Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

SPC Applied Geoscience and Technology Division (SOPAC)

September 2013

Aseri Baleilevuka, Jens Kruger, Salesh Kumar, Maleli Turagabeci, Hervé Damlamian & Zulfikar Begg

SPC SOPAC DATA RELEASE REPORT (PR105)

Ocean and Islands Programme

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The SPC Applied Geoscience and Technology (SOPAC) Division undertook the work in collaboration with 'Service de l'Urbanisme' of French Polynesia

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EXECUTIVE SUMMARY

The Applied Geoscience and Technology Division of the Secretariat of the Pacific Community carried out an oceanographic survey on five atolls — Apataki, Arutua, Kauehi, Manihi and Rangiroa — in the Tuamotu Archipelago of French Polynesia from July to December 2011. The objective of the survey was to study storm surge hazard and to include this hazard into future development plans.

This report details the deployment of oceanographic instruments to measure current velocities, surface water parameters and water elevation. These oceanographic data improve our understanding of atoll hydrodynamics. The emphasis of the study was on Rangiroa Lagoon and wave transformation on the atoll's outer rim to support cyclone wave inundation modelling.

Current velocities (speed and direction of water flow) were measured in situ using three Nortek acoustic doppler current profilers, or Aquadopps (AQDs), and two Nortek acoustic wave and current meters (AWACs) at Rangiroa and one AQD at each of the other four atolls. Data from the AQD in the Tiputa channel show that the flow of water is tidally influenced, with a dominant flow out of the lagoon towards the northeast at an average speed of 1.5 meters per second (m/s). A maximum speed of about 4.6 m/s was observed on a single occasion and coincided with the higher incident offshore swell wave event that occurred on 27 August 2011. Other current profilers recorded average speeds of less than 0.3 m/s, with their maximum speed corresponding to the offshore wave event in August, with the exception of the AQD on the Avatoru reef flat.

Surface wave parameters and water elevation were measured in situ using eight RBR tide and wave recorders (TWRs), pressure sensors, in Rangiroa and three TWRs for each of the other four atolls. The TWRs deployed at Rangiroa recorded maximum water levels during the extreme offshore wave event on 27 August. The exceptions were the TWRs on the Tivaru reef slope and the ones on the Avatoru reef crest and shore. These TWRs are on the northern part of the atoll, and were protected by islets from incident swell waves.

The AQDs and TWRs deployed at Apataki, Arutua, Kauehi and Manihi atolls recorded no swell events because the earliest deployment was at Kauehi in November 2011. Average speeds observed by the AQDs were 0.2 m/s or less, with the TWRs recording wave heights between 0.1 m and 0.9 m.

1 INTRODUCTION

This report describes an oceanographic survey of five atolls in the Tuamotu Archipelago of French Polynesia. The survey was a component of the project, 'Supporting Disaster Risk Reduction in Pacific Overseas Countries and Territories', which was conducted by the Secretariat of the Pacific Community through its Applied Geoscience and Technology Division, and in collaboration with the Ministry of Lands, Housing and Infrastructure, which is responsible for urban planning.

The purpose of the project was to study the storm surge hazard in the Tuamotu Archipelago of French Polynesia and to include this hazard into future development plans.

This part of the project comprised the acquisition of oceanographic data to better understand the hydrodynamics within Rangiroa's lagoon, and investigate wave transformation on the outer rim of the atoll. The data acquired will be processed and analysed to support the modelling of cyclone wave inundation.

This report describes the details of the oceanographic instrument deployment data at Arutua, Apataki, Kauehi, Manihi, and Rangiroa, from July to December 2011 (Figure 1). The data were used to derive coastal inundation hazard maps by Damlamian et al. (2013), a companion report of the Overseas Countries and Territories – Tuamotu Project.

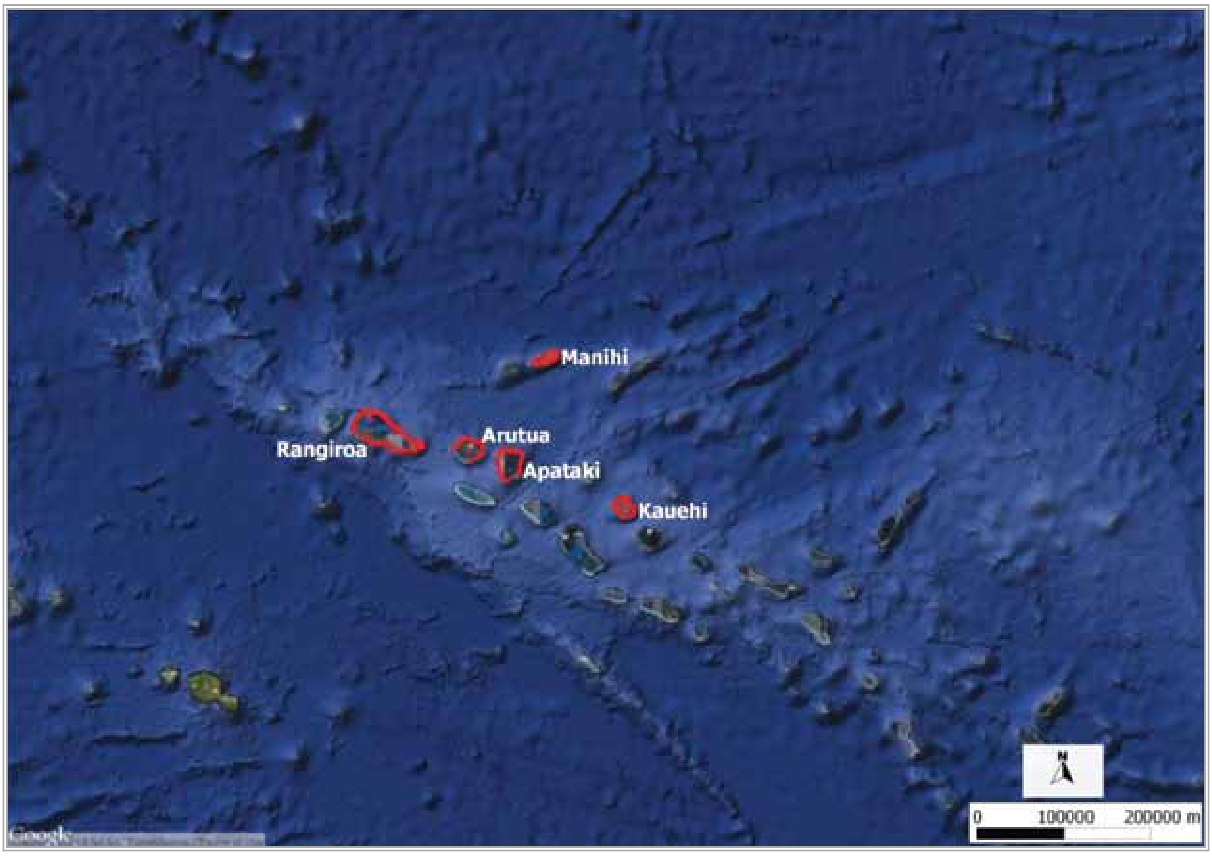

Figure 1: Google Earth image showing the location of the survey sites in the Tuamotu Archipelago of French Polynesia.

2 METHOD

2.1 Rangiroa instrument deployments

Current velocities (speed and direction of water flow) were measured in situ using four Nortek acoustic doppler current profilers (or Aquadopps, abbreviated to AQDs) and two Nortek acoustic wave and current meters (AWACs). One AQD each were deployed in the Tiputa and Avatoru channels while the other two were deployed at the Avatoru reef flat and at Tivaru Hoa. One AWAC was deployed in the middle of the lagoon while the other was deployed on the north side of the Avatoru reefslope (see Figure 2 for locations, and the appendix for deployment frames).

The AQDs and one AWAC (mid-lagoon) were programmed to profile current speed and directions while one AWAC (Avatoru reef slope) recorded both current readings and directional waves. All instruments were also programmed to record water pressure and temperature.

All of the instruments recorded good data, except for the AQD deployed in Avatoru channel, which was not recovered.

Figure 2: Rangiroa IKONOS 2002 satellite image with oceanographic instrument deployment sites shown by red circles.

Surface wave parameters and water elevation were measured in situ using eight RBR tide and wave recorder TWR-2050P pressure sensors. The TWRs were deployed in sets of two, with one on the reef slope, and the second farther inshore on the reef flat (see Figure 2 for locations, and the appendix for deployment photos). Details of the instrumental operating parameters are provided in the tables below.

Table 1: Rangiroa instrument summary.

Instrument	AQD	AWAC	TWR
Description	Acoustic Doppler Profiler	Acoustic Wave and Current Meter	Tide and Wave Recorder
Make	Nortek		RBR
Model	AQD	AWAC-AST	TWR-2050
Type	Acoustic, 1000 Hz (Tiputa channel) and 2000 Hz (Avatoru reef flat and Tivaru Hoa)	Acoustic, 600Hz	Pressure sensor
Digital recorder	Internal		
Data recorded	Current speed and direction, temperature, pressure	Current speed and direction, temperature, pressure (mid lagoon), directional waves, temperature, pressure (reef slope)	Tides, temperature, waves

Table 2: Rangiroa instrument settings.

