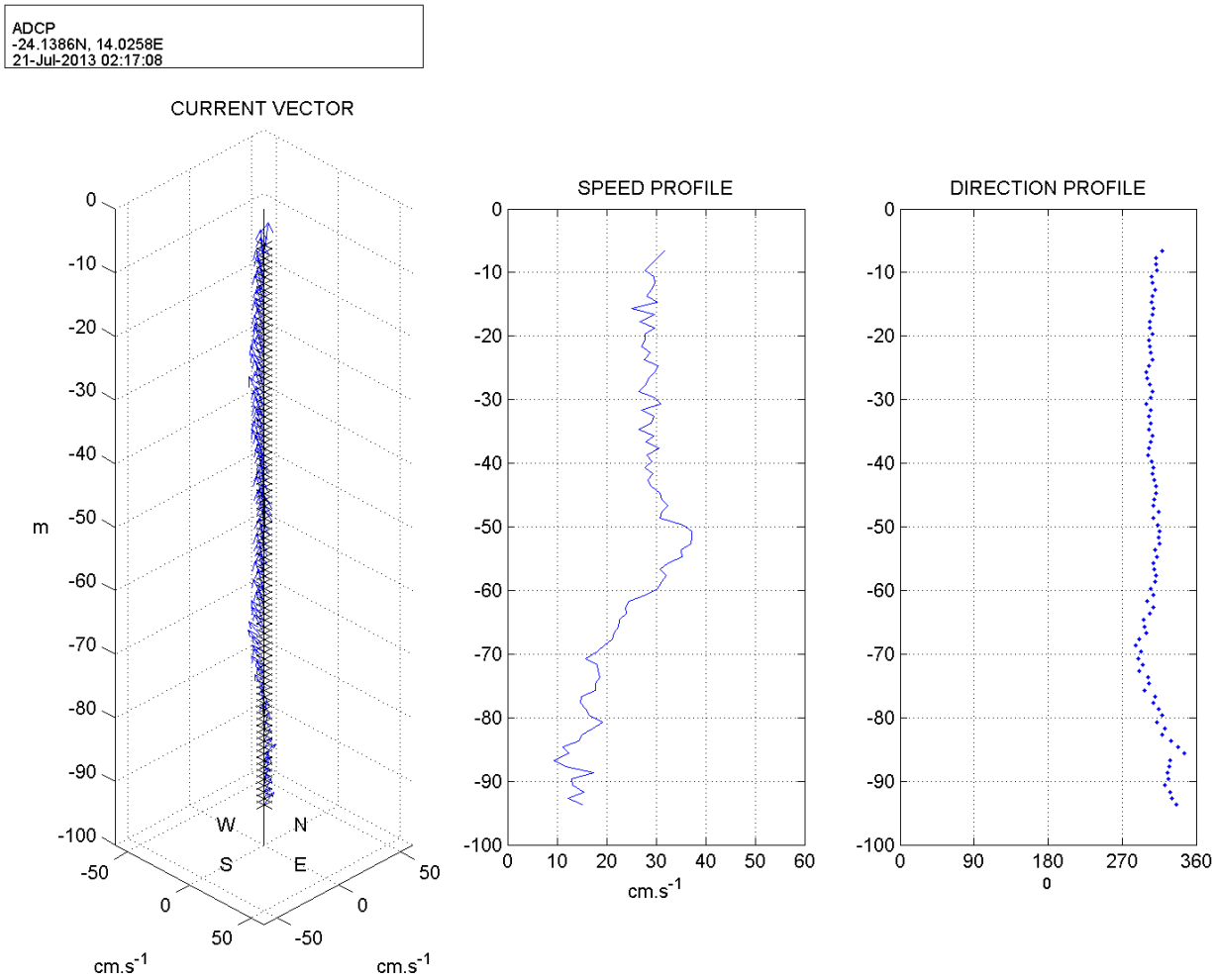


Figure 18: Profile plot at the time of maximum current speed in the mid water column

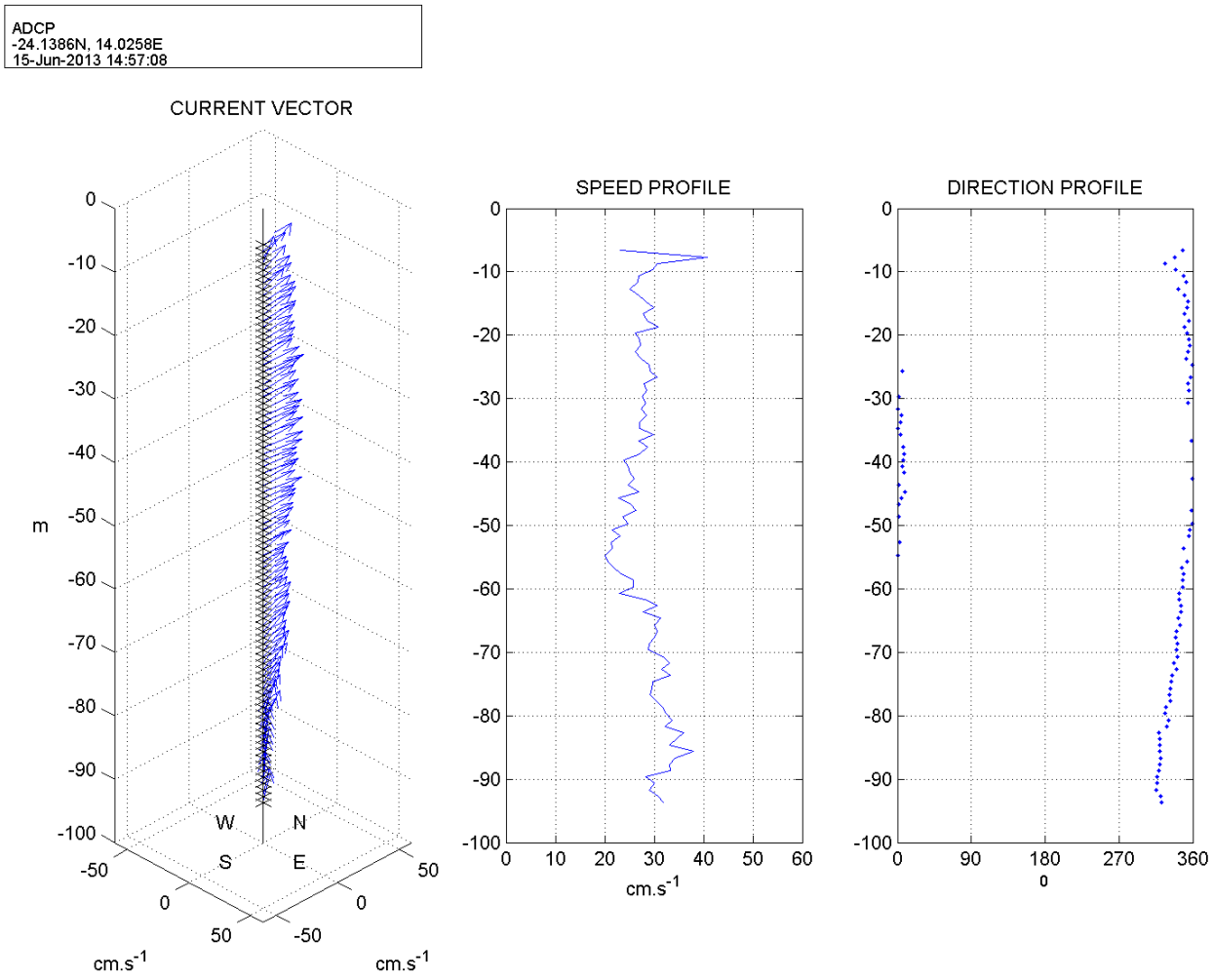


Figure 19: Profile plot at the time of maximum current speed in the lower water column

4.1.2 Pressure and water temperature data

4.1.2.1 Time **series plot**

Figure 20 on the following page displays a time series plot, which consists of:

- The first (upper) panel is of the observed pressure against time.
- The second panel is of the observed water temperature against time.
- The first day of each month is indicated visually by a thin red line on each of the plots.

