APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT

1.9 Instrument Mooring Report: Day 45 to 90

NAMIBIAN MARINE PHOSPHATE

VERIFICATION SURVEY

DATA REPORT

Day 45 to 90

Prepared for:
Namibian Marine Phosphate (Pty) Ltd.

Prepared by:

October 2014

Project: 267

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REVISION HISTORY

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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 second and final measurement period (nominally from 2 August 2013 to 13 Sep 2013) are presented in this section, together with an indication of the data return achieved. Data return was good, with all instruments returning complete datasets, however no dissolved oxygen data was recorded by the CTD (Tables 1 – 4).

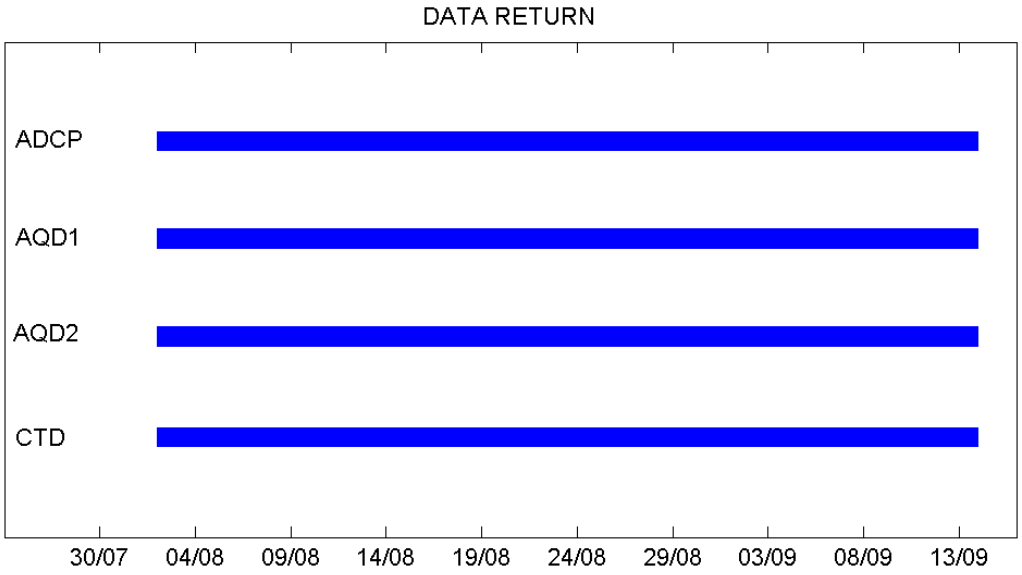


Figure 1: Data return for the measurement period for each instrument. Every day for which greater than 50% data return was achieved is marked in colour.

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	-6.2	02/08/13	13/09/13	72.00	68.38	325.94	04/09/13	22.29	9.60	14.34	334.22
ADCP	-7.2	02/08/13	13/09/13	86.91	56.59	284.52	06/09/13	19.25	9.08	11.79	332.03
ADCP	-8.2	02/08/13	13/09/13	89.21	66.09	322.92	05/09/13	18.33	9.02	10.77	323.81
ADCP	-9.2	02/08/13	13/09/13	91.22	54.17	340.78	15/08/13	16.63	8.40	8.99	316.31
ADCP	-10.2	02/08/13	13/09/13	93.03	53.45	272.75	06/09/13	16.03	8.09	8.47	314.10
ADCP	-11.2	02/08/13	13/09/13	94.69	51.58	273.87	06/09/13	15.77	7.89	8.24	313.66
ADCP	-12.2	02/08/13	13/09/13	96.12	53.48	276.72	06/09/13	15.56	7.75	8.12	313.74
ADCP	-13.2	02/08/13	13/09/13	97.30	52.83	275.14	06/09/13	15.32	7.58	7.93	314.19
ADCP	-14.2	02/08/13	13/09/13	97.76	52.35	272.56	06/09/13	15.13	7.46	7.82	314.89
ADCP	-15.2	02/08/13	13/09/13	98.21	50.75	275.62	06/09/13	15.00	7.38	7.75	315.18
ADCP	-16.2	02/08/13	13/09/13	98.60	49.54	270.55	06/09/13	14.86	7.29	7.67	315.68
ADCP	-17.2	02/08/13	13/09/13	98.83	49.52	274.06	06/09/13	14.76	7.21	7.59	316.50
ADCP	-18.2	02/08/13	13/09/13	99.01	47.37	273.15	06/09/13	14.60	7.18	7.51	316.91
ADCP	-19.2	02/08/13	13/09/13	99.21	47.60	268.20	06/09/13	14.53	7.17	7.43	317.49
ADCP	-20.2	02/08/13	13/09/13	99.29	45.98	273.45	06/09/13	14.40	7.12	7.33	317.84
ADCP	-21.2	02/08/13	13/09/13	99.36	45.32	268.08	06/09/13	14.26	7.06	7.22	318.68
ADCP	-22.2	02/08/13	13/09/13	99.46	47.68	269.66	06/09/13	14.15	7.02	7.09	319.36
ADCP	-23.2	02/08/13	13/09/13	99.51	45.60	266.72	06/09/13	14.01	6.98	7.05	319.78
ADCP	-24.2	02/08/13	13/09/13	99.62	46.45	269.67	06/09/13	13.90	6.97	6.97	320.60
ADCP	-25.2	02/08/13	13/09/13	99.79	44.94	265.72	06/09/13	13.73	6.97	6.84	320.99
ADCP	-26.2	02/08/13	13/09/13	99.85	42.93	272.12	06/09/13	13.57	6.94	6.76	321.87
ADCP	-27.2	02/08/13	13/09/13	99.88	43.48	266.87	06/09/13	13.44	6.94	6.68	322.12
ADCP	-28.2	02/08/13	13/09/13	99.90	43.99	273.89	06/09/13	13.29	6.89	6.59	322.44

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	-29.2	02/08/13	13/09/13	99.97	42.43	267.99	06/09/13	13.16	6.89	6.54	323.38
ADCP	-30.2	02/08/13	13/09/13	100.00	41.96	265.49	06/09/13	13.00	6.86	6.45	323.80
ADCP	-31.2	02/08/13	13/09/13	100.00	41.90	265.78	06/09/13	12.87	6.82	6.37	324.15
ADCP	-32.2	02/08/13	13/09/13	100.00	43.26	270.75	06/09/13	12.76	6.78	6.32	324.81
ADCP	-33.2	02/08/13	13/09/13	100.00	43.03	359.05	07/08/13	12.62	6.75	6.31	325.26
ADCP	-34.2	02/08/13	13/09/13	100.00	45.96	2.54	07/08/13	12.58	6.73	6.32	325.83
ADCP	-35.2	02/08/13	13/09/13	100.00	42.52	2.15	07/08/13	12.45	6.68	6.28	326.71
ADCP	-36.2	02/08/13	13/09/13	100.00	39.94	273.27	06/09/13	12.37	6.61	6.24	327.31
ADCP	-37.2	02/08/13	13/09/13	100.00	40.96	262.91	06/09/13	12.31	6.53	6.26	327.38
ADCP	-38.2	02/08/13	13/09/13	100.00	39.48	266.73	06/09/13	12.18	6.52	6.22	327.80
ADCP	-39.2	02/08/13	13/09/13	100.00	39.79	260.96	06/09/13	12.14	6.52	6.25	328.38
ADCP	-40.2	02/08/13	13/09/13	100.00	38.37	263.27	06/09/13	12.06	6.47	6.23	329.00
ADCP	-41.2	02/08/13	13/09/13	100.00	39.46	276.89	06/09/13	11.98	6.44	6.27	329.54
ADCP	-42.2	02/08/13	13/09/13	100.00	39.13	267.13	06/09/13	11.89	6.42	6.25	329.90
ADCP	-43.2	02/08/13	13/09/13	100.00	39.42	343.30	02/09/13	11.86	6.46	6.33	330.71
ADCP	-44.2	02/08/13	13/09/13	100.00	39.58	272.07	06/09/13	11.78	6.46	6.34	331.06
ADCP	-45.2	02/08/13	13/09/13	100.00	38.23	339.02	02/09/13	11.69	6.47	6.35	331.68
ADCP	-46.2	02/08/13	13/09/13	100.00	37.23	276.59	06/09/13	11.58	6.50	6.33	332.04
ADCP	-47.2	02/08/13	13/09/13	100.00	40.28	277.50	06/09/13	11.51	6.51	6.36	332.57
ADCP	-48.2	02/08/13	13/09/13	100.00	39.85	270.31	23/08/13	11.43	6.54	6.37	332.82
ADCP	-49.2	02/08/13	13/09/13	100.00	39.29	272.20	23/08/13	11.33	6.55	6.39	333.09
ADCP	-50.2	02/08/13	13/09/13	99.98	40.85	337.88	04/09/13	11.29	6.56	6.42	333.46
ADCP	-51.2	02/08/13	13/09/13	99.98	40.84	336.03	04/09/13	11.20	6.58	6.45	333.38
ADCP	-52.2	02/08/13	13/09/13	99.98	40.96	335.06	04/09/13	11.16	6.60	6.51	333.38

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	-53.2	02/08/13	13/09/13	99.98	40.94	335.20	04/09/13	11.12	6.57	6.51	332.74
ADCP	-54.2	02/08/13	13/09/13	99.98	40.29	341.49	04/09/13	11.09	6.59	6.49	332.45
ADCP	-55.2	02/08/13	13/09/13	99.98	39.10	332.33	04/09/13	11.08	6.56	6.55	332.58
ADCP	-56.2	02/08/13	13/09/13	99.98	41.57	330.56	04/09/13	11.05	6.54	6.56	332.37
ADCP	-57.2	02/08/13	13/09/13	99.97	41.80	346.15	04/09/13	11.05	6.55	6.56	331.98
ADCP	-58.2	02/08/13	13/09/13	100.00	42.03	343.15	04/09/13	11.03	6.54	6.59	331.59
ADCP	-59.2	02/08/13	13/09/13	100.00	42.45	348.03	04/09/13	10.99	6.56	6.56	331.76
ADCP	-60.2	02/08/13	13/09/13	100.00	41.20	352.30	04/09/13	11.00	6.54	6.62	331.39
ADCP	-61.2	02/08/13	13/09/13	100.00	44.22	347.15	04/09/13	10.99	6.50	6.58	331.31
ADCP	-62.2	02/08/13	13/09/13	100.00	44.07	348.58	04/09/13	10.94	6.51	6.55	330.90
ADCP	-63.2	02/08/13	13/09/13	100.00	44.93	349.67	04/09/13	10.95	6.54	6.57	330.30
ADCP	-64.2	02/08/13	13/09/13	100.00	44.06	354.47	04/09/13	10.92	6.53	6.58	330.17
ADCP	-65.2	02/08/13	13/09/13	100.00	43.92	347.03	04/09/13	10.93	6.49	6.57	329.66
ADCP	-66.2	02/08/13	13/09/13	100.00	44.95	354.29	04/09/13	10.90	6.49	6.55	328.92
ADCP	-67.2	02/08/13	13/09/13	100.00	45.05	352.47	04/09/13	10.86	6.48	6.52	328.53
ADCP	-68.2	02/08/13	13/09/13	100.00	44.54	342.89	04/09/13	10.87	6.47	6.47	327.96
ADCP	-69.2	02/08/13	13/09/13	99.98	46.00	345.95	04/09/13	10.85	6.42	6.46	327.26
ADCP	-70.2	02/08/13	13/09/13	99.97	45.51	346.72	04/09/13	10.83	6.41	6.42	326.54
ADCP	-71.2	02/08/13	13/09/13	99.97	44.30	344.69	04/09/13	10.78	6.38	6.36	325.80
ADCP	-72.2	02/08/13	13/09/13	99.97	43.71	346.38	04/09/13	10.79	6.39	6.34	325.00
ADCP	-73.2	02/08/13	13/09/13	99.97	44.44	347.78	04/09/13	10.74	6.37	6.30	324.18
ADCP	-74.2	02/08/13	13/09/13	99.97	44.35	340.68	04/09/13	10.68	6.35	6.28	323.28
ADCP	-75.2	02/08/13	13/09/13	99.98	44.92	343.67	04/09/13	10.69	6.31	6.25	322.58
ADCP	-76.2	02/08/13	13/09/13	100.00	43.79	349.00	04/09/13	10.67	6.31	6.22	321.17

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	-77.2	02/08/13	13/09/13	100.00	44.60	345.20	04/09/13	10.62	6.29	6.18	320.43
ADCP	-78.2	02/08/13	13/09/13	100.00	45.40	345.21	04/09/13	10.60	6.25	6.15	319.74
ADCP	-79.2	02/08/13	13/09/13	100.00	44.57	336.17	04/09/13	10.59	6.21	6.17	318.85
ADCP	-80.2	02/08/13	13/09/13	100.00	44.97	334.05	04/09/13	10.57	6.19	6.13	318.36
ADCP	-81.2	02/08/13	13/09/13	100.00	43.93	340.89	04/09/13	10.50	6.17	6.09	317.39
ADCP	-82.2	02/08/13	13/09/13	100.00	42.58	335.05	04/09/13	10.46	6.10	6.06	316.69
ADCP	-83.2	02/08/13	13/09/13	100.00	43.38	337.78	04/09/13	10.41	6.10	6.04	316.01
ADCP	-84.2	02/08/13	13/09/13	100.00	42.19	341.53	04/09/13	10.32	6.03	5.95	315.39
ADCP	-85.2	02/08/13	13/09/13	100.00	42.84	339.30	04/09/13	10.28	6.01	5.96	314.74
ADCP	-86.2	02/08/13	13/09/13	100.00	43.28	334.41	04/09/13	10.19	5.99	5.90	313.38
ADCP	-87.2	02/08/13	13/09/13	100.00	41.17	334.98	04/09/13	10.12	5.93	5.89	312.95
ADCP	-88.2	02/08/13	13/09/13	100.00	40.78	334.88	04/09/13	10.06	5.88	5.87	312.13
ADCP	-89.2	02/08/13	13/09/13	100.00	40.82	333.17	04/09/13	10.08	5.86	5.93	311.45
ADCP	-90.2	02/08/13	13/09/13	100.00	40.80	333.31	04/09/13	10.14	5.82	6.00	312.30
AQD1	-141.8	02/08/13	13/09/13	100.00	33.81	33.61	04/09/13	9.33	5.53	1.97	48.33
AQD2	-187.9	02/08/13	13/09/13	99.87	26.67	30.67	04/09/13	8.81	4.63	0.14	46.62

Table 2: Temperature summary

Instrument	Mean Depth (m)	Data Return (%)	Max (°C)	Mean (°C)	Min (°C)
ADCP	-93	99.95	12.71	11.72	10.92
AQD1	-142	99.93	12.00	11.23	10.72
AQD2	-188	99.92	11.43	10.94	10.51
CTD	-188	100.00	11.21	10.71	10.29

Table 3: Pressure summary

Instrument	Mean Depth (m)	Data Return (%)	Max (Bar)	Mean (Bar)	Min (Bar)
ADCP	-93	100.00	9.46	9.38	9.29
AQD1	-142	100.00	14.32	14.23	14.15
AQD2	-188	100.00	18.94	18.85	18.77
CTD	-188	100.00	18.91	18.81	18.73

Table 4: CTD summary

Parameter	Unit	Data Return (%)	Max	Mean	Min
Temperature	˚C	100.00	11.21	10.71	10.29
Conductivity	$S.m^{-1}$	100.00	39.93	39.27	31.23
Salinity	psu	96.51	35.62	35.53	35.43
Depth	m	100.00	-186.62	-187.48	-188.40
Dissolved Oxygen	$\mu mol.l^{-1}$	0.00	-	-	-
Fluorescence	$\mu g.l^{-1}$	99.84	0.78	0.01	0.00
Turbidity	NTU	99.90	1316.51	17.26	0.39
Height	m	100.00	0.92	0.00	-0.86

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 second and final measurement period (nominally from 2 August 2013 to 13 September 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 metres (m) referenced to mean sea level.
OBS	Optical back-scatter sensor
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' 19.32" S	14° 01' 32.88" E	~ 193 m
*(Position calculated using slant-range position & depth information)			

Figure 2: Oceanographic measurement location offshore Namibia.

2.4 MOORING CONFIGURATION

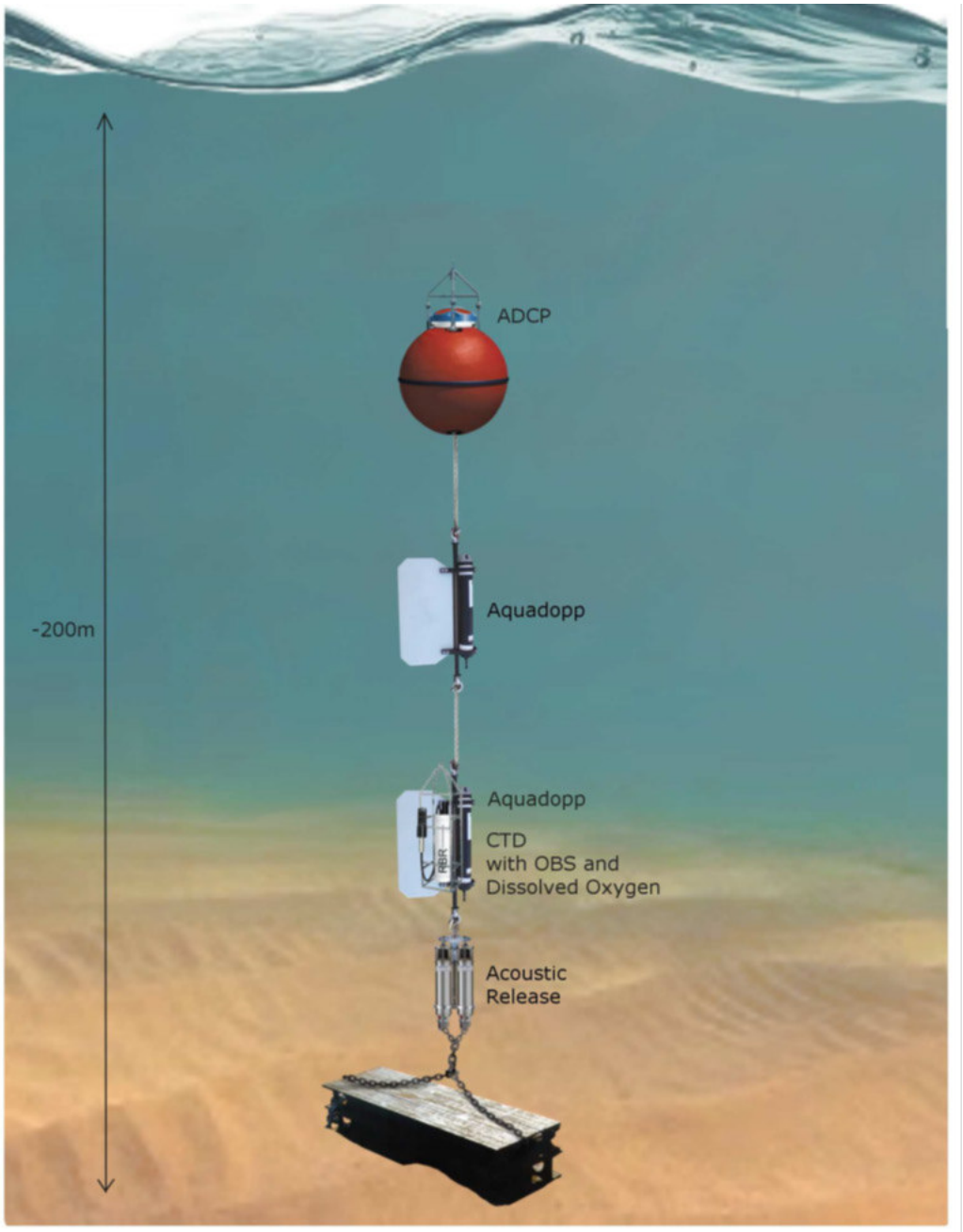


Figure 3: Mooring configuration.