Instrument	AQD Tiputa channel	AQD Avatoru reef	AQD Tivaru Hoa	AWAC mid lagoon	AWAC reef slope	TWR
Default temperature (°C)	Measured					
Default salinity (ppt)	35.0	35.0	35.0	35.0	35.0	N/A
Sampling interval (s)	Max. rate	Max.rate	Max.rate	Max. rate	1 Hz	2 Hz
No. of samples/ bursts	N/A	N/A	N/A	N/A	1024 for waves	2048 for waves
Averaging interval (s)	60	60	60	60	120 for currents and 10,800 for waves	120 for tides
Record interval (s)	600	900	900	600	600	10,00 for waves and 900 for tides
Number of cells in profile	12	20	30	20	20	N/A
Blanking distance (m)	0.4	0.1	0.1	0.5	0.5	N/A
Cell size (m)	2	0.1	0.1	2	2	N/A

The raw binary file from the AQD deployed in the Tiputa channel was processed using Nortek SeaReport software. Plots generated by the software are shown in the Results section of this report. The raw binary files from the rest of the current profiler instruments were loaded into Nortek software Storm Ver.1.09, and processed. The raw data were then exported to readable ASCII listings and a Matlab script was used to plot the data also shown in the Results section.

In the case of the wave gauge instruments (TWRs), the raw data (.hex files) were downloaded and exported from the RBR software Ruskin v1.7.3 to readable ASCII listings. A Matlab script was also used to generate plots from these data. These are available in the Results section.

Table 3: Rangiroa instrument deployment summary.

Location name	Instrument	Serial No	Easting (m)	Northing (m)	Water depth (m)	Height above seabed (m)	Date, local time, number of first good sample	Duration (days)	Date, local time, number of last good sample	Raw data filename
Tiputa (Rangiroa NE) Shipping channel	AQD	9161	432346	8344526	21	0.21	22/07/2011, 11:40:00 AM, 398	134	3/12/2011, 12:10:00 PM, 19698	TIP_ch01.prf
Avatoru Village reef flat	AQD	AQD 9471	424549.5	8348375	1	0.10	19/07/2011, 1:30:00 PM, 85	140	6/12/2011, 8:00:00 AM, 13500	AVA_RF01.prf & AVA_RF01.wpb
Tivaru Hoa	AQD	AQD 9440	404662.7	8341918	1	0.23	23/07/2011, 1:00:00 PM,191	131	1/12/2011, 12:45:00 PM, 12767	TIV_Ho01.prf
Centre of Rangiroa Lagoon	AWAC-AST	WPR 1532	426121.3	8332630	24	0.55	15/07/2011, 10:40:00 AM, 252	140	2/12/2011, 9:00:00 AM, 20400	RGI_L01.wpr & RGI_L01.wpb
North of Avatoru reef slope	AWAC-AST	WPR 0301	424583.4	8348552	40	0.55	14/07/2011, 12:00:00 PM, 107	144	5/12/2011, 6:00:00 AM, 20838	RGI_R01.wpr & RGI_R01.wpb
Avatoru village reef flat/ shore	TWR-2050	21577	424534.6	8348328	0.3	0.50	20/07/2011, 1:45:00 PM, 117	139	6/12/2011, 7:45:00 AM, 13435	Avatoru shoreline_021577 _2011126_1110.hex
Avatoru lagoon	TWR-2050	15484	427691	8346589	7	0.20	16/07/2011, 10:15:00 AM, 151	135	28/11/2011, 12:15:00 PM, 13118	North_lagoon-015484 _20111228_1821.hex
Tivaru reef slope	TWR-2050	15485	404249.4	8342017	16	0.20	18/07/2011, 9:30:00 AM, 64	136	1/12/2011, 1:30:00 PM, 13134	Tivaru reefslope_015485 _20111201_1708.hex
Avatoru village reef crest	TWR-2050	21578	424556	8348384	2	0.50	21/07/2011, 11:00:00 AM, 11	138	6/12/2011, 1:00:00 AM, 13438	Avatoru reefcrest_021578 _20111206_1047.hex
Tivaru Lagoon	TWR-2050	21573	405400.4	8341359	6	0.15	23/07/2011, 2:15:00 PM, 71	131	1/12/2011, 12:30:00 PM, 12638	Tivaru_lagoon_021573 _20111201_1648.hex
Otupipi Lagoon	TWR-2050	21575	455507.1	8308945	7	0.20	22/07/2011, 11:15:00 AM, 59	130	29/11/2011, 12:30:00 PM, 12542	Otupipi-lagoon_021575 _20111129_1820.hex
Utoto reef flat	TWR-2050	21572	433441.1	8314877	0.3	0.50	25/07/2011, 11:30:00 AM, 59	127	29/11/2011, 9:15:00 AM, 12167	Utoto reefflat-021572 _20111229_1841.hex
Utoto Lagoon	TWR-2050	21571	433391.2	8315791	6	0.20	25/07/2011, 12:30:00 PM, 64	128	30/11/2011, 9:00:01 AM, 12337	Utoto lagoon_021571 _20111130_1745.hex

2.2 Apataki, Arutua, Kauehi and Manihi instrument deployments

Instruments were deployed in sets of four at each consecutive atoll. Kauehi was the first atoll surveyed, followed by Arutua, Apataki and Manihi.

One AQD was deployed on the reef flat to measure current velocities (speed and direction of water flow) and three TWRs were deployed (to measure wave parameters and water elevation), with one on the reef slope, one on the reef crest, and the third on the reef flat (see Figures 3–6 for locations).

Table 4: Kauehi, Arutua, Apataki, Manihi instrument summary.

Instrument	AQD	TWR
Description	Acoustic Doppler Profiler	Tide and Wave Recorder
Make	Nortek	RBR
Model	AQD	TWR-2050
Type	Acoustic, 2000 Hz	Pressure sensor
Digital recorder	Internal	
Data recorded	Current speed and direction, temperature, pressure	Tides, temperature, waves

Table 5: Kauehi, Arutua, Apataki, Manihi instrument settings.

Instrument	AQD Kauehi and Arutua	AQD Apataki and Manihi	TWR
Default temperature (°C)	Measured		
Default salinity (ppt)	35.0	35.0	N/A
Sampling interval (s)	1 Hz	2 Hz	2 Hz
No. of samples/bursts	N/A	1024 for waves	2048 for waves
Averaging interval (s)	60	60 for currents and 600 for waves	60 for tides
Record interval (s)	600	600	3,600 for waves and 300 for tides
Number of cells in profile	20	20	N/A
Blanking distance (m)	0.1	0.1	N/A
Cell size (m)	0.1	0.1	N/A