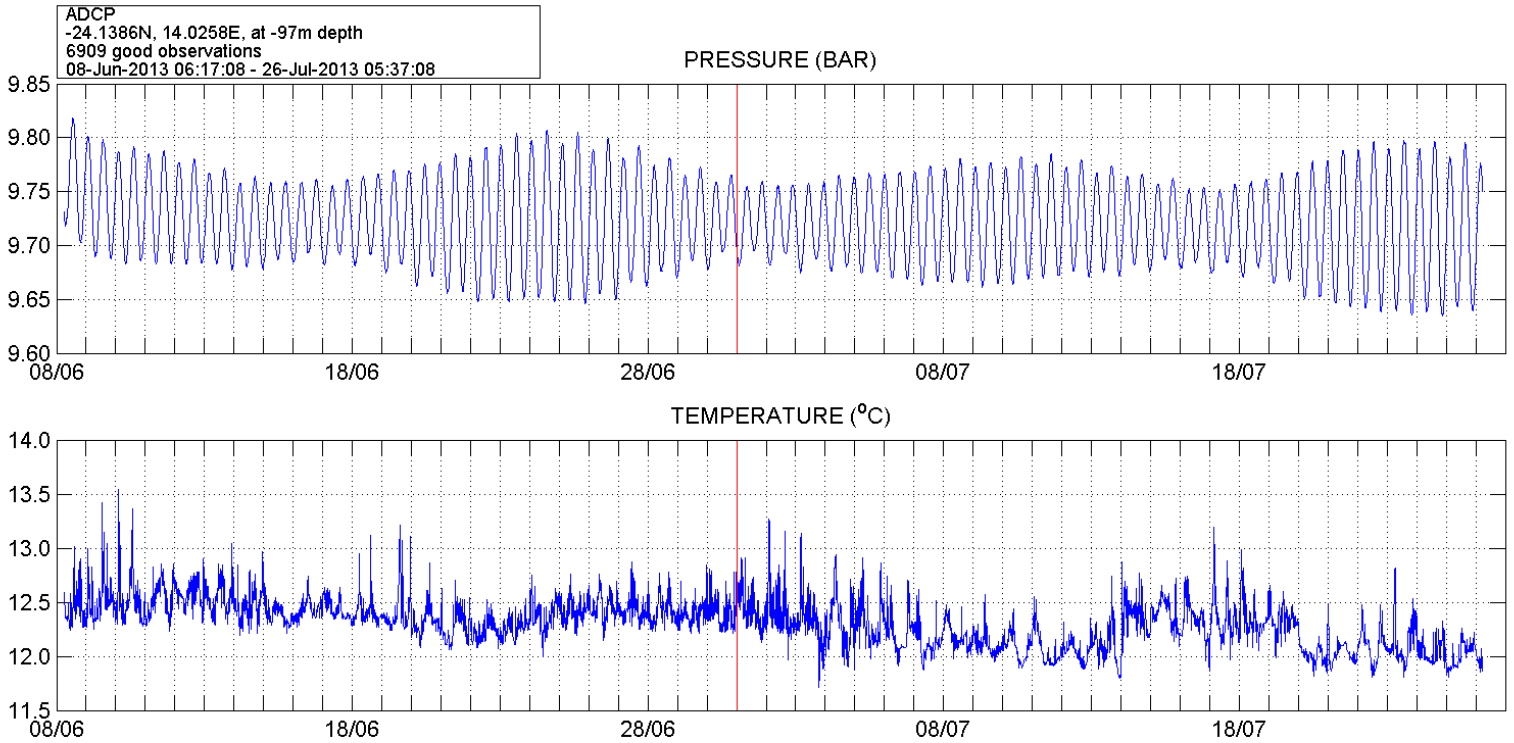


Figure 20: Upper panel: time series plot of pressure. Lower panel: time series plot of temperature.
Note: the first day of the month is indicated by a thin red line on each of the plots.

4.2 AQD 1

4.2.1 Current data

4.2.1.1 Time series plot

Figure 21 on the following page displays a time series plot which consists of:

- The first (upper) panel is of the observed current speed against time.
- The second panel is of the observed 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.

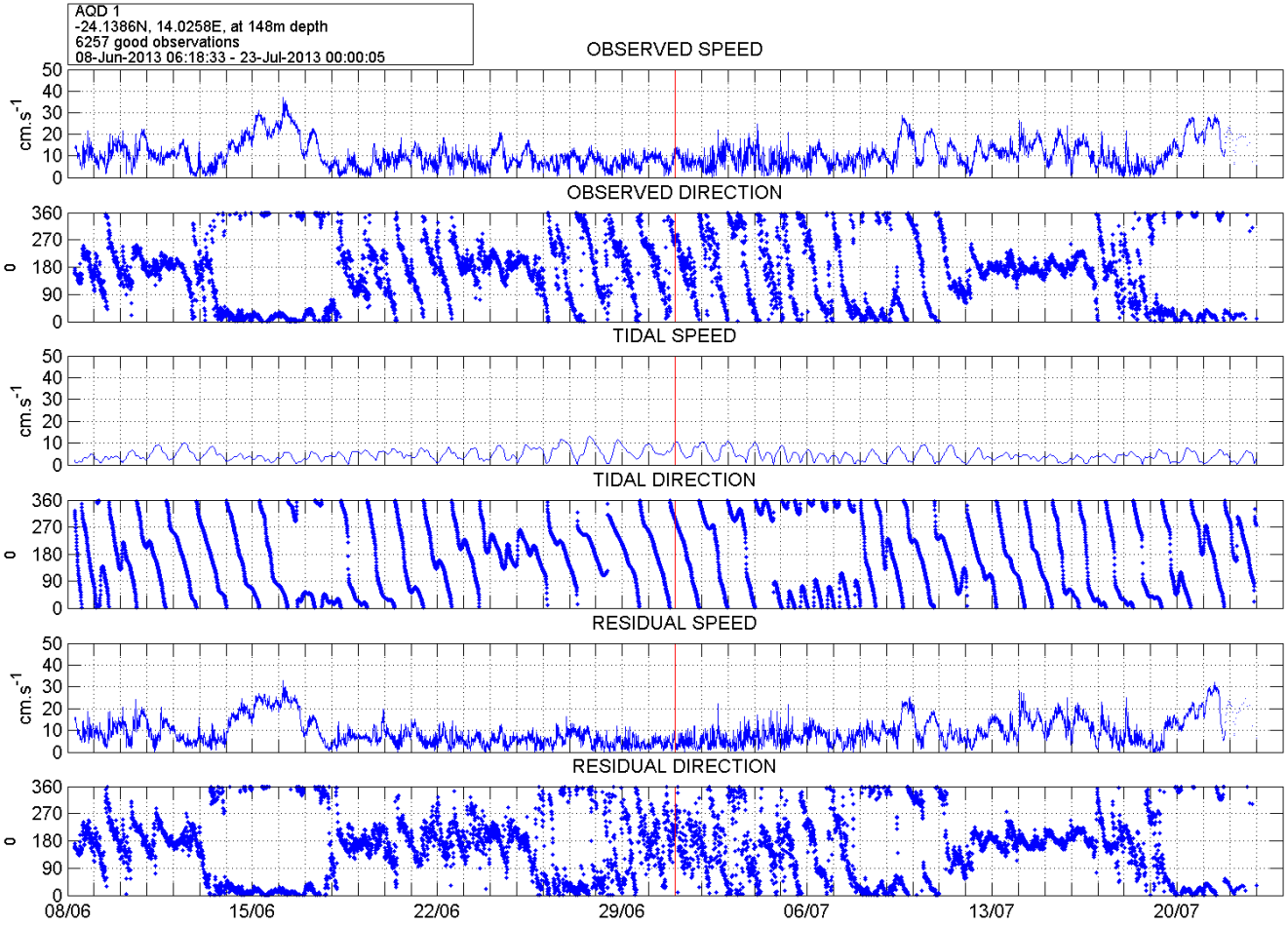


Figure 21: Time series plots of current data at 148 m depth

4.2.1.2 Summary plot

Figure 22 on the following page displays a summary plot which consists 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.

AQD 1
-24.1386N, 14.0258E, at 148m depth
6257 good observations
08-Jun-2013 06:18:33 - 23-Jul-2013 00:00:05

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-5	0.72	1.12	0.83	1.17	1.12	1.20	1.21	0.93	1.58	1.29	1.09	0.94	0.91	0.75	0.78	1.02	16.67
5-10	2.14	2.38	2.41	1.65	2.09	2.35	2.67	3.21	4.09	3.88	2.59	2.01	1.55	1.36	1.29	1.61	37.30
10-15	1.95	2.38	1.47	1.09	0.96	1.18	1.55	3.04	3.71	2.88	2.17	1.07	0.88	0.46	0.32	0.64	25.75
15-20	1.37	1.95	0.37	0.35	0.29	0.35	0.27	1.13	2.14	0.88	0.94	0.29	0.05	0.10	0.14	0.27	10.90
20-25	1.34	2.53	0.42	0.19	0.02			0.13	0.46	0.22	0.13	0.08	0.02		0.11	0.32	5.96
25-30	1.37	1.34	0.11						0.02	0.02						0.10	2.96
30-35	0.14	0.29															0.43
35-40		0.03															0.03
40-45																	0.00
45-50																	0.00
Σ	9.05	12.02	5.61	4.44	4.47	5.08	5.71	8.44	12.00	9.17	6.92	4.40	3.40	2.67	2.65	3.96	100.00

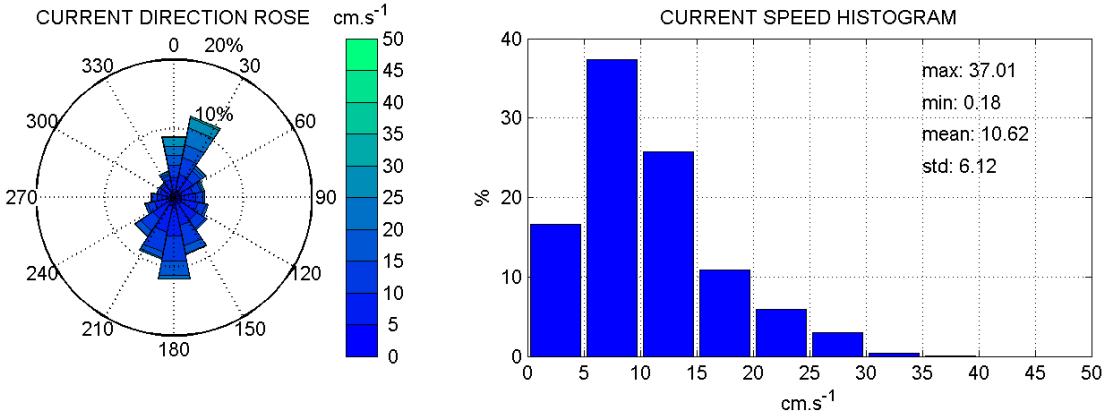


Figure 22: Current speed and direction plots for 148 m depth

4.2.1.3 Progressive vector plot

Figure 23 on the following page displays a progressive vector plot which consists 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.