2.5 EQUIPMENT CONFIGURATION

Table 7: TRDI 300 kHz 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	1 m
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	0.50m	0.35m
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: RBR 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 -14.6682°. 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. Beam correlation dropped below the threshold intermittently throughout the measurement period in the uppermost bins which resulted in reduced data return for these bins.
- 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 with the centre

point. A tolerance of 50 $cm.s^{-1}$ was allowed. Outliers identified by this method were then examined visually 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 90% data return was presented as representative of the near-surface currents.

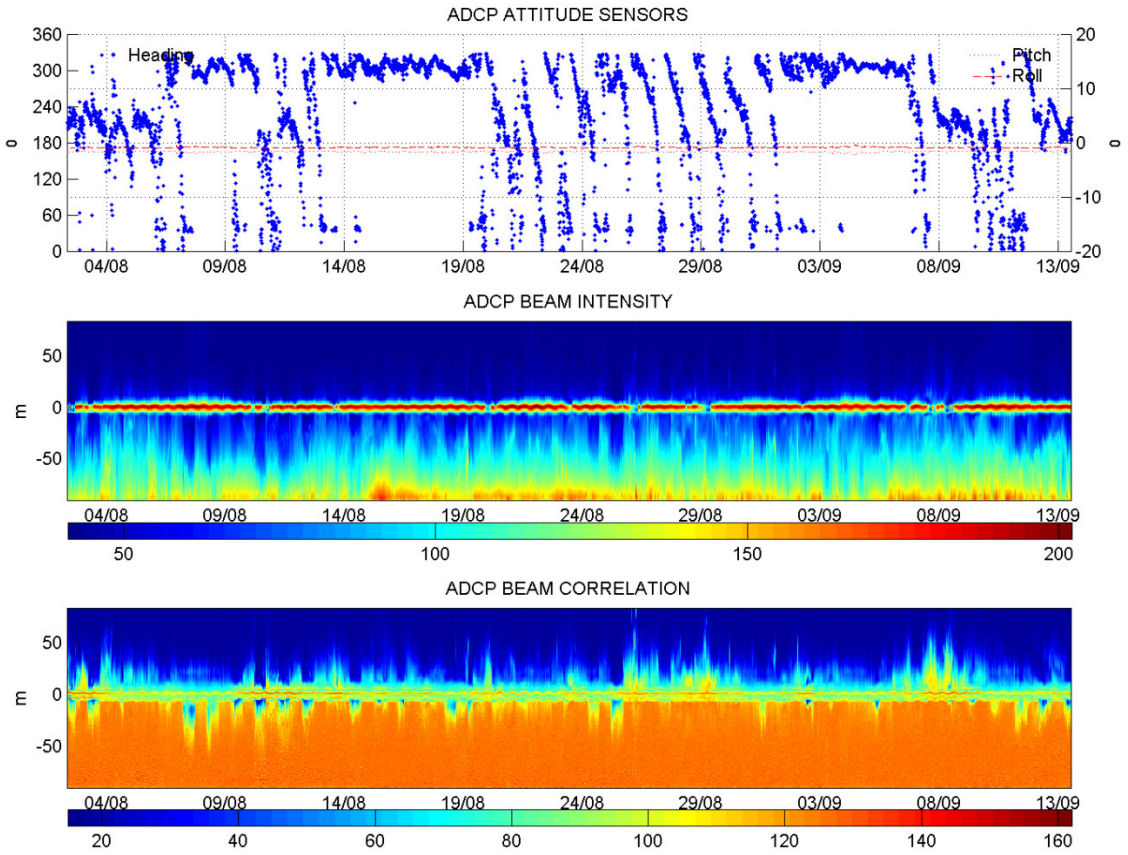


Figure 4: Quality control data from the ADCP.
The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The middle panel shows the time-series of ADCP beam intensity through the water column, while the lower panel shows similar information 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 -14.6682°. 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 examined visually 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 2 showed unusual data which did not compare well to data recorded during the previous deployment. Visual inspection of the signal strength from the individual beams showed some unusual characteristics in the data from beam 1 (please see Figure 7). This may have been caused by a fault in the transducer. As a result, the data was re-processed using the Nortek Storm software using a two-beam solution which excluded Beam 1 from the calculation. The data were then imported into Matlab and the quality control measures outlined above were applied. Note that the calculation of velocity using a two-beam solution requires the assumption that the vertical velocity is zero. As the instrument was moored, this assumption may have incorrectly influenced the calculated velocities for some data records. The velocity data from AQD 2 should therefore be viewed with caution. A comparison of the speed and direction data calculated using the two-beam and three-beam solutions is included as Figure 8.)

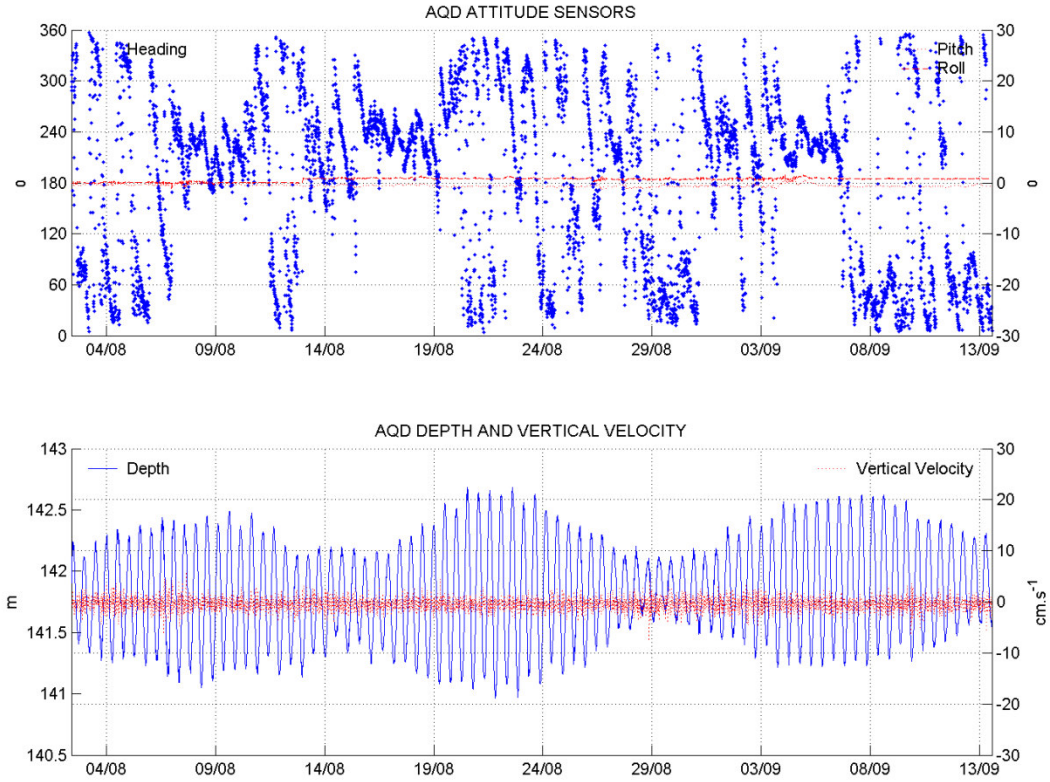


Figure 5: Quality control data from AQD 1.
The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The lower panel shows the depth (scaled to the left axis) and the vertical velocity (scaled to the right axis).

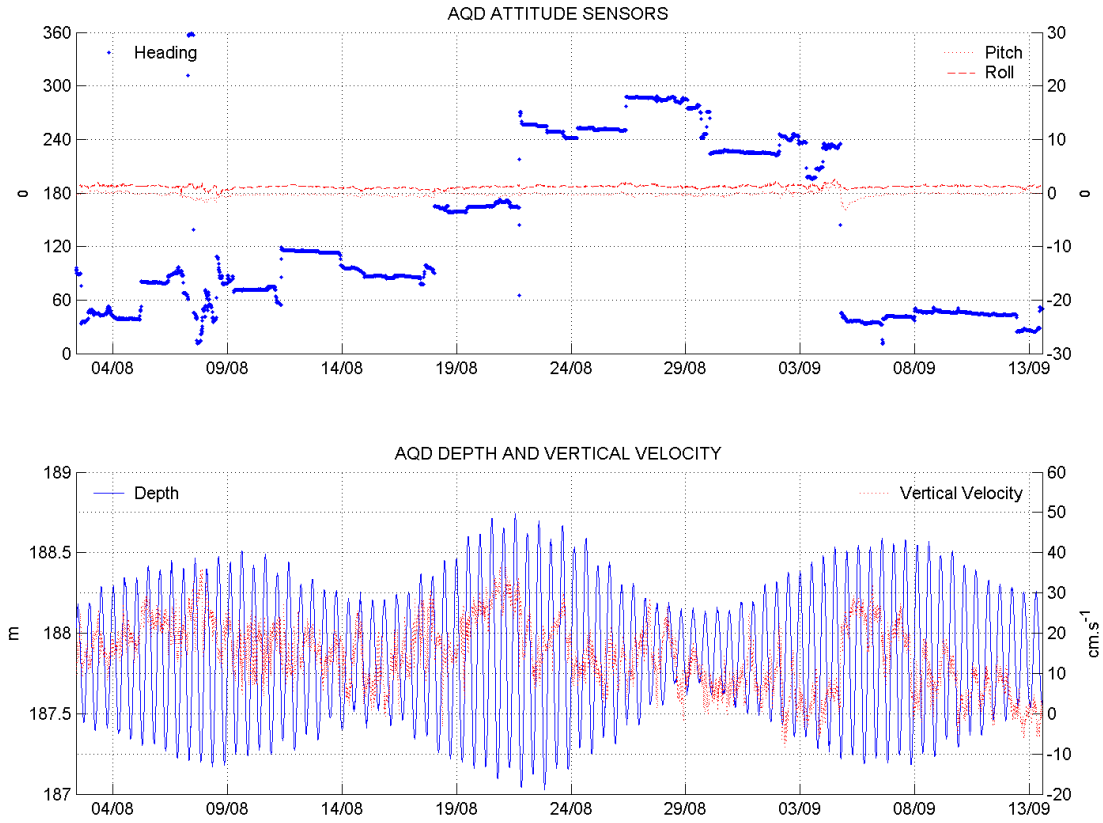


Figure 6: Quality control data from AQD 2.
The upper panel shows the sensor attitude data (heading scaled to the left axis and pitch and roll to the right axis). The lower panel shows the depth (scaled to the left axis) and the vertical velocity (scaled to the right axis).

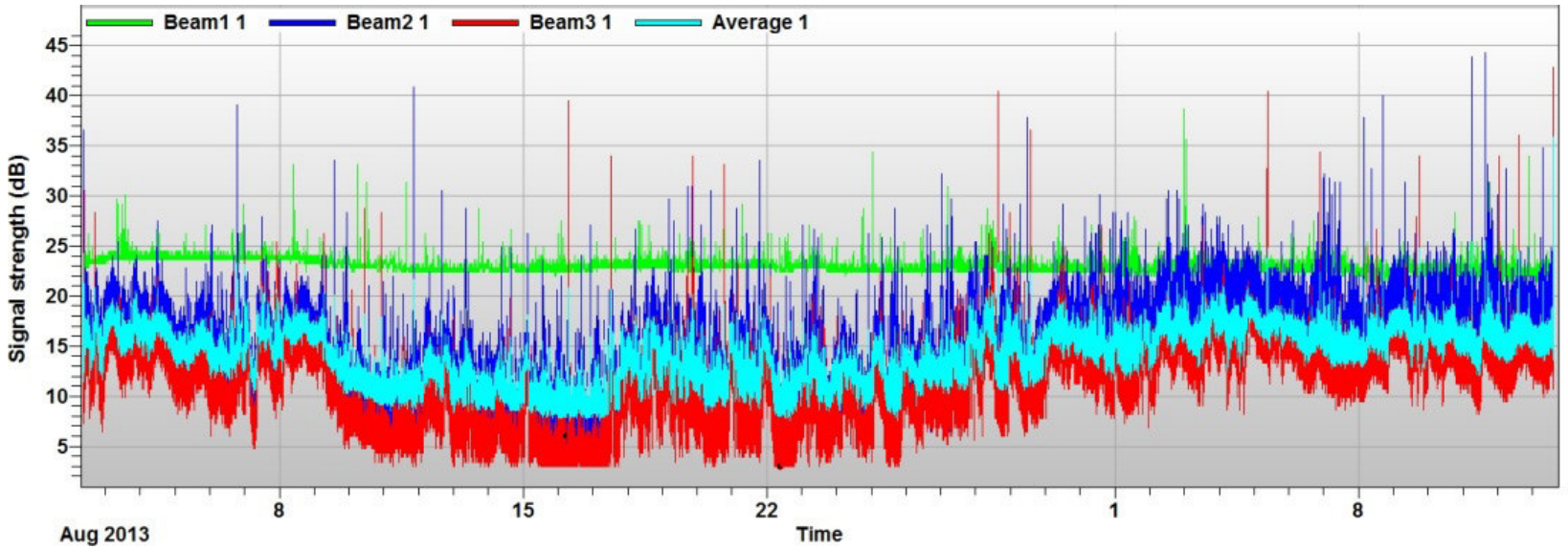


Figure 7: Plot exported from the Nortek Storm Software comparing the signal strength from each beam from AQD 2 during the deployment.

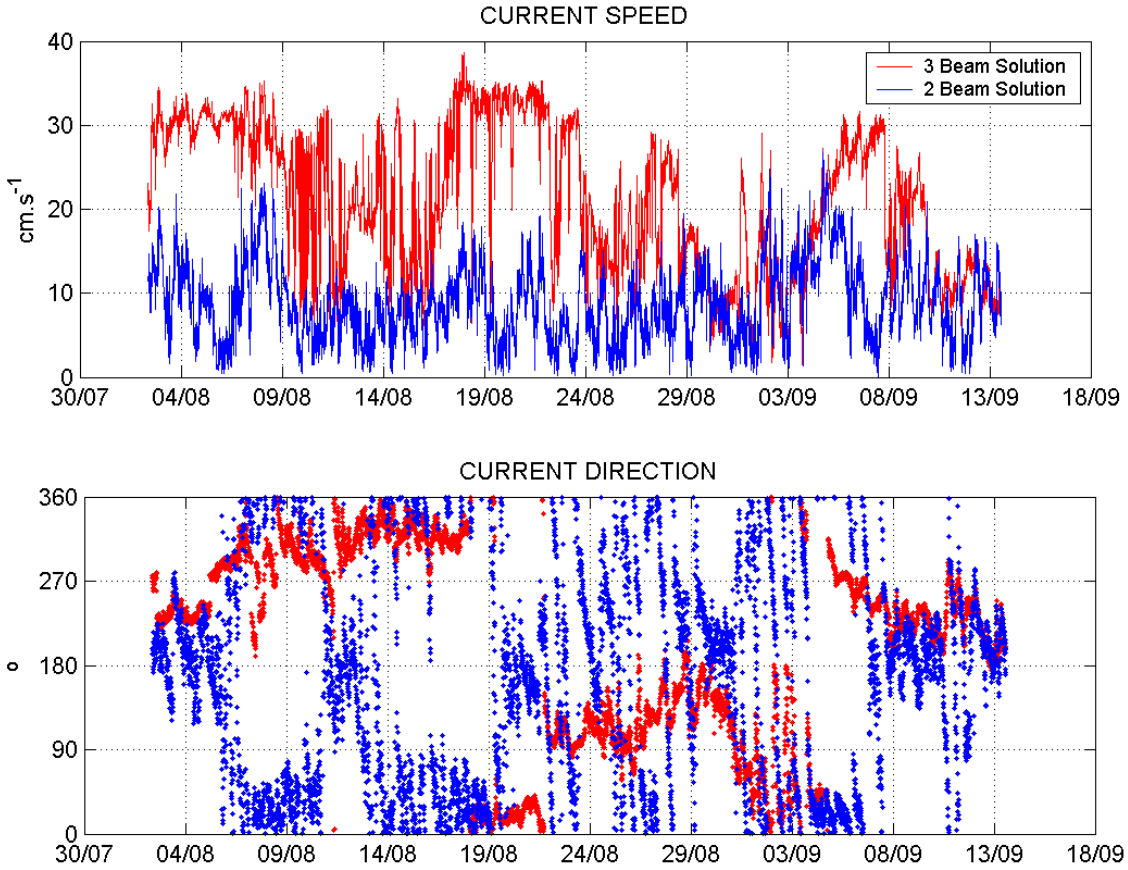


Figure 8: Comparison of speed and direction data from AQD 2.
Data processed using the standard three-beam solution (plotted in red) and a two-beam solution which excluded Beam 1 (plotted in blue).

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 1psu was allowed. For turbidity, a tolerance of 250 NTU was allowed.
- 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 examined visually 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.
- No dissolved oxygen data were recorded by the RBR CTD. This may be the result of a failure of the oxygen sensor.
- 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.

4 DATA PRESENTATION

4.1 ADCP

4.1.1 Current Data

4.1.1.1 Time series plots

Figures 9 to 11 display time series plots for the depths: -9 m, -50 m and -90 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.