2.2.1 Kauehi instrument deployments

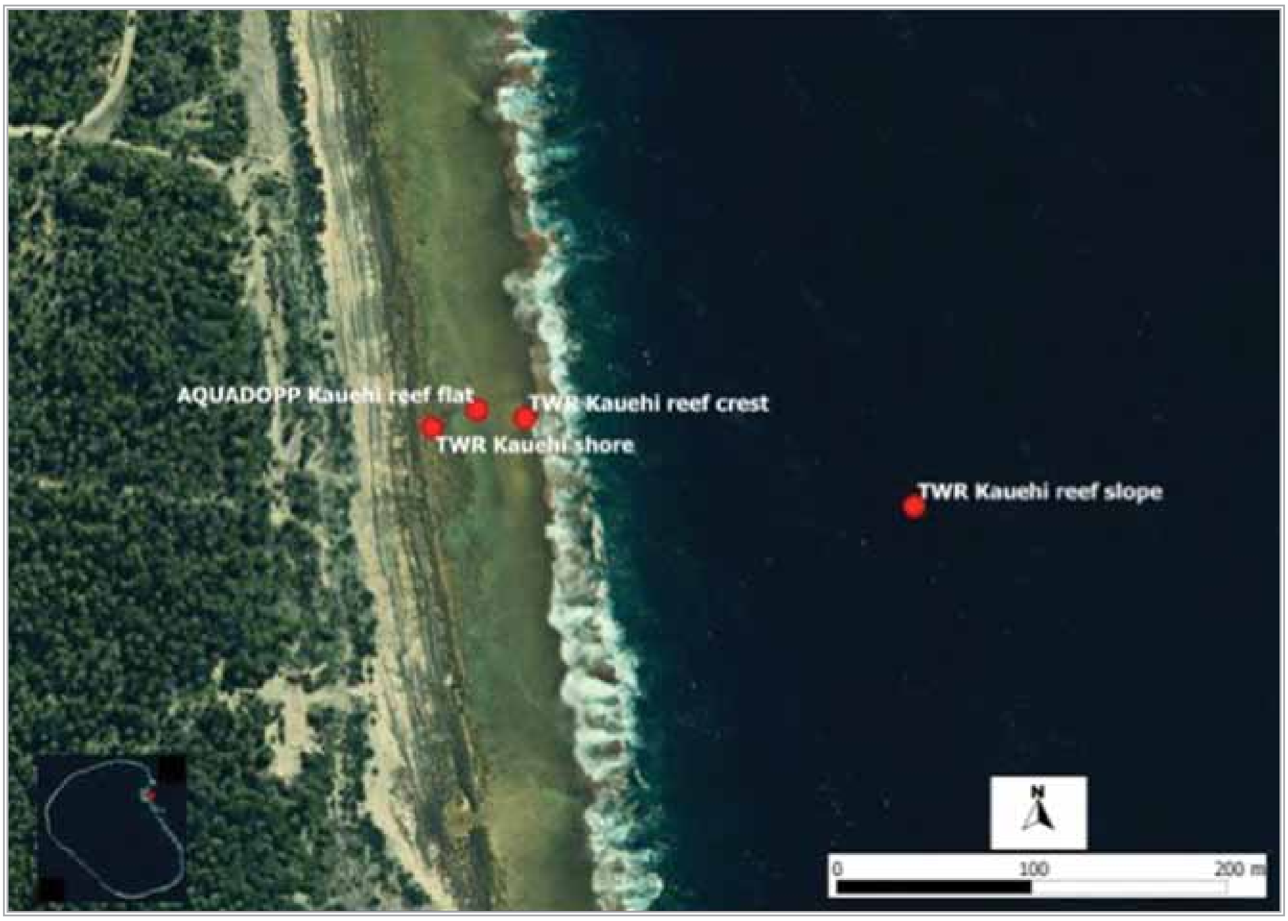

Figure 3: Kauehi IKONOS 2003 satellite image with oceanographic instrument deployment sites.

Table 6: Kauehi instrument deployment summary.

Location name	Instrument	Serial No	Easting	Northing	Water depth (m)	Date, local time, number of first good sample	Duration (days)	Date, local time, number of last good sample	Filename
Kauehi shore	TWR-2050	21574	703189.4	8249219	0.3	13/11/2011, 11:00:00 AM, 339	4	17/11/2011, 3:20:00 PM, 1127	021574_20111117_1823.hex
Kauehi reef slope	TWR-2050	21579	703435.4	8249178	13.5	13/11/2011, 11:00:00 AM, 55	3	16/11/2011, 10:55:00 AM, 850	Kauehi_RBR_reefslope _021579_20111116_1210.hex
Kauehi reef crest	TWR-2050	21576	703232.3	8249223	0.1	13/11/2011, 11:00:00 AM,335	4	17/11/2011, 05:55:00 PM, 1123	021576_20111117_1815.hex
Kauehi reef flat	AQD	6550	703210.9	8249228	0.2	13/11/2011, 12:00:00 PM, 277	4	17/11/2011, 06:20:00 PM, 564	Aqdp_kauehi.prf

2.2.2 Arutua instrument deployments

Figure 4: Arutua IKONOS 2003 satellite image with oceanographic instrument deployment sites.

Table 7: Arutua instrument deployment summary.

Location name	Instrument	Serial No	Easting	Northing	Water depth (m)	Date, local time, number of first good sample	Duration (days)	Date, local time, number of last good sample	Filename
Arutua shore	TWR-2050	21576	540965.9	8301535.4	0.2	21/11/2011, 11:00:00 AM, 30	4	25/11/2011, 5:55:00 PM, 1208	Reef_shore _arutua.hex
Arutua reef slope	TWR-2050	21579	541083.8	8301445.6	3.2	21/11/2011, 11:00:00 AM, 271	4	25/11/2011, 10:40:00 AM, 1142	Reef_slope _arutua.hex
Arutua reef crest	TWR-2050	21574	541051.7	8301518.6	0.4	21/11/2011, 11:00:00 AM,17	5	26/11/2011, 05:20:00 AM, 1363	Reef_crest _arutua.hex
Arutua reef flat	AQD	6550	541030.3	8301523.1	0.2	21/11/2011, 12:00:00 PM, 54	4	25/11/2011, 06:30:00 PM, 605	Arutua01.prf

2.2.3 Apataki instrument deployments

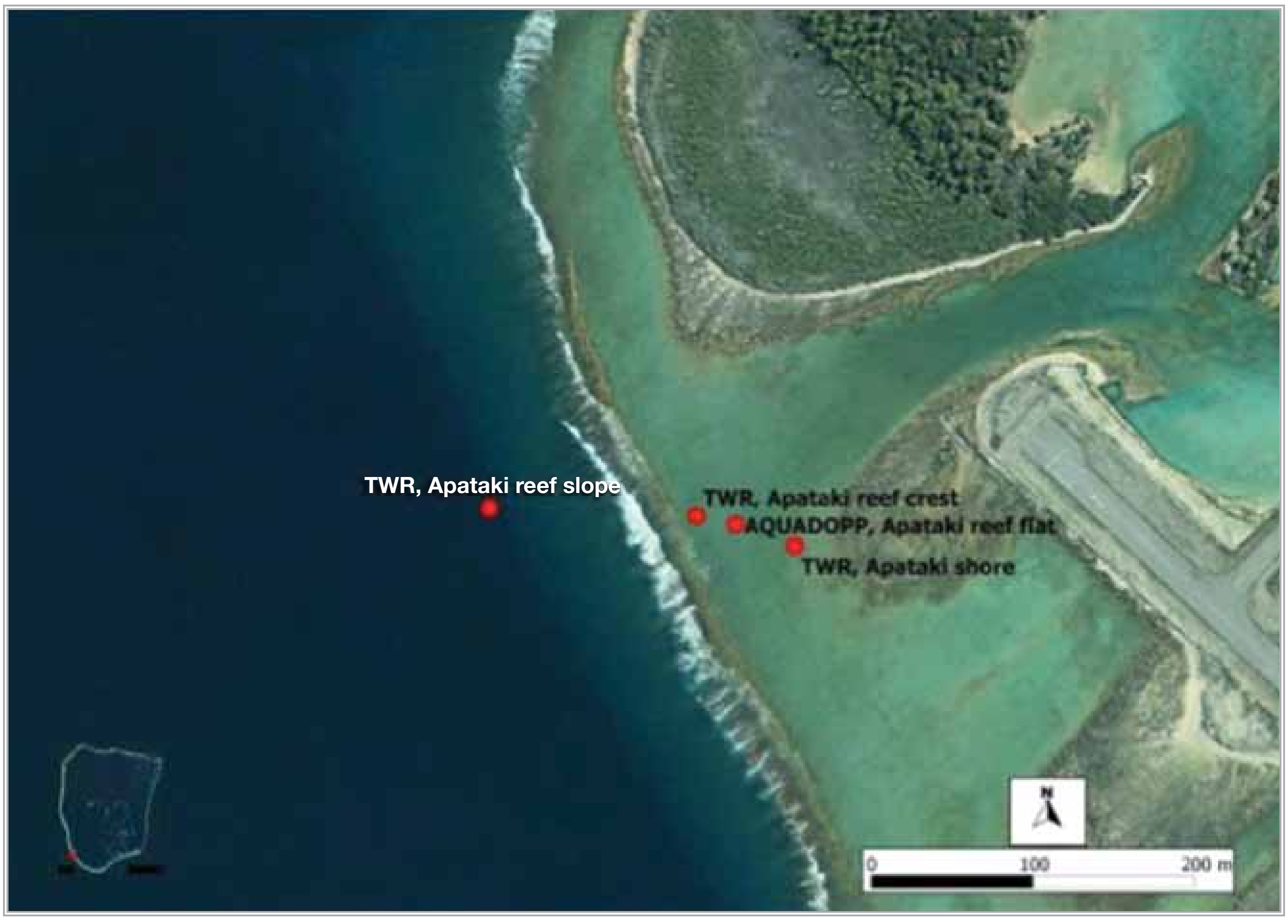

Figure 5: Apataki IKONOS 2003 satellite image with oceanographic instrument deployment sites.

Table 8: Apataki instrument deployment summary.

Location name	Instrument	Serial No	Easting	Northing	Water depth (m)	Date, local time, number of first good sample	Duration (days)	Date, local time, number of last good sample	Filename
Apataki shore	TWR-2050	21576	562475.5	8278176.5	0.2	28/11/2011, 9:00:00 AM, 11	5	3/12/2011, 15:55:00 PM, 1128	RBR_shore _apataki.hex
Apataki reef slope	TWR-2050	21579	562293.3	8278199.1	8.4	27/11/2011, 11:00:00 AM,2	6	3/12/2011, 03:55:00 PM,1450	RBR_slope _apataki.hex
Apataki reef crest	TWR-2050	21574	562411.2	8278194.3	0.3	28/11/2011, 09:00:00 AM,53	5	3/12/2011, 03:55:00 PM, 1130	RBR_crest _apataki.hex
Apataki reef flat	AQD	6550	562443.4	8278189.8	0.2	28/11/2011, 10:00:00 AM, 31	5	3/12/2011, 02:50:00 PM, 565	Apatak01.prf

2.2.4 Manihi instrument deployments

Figure 6: Manihi 2013 Google Earth image with oceanographic instrument deployment sites.

Table 9: Manihi instrument deployment summary.