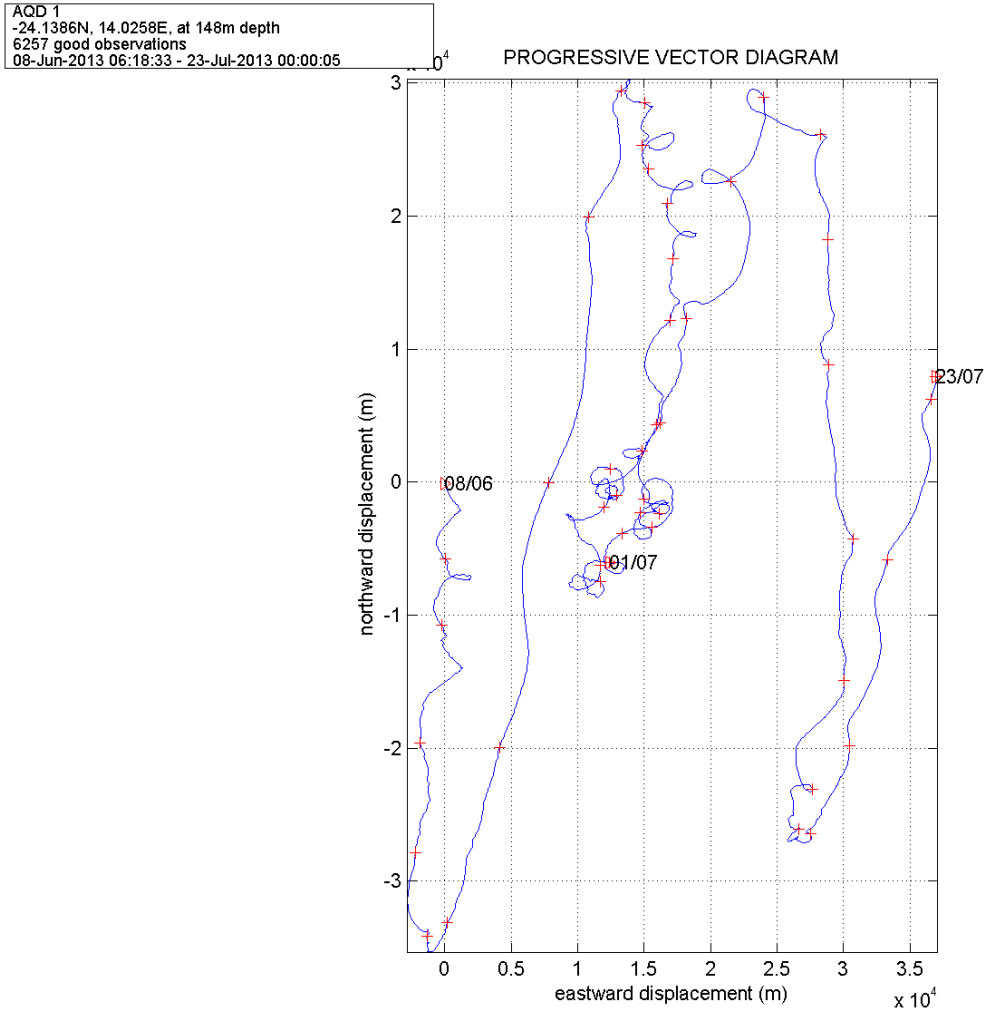


Figure 23: Current progressive vector plot for 148 m depth

4.2.1.4 Tidal harmonic data

Table 13 on the following page presents current harmonic data which consist of:

- 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 major and minor axis amplitudes are given in knots.
- The ellipse orientation and Greenwich phase are given in degrees.

Table 13 : Current harmonic data for 148 m depth

AQD 1
-24.1386N, 14.0258E, in 148m depth
6257 good observations
08-Jun-2013 06:18:33 - 23-Jul-2013 00:00:05

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	2.01	-0.77	49.61	229.40
MSF	3.60	-0.55	85.11	258.30
ALP1	2.34	2.25	165.96	123.97
2Q1	2.40	1.70	23.62	345.67
Q1	3.16	2.46	16.85	72.86
O1	1.42	0.98	146.91	21.19
NO1	2.20	1.57	17.50	278.88
K1	0.58	0.26	101.17	183.84
J1	0.89	0.81	106.94	327.61
OO1	1.31	1.07	115.49	353.69
UPS1	0.80	0.43	71.56	251.23
EPS2	0.60	0.20	72.46	66.17
MU2	0.22	0.12	179.13	67.11
N2	0.51	0.35	4.41	279.39
M2	1.82	1.51	154.18	109.50
L2	0.57	0.27	104.25	102.51
S2	1.12	0.61	159.15	94.04
ETA2	0.48	0.33	110.89	38.60
MO3	0.35	0.14	64.37	142.28
M3	0.36	-0.10	21.20	127.95
MK3	0.39	0.07	18.68	351.98
SK3	0.36	-0.06	166.11	198.29
MN4	0.06	0.03	166.52	214.29
M4	0.27	0.05	11.22	264.57
SN4	0.26	0.12	163.56	171.64
MS4	0.22	0.15	12.98	99.68
S4	0.33	-0.08	21.78	340.08
2MK5	0.20	-0.04	149.63	186.02
2SK5	0.12	0.04	10.20	251.73
2MN6	0.13	0.06	111.43	105.87
M6	0.16	0.06	58.38	189.54
2MS6	0.16	-0.07	157.59	113.08
2SM6	0.14	0.06	78.69	103.49
3MK7	0.14	-0.08	10.18	97.50
M8	0.08	0.00	53.17	33.33

4.2.2 Pressure and water temperature data

4.2.2.1 Time series plot

Time series plots of water level and water temperature variations as a function of time over the recording period are presented in Figure 24.

- The first (upper) panel is of the observed 10 minute water level against time.
- The second panel is of the observed 10 minute water temperature against time.

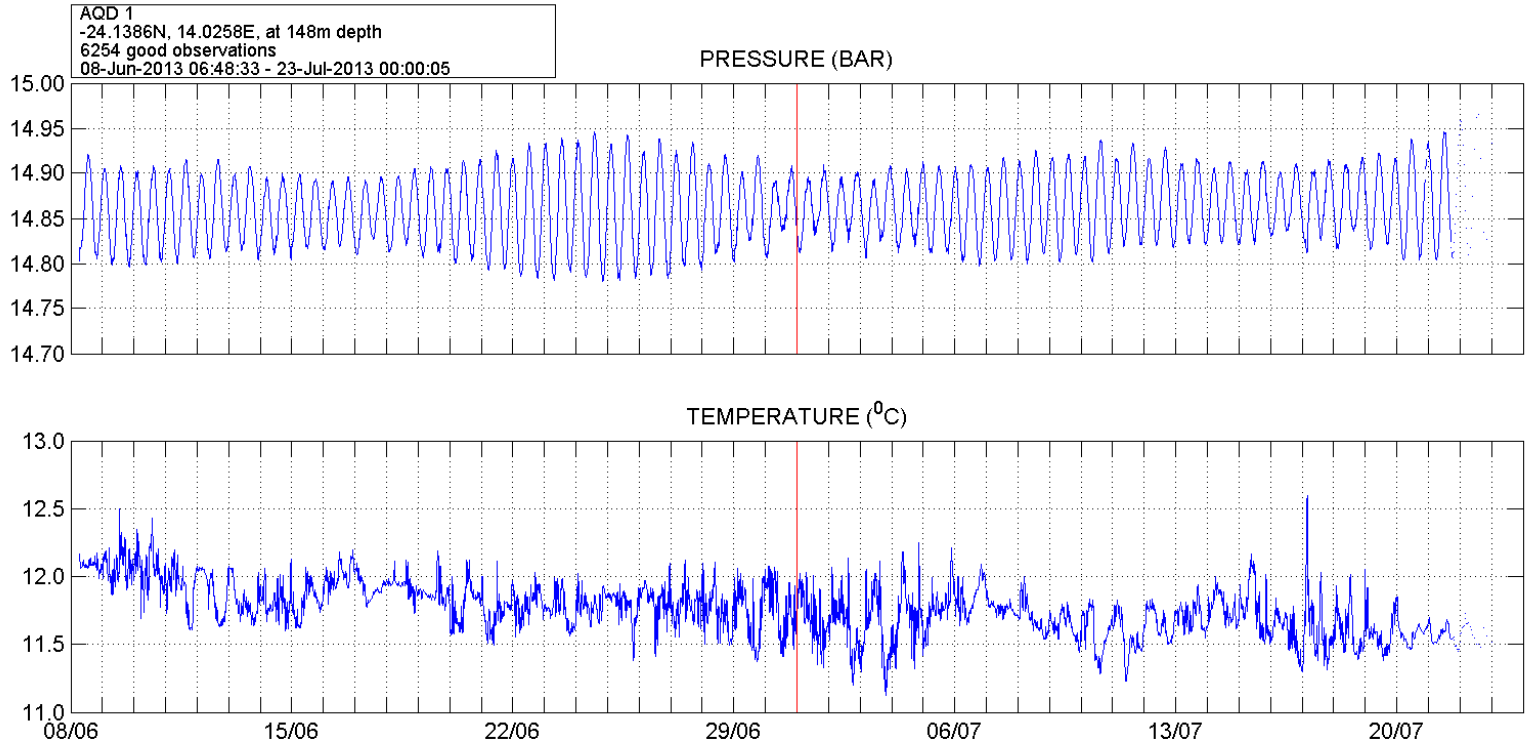


Figure 24: Time series plots of pressure (water level) and water temperature at 148 m depth

4.3 AQD 2

4.3.1 Current data

4.3.1.1 Time series plot

Figure 25 on the following page displays a time series plot which consists of:

- The first (upper) panel is of the observed current speed against time.
- The second panel is of the observed 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.