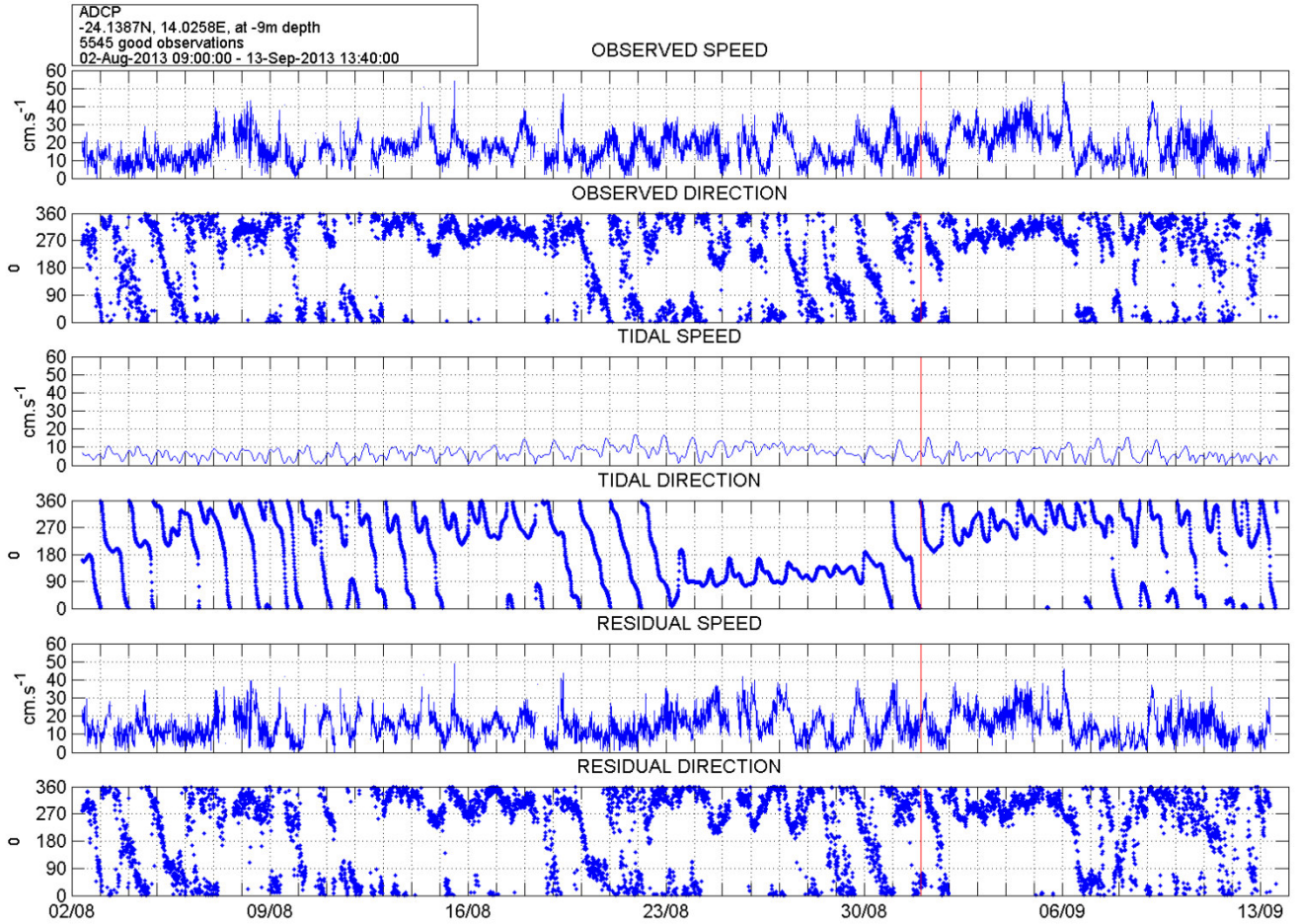


Figure 9: Current time series data for 9 m depth

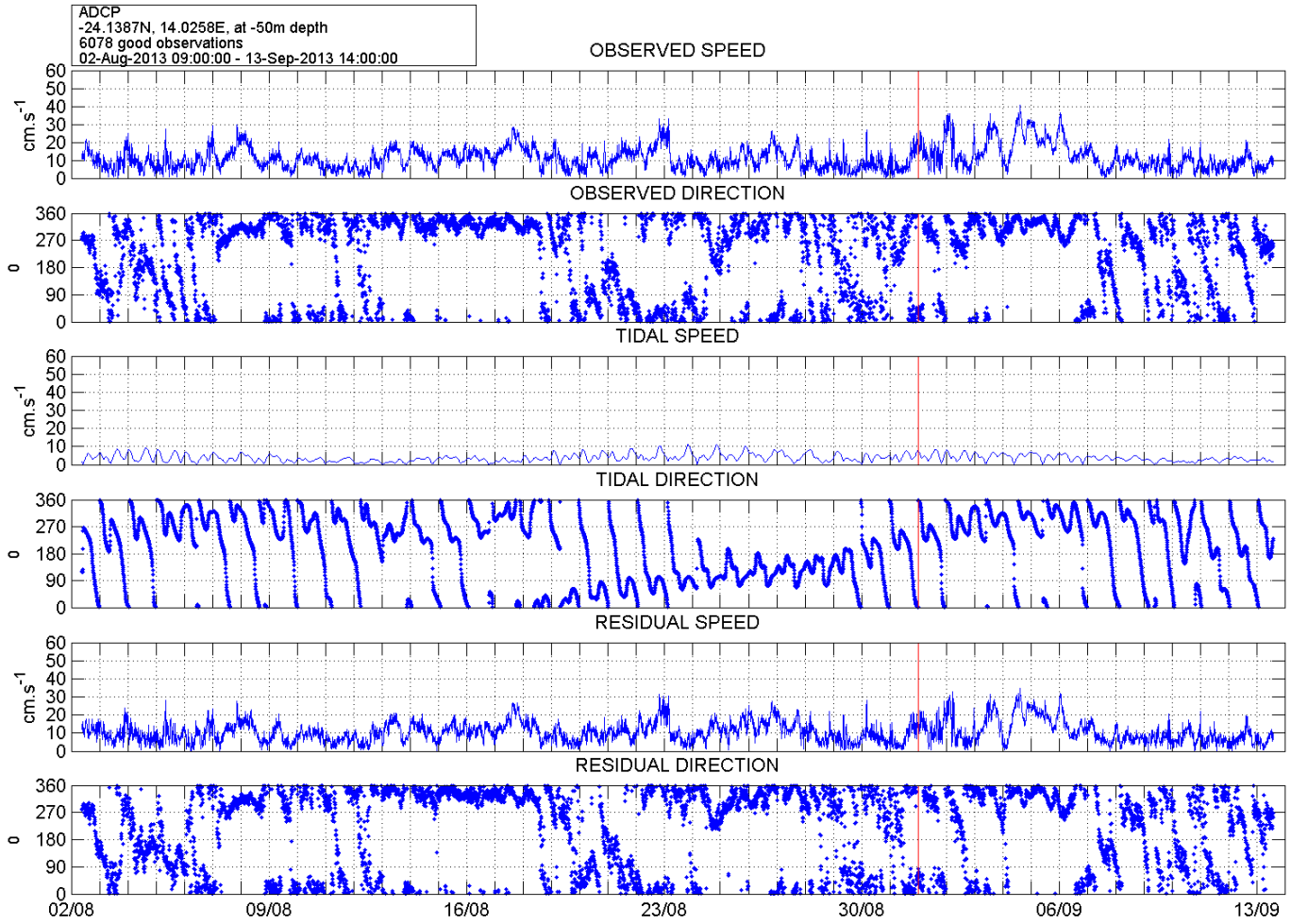


Figure 10: Current time series for 50 m depth

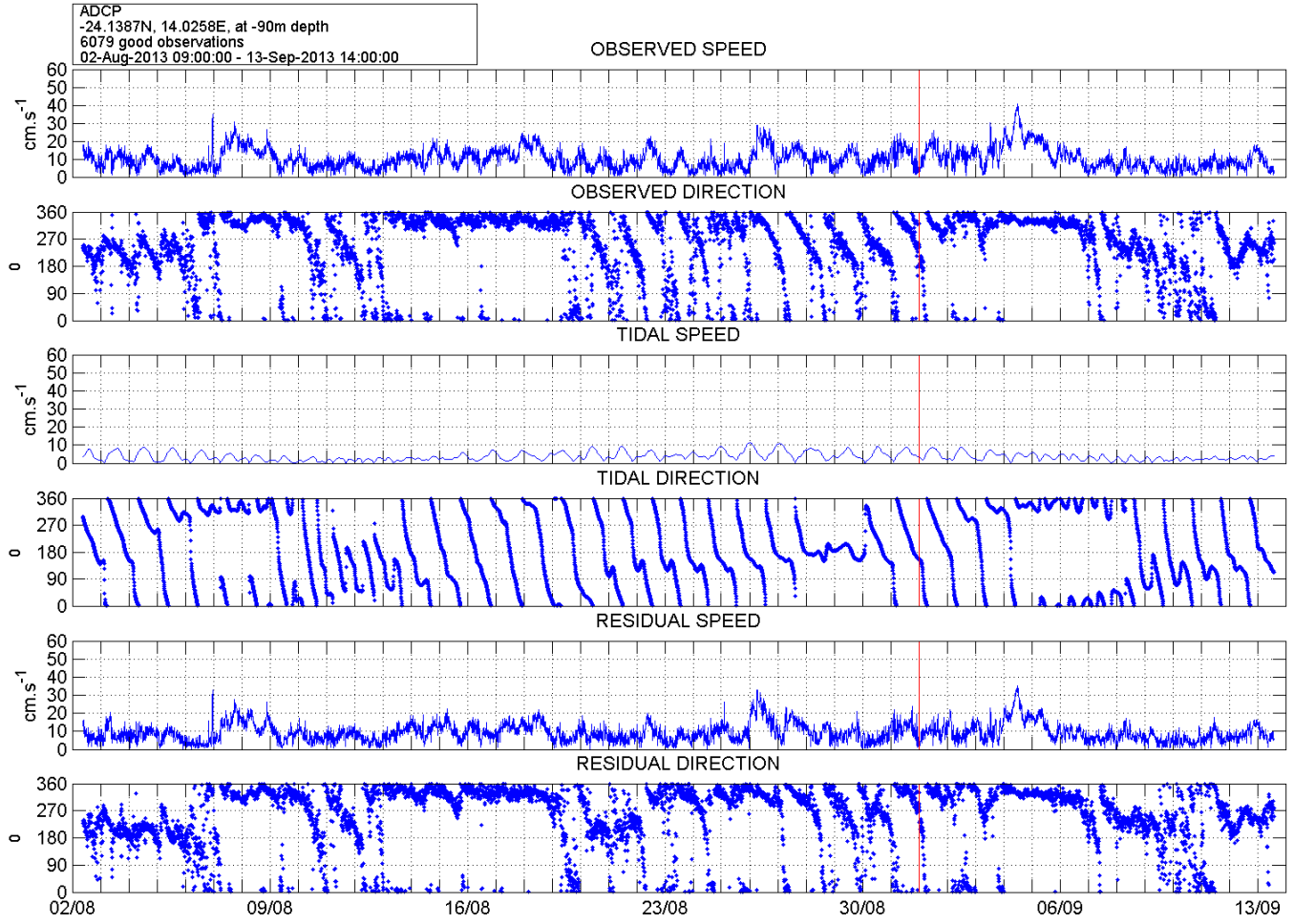


Figure 11: Current time series for 90 m depth

4.1.1.2 Summary plots

Figures 12 to 14 display summary plots of the current depths at: -9 m, -50 m and -90 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 indicates 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
-24.1387N, 14.0258E, at -9m depth
5545 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 13:40:00

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	0.40	0.38	0.29	0.27	0.47	0.20	0.25	0.36	0.29	0.38	0.34	0.36	0.41	0.34	0.49	0.41	5.64
5-10	1.55	1.30	1.15	0.81	0.76	0.79	0.74	0.76	0.58	0.72	0.96	1.24	1.28	1.95	1.91	1.44	17.94
10-15	2.47	1.86	0.97	0.92	0.61	0.96	0.83	0.65	0.50	0.43	0.76	1.57	2.31	2.80	3.41	2.71	23.75
15-20	2.09	1.82	1.12	0.99	0.27	0.32	0.27	0.27	0.23	0.43	0.70	1.23	1.79	2.47	3.77	3.05	20.83
20-25	1.21	1.42	1.12	0.50	0.25	0.02		0.02	0.13	0.52	1.01	0.97	1.41	2.18	2.81	1.95	15.53
25-30	0.63	0.87	0.34	0.20		0.02	0.02		0.11	0.32	0.31	0.81	1.03	1.84	1.48	1.15	9.13
30-35	0.31	0.41	0.04						0.02	0.07	0.11	0.31	0.49	1.01	0.96	0.54	4.26
35-40	0.31	0.18								0.04	0.02	0.16	0.32	0.38	0.49	0.34	2.24
40-45	0.02											0.04	0.14	0.04	0.14	0.13	0.50
45-50													0.04	0.04			0.07
50-55													0.07	0.02		0.02	0.11
55-60																	0.00
Σ	8.98	8.24	5.03	3.70	2.36	2.31	2.11	2.06	1.86	2.92	4.20	6.69	9.29	13.06	15.46	11.74	100.00

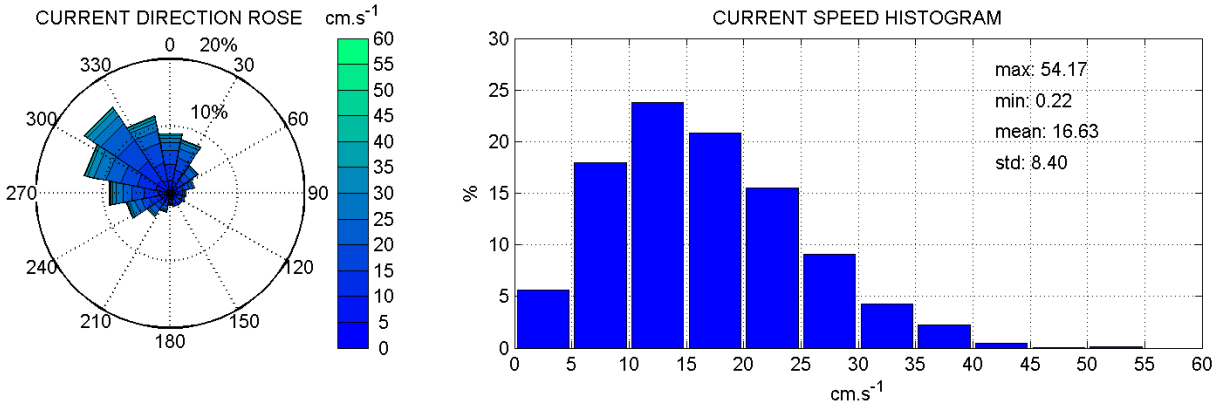


Figure 12: Summary of current data at 9 mm depth

ADCP
-24.1387N, 14.0258E, at -50m depth
6078 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 14:00:00

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	1.33	1.17	0.66	0.63	0.76	0.59	0.71	0.79	0.97	0.71	0.77	0.87	1.09	1.50	1.53	1.60	15.66
5-10	3.47	2.57	1.66	1.25	1.18	0.97	0.81	0.92	0.82	1.20	1.50	1.97	2.58	3.36	4.71	4.13	33.10
10-15	3.46	2.07	1.46	1.53	1.18	0.67	0.56	0.36	0.58	0.43	0.66	1.05	1.84	3.24	4.79	3.95	27.84
15-20	1.96	1.28	1.07	0.51	0.26	0.30	0.08	0.08	0.07		0.07	0.31	0.86	1.40	2.44	2.76	13.44
20-25	0.48	0.61	0.30	0.05	0.05	0.05	0.03	0.02			0.02	0.10	0.28	0.71	1.37	1.38	5.43
25-30	0.23	0.26	0.15			0.02						0.02	0.28	0.35	0.61	0.99	2.90
30-35	0.15	0.02											0.10	0.08	0.26	0.76	1.37
35-40	0.02												0.05	0.02	0.02	0.15	0.25
40-45																0.02	0.02
45-50																	0.00
50-55																	0.00
55-60																	0.00
Σ	11.09	7.98	5.30	3.97	3.44	2.60	2.19	2.17	2.44	2.34	3.01	4.33	7.07	10.64	15.71	15.73	100.00

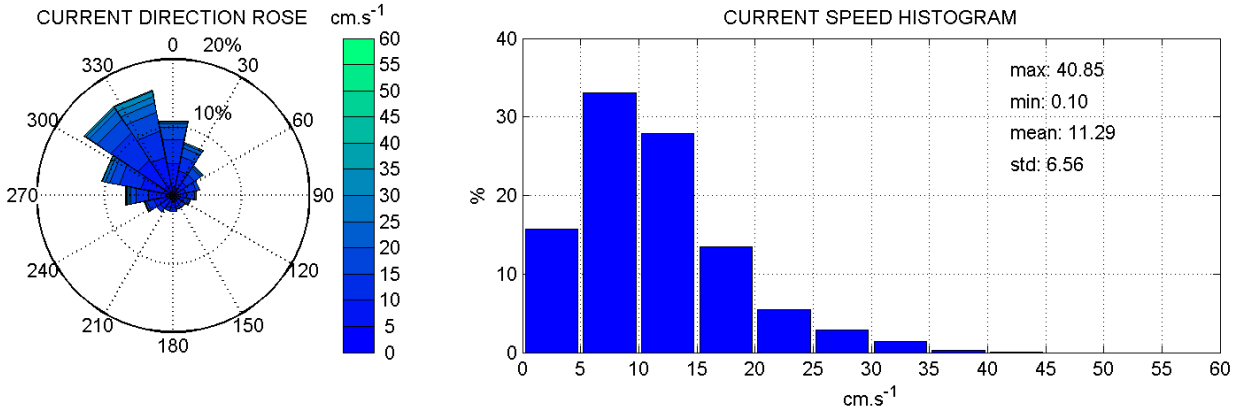


Figure 13: Summary of current data at 50 mm depth

ADCP
-24.1387N, 14.0258E, at -90m depth
6079 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 14:00:00

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	1.27	1.18	1.05	0.82	0.79	0.74	0.92	1.00	1.32	1.48	1.15	1.61	1.43	1.55	1.83	1.65	19.79
5-10	2.93	1.55	0.76	0.53	0.44	0.41	0.86	1.20	2.09	3.06	3.04	3.42	3.39	2.81	4.34	4.39	35.22
10-15	2.48	0.76	0.43	0.07	0.23	0.12	0.20	0.31	0.64	1.65	2.35	2.35	1.10	1.50	5.40	6.53	26.11
15-20	1.56	0.07	0.05	0.02		0.03	0.02	0.07	0.16	0.18	0.51	0.71	0.20	0.58	3.64	4.87	12.65
20-25	0.41	0.02											0.05	0.20	1.41	2.63	4.72
25-30	0.07													0.02	0.36	0.53	0.97
30-35															0.08	0.20	0.28
35-40																0.23	0.23
40-45																0.03	0.03
45-50																	0.00
50-55																	0.00
55-60																	0.00
Σ	8.72	3.57	2.29	1.43	1.46	1.30	1.99	2.58	4.21	6.37	7.06	8.09	6.17	6.65	17.06	21.06	100.00

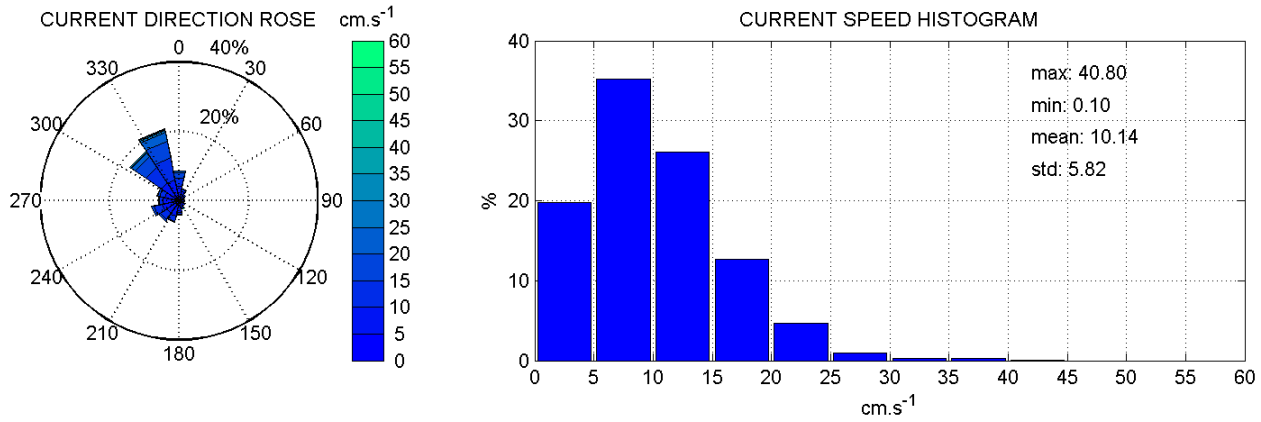


Figure 14: Summary of current data at 90 mm depth

4.1.1.3 Progressive vector plots

Figures 15 to 17 display progressive vector plots for the depths: -9 m, -50 m and -90 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.