Location name	Instrument	Serial No	Easting	Northing	Water depth (m)	Date, local time, number of first good sample	Duration (days)	Date, local time, number of last good sample	Filename
Manihi shore	TWR-2050	21574	601567.7	8400913	0.3	6/12/2011, 11:00:00 AM, 336	6	12/12/2011, 2:40:00 PM, 1741	021574_20111212_1545.hex
Manihi reef slope	TWR-2050	21579	601513.5	8400835	7.1	6/12/2011, 11:00:00 AM, 31	7	13/12/2011, 7:50:00 AM, 1972	RBR_slope.hex
Manihi reef crest	TWR-2050	21576	601535.2	8400872	0.2	6/12/2011, 11:00:00 AM, 361	6	12/12/2011, 2:35:00 PM, 1742	021576_20111212_1536.hex
Manihi reef flat	AQD	6550	601567.7	8400906	0.1	6/12/2011, 12:00:00 PM, 213	6	12/12/2011, 3:51:01 AM, 838	Manihi01.prf

3 RESULTS

3.1 Rangiroa instruments

3.1.1 AQD — Tiputa channel

The following time series plots and matrix show water flow observations by the AQD in mid-water (bin 10) in Tiputa channel. These plots were generated by Nortek SeaReport software and the data show that the flow of water is predominantly out of the lagoon towards the northeast at an average speed of 1.5 m/s (Figure 7). A maximum speed of about 4.6 m/s was observed on a single occasion and coincided with the higher incident offshore wave event that occurred on 27 August 2011.

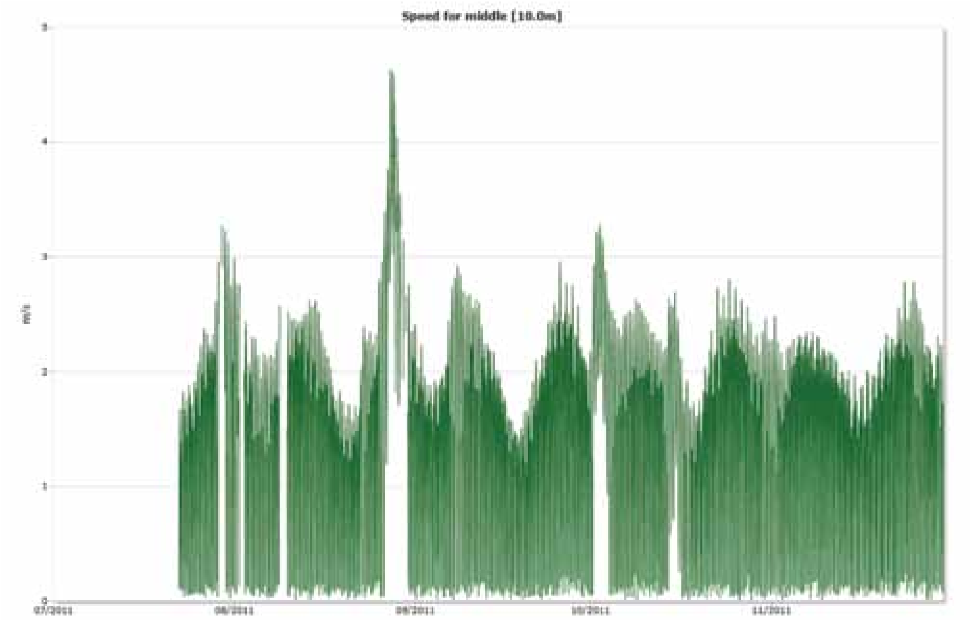

Figure 7: Time series plot of current speed for mid-depth within Tiputa channel as measured by the AQD. Direction is given from true north in oceanographic convention (going toward). Note maximum speed on 27 August 2011.

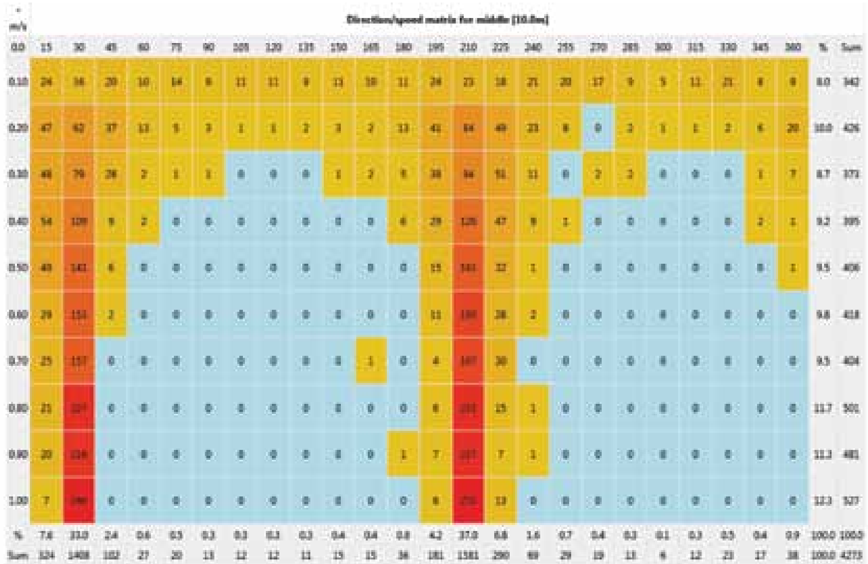

Figure 8: Matrix of current speed and direction for mid-depth within Tiputa channel as measured by the AQD. Direction is given from true north in oceanographic convention (going toward).

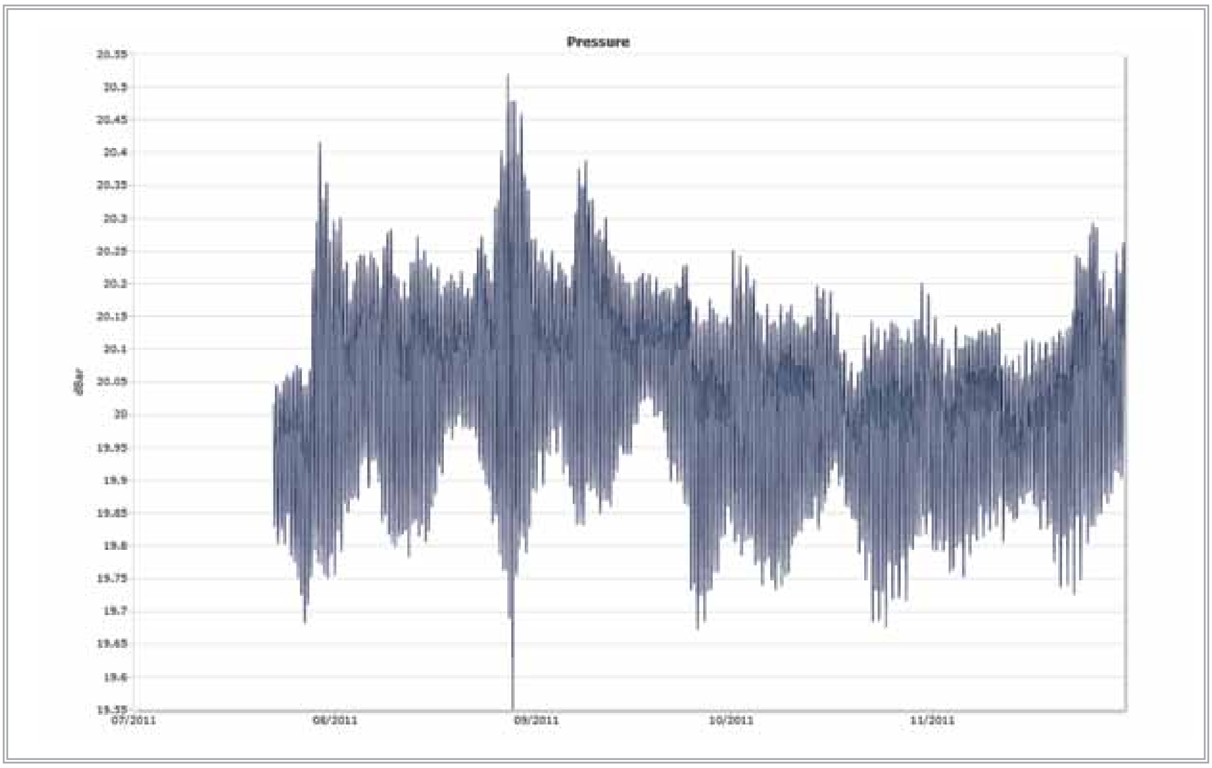

Figure 9: Time series plot of depth-averaged current pressure as measured by the AQD in Tiputa channel.