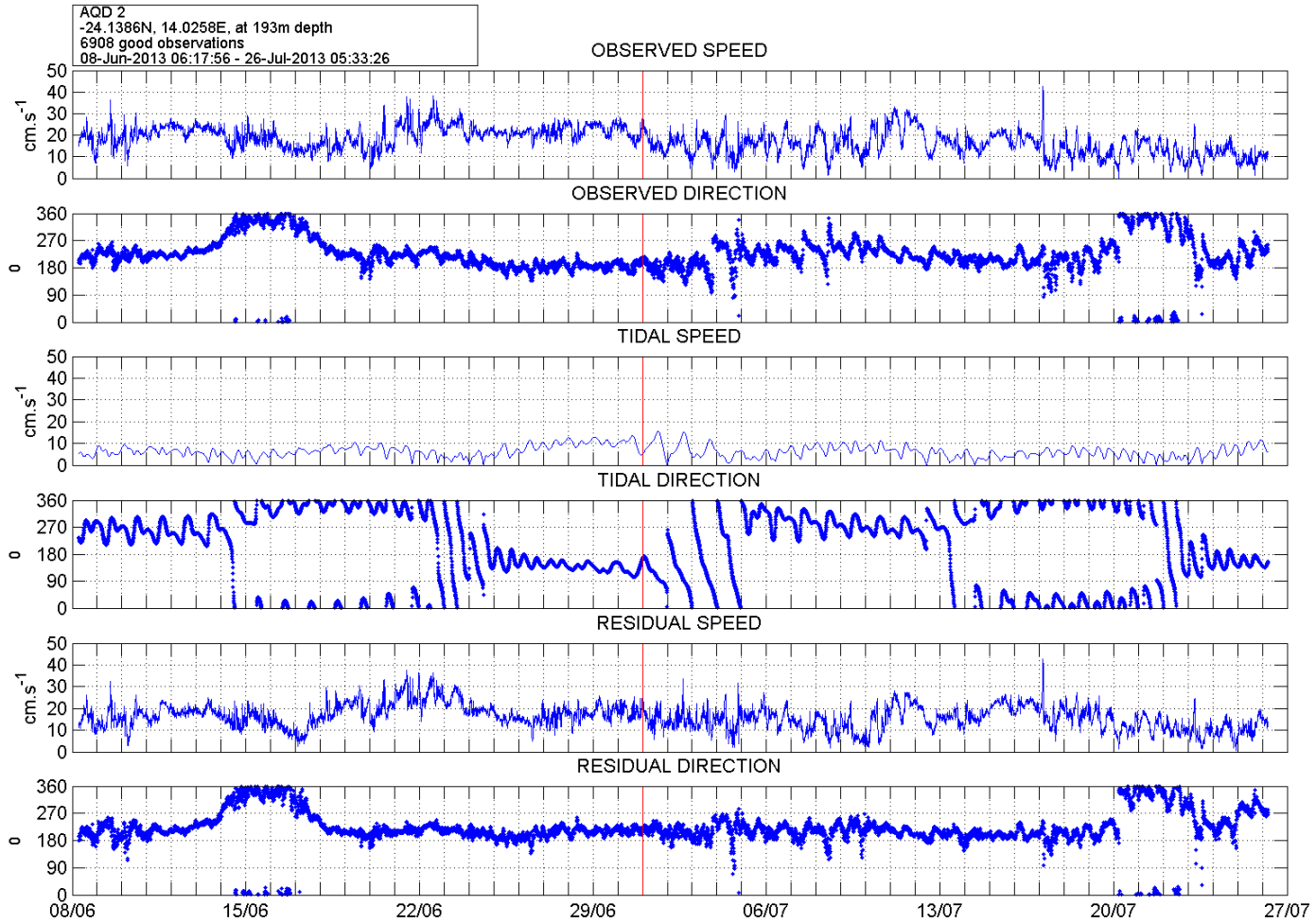


Figure 25: Time series plots of current data at 193 m depth

4.3.1.2 Summary plot

Figure 26 on the following page displays a summary plot which consists 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.

AQD 2
-24.1386N, 14.0258E, at 193m depth
6908 good observations
08-Jun-2013 06:17:56 - 26-Jul-2013 05:33:26

JOINT DISTRIBUTION OF SPEED AND DIRECTION

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Σ
0-5	0.04	0.01				0.03	0.17	0.12	0.16	0.10	0.09	0.12	0.10	0.12	0.13	0.06	1.24
5-10	0.14	0.12			0.04	0.22	0.20	0.72	1.36	1.16	1.38	1.46	1.16	0.68	0.45	0.35	9.44
10-15	1.23	0.20			0.07	0.09	0.39	0.74	2.74	5.04	3.65	3.40	2.39	1.11	1.26	1.61	23.91
15-20	1.85	0.26	0.01			0.03	0.26	0.97	4.00	7.28	7.41	3.56	0.87	0.58	0.36	1.90	29.34
20-25	0.20	0.04			0.01		0.04	0.87	5.52	6.12	8.61	3.56	0.38	0.30	0.43	0.54	26.64
25-30								0.07	1.14	1.85	3.21	1.62	0.04		0.14	0.03	8.12
30-35										0.01	0.65	0.41					1.07
35-40												0.22					0.22
40-45												0.01					0.01
45-50																	0.00
Σ	3.47	0.64	0.01	0.00	0.13	0.36	1.07	3.49	14.91	21.57	25.00	14.36	4.94	2.79	2.78	4.47	100.00

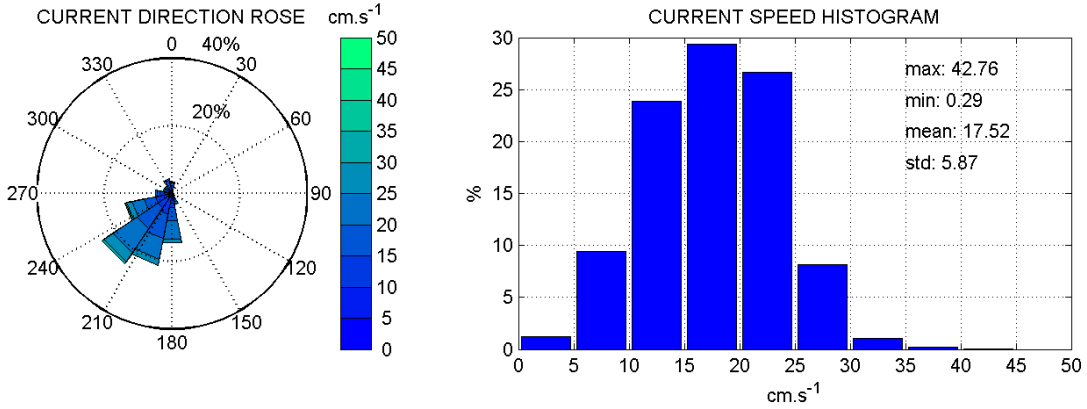


Figure 26: Current speed and direction plots of 193 m depth

4.3.1.3 Progressive vector plot

Figure 27 on the following page displays a progressive vector plot which consists 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.

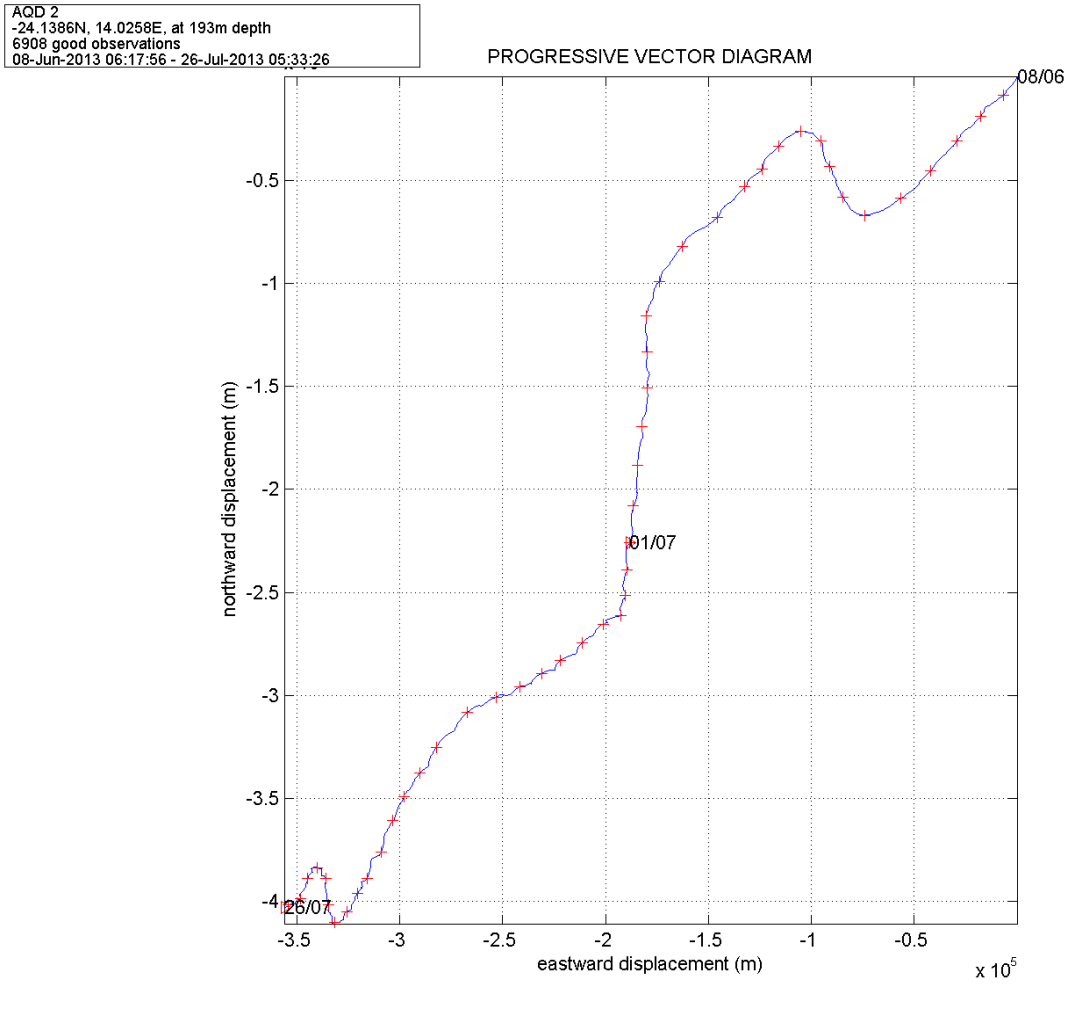


Figure 27: Current progressive vector plot for 193 m depth

4.3.1.4 Tidal harmonic data

Table 14 on the following page presents current harmonic data which consist of:

- 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 major and minor axis amplitudes are given in knots.
- The ellipse orientation and Greenwich phase are given in degrees.