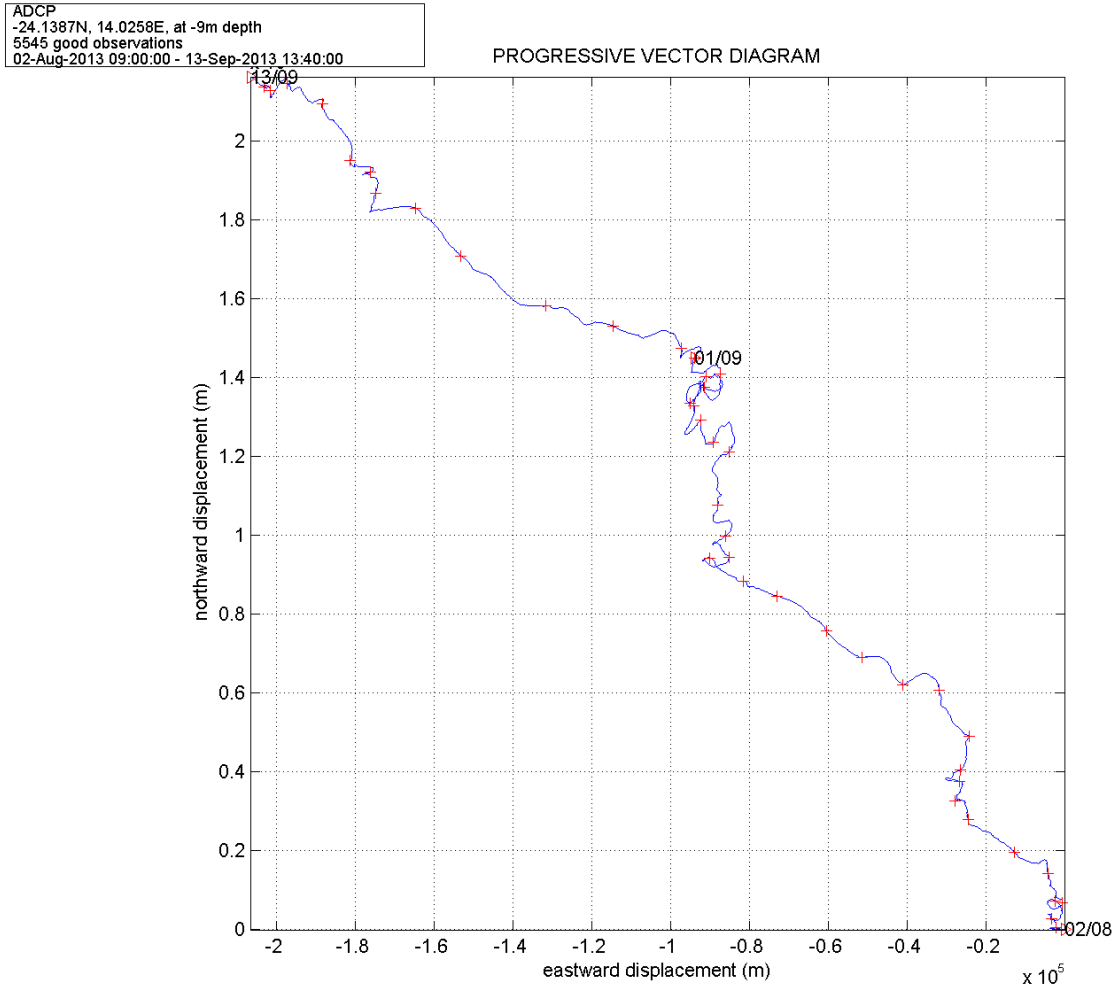


Figure 15: Current progressive vector plot for 9 m depth

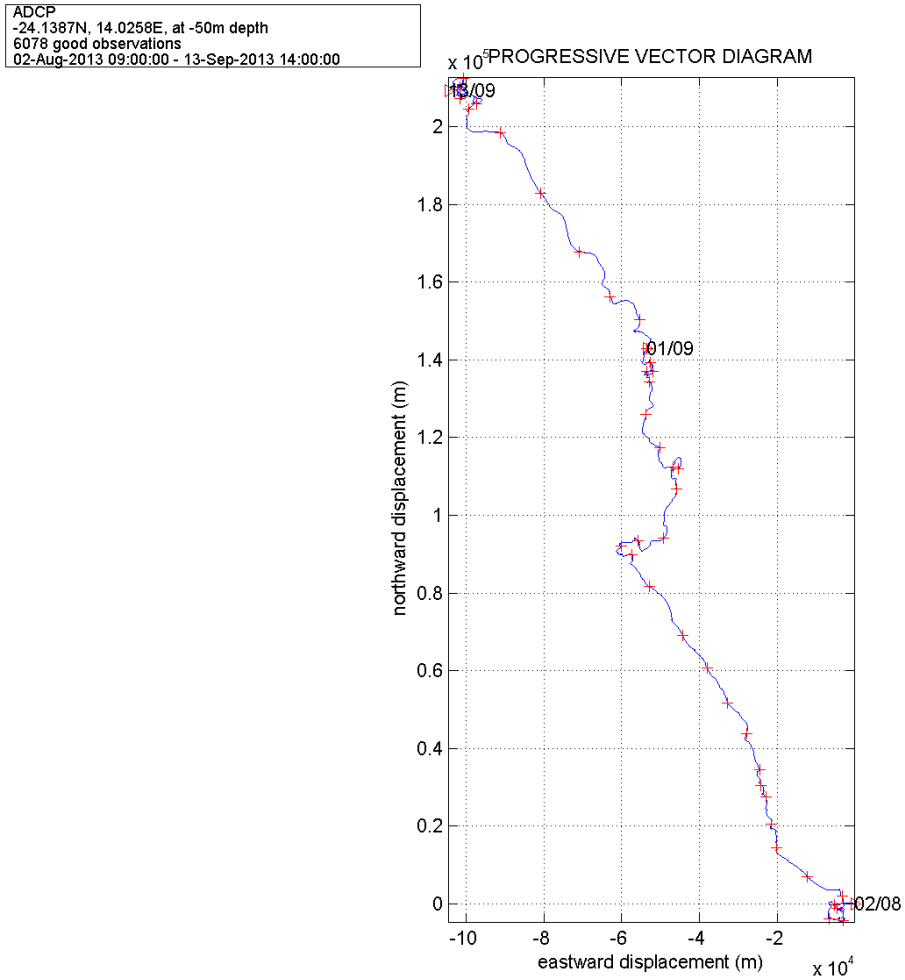


Figure 16: Current progressive vector plot for 50 m depth

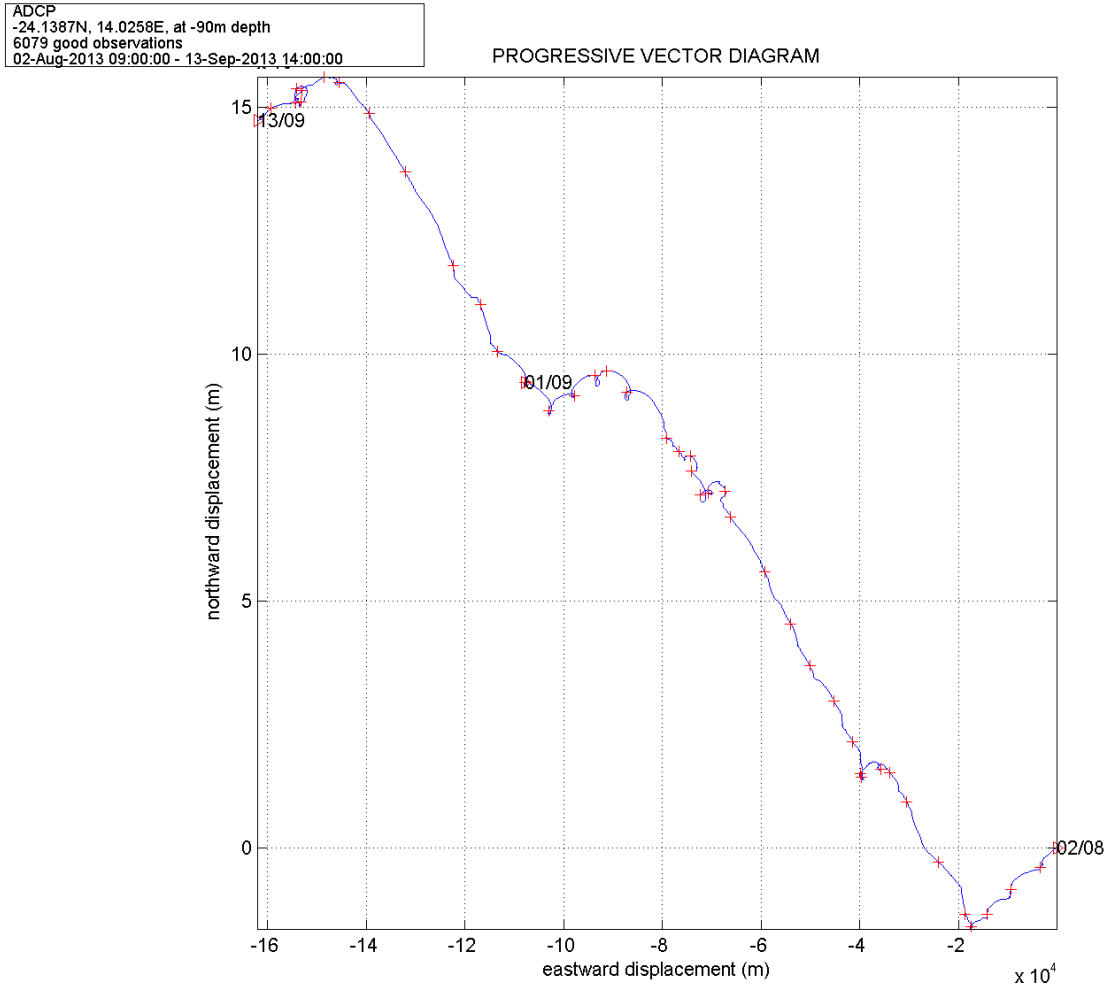


Figure 17: Current progressive vector plot for 90 m depth

4.1.1.4 Tidal harmonic plots

Tables 10 – 12 present current harmonic data for the depths: -9 m, -50 m and -90 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 9 m depth

ADCP
-24.1387N, 14.0258E, in -9m depth
5545 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 13:40:00

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	5.90	-0.77	159.24	293.08
MSF	3.62	-1.99	0.13	120.08
ALP1	3.26	1.65	60.55	87.79
2Q1	1.82	0.93	62.74	48.09
Q1	3.05	1.65	21.84	13.84
O1	3.05	2.05	170.65	181.43
NO1	1.63	-0.73	138.74	23.47
K1	3.63	2.17	31.23	203.53
J1	2.03	0.33	99.13	359.99
OO1	2.17	0.21	170.48	114.27
UPS1	2.43	1.27	37.03	288.01
EPS2	1.20	0.39	57.32	23.59
MU2	0.78	0.18	155.14	31.04
N2	1.40	0.50	62.57	203.55
M2	1.23	-0.14	139.52	109.25
L2	0.87	0.11	59.72	70.65
S2	1.60	0.29	31.00	336.04
ETA2	1.53	-0.70	59.74	248.30
MO3	0.75	-0.34	51.09	4.27
M3	1.12	0.71	143.21	108.99
MK3	0.88	0.39	60.60	199.88
SK3	0.77	-0.27	19.90	40.20
MN4	0.29	-0.22	100.24	163.41
M4	0.29	0.01	98.76	357.19
SN4	0.37	0.04	14.85	43.26
MS4	0.27	-0.13	27.05	179.39
S4	0.55	0.19	92.58	336.08
2MK5	0.42	-0.10	52.73	207.33
2SK5	0.46	0.11	6.19	62.77
2MN6	0.36	-0.24	24.51	345.71
M6	0.28	0.14	108.90	267.21
2MS6	0.21	-0.10	96.95	109.26
2SM6	0.20	0.00	48.22	347.13
3MK7	0.41	-0.09	57.54	14.23
M8	0.27	-0.01	175.22	209.78

Table 11: Current harmonic data for 50 m depth

ADCP
-24.1387N, 14.0258E, in -50m depth
6078 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 14:00:00

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	3.14	-0.69	158.92	271.19
MSF	2.04	-1.04	139.85	308.77
ALP1	1.47	0.81	39.78	84.52
2Q1	0.99	0.91	158.98	358.46
Q1	1.08	0.55	50.93	355.89
O1	1.31	-0.20	176.29	168.22
NO1	2.14	-1.28	31.80	106.16
K1	1.78	0.20	36.35	197.73
J1	0.63	-0.06	21.81	205.04
OO1	1.18	0.90	7.57	71.21
UPS1	1.90	0.73	76.80	24.26
EPS2	0.57	0.23	72.21	350.54
MU2	0.22	0.15	140.88	26.07
N2	0.77	0.70	73.49	262.04
M2	1.55	0.97	90.59	36.12
L2	0.49	0.14	65.33	81.43
S2	1.31	0.95	170.62	101.57
ETA2	0.88	-0.27	179.07	109.64
MO3	0.44	-0.10	47.36	54.18
M3	0.60	0.17	25.78	13.50
MK3	0.35	0.12	166.09	201.81
SK3	0.45	-0.09	147.31	254.47
MN4	0.18	0.02	65.30	169.83
M4	0.36	0.10	24.48	54.33
SN4	0.32	-0.06	18.82	18.35
MS4	0.43	0.23	13.18	136.29
S4	0.20	0.08	72.97	298.91
2MK5	0.28	0.14	91.91	3.86
2SK5	0.17	-0.01	171.33	257.13
2MN6	0.15	-0.11	168.68	249.64
M6	0.26	0.16	35.64	188.77
2MS6	0.12	0.00	74.67	290.75
2SM6	0.27	-0.05	140.47	315.34
3MK7	0.07	0.03	147.28	144.40
M8	0.11	0.01	28.63	109.04

Table 12: Current harmonic data for 90 m depth

ADCP
-24.1387N, 14.0258E, in -90m depth
6079 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 14:00:00

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	2.17	-1.16	86.04	308.81
MSF	3.06	-0.96	106.86	325.67
ALP1	1.92	1.20	96.51	279.86
2Q1	1.62	1.22	112.73	283.18
Q1	1.81	1.33	106.44	169.40
O1	1.78	1.16	103.87	262.28
NO1	1.47	0.29	134.41	343.51
K1	1.76	1.12	135.95	103.44
J1	1.50	0.78	134.42	215.59
OO1	0.66	0.46	66.17	103.46
UPS1	0.56	-0.06	125.20	185.65
EPS2	0.37	-0.24	55.98	276.43
MU2	0.23	0.10	144.79	238.40
N2	0.25	0.05	61.83	55.19
M2	1.37	1.15	73.62	349.75
L2	0.18	-0.06	158.48	285.05
S2	0.48	0.22	179.07	121.49
ETA2	0.48	-0.18	176.47	190.72
MO3	0.44	0.32	4.47	106.87
M3	0.20	0.11	46.40	69.26
MK3	0.33	0.15	11.79	332.93
SK3	0.34	0.01	95.17	202.55
MN4	0.31	-0.02	59.34	21.68
M4	0.11	0.01	121.57	51.00
SN4	0.19	-0.04	31.34	241.02
MS4	0.25	0.05	118.15	301.11
S4	0.11	0.03	31.79	111.47
2MK5	0.21	-0.10	76.41	217.14
2SK5	0.24	0.01	119.22	63.47
2MN6	0.12	-0.07	20.15	197.42
M6	0.17	0.00	118.67	240.38
2MS6	0.15	-0.06	31.43	273.57
2SM6	0.04	-0.00	112.01	289.02
3MK7	0.24	0.09	120.74	136.42
M8	0.13	-0.01	178.22	8.21

4.1.1.5 Profile plots

Figures 19 to 21 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 82, 41 and 1. These represent the flow for the depths -9 m, -50 m and -90 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).