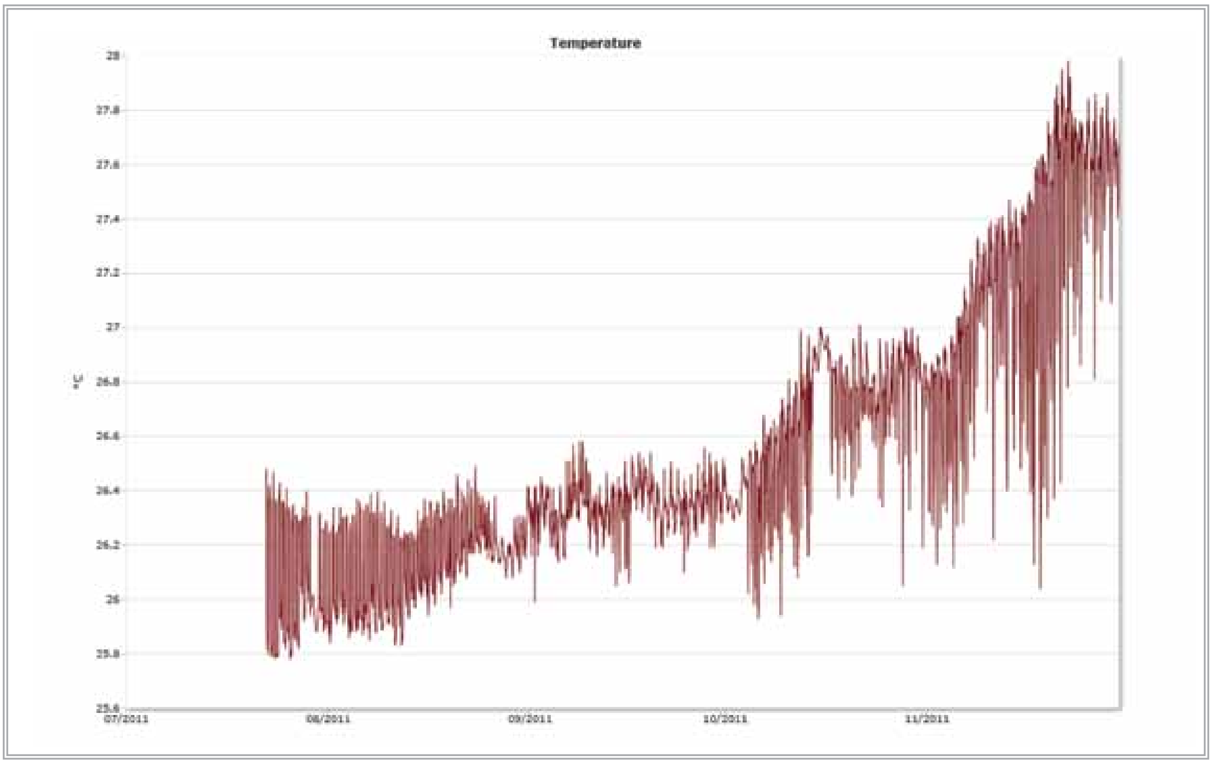

Figure 10: Time series plot of depth-averaged current temperature as measured by the AQD in Tiputa channel.

3.1.2 AQD — Avatoru reef flat

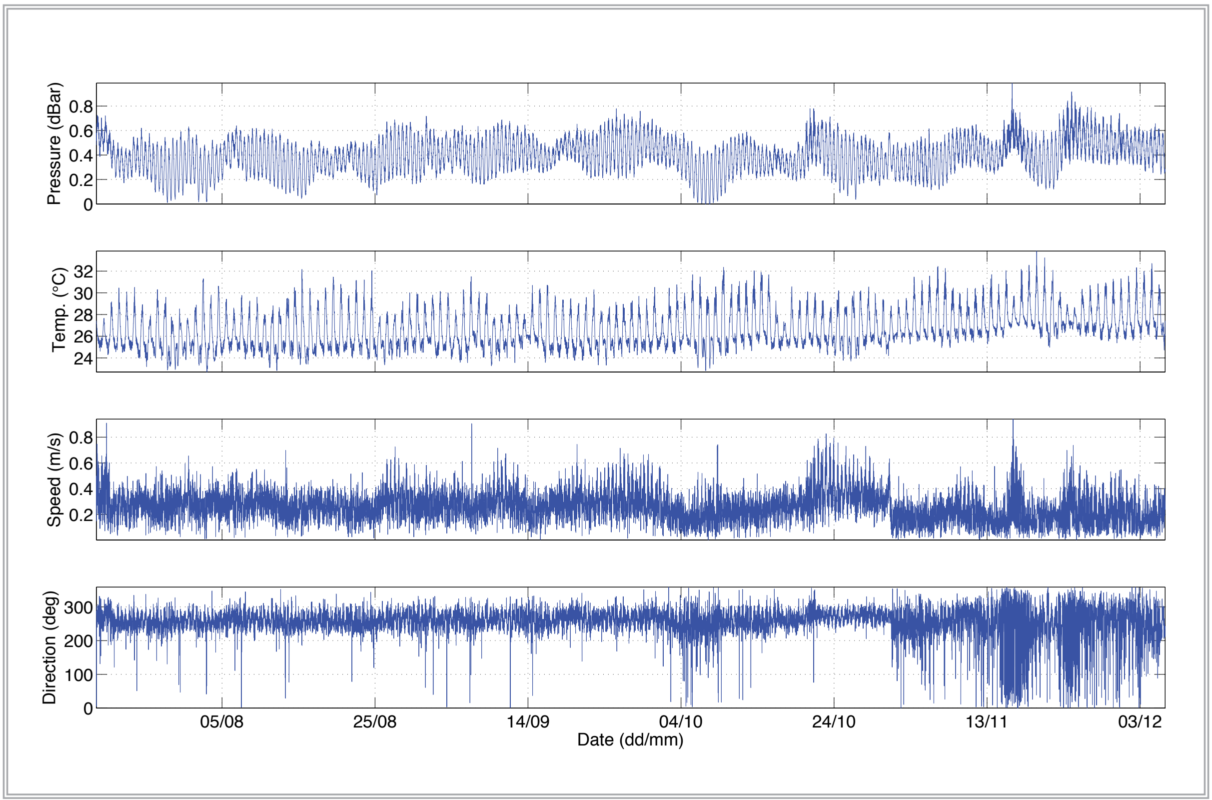

Figure 11: Time series plot of pressure, temperature and current speed and direction, as measured by the AQD on the Avatoru reef flat. Direction is given from true north in oceanographic convention (going toward).

3.1.3 AQD — Tivaru Hoa

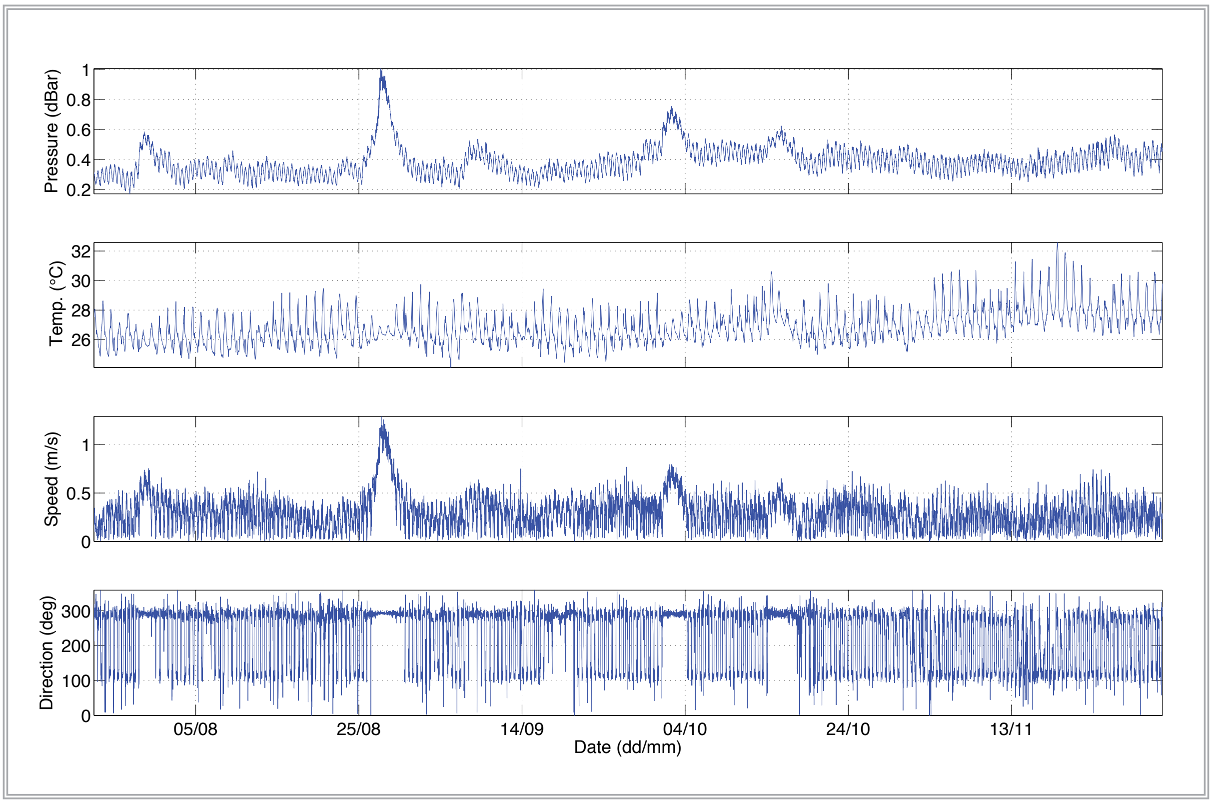

Figure 12: Time series plot of pressure, temperature and current speed and direction, as measured by the AQD in Tivaru Hoa. Direction is given from true north in oceanographic convention (going toward). Note maximum pressure and current speed on 27 August 2011, coinciding with the extreme southerly swell event.