Table 14 : Current harmonic data for 193 m depth

AQD 2
-24.1386N, 14.0258E, in 193m depth
6908 good observations
08-Jun-2013 06:17:56 - 26-Jul-2013 05:33:26

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	6.91	-1.55	141.46	250.26
MSF	4.17	3.13	95.77	283.69
ALP1	1.38	0.73	176.29	7.69
2Q1	1.63	0.65	15.34	307.27
Q1	1.26	0.59	65.77	85.25
O1	2.24	0.69	173.53	358.43
NO1	0.88	0.58	35.11	297.07
K1	2.08	0.79	21.69	66.72
J1	1.39	0.75	92.50	297.55
OO1	2.05	0.87	129.74	354.06
UPS1	0.81	0.15	153.18	107.29
EPS2	0.41	0.09	76.11	353.68
MU2	0.46	0.06	120.74	55.13
N2	0.86	0.15	172.38	91.88
M2	1.63	1.29	126.69	53.31
L2	0.70	-0.40	3.39	159.69
S2	1.05	0.64	155.01	76.35
ETA2	0.65	0.10	59.75	120.74
MO3	0.48	-0.04	18.16	69.25
M3	0.31	-0.17	164.90	334.73
MK3	0.57	0.31	20.17	325.20
SK3	0.28	0.08	52.15	6.18
MN4	0.11	0.09	50.11	258.74
M4	0.25	-0.00	179.55	87.62
SN4	0.10	0.09	21.62	39.06
MS4	0.25	-0.01	19.09	148.90
S4	0.17	-0.11	29.86	277.55
2MK5	0.08	0.02	169.09	290.33
2SK5	0.28	0.02	4.58	301.12
2MN6	0.23	0.04	16.31	326.55
M6	0.08	0.06	16.53	256.56
2MS6	0.18	-0.09	20.25	271.25
2SM6	0.14	-0.02	147.07	69.65
3MK7	0.14	-0.07	156.10	310.00
M8	0.12	0.02	36.38	42.32

4.3.2 Pressure and water temperature data

4.3.2.1 Time series plot

Time series plots of water level and water temperature variations as a function of time over the recording period are presented in Figure 28:

- The first (upper) panel is of the observed 10 minute water level against time.
- The second panel is of the observed 10 minute water temperature against time.

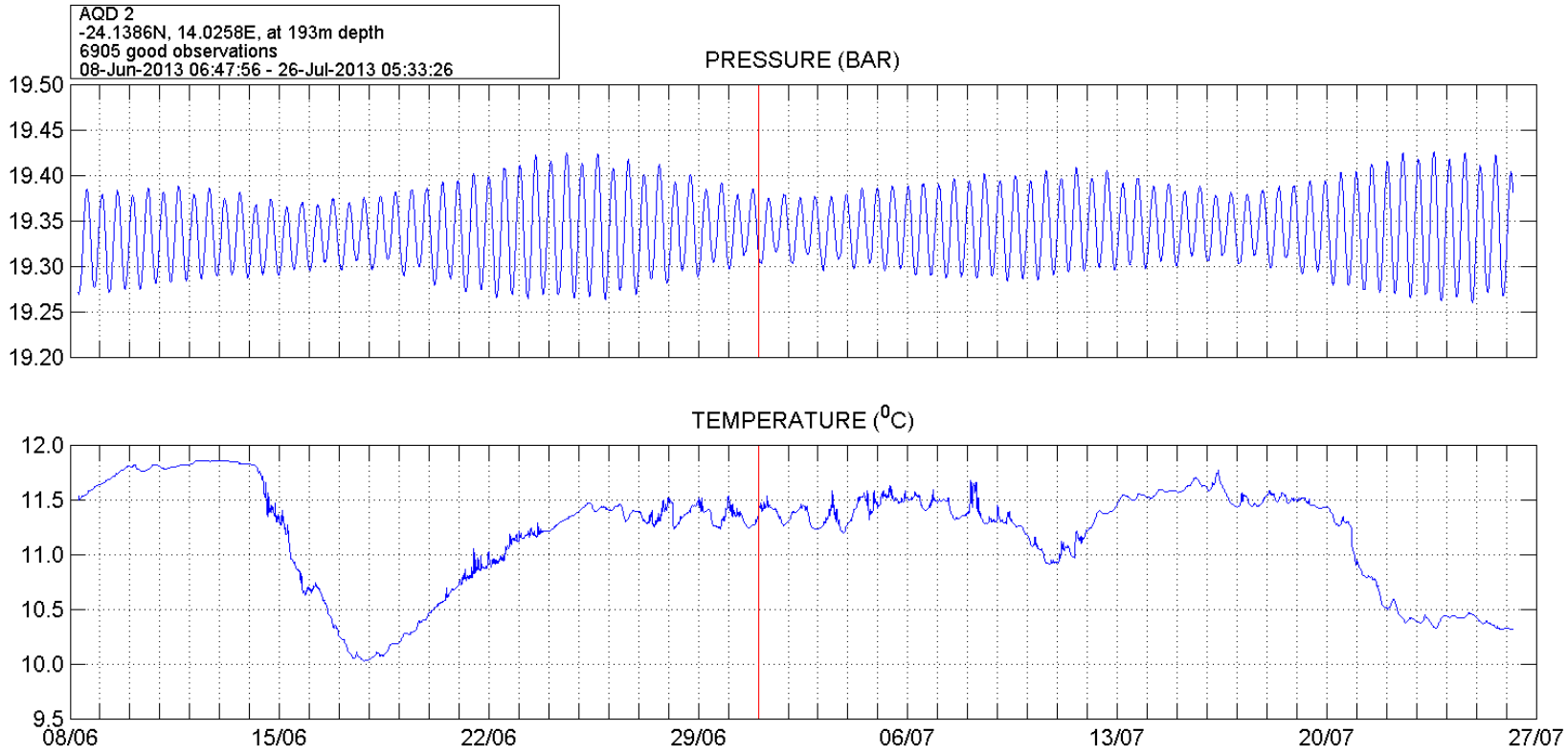


Figure 28: Time series plots of pressure (water level) and water temperature at 193 m depth

4.4 CTD

4.4.1 Water quality data

4.4.1.1 Time series plot

Figure 29 on the following page displays a set of time series plots, which consist of:

- The first (upper) panel is of the observed water temperature against time.
- The second panel is of the derived salinity against time.
- The third panel is of the observed depth against time.
- The fourth panel is of the observed dissolved oxygen against time.
- The fifth panel is of the observed fluorescence against time.
- The sixth panel is of the observed turbidity against time.