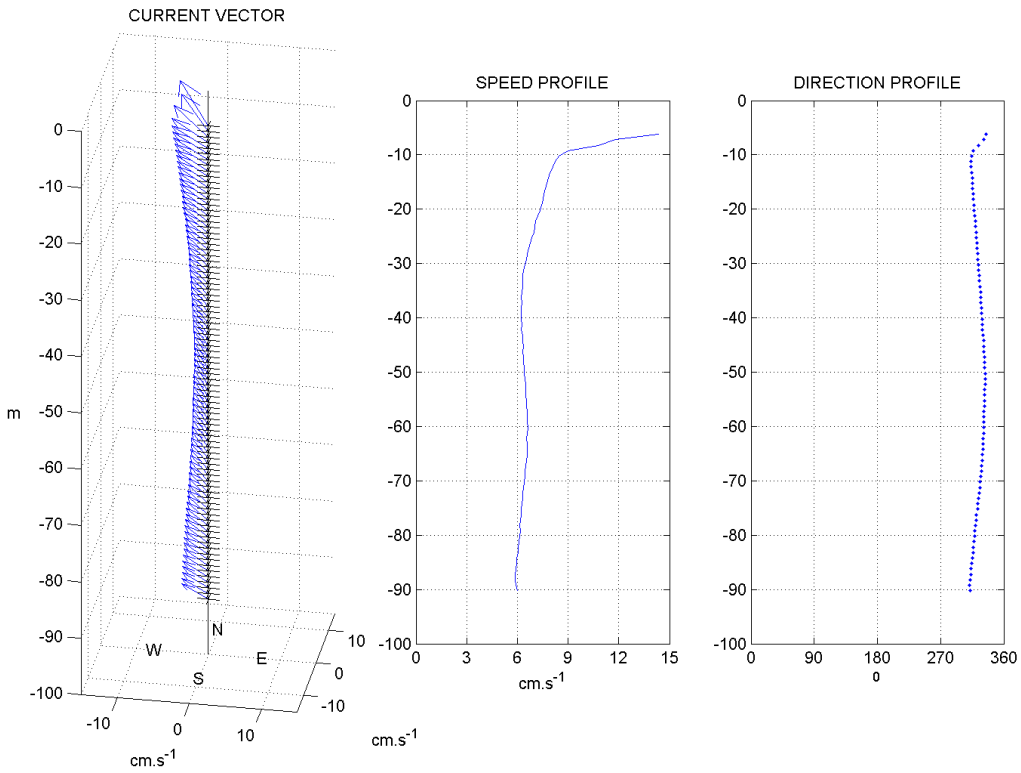


Figure 18: Mean profile plot

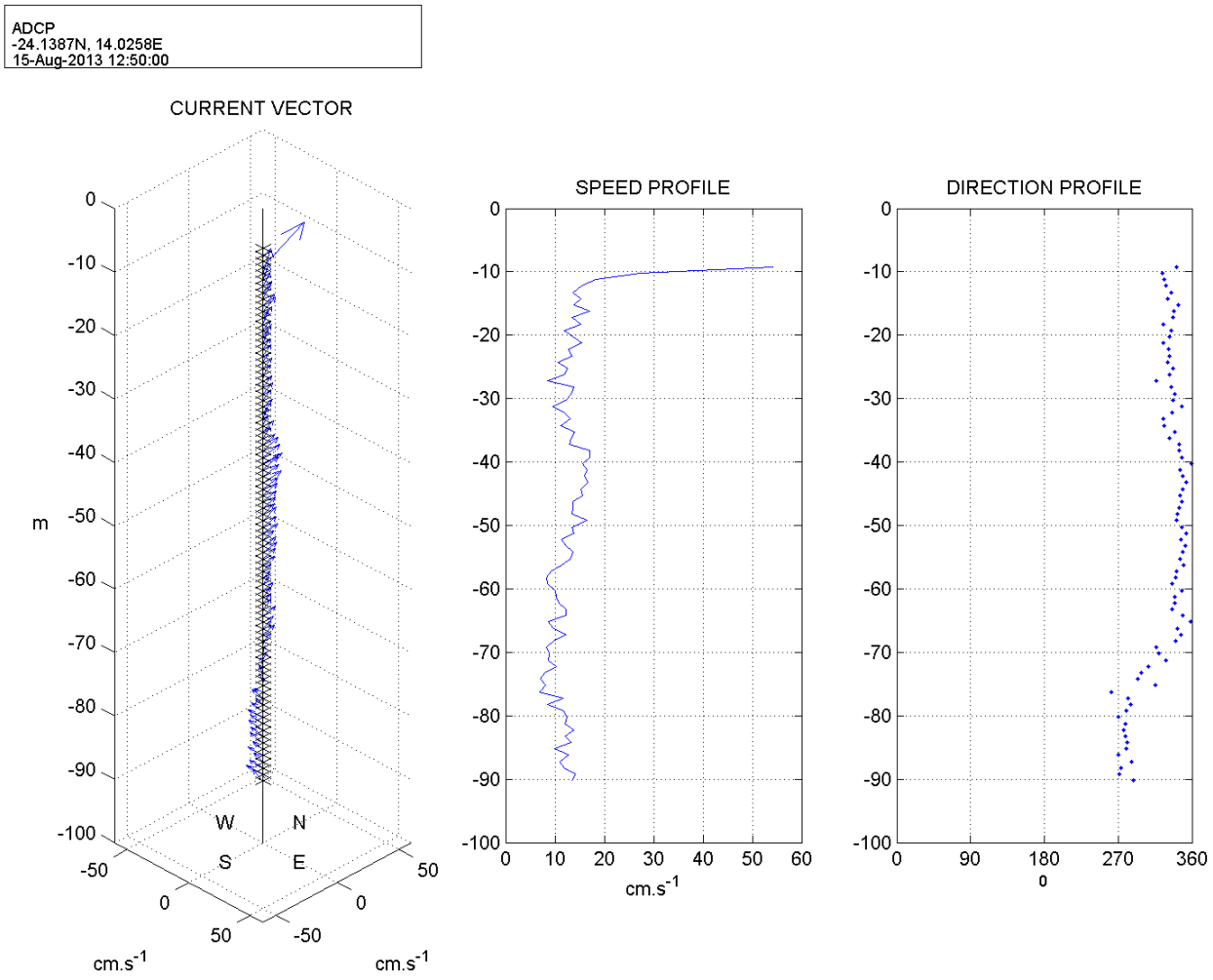


Figure 19: Profile plot at the time of maximum current speed in the upper water column

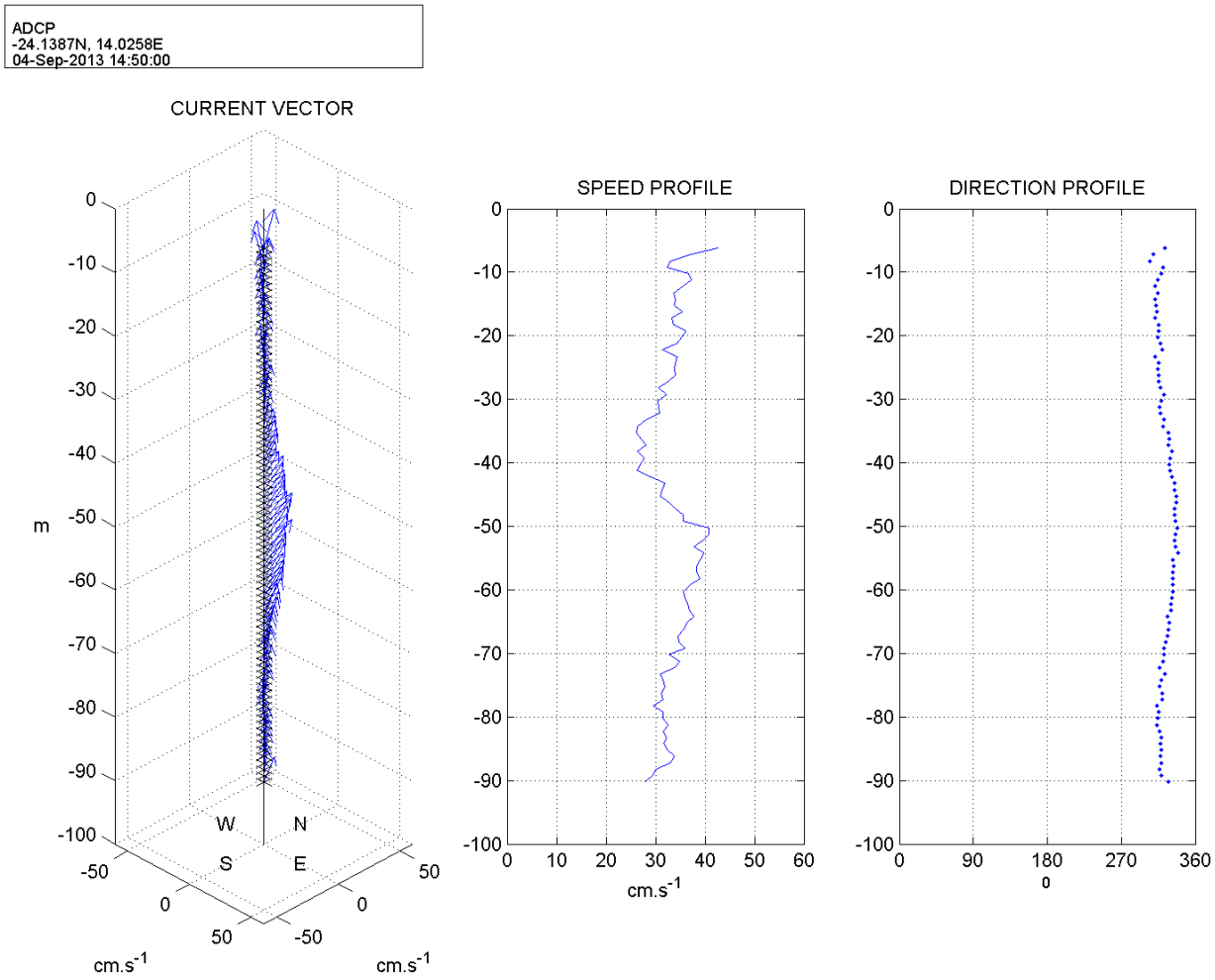


Figure 20: Profile plot at the time of maximum current speed in the mid water column

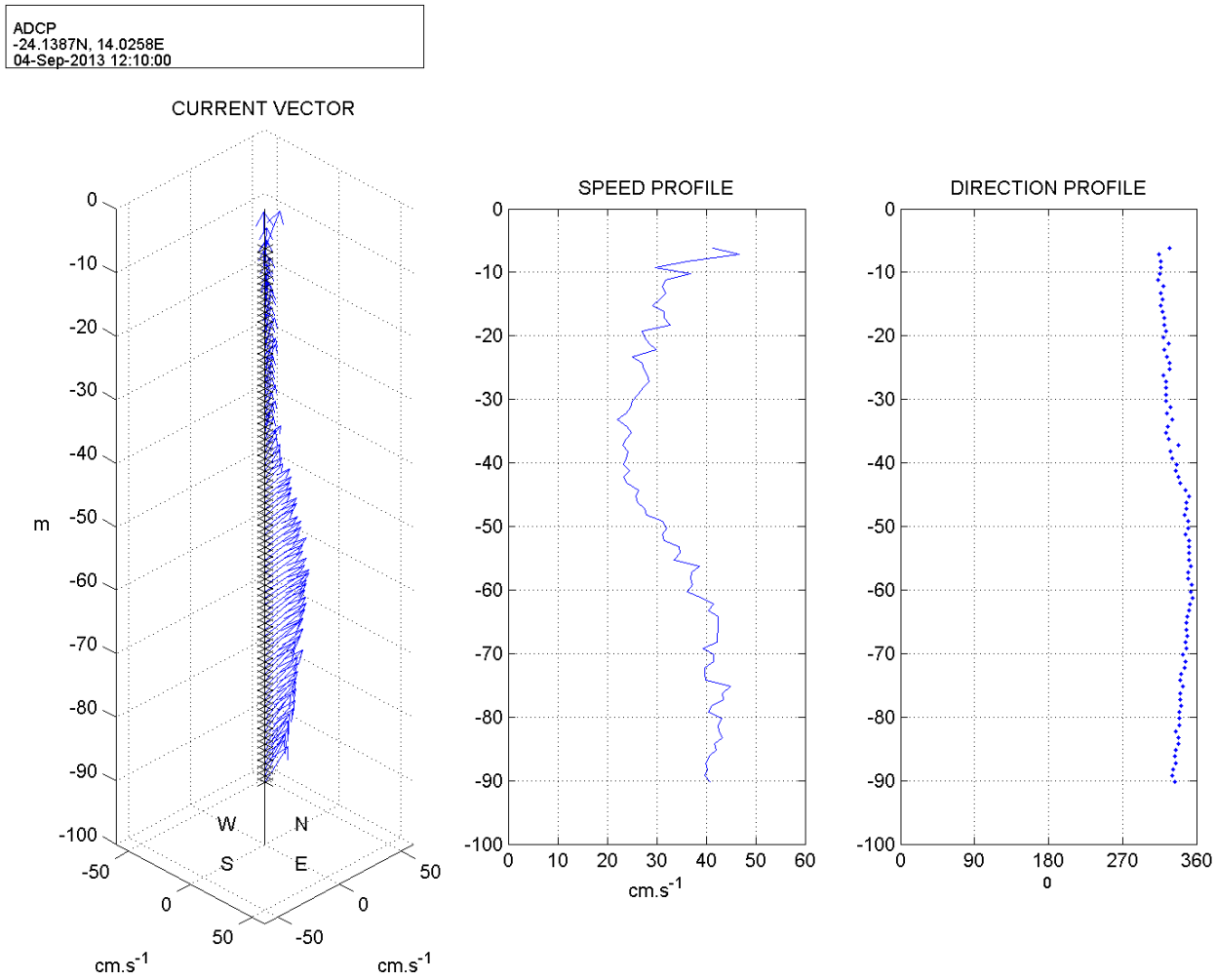


Figure 21: Profile plot at the time of maximum current speed in the lower water column

4.1.2 Pressure and water temperature data

4.1.2.1 Time series plot

Figure 22 displays a time series plot, which consists of:

- The first (upper) panel is of the observed pressure (water level) 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.

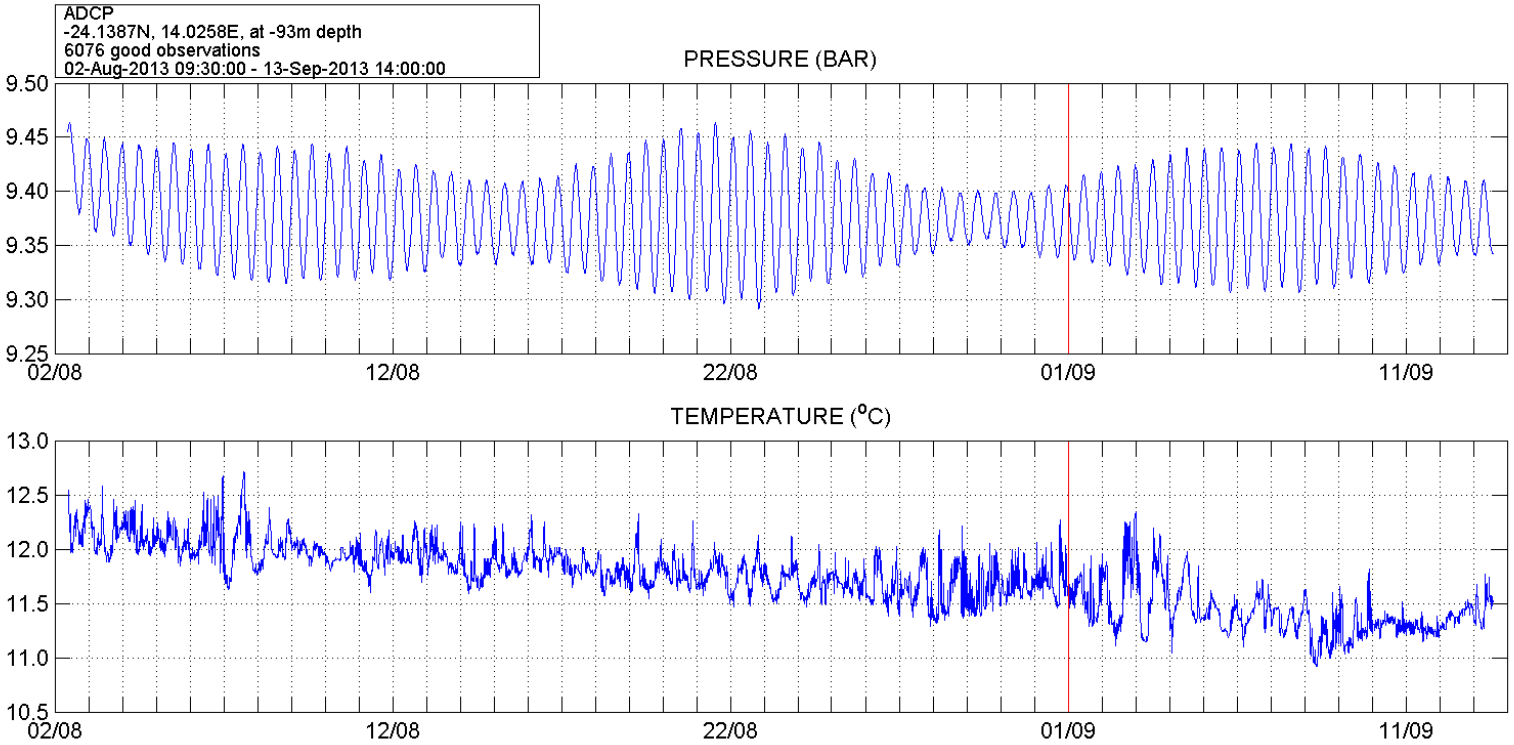


Figure 22: Pressure (water level) and temperature at 93 m depth

4.2 AQD 1

4.2.1 Current data

4.2.1.1 Time series plot

Figure 23 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.

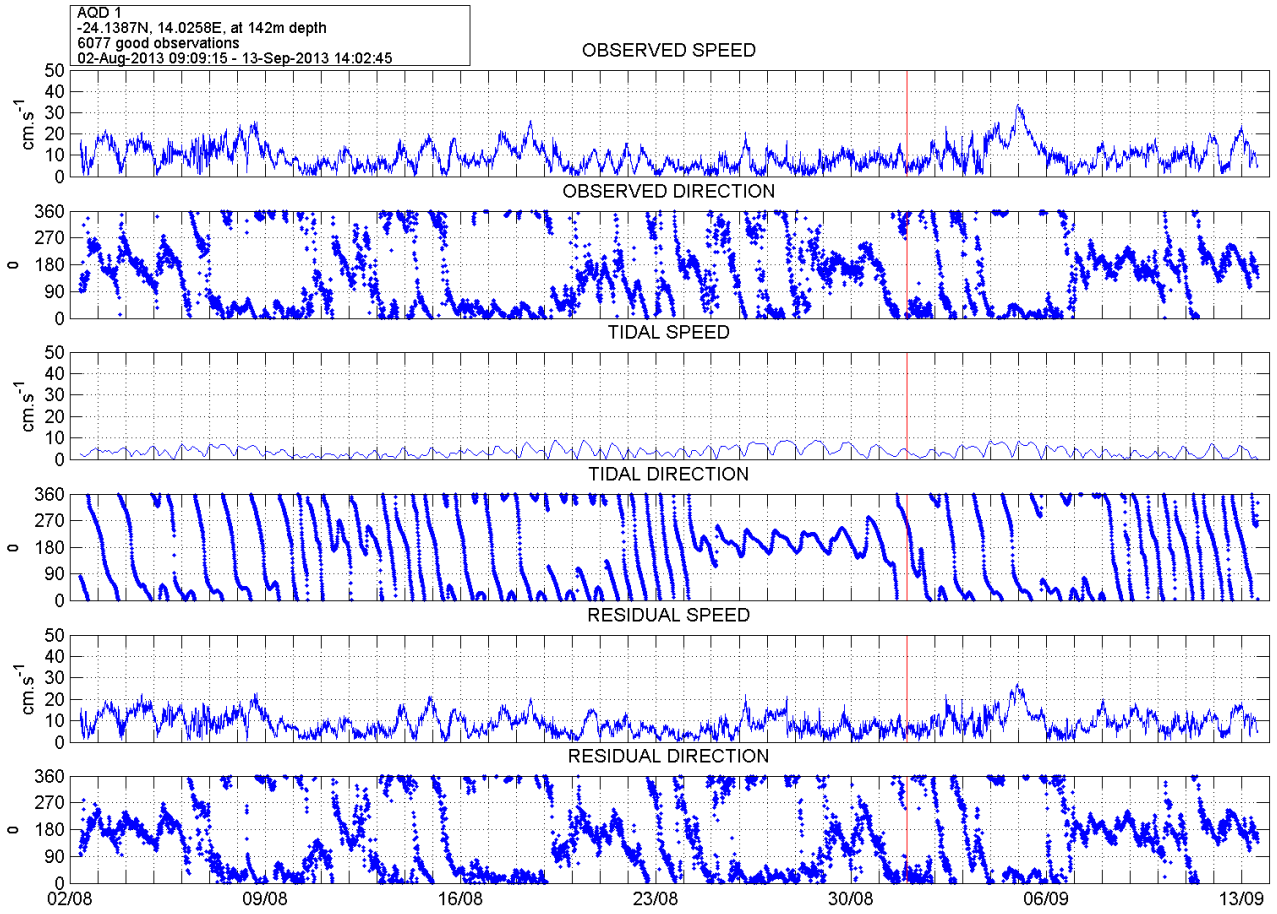


Figure 23: Current time series data for 142 m depth

4.2.1.2 Summary plot

Figure 24 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
-24.1387N, 14.0258E, at 142m depth
6077 good observations
02-Aug-2013 09:09:15 - 13-Sep-2013 14:02:45