3.1.4 AWAC — centre of the lagoon

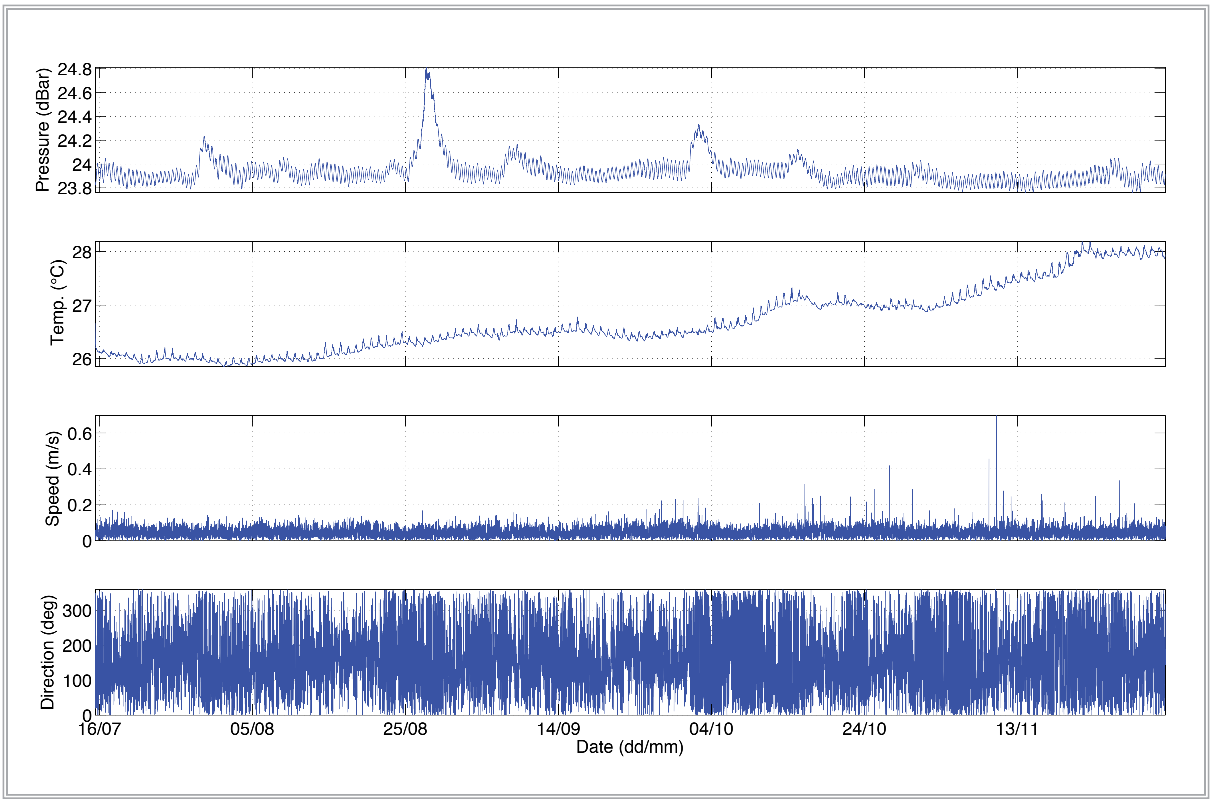

Figure 13: Time series plot of pressure, temperature, and current speed and direction, as measured by the AWAC in the centre of the lagoon. Direction is given from true north in oceanographic convention (going toward). Note maximum pressure on 27 August 2011, coinciding with the extreme southerly swell event.

3.1.5 AWAC — Avatoru reef slope

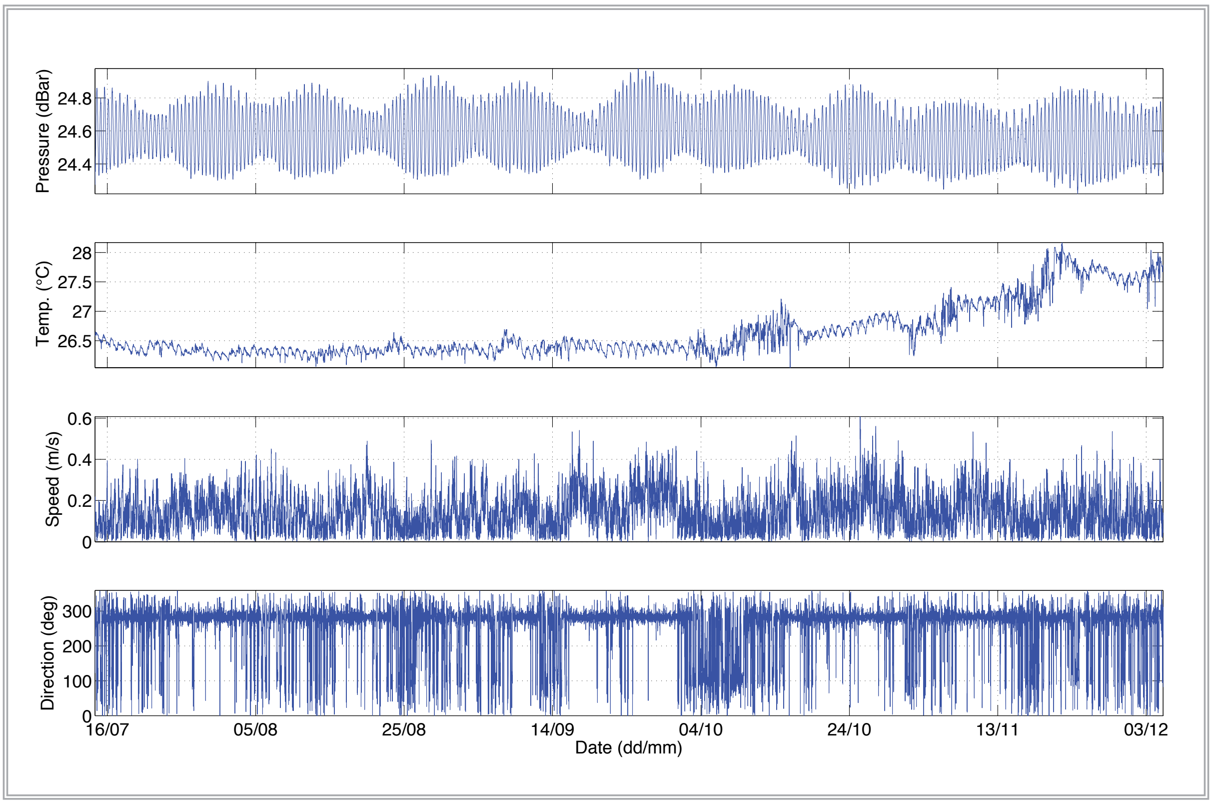

Figure 14: Time series plot of pressure, temperature, and current speed and direction, as measured by the AWAC on the reef slope of Avatoru. Direction is given from true north in oceanographic convention (going toward).