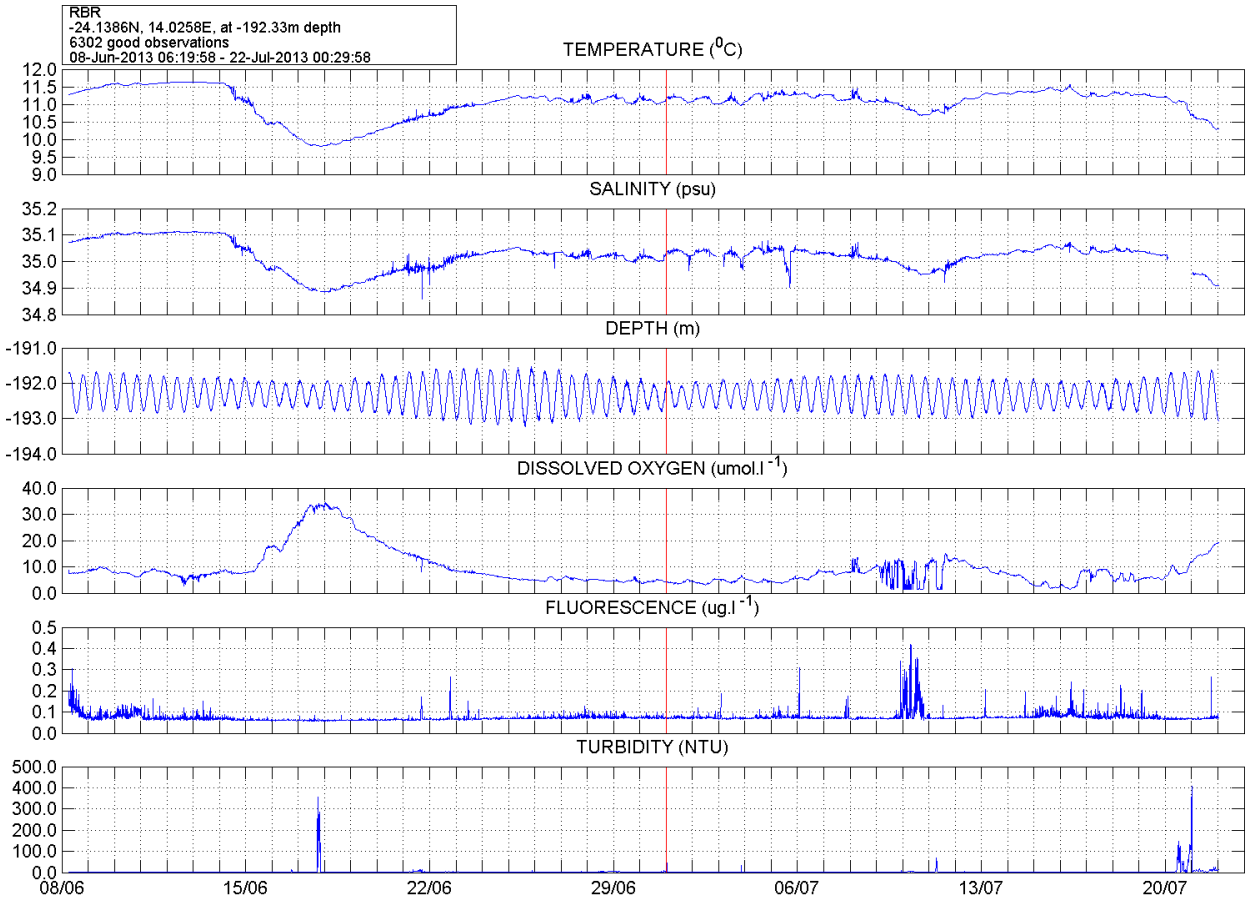


Figure 29: Water quality data for 192.33 m depth

4.4.1.2 Summary plot

Figure 30 on the following page displays frequency distributions of measurements of water temperature, depth, dissolved oxygen, fluorescence and turbidity at 192.33 m water depth.

- The upper 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 upper middle panel is a histogram of the water salinity. This reflects the percentage of observations that fall within each salinity interval. Included on the plot are basic statistics for the distribution.
- The upper right hand panel is a histogram of the water depth. This reflects the percentage of observations that fall within each depth interval. Included on the plot are basic statistics for the distribution.
- The lower left hand panel is a histogram of the dissolved oxygen. This reflects the percentage of observations that fall within each sound velocity interval. Included on the plot are basic statistics for the distribution.
- The lower middle panel is a histogram of the fluorescence. This reflects the percentage of observations that fall within each density interval. Included on the plot are basic statistics for the distribution.
- The lower right hand panel is a histogram of the turbidity. This reflects the percentage of observations that fall within each turbidity interval. Included on the plot are basic statistics for the distribution.

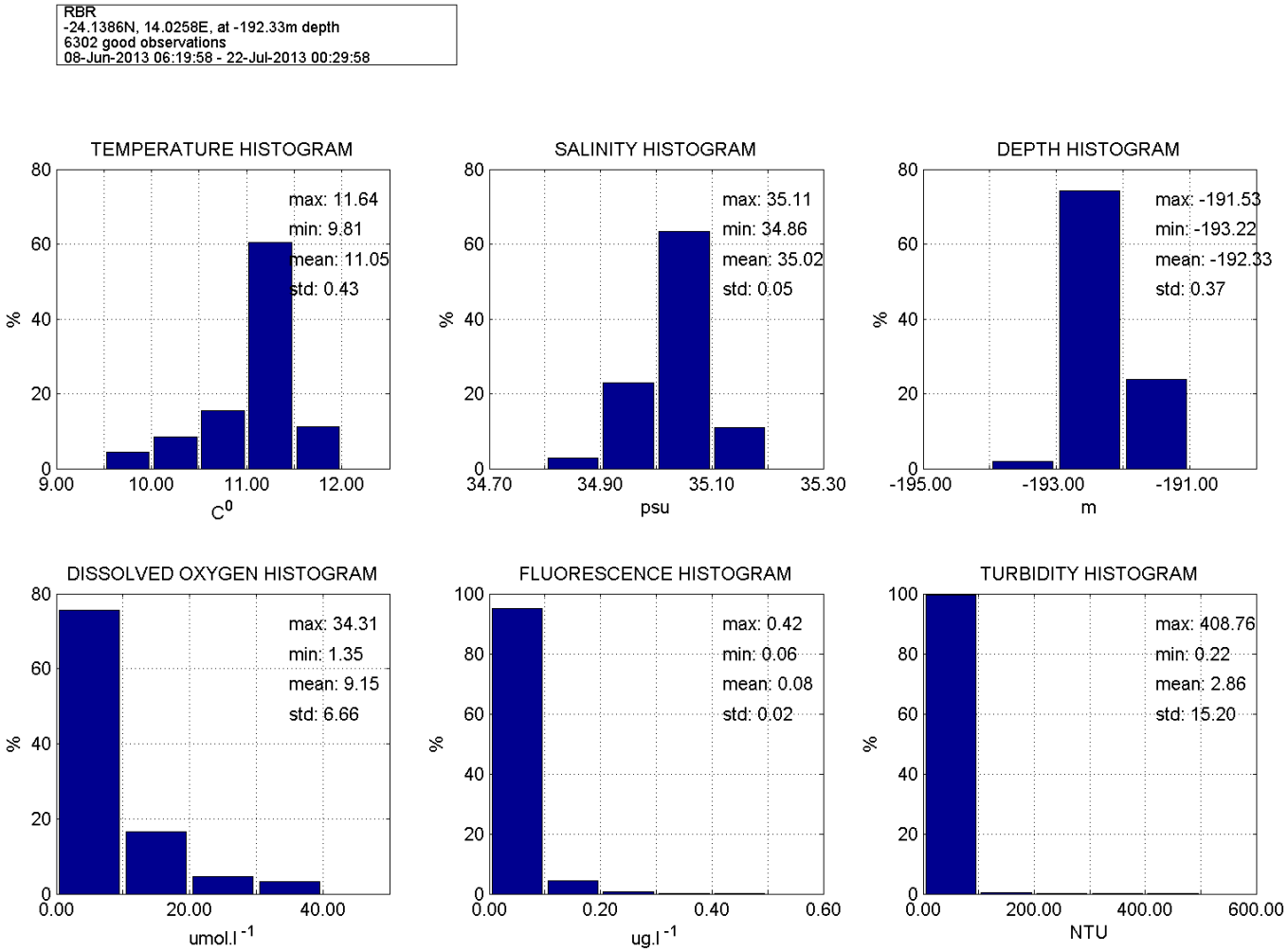


Figure 30: Summary data for environmental parameters at 192.33 m depth

4.4.2 Tide data

4.4.2.1 Time series plot

Figure 31 on the following page displays a time series plot of the tidal height. The time series plot consists of:

- 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.

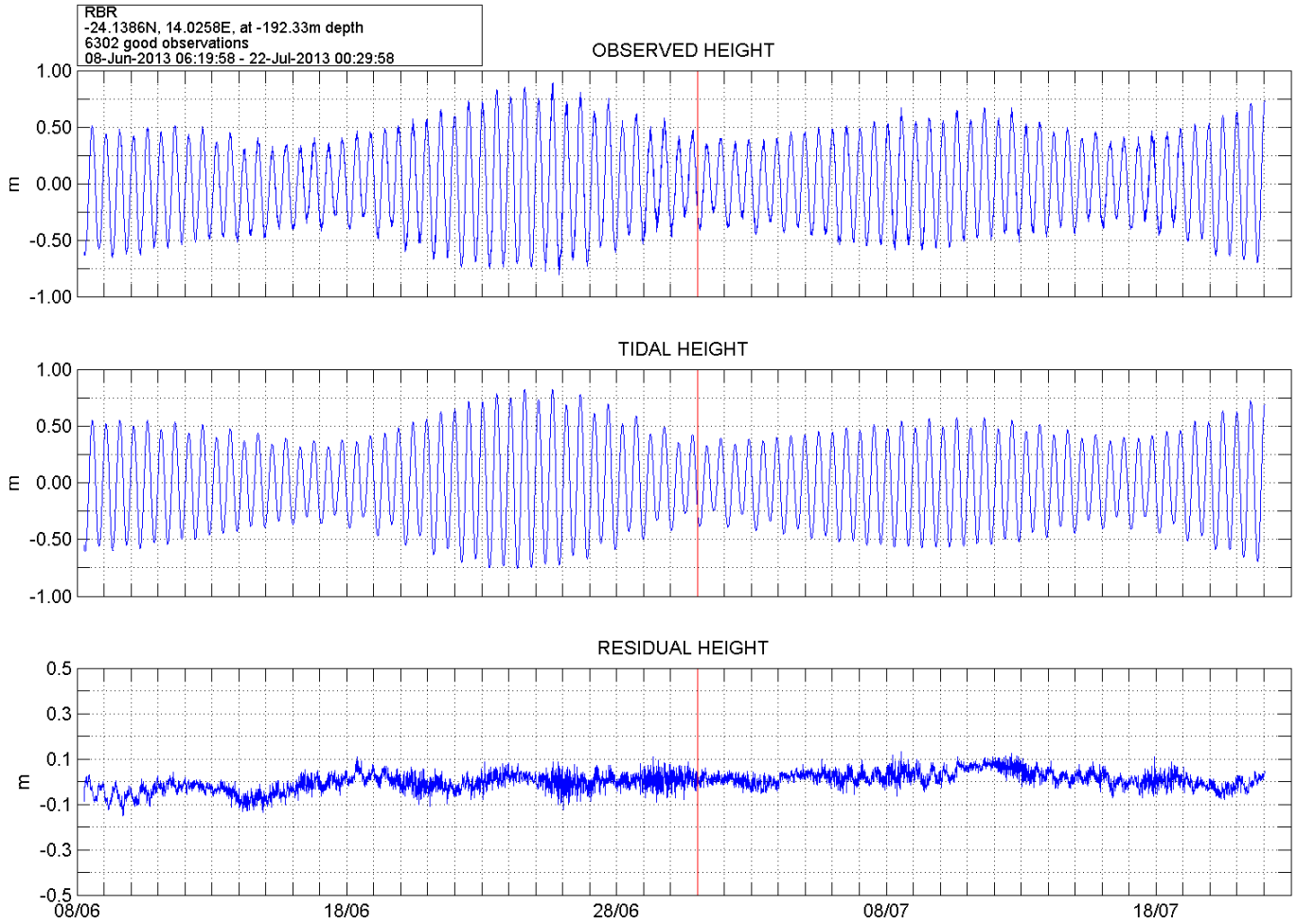


Figure 31: Time series of tidal height

4.4.2.2 Tidal harmonics table

The tidal harmonics resulting from the analysis are presented in Table 15. 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*).