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	1.17	1.69	1.91	1.56	1.76	1.43	1.97	1.93	1.94	1.71	1.40	1.35	1.00	1.25	1.02	1.14	24.24
5-10	3.47	4.51	3.31	1.99	2.02	2.37	1.79	2.60	3.32	2.40	1.97	1.33	0.76	0.86	1.37	1.69	35.77
10-15	2.81	3.19	2.27	1.48	0.64	0.76	1.78	2.58	1.96	2.07	1.07	0.63	0.41	0.46	0.87	1.38	24.37
15-20	1.78	1.99	1.60	0.38	0.12	0.15	0.48	1.27	0.61	0.81	0.82	0.30	0.07	0.21	0.08	0.66	11.30
20-25	0.94	1.14	0.49	0.02				0.16	0.23	0.15					0.07	0.16	3.36
25-30	0.26	0.08	0.07													0.02	0.43
30-35		0.38	0.15														0.53
35-40																	0.00
40-45																	0.00
45-50																	0.00
Σ	10.43	12.98	9.79	5.43	4.54	4.71	6.02	8.54	8.06	7.14	5.27	3.60	2.24	2.78	3.41	5.05	100.00

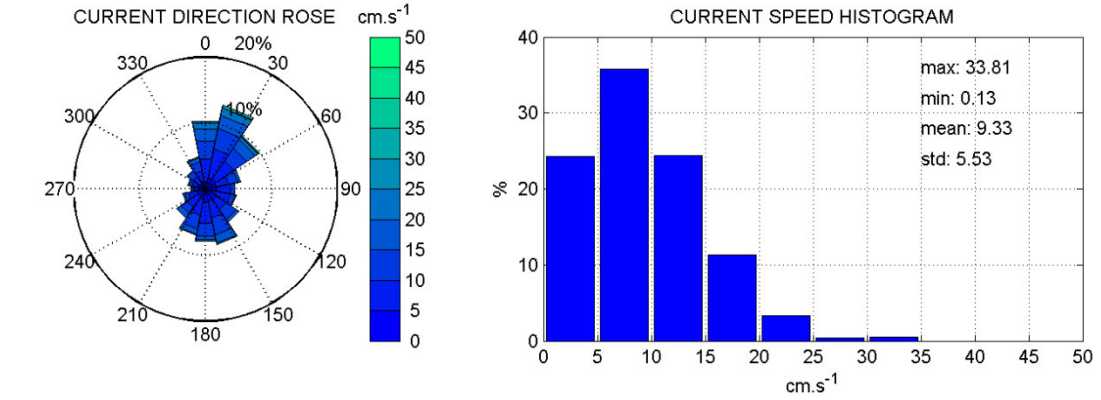


Figure 24: Summary of current data at 142 depth

4.2.1.3 Progressive vector plot

Figure 25 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.

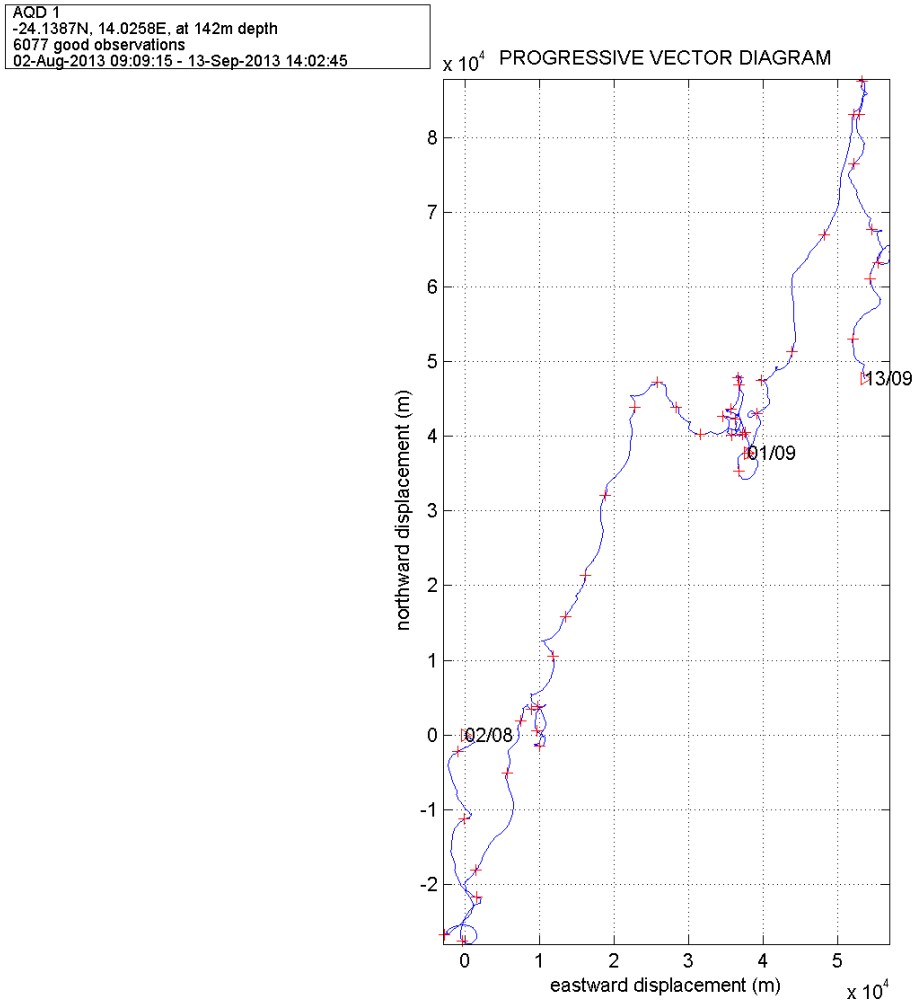


Figure 25: Current progressive vector plot at 142 m depth

4.2.1.4 Tidal harmonic plot

Table 13 presents a current harmonic data which consists 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 142 m depth

AQD 1
-24.1387N, 14.0258E, in 142m depth
6077 good observations
02-Aug-2013 09:09:15 - 13-Sep-2013 14:02:45

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	2.44	-0.67	76.26	303.08
MSF	3.73	-0.11	65.51	333.28
ALP1	1.06	0.91	41.55	332.28
2Q1	1.25	1.13	87.72	128.42
Q1	1.42	0.85	168.32	39.40
O1	1.11	0.68	112.80	106.45
NO1	1.25	0.56	44.95	116.45
K1	1.49	0.81	17.12	341.03
J1	0.65	0.41	44.70	111.07
OO1	1.76	0.93	173.81	94.02
UPS1	1.02	0.44	18.40	127.06
EPS2	0.26	0.07	5.05	133.61
MU2	0.52	0.27	34.40	17.55
N2	0.81	0.57	174.15	137.37
M2	1.67	1.37	44.24	342.62
L2	0.34	0.17	172.55	16.88
S2	0.58	0.32	126.75	117.87
ETA2	0.42	0.20	43.27	109.81
MO3	0.34	0.19	30.55	228.30
M3	0.19	0.05	156.28	323.19
MK3	0.36	0.16	1.78	273.08
SK3	0.18	-0.07	137.87	181.28
MN4	0.18	0.04	168.60	97.34
M4	0.17	0.03	150.83	257.96
SN4	0.11	-0.11	42.65	49.24
MS4	0.09	-0.00	156.47	23.29
S4	0.09	0.04	159.81	101.14
2MK5	0.14	-0.04	130.81	259.89
2SK5	0.36	0.03	20.73	290.82
2MN6	0.13	0.09	154.85	299.65
M6	0.13	0.02	48.05	20.04
2MS6	0.27	0.00	77.16	251.31
2SM6	0.18	0.04	22.72	336.29
3MK7	0.20	0.01	169.76	12.11
M8	0.09	0.01	57.77	149.31

4.2.2 Pressure and water temperature data

4.2.2.1 Time series plot

Figure 26 displays a time series plot of pressure (water level) and water temperature variations as a function of time over the recording period.

- 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.

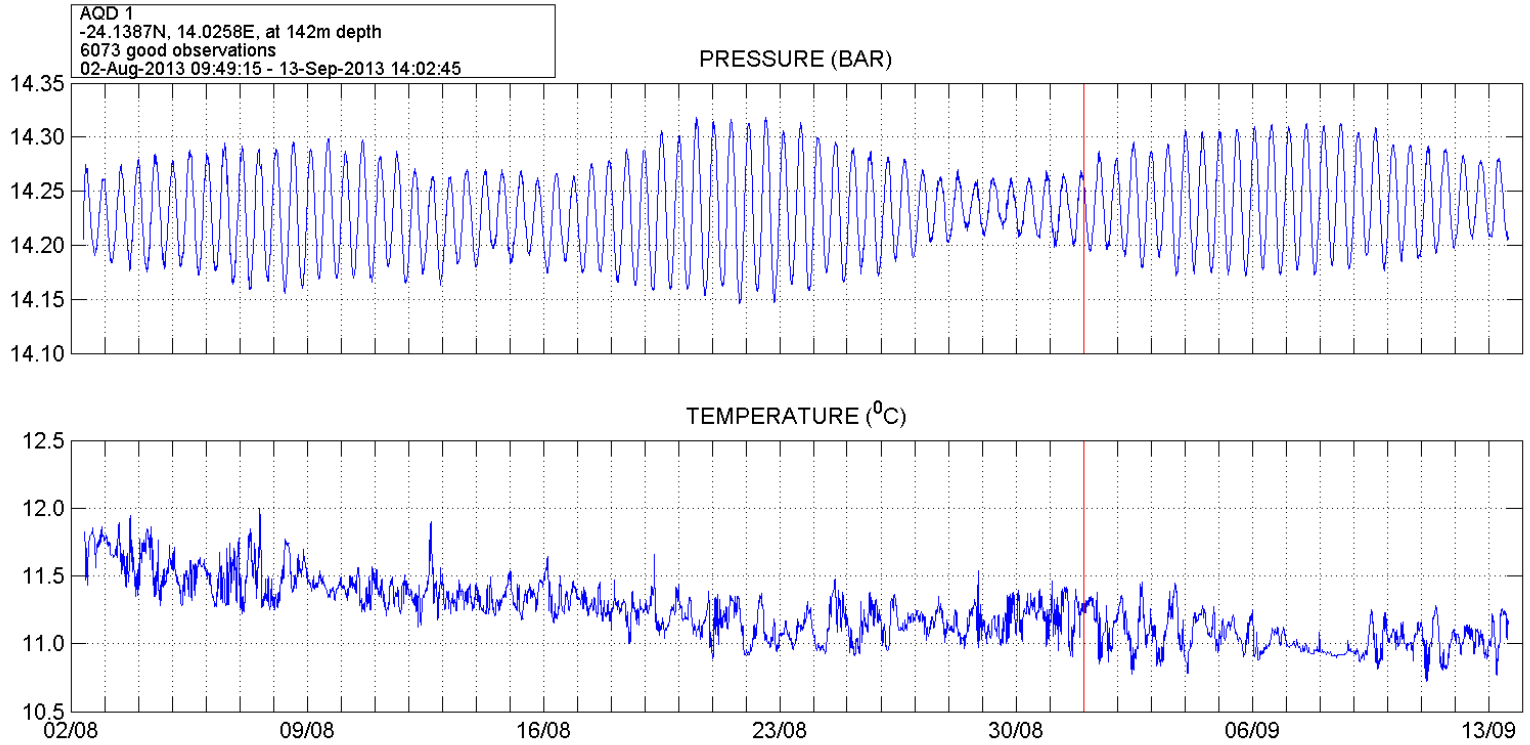


Figure 26: Pressure (water level) and temperature at 142 m depth

4.3 AQD 2

4.3.1 Current data

4.3.1.1 Time series plot

Figure 27 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.

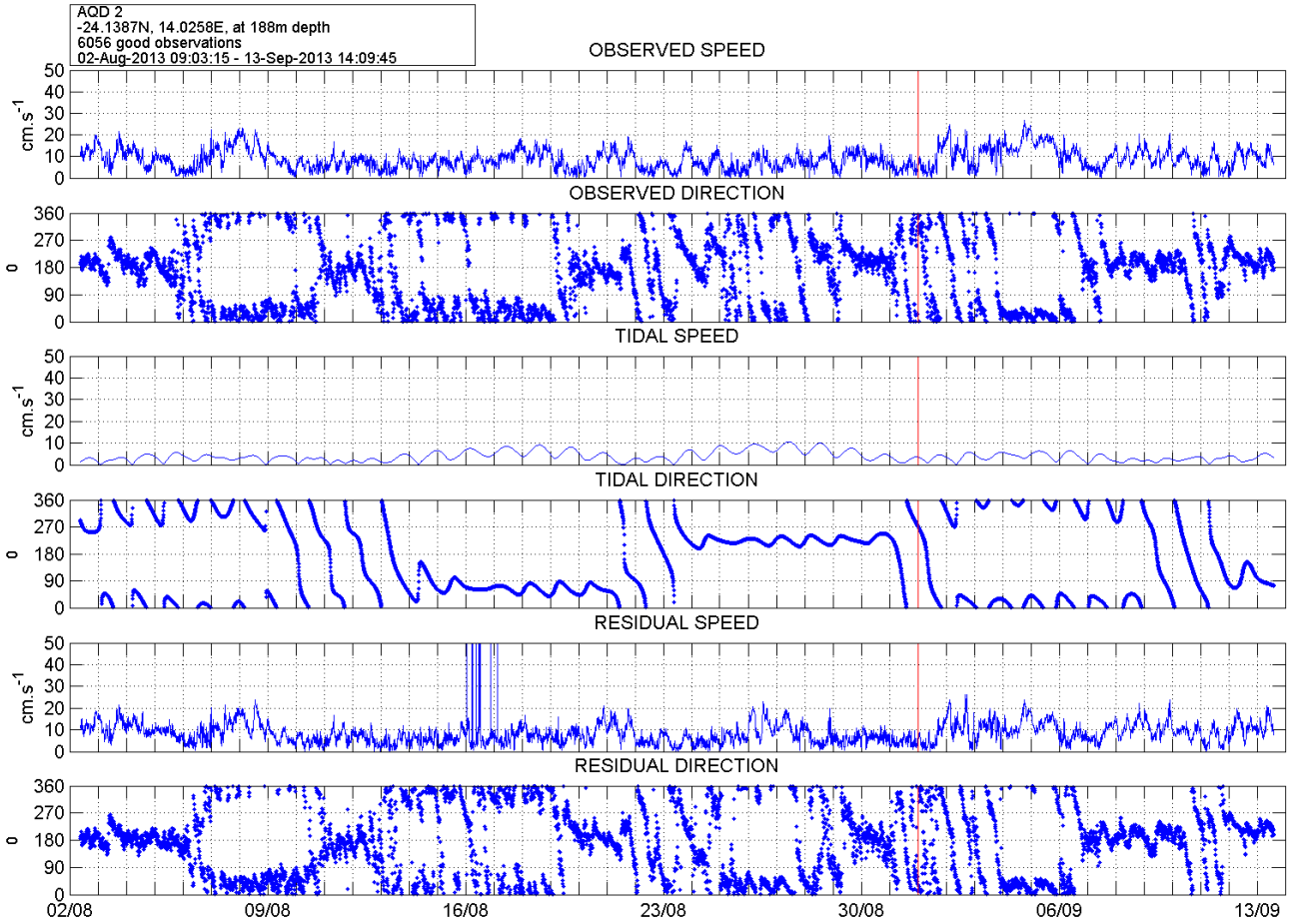


Figure 27: Current time series data for 188 m depth

4.3.1.2 Summary plot

Figure 28 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
-24.1387N, 14.0258E, at 188m depth
6056 good observations
02-Aug-2013 09:03:15 - 13-Sep-2013 14:09:45

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	1.72	1.62	1.40	1.54	1.42	1.34	1.37	1.42	1.57	1.52	1.49	1.29	1.30	1.25	1.22	1.21	22.67
5-10	3.27	3.52	3.63	2.34	1.44	1.21	2.23	3.34	4.05	4.18	3.22	2.15	1.47	1.16	1.30	1.78	40.27
10-15	2.16	3.76	2.05	1.24	0.40	0.23	0.56	1.80	2.96	4.16	3.09	1.47	0.88	0.31	0.63	1.09	26.78
15-20	0.83	2.20	1.49	0.30	0.07	0.03	0.05	0.25	0.40	0.88	0.79	0.35	0.13	0.23	0.30	0.21	8.49
20-25	0.20	0.73	0.36							0.03	0.18	0.15	0.02	0.02		0.05	1.73
25-30		0.05															0.05
30-35																	0.00
35-40																	0.00
40-45																	0.00
45-50																	0.00
Σ	8.17	11.87	8.93	5.42	3.32	2.81	4.21	6.80	8.97	10.77	8.77	5.40	3.80	2.97	3.45	4.34	100.00

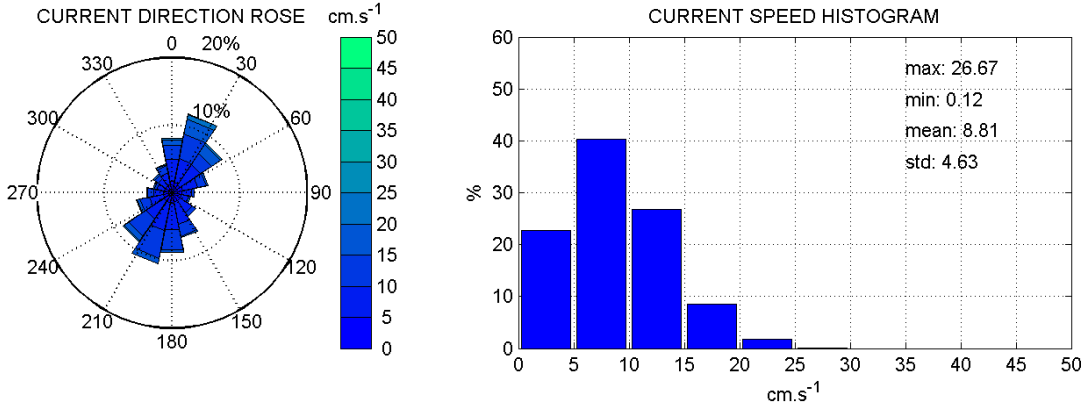


Figure 28: Summary of current data at 188 m depth

4.3.1.3 Progressive vector plot

Figure 29 depicts 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.