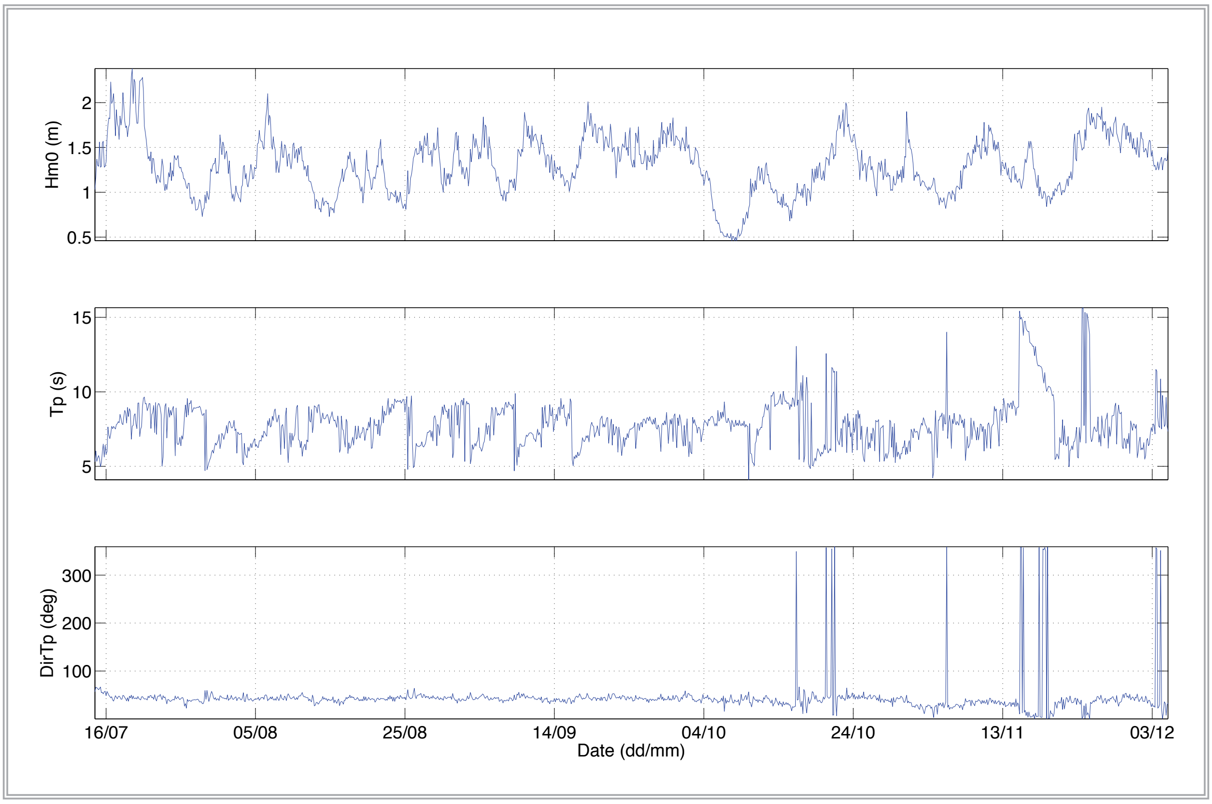

Figure 15: Time series plot of significant wave height (Hm0), peak wave period (Tp) and peak wave direction (DirTp) as measured by the AWAC on the reef slope of Avatoru. Direction is given from true north in meteorological convention (coming from).

3.1.6 TWR — Avatoru reef flat

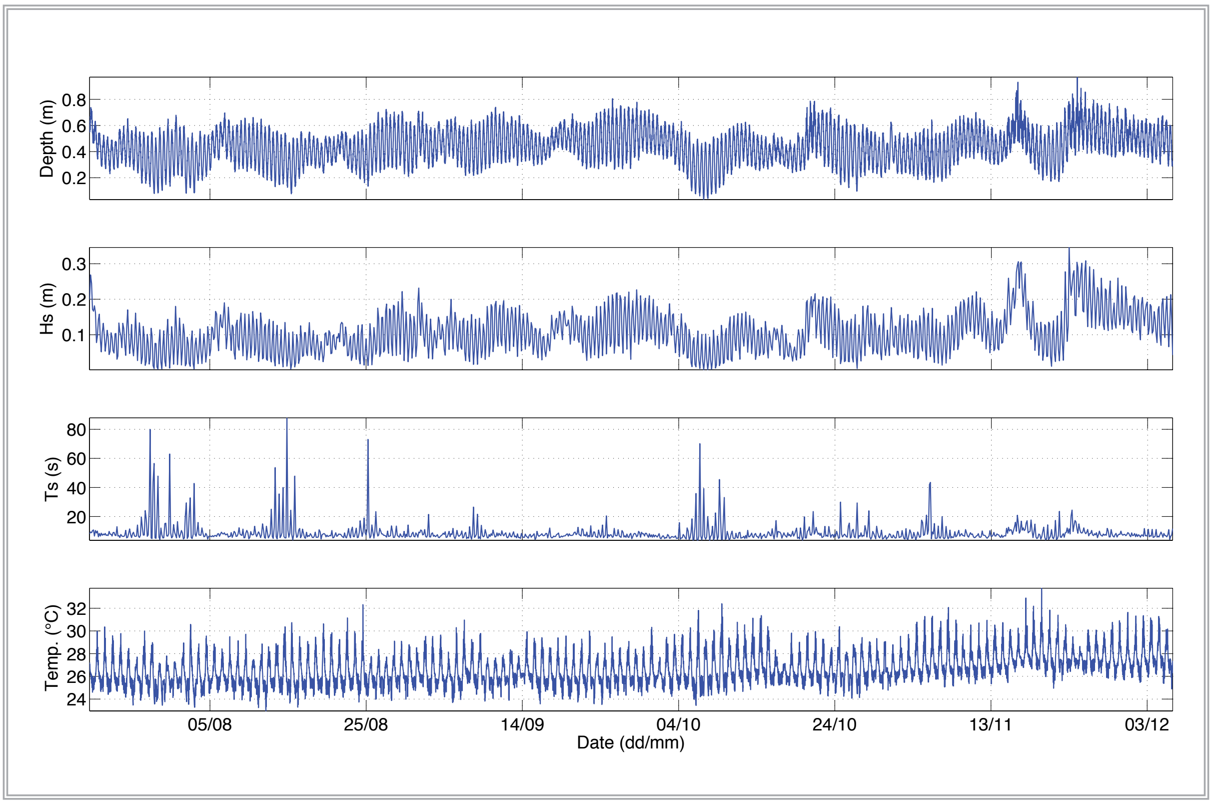

Figure 16: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Avatoru reef flat. Direction is given from true north in oceanographic convention (going toward).

3.1.7 TWR — Avatoru Lagoon

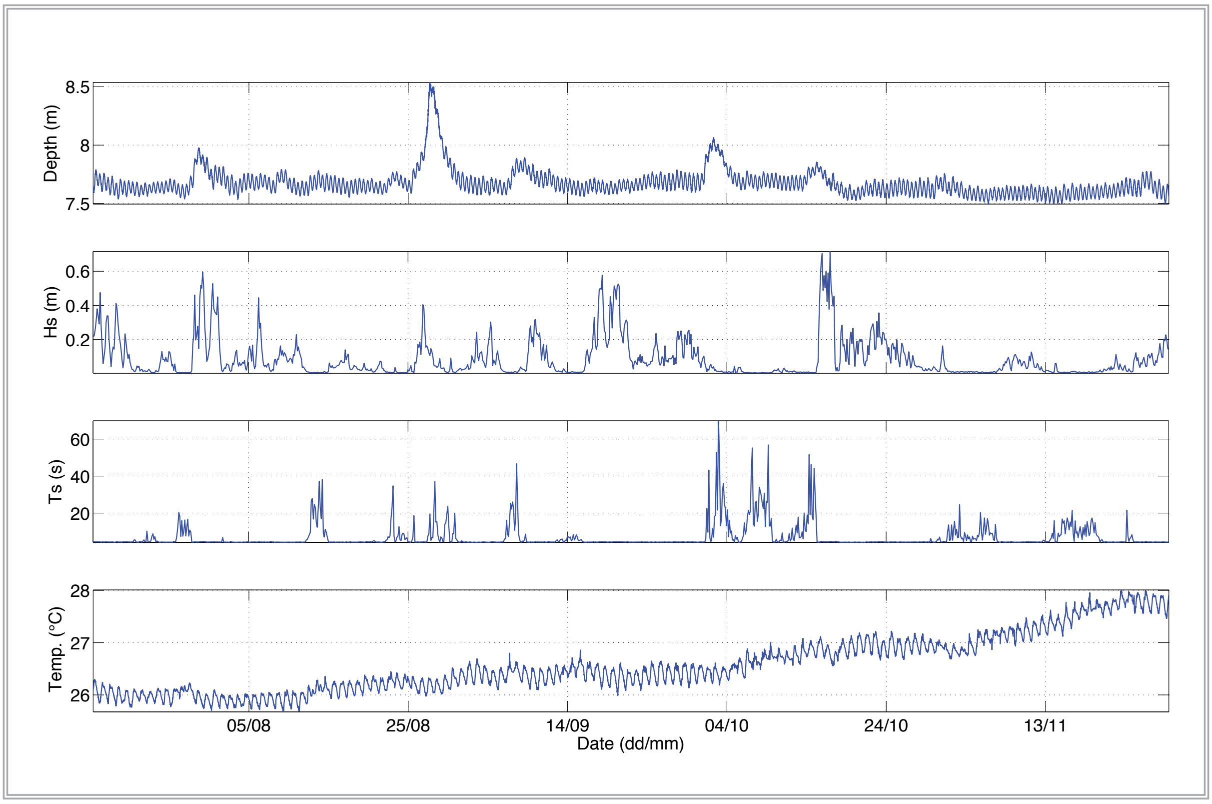

Figure 17: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR in Avatoru Lagoon. Direction is given from true north in oceanographic convention (going toward). Note the maximum water level recorded on 27 August 2011, coinciding with the extreme southerly swell event.