Table 15 : Tidal harmonic data for 192.33 m depth

RBR
-24.1386N, 14.0258E, in -192.33m depth
6302 good observations
08-Jun-2013 06:19:58 - 22-Jul-2013 00:29:58

HARMONIC COMPONENTS

Component	Amplitude (m)	Phase (deg)
MM	0.014	19.690
MSF	0.012	148.287
ALP1	0.001	193.059
2Q1	0.001	182.746
Q1	0.012	182.008
O1	0.019	218.151
NO1	0.010	51.353
K1	0.053	66.993
J1	0.004	90.369
OO1	0.004	54.951
UPS1	0.001	21.737
EPS2	0.007	1.410
MU2	0.030	15.540
N2	0.120	23.785
M2	0.477	38.257
L2	0.016	43.947
S2	0.137	61.073
ETA2	0.006	351.679
MO3	0.003	75.746
M3	0.006	292.182
MK3	0.000	243.432
SK3	0.004	188.576
MN4	0.005	70.813
M4	0.009	117.790
SN4	0.001	185.676
MS4	0.004	234.380
S4	0.003	236.715
2MK5	0.003	88.039
2SK5	0.005	279.117
2MN6	0.002	262.996
M6	0.004	315.066
2MS6	0.003	67.264
2SM6	0.000	13.469
3MK7	0.001	349.214
M8	0.002	191.633

4.4.2.3 Tidal harmonics plot

Graphical representations of the tidal harmonic components presented in Table 15 are displayed in Figure 32:

- Components with periods between 0 to 10hours are displayed in the top panel, while the left and right bottom panels display components with periods of 10 to 14 hours and greater than 14 hours respectively.
- Amplitudes for each component are indicated by the bar graph, while the phase of each component is indicated by the pie chart above each amplitude bar.
- The period associated with each component is indicated below the amplitude bar.

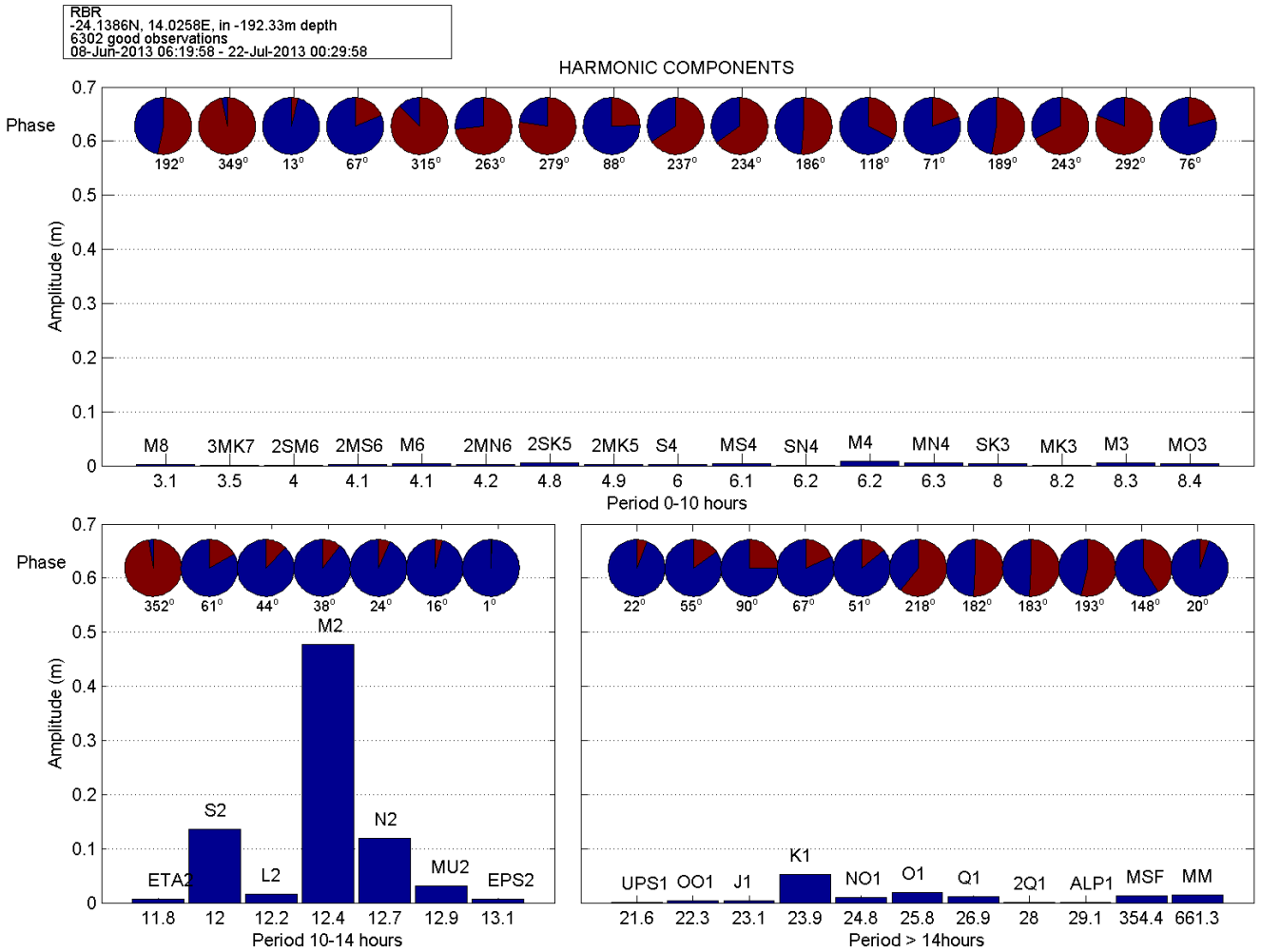


Figure 32: Graphical representation of the tidal harmonic components presented in Table 15.

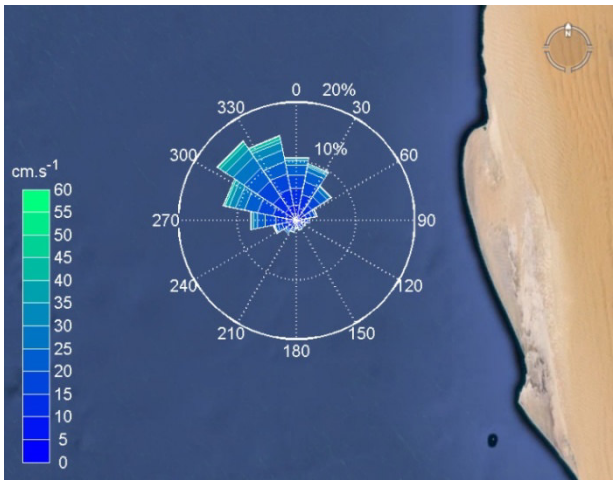
5 DISCUSSION

Metocean Services International (Pty) Limited (MSI) has been awarded a contract by Lwandle Technologies, under sub contract from Namibian Marine Phosphate (Pty) Ltd (NMP), to deploy an oceanographic mooring offshore Namibia. NMP intends dredging marine phosphate reserves at the site and requires verification of previous studies regarding the behaviour of the water column and sediment re-suspension events. Current measurements throughout the water column were undertaken with an ADCP and two single point current meters and water quality measurements were undertaken with a CTD near the seabed. Data collected during the first measurement period (nominally from 8 June 2013 to 26 July 2013) are presented in this report. Data return was good, however the upper AQD and CTD stopped logging data shortly before recovery as a result of depleted batteries.