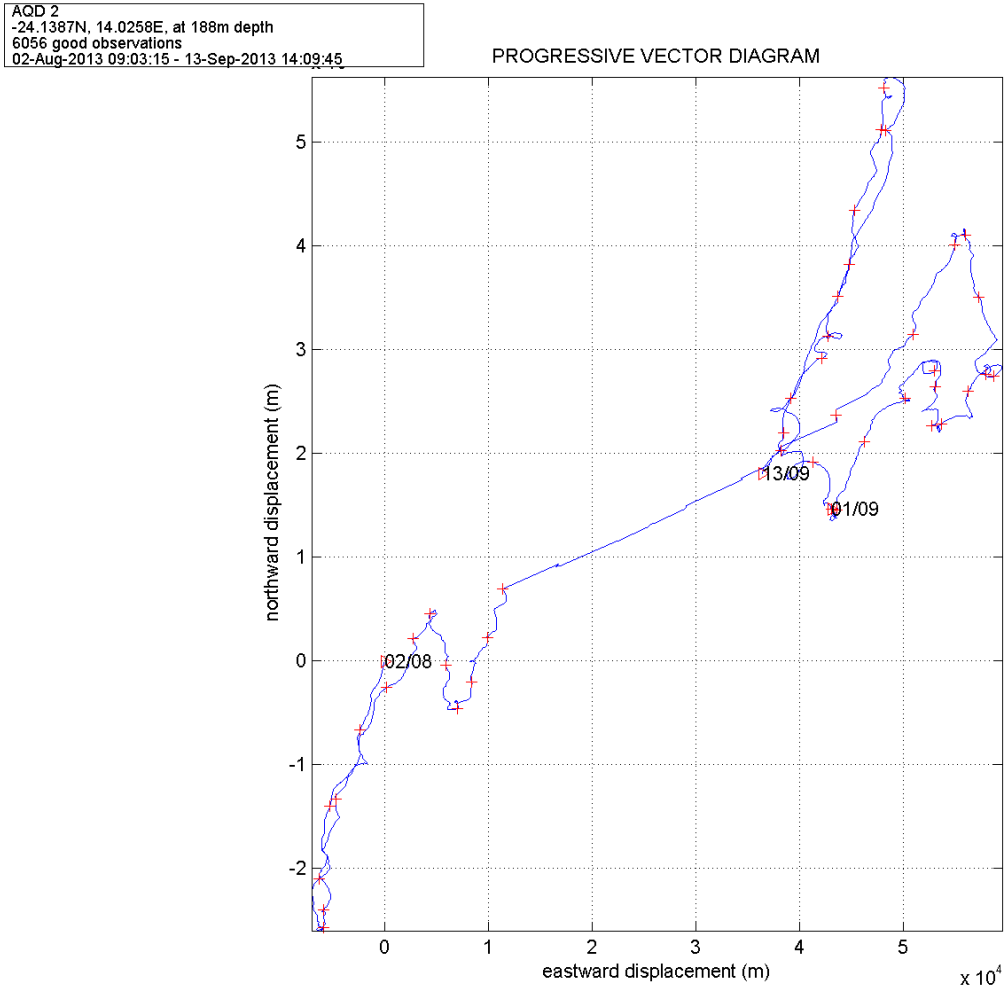


Figure 29: Current progressive vector plot at 188 m depth

4.3.1.4 Tidal harmonic plot

Table 14 presents a current harmonic data which consists 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 188 m depth

AQD 2
-24.1387N, 14.0258E, in 188m depth
6056 good observations
02-Aug-2013 09:03:15 - 13-Sep-2013 14:09:45

HARMONIC COMPONENTS

Component	Major	Minor	Ellipse	Phase
MM	4.35	-1.64	35.94	319.59
MSF	3.84	0.97	49.25	305.48
ALP1	0.59	-0.03	36.35	66.53
2Q1	2.91	1.67	30.94	348.61
Q1	0.82	0.47	159.90	252.89
O1	0.32	0.06	150.67	313.82
NO1	1.04	0.63	81.41	218.90
K1	1.57	0.37	26.45	301.76
J1	0.87	0.36	11.80	346.95
OO1	1.80	0.74	102.22	59.20
UPS1	1.50	-0.24	178.13	304.52
EPS2	1.09	0.60	30.66	131.63
MU2	0.21	-0.13	108.77	5.27
N2	0.47	0.39	144.51	65.86
M2	1.19	0.72	43.22	303.47
L2	0.83	0.52	45.65	190.67
S2	0.56	0.49	59.63	306.84
ETA2	0.85	0.51	49.55	343.70
MO3	0.47	-0.39	173.10	324.50
M3	0.44	0.01	42.05	290.00
MK3	0.62	0.13	170.33	329.19
SK3	1.17	0.39	22.10	17.45
MN4	0.59	0.16	34.28	255.70
M4	0.64	-0.05	21.27	280.32
SN4	0.73	0.18	34.84	136.95
MS4	0.63	0.26	17.11	134.02
S4	0.59	-0.04	32.58	359.33
2MK5	1.55	-0.09	23.85	189.53
2SK5	1.48	-0.10	18.50	302.61
2MN6	0.57	-0.02	13.67	126.57
M6	0.68	-0.02	23.70	139.50
2MS6	0.64	0.09	32.54	356.75
2SM6	0.60	0.02	8.36	195.87
3MK7	0.40	0.04	22.11	38.83
M8	0.58	-0.02	22.99	336.52

4.3.2 Pressure and water temperature data

4.3.2.1 Time series plot

Figure 30 depicts a time series plot of pressure (water level) and water temperature variations as a function of time over the recording period.

- 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.

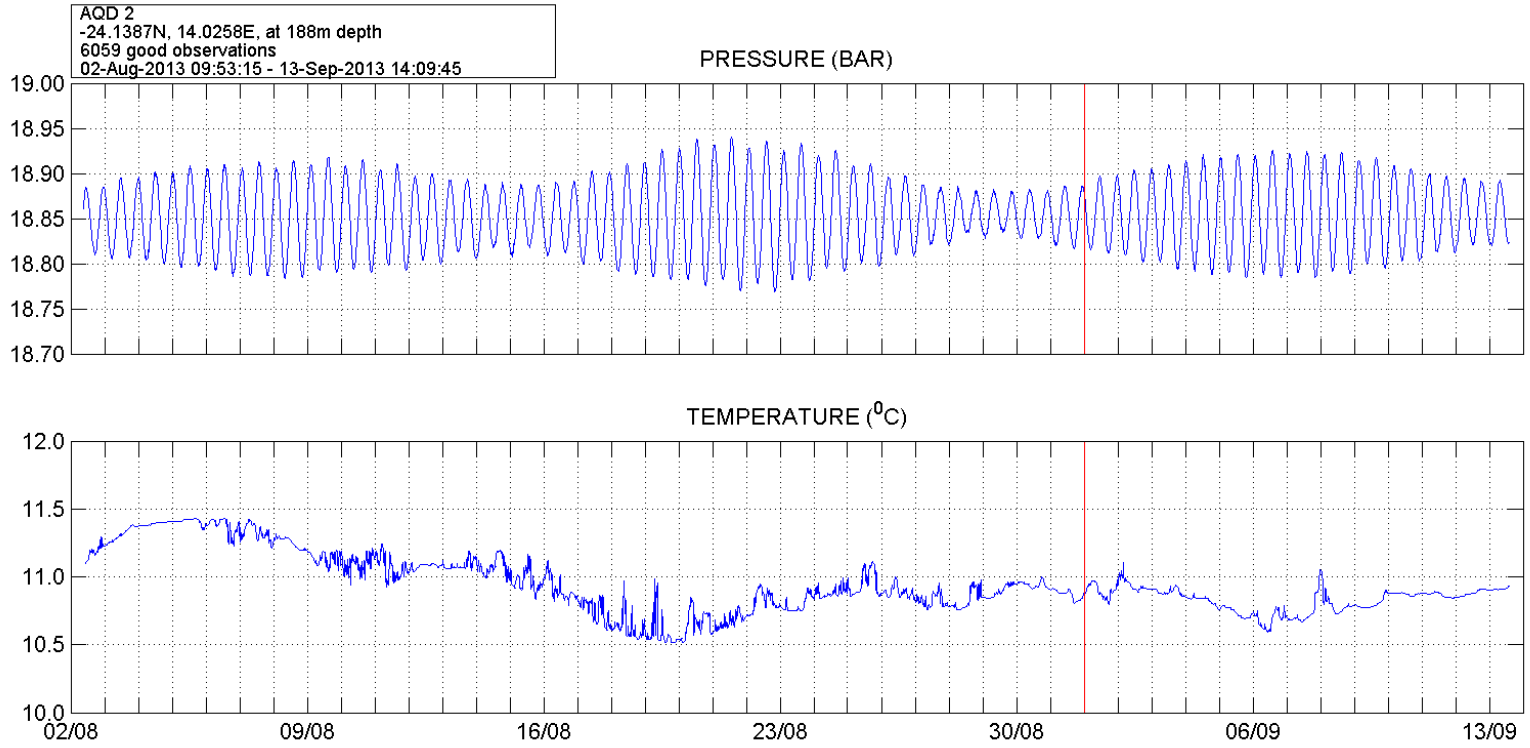


Figure 30: Pressure (water level) and temperature at 188 m depth

4.4 CTD

4.4.1 Water quality data

4.4.1.1 Time series plot

Figure 31 depicts a time series plot, which consists 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 forth panel is of the observed fluorescence against time.
- The fifth panel is of the observed turbidity against time.

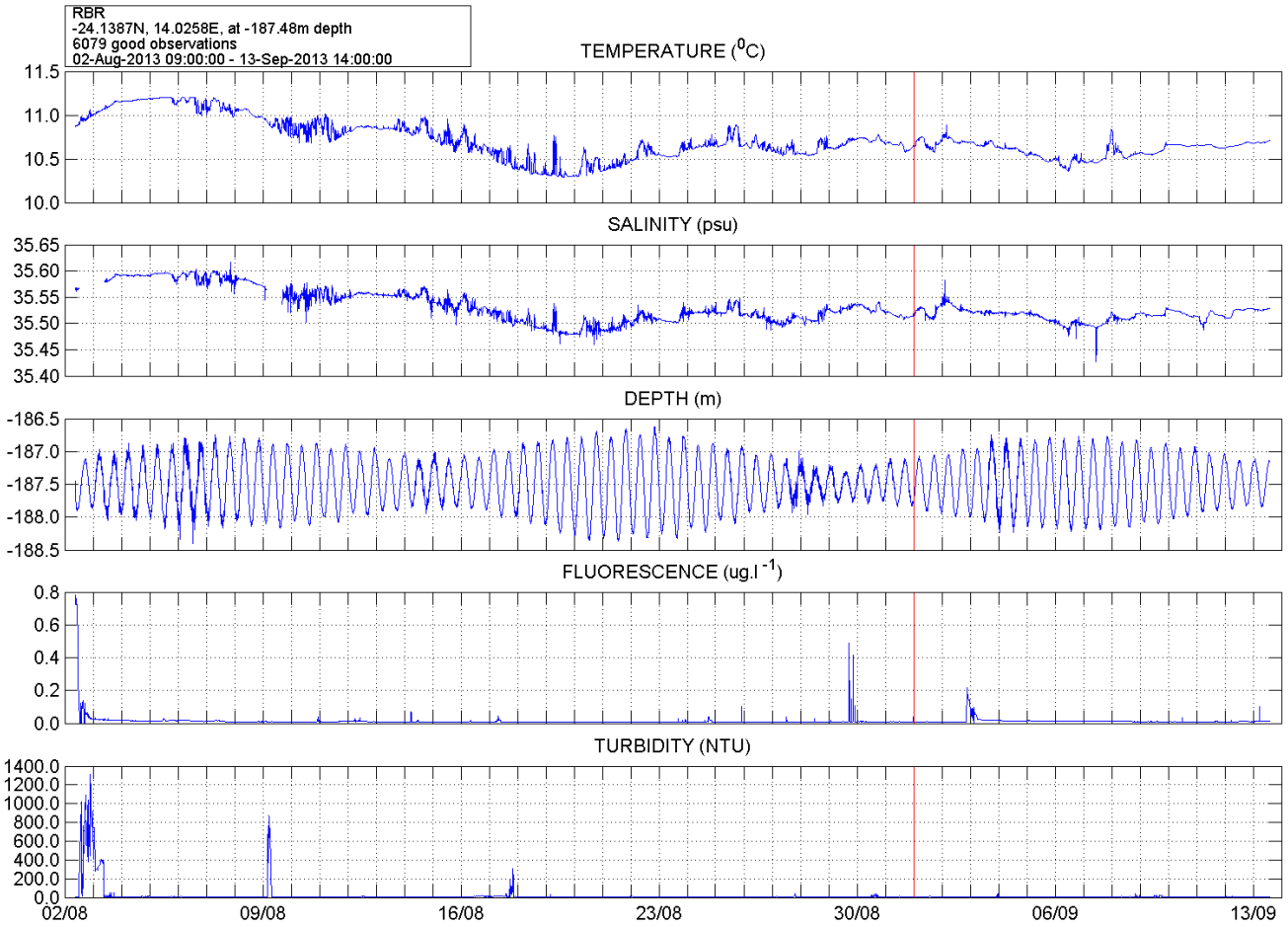


Figure 31: Water quality data for 187.48 m depth

4.4.1.2 Summary plot

Figure 32 depicts a summary plot, which consists of:

- 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 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.

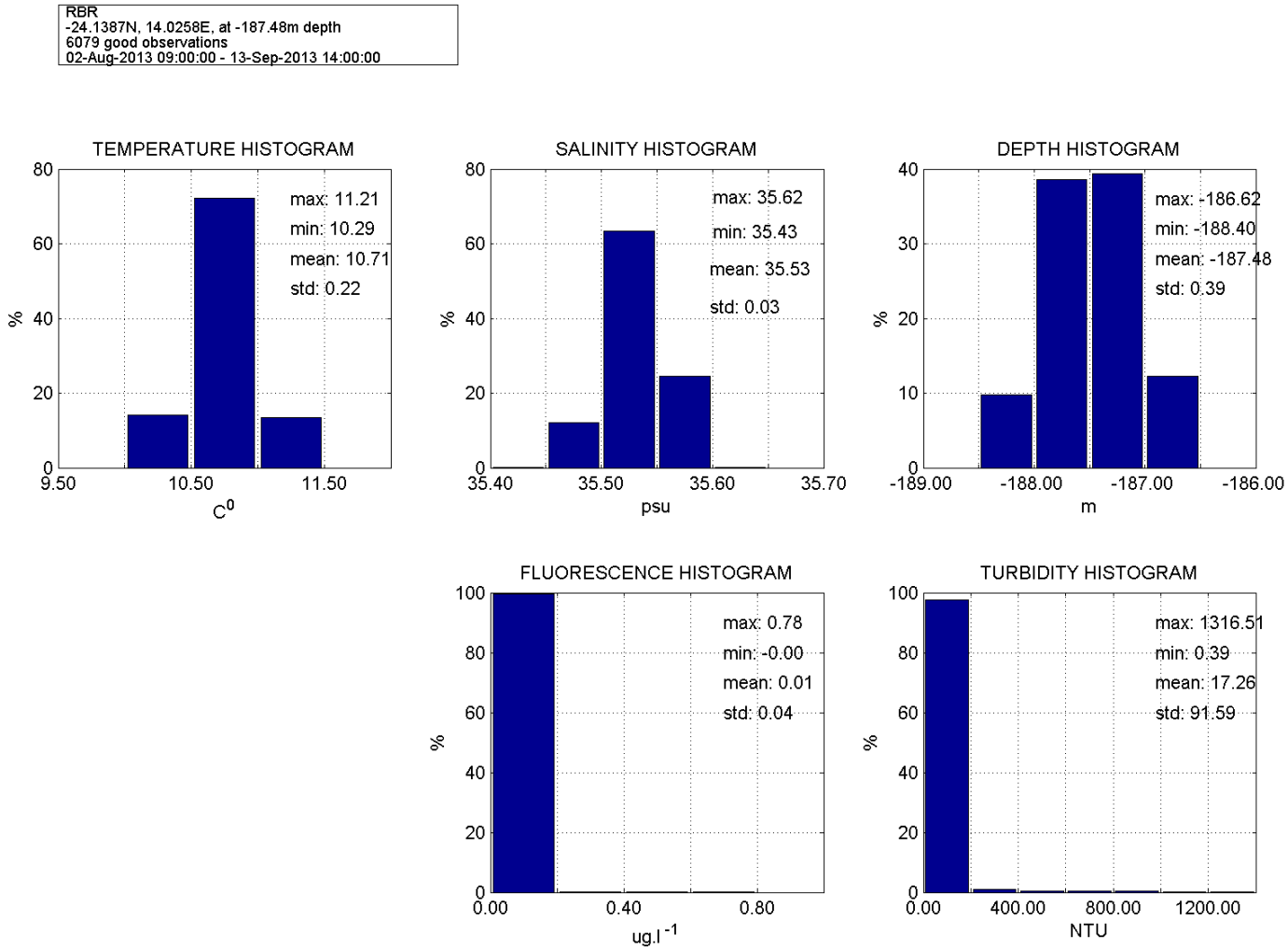


Figure 32: Summary data for environmental parameters at 187.48 m depth

4.4.2 Tide data

4.4.2.1 Time series plot

Figure 33 depicts 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.