3.1.8 TWR — Avatoru reef crest

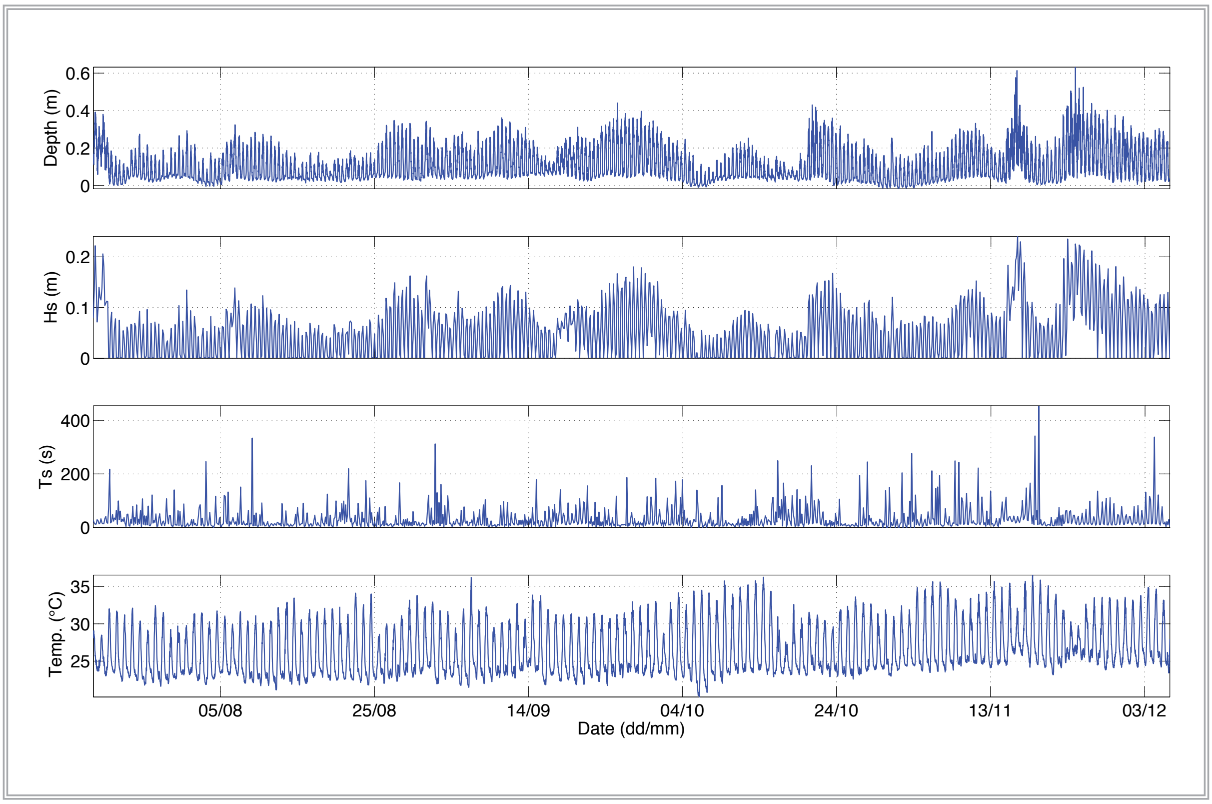

Figure 18: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Avatoru reef crest. Direction is given from true north in oceanographic convention (going toward).

3.1.9 TWR — Tivaru Lagoon

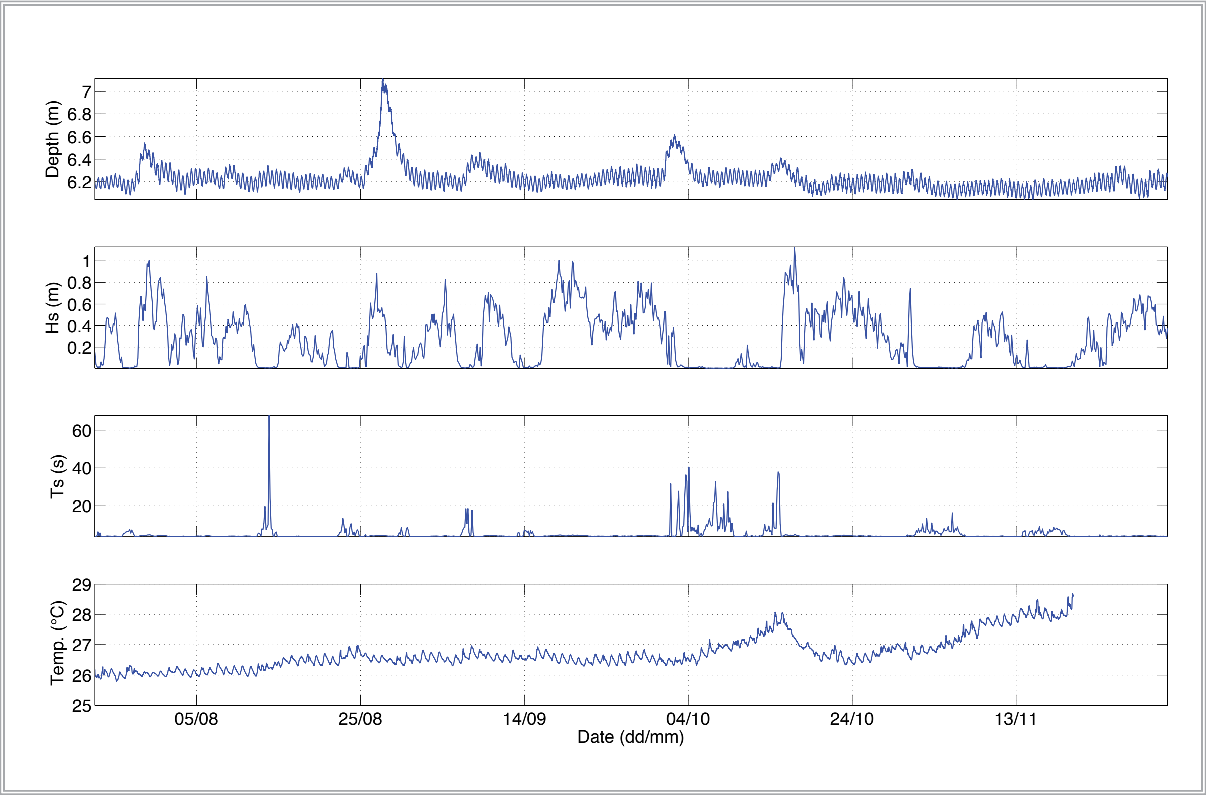

Figure 19: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR in Tivaru Lagoon. Direction is given from true north in oceanographic convention (going toward). Note the maximum water level on 27 August 2011, coinciding with the extreme southerly swell event.

3.1.10 TWR — Tivaru reef slope

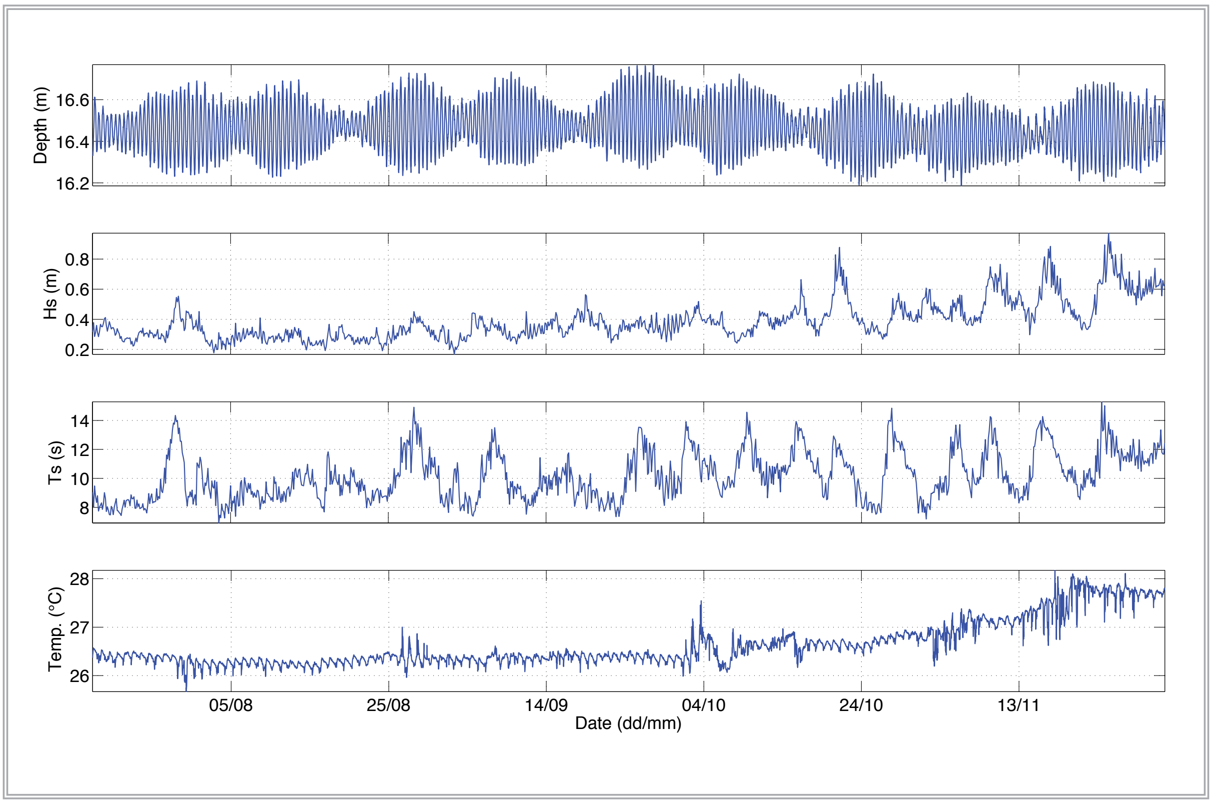

Figure 20: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Tivaru reef slope. Direction is given from true north in oceanographic convention (going toward).

3.1.11 TWR — Otupipi Lagoon