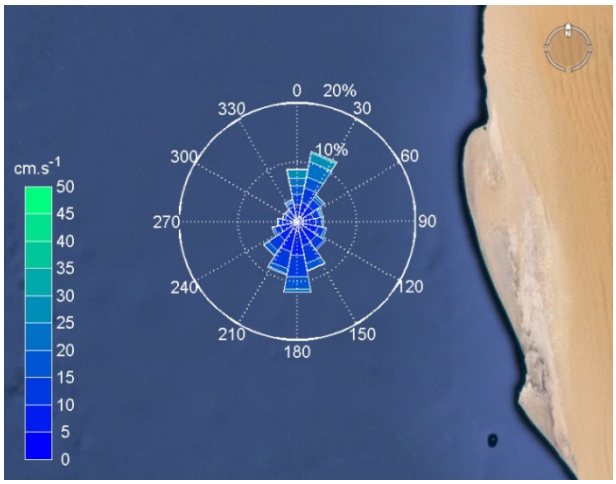
Current speeds at the measurement location were low, with maximum speeds not exceeding 60 $cm.s^{-1}$ and maximum current speeds exceeding 50 $cm.s^{-1}$ above approximately 8m depth only. Near the seabed, a maximum current speed of 43 $cm.s^{-1}$ was recorded. Mean current speeds showed a general decrease with depth from a mean current speed of 17 $cm.s^{-1}$ at a depth of 7 m to mean speeds of approximately 10 $cm.s^{-1}$ in the mid water column. Near the seabed, mean current speeds show a significant increase with a mean speed of 18 $cm.s^{-1}$ determined at 193 m depth. Current flow was primarily towards the WNW to N sectors in the upper water column, with secondary SW to WSW flow apparent at a depth of 94 m. At a depth of 148 m, SSE to SSW flow was more prevalent with N to NNE flow becoming secondary. Near the seabed current flow was predominantly towards the S to WSW sectors. An overview of current directions at depths of 7 m, 148 m and 193 m is presented in Figure 33. A contour plot of the northward and eastward current velocity components throughout the water column is included in Figure 34 below. High current speed events occurred around 15 and 16 June and 21 July 2013, with increased speeds most notable in the northward velocity component. Maximum current speeds were recorded at most depths during these events.

Water temperature at the measurement location ranged between a maximum of 14˚C at a depth of 97 m to a minimum of 10˚C near the seabed. The temperature records at 97 m depth and near the seabed showed temperature ranges of 1.8˚C, while the temperature range at 148 m was smaller, at 1.4˚C. Mean temperatures decreased from 12˚C at 100 m to 11˚C near the seabed. A contour plot of the temperature recorded throughout the water column is included as Figure 35 below. A significant cooling event occurred near the seabed between 14 June and 25 June 2013 which was evident in both the AQD and CTD data sets. This cooling event was associated with northward current flow near the seabed, in contrast to the predominantly southward currents at this depth. Dissolved oxygen concentration reached a maximum of 34.31 $\mu mol.l^{-1}$ during this event, while the mean over the measurement period was 9.15 $\mu mol.l^{-1}$. A maximum fluorescence of 0.42 $\mu g.l^{-1}$ was recorded during a period of low oxygen concentration in early July, with over 90% of values recorded below 0.1 $\mu g.l^{-1}$. Salinity ranged between 32.24 psu and 35.11 psu with a mean of 35 psu. Turbidity was low for much of the measurement period with a mean turbidity of 2.86 NTU, however intermittent increases were noted, with turbidity values exceeding 350NTU on two occasions. A tidal range of approximately 1.7 m was calculated for this location, with the height measured by the CTD ranging between -0.81 m and 0.89 m. The dominant tidal constituents were determined to be M_2, S_2 and N_2 with amplitudes of 0.48 m, 0.14 m and 0.12 m respectively.

NEAR SURFACE CURRENTS (-7m)



MID WATER COLUMN CURRENTS (-148m)



NEAR SEABED CURRENTS (-193m)

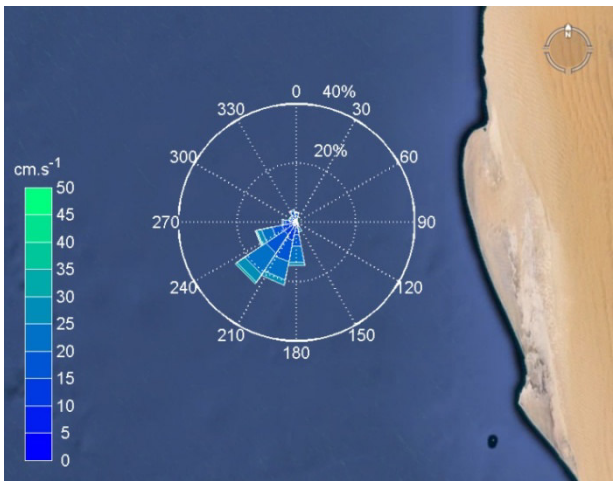


Figure 33: Overview of current directions recorded in the upper, mid and lower water column respectively. Current speeds are indicated by the colour scale.

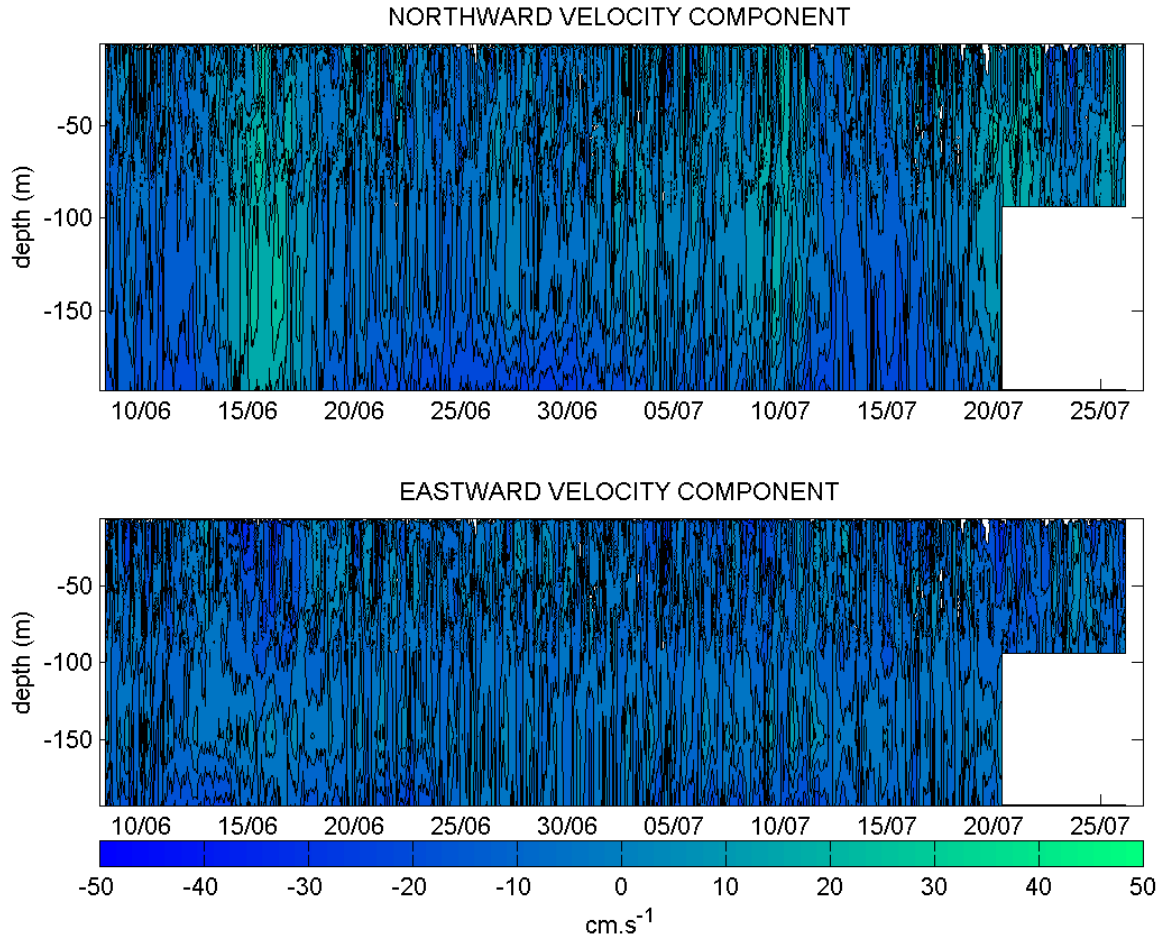


Figure 34: Time series of hourly mean current velocity throughout the water column. The upper panel is the northward velocity component in cm.s^{-1} (negative blue values indicate southward flow and positive green values indicate northward flow) while the eastward component is in the lower panel. White patches indicate missing data.

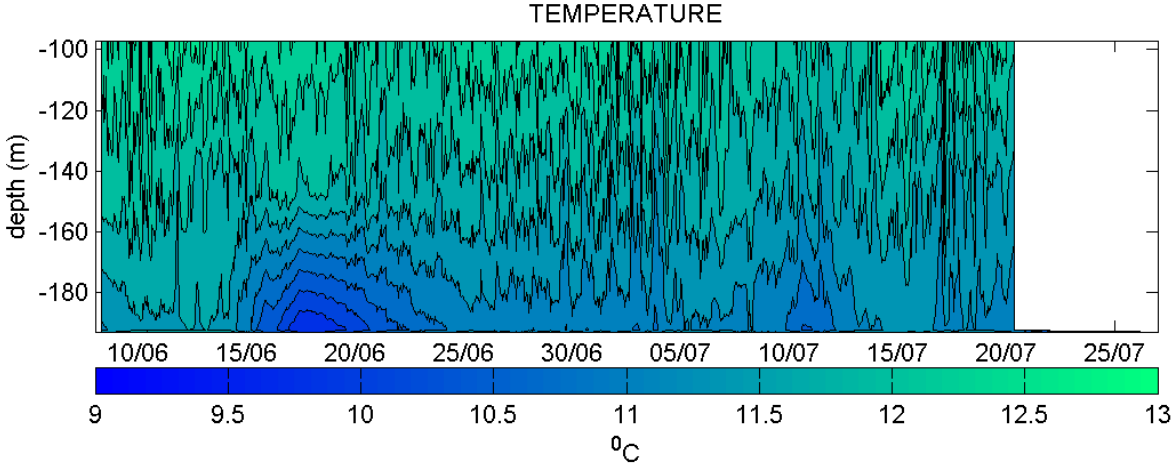


Figure 35: Time series of hourly mean temperature throughout the water column. White patches indicate missing data.