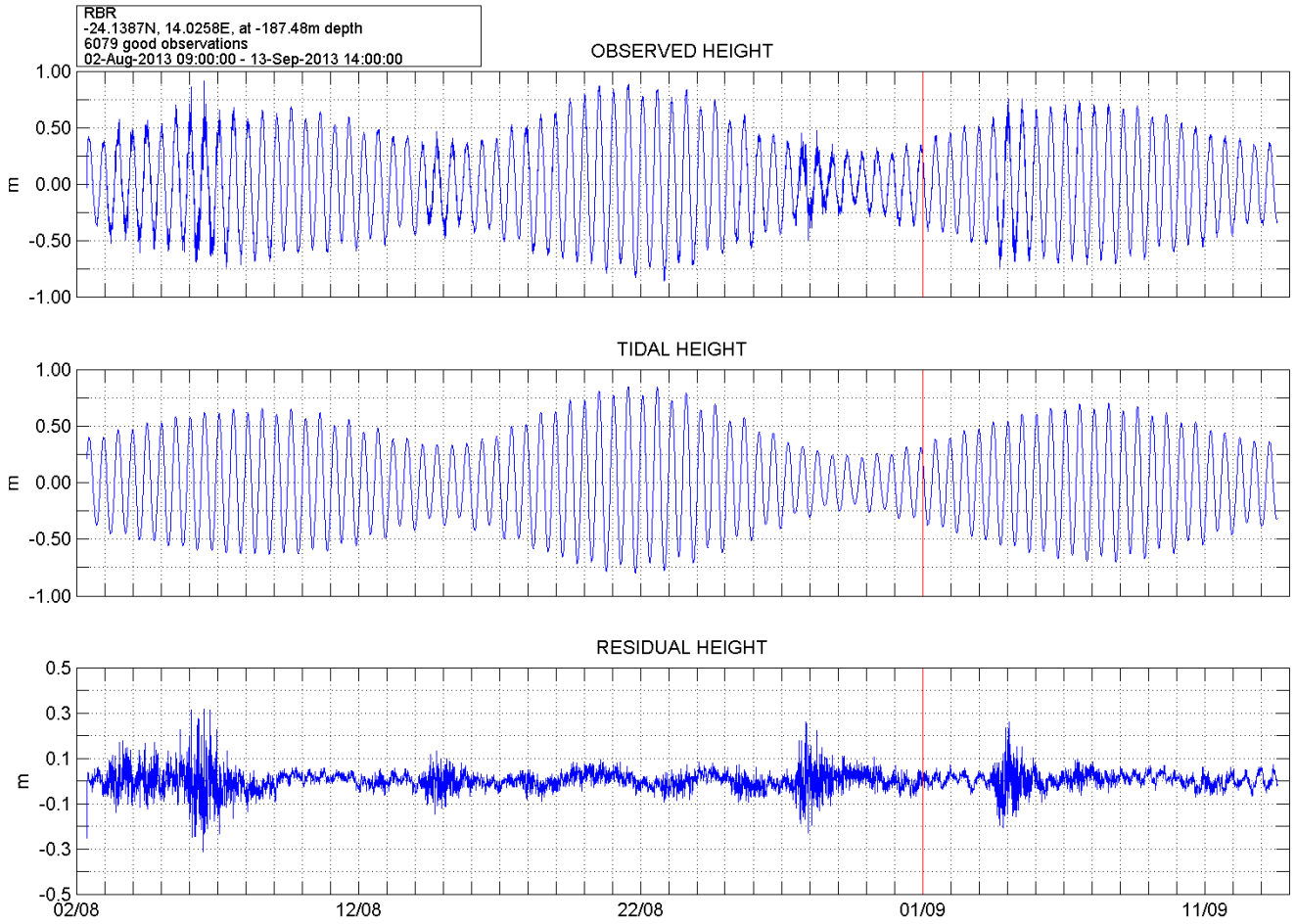


Figure 33: Time series of tidal height at 187.48 m depth

4.4.2.2 Tidal harmonics table

Table 15 displays the tidal harmonics resulting from the analysis. 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 at 187.48 m depth

RBR
-24.1387N, 14.0258E, in -187.48m depth
6079 good observations
02-Aug-2013 09:00:00 - 13-Sep-2013 14:00:00

HARMONIC COMPONENTS

Component	Amplitude (m)	Phase (deg)
MM	0.014	93.194
MSF	0.010	46.972
ALP1	0.002	104.851
2Q1	0.003	79.356
Q1	0.010	184.144
O1	0.014	198.044
NO1	0.003	57.382
K1	0.039	75.061
J1	0.003	105.814
OO1	0.005	99.532
UPS1	0.003	99.910
EPS2	0.004	15.755
MU2	0.022	52.981
N2	0.101	16.563
M2	0.479	38.398
L2	0.013	61.329
S2	0.198	57.690
ETA2	0.002	346.943
MO3	0.002	86.385
M3	0.007	290.554
MK3	0.003	335.692
SK3	0.004	229.034
MN4	0.003	94.496
M4	0.009	120.102
SN4	0.002	196.553
MS4	0.004	207.228
S4	0.003	58.615
2MK5	0.003	145.274
2SK5	0.006	355.997
2MN6	0.001	267.704
M6	0.005	324.281
2MS6	0.005	32.882
2SM6	0.001	215.995
3MK7	0.001	239.196
M8	0.001	142.209

4.4.2.3 Tidal harmonics plot

Figure 34 depicts a graphical representation of the harmonic components presented in the previous table.

- Components with periods between 0 to 10 hours 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.

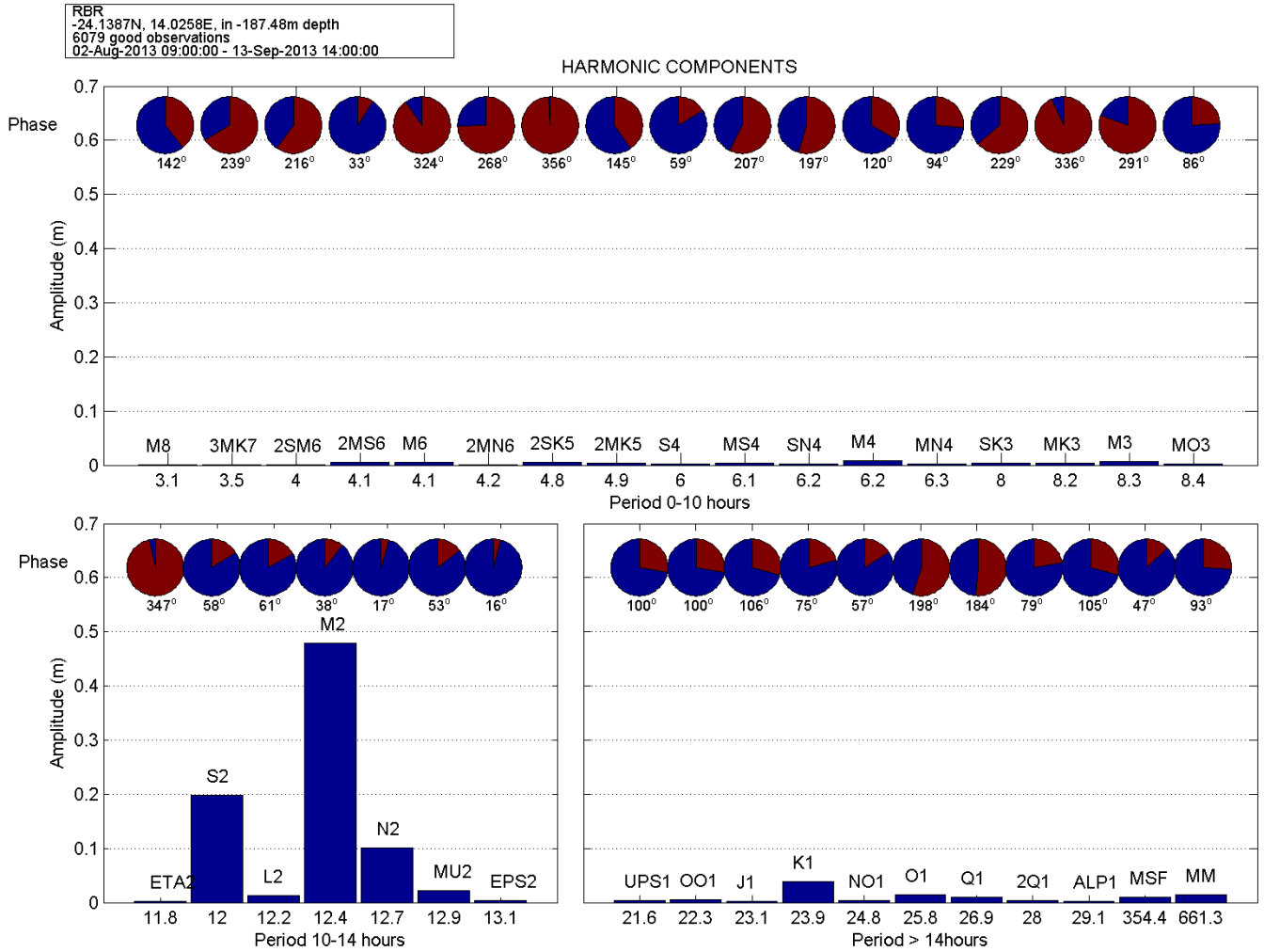


Figure 34: Tidal harmonic components in 187.48 m depth

5 DISCUSSION

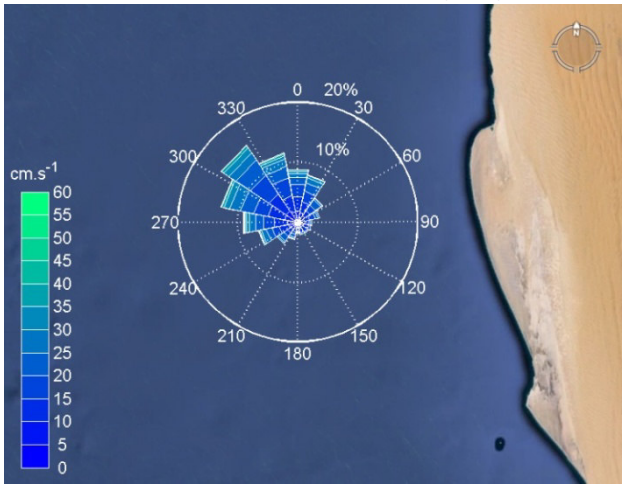
Metocean Services International (Pty) Limited (MSI) has been awarded a contract by Lwandle Technologies, under sub-contract from Namibian Marine Phosphate (Pty) Ltd (NMP), to deploy an oceanographic mooring offshore Namibia. NMP intends dredging marine phosphate reserves at the site and requires verification 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 second and final measurement period (nominally from 2 August 2013 to 13 September 2013) are presented in this report. Data return was good with all instruments returning complete datasets, however no dissolved oxygen data was recorded by the CTD. This may have been the result of a failure of the oxygen sensor.

Current speeds at the measurement location were low, with maximum current speeds exceeding 50 $cm.s^{-1}$ above approximately 15 m depth only. Near the seabed, a maximum current speed of 26.67 $cm.s^{-1}$ 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 9 m to mean speeds of approximately 9$cm.s^{-1}$ in the mid and lower water column. Current flow was primarily towards the WNW to NNW sectors in the upper water column. At a depth of 142 m, current flow was more strongly aligned to the N to NNE sectors, while near the seabed, current flow became polarised, with flow directions mostly recorded between N to NE and S to SW sectors. An overview of current directions at depths of 9 m, 142 m and 188 m is presented in Figure 35. A high current speed event was noted throughout the water column in early September. The maximum current speeds at most depths were recorded during this period. A contour plot of the northward and eastward current velocity components throughout the water column is included in Figure 36 below.

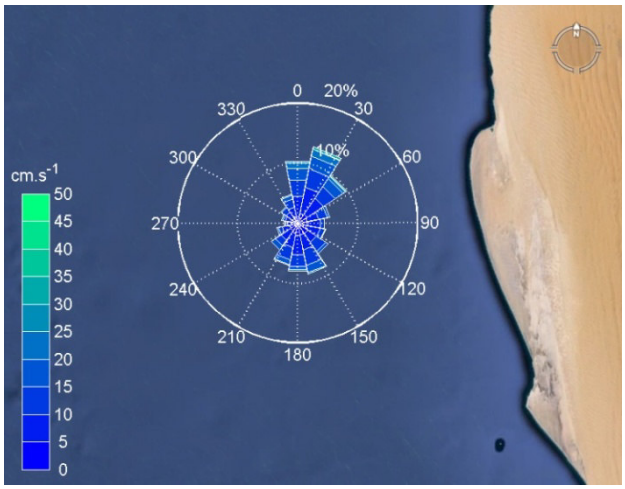
The water temperature was lower than the previous measurement period, with temperatures ranging between a maximum of 13˚C at a depth of 93 m to a minimum of 10˚C near the seabed. The temperature records show a decrease in temperature ranges from 1.8˚C at 93m depth to 0.9˚C near the seabed. Mean temperatures decreased from 12˚C at 93 m to 11˚C near the seabed. A contour plot of the temperature recorded throughout the water column is included as Figure 37 below.

Temperatures showed a general cooling trend at 93 m, with a cooling event occurring near the seabed between 17 and 19 August. This event was visible in both the CTD and AQD data records and is associated with increased current speeds recorded during this period. A maximum fluorescence of 0.78 $\mu g.l^{-1}$ was recorded near the beginning of the measurement period, with fluorescence values exceeding 0.45 $\mu g.l^{-1}$ once more during the data record, while the majority of fluorescence values were recorded between 0 and 0.2 $\mu g.l^{-1}$. The salinity range was small, varying between a maximum of 35.62 psu and a minimum of 35.43 psu with a calculated mean of 35.53 psu. Turbidity was low for much of the measurement period with a mean turbidity of 17.26 NTU, however intermittent increases were noted, with turbidity values exceeding 200 NTU on three occasions. A prolonged period of increased turbidity was noted at the beginning of the measurement period with a maximum value exceeding 1300 NTU. A tidal range of approximately 1.8m was calculated for this location, with the height measured by the CTD ranging between -0.86 m and 0.92 m. The dominant tidal constituents were determined to be M_2, S_2 and N_2 with amplitudes of 0.48 m, 0.20 m and 0.10 m respectively.

NEAR SURFACE CURRENTS (-9m)



MID WATER COLUMN CURRENTS (-142m)



NEAR SEABED CURRENTS (-188m)

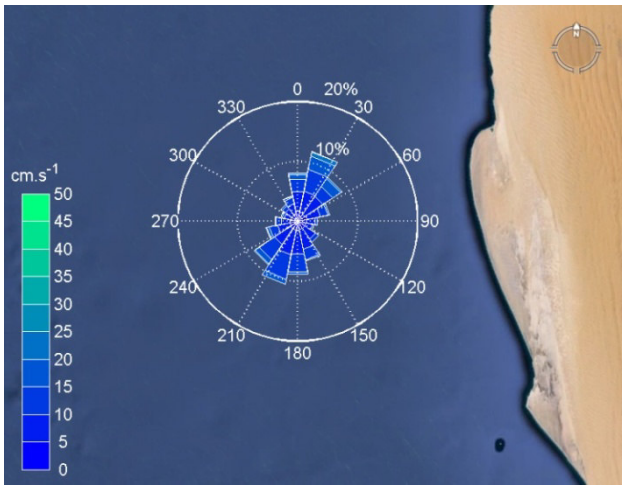


Figure 35: Overview of current directions recorded in the upper, mid and lower water column respectively. Current speeds are indicated by the colour scale.

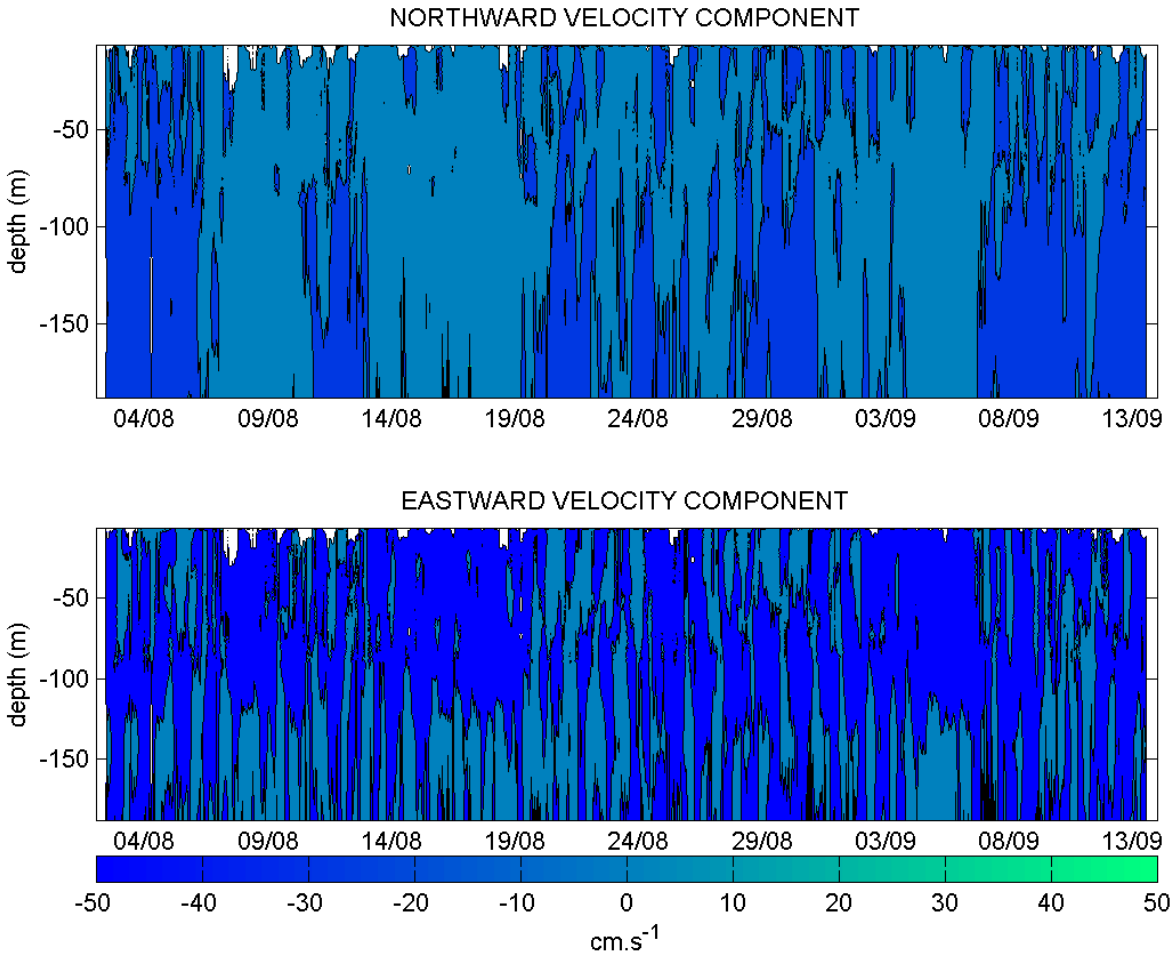


Figure 36: Time series of hourly mean current velocity throughout the water column. The upper panel is the northward velocity component in cm.s^{-1} (negative blue values indicate southward flow and positive green values indicate northward flow) while the eastward component is in the lower panel. White patches indicate missing data.

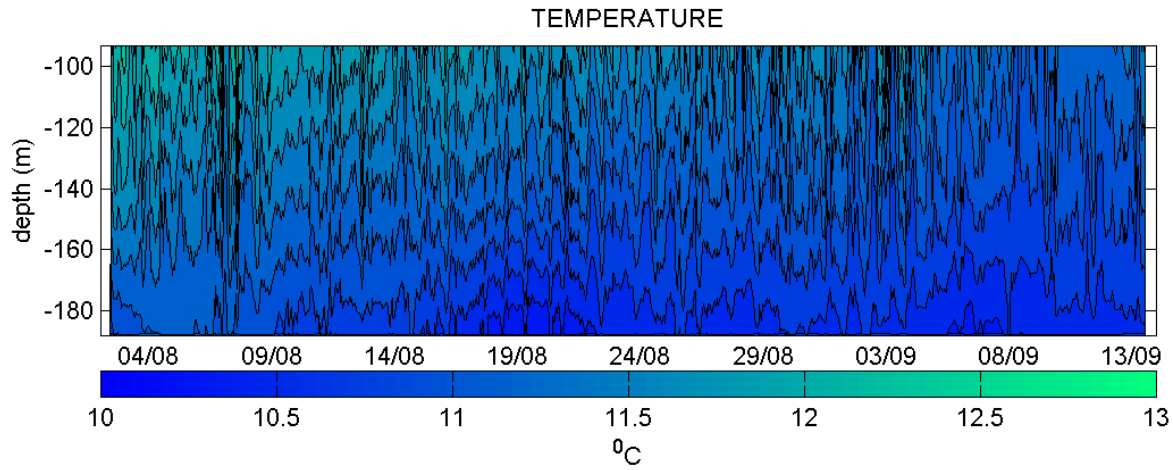


Figure 37: Time series of hourly mean temperature throughout the water column. White patches indicate missing data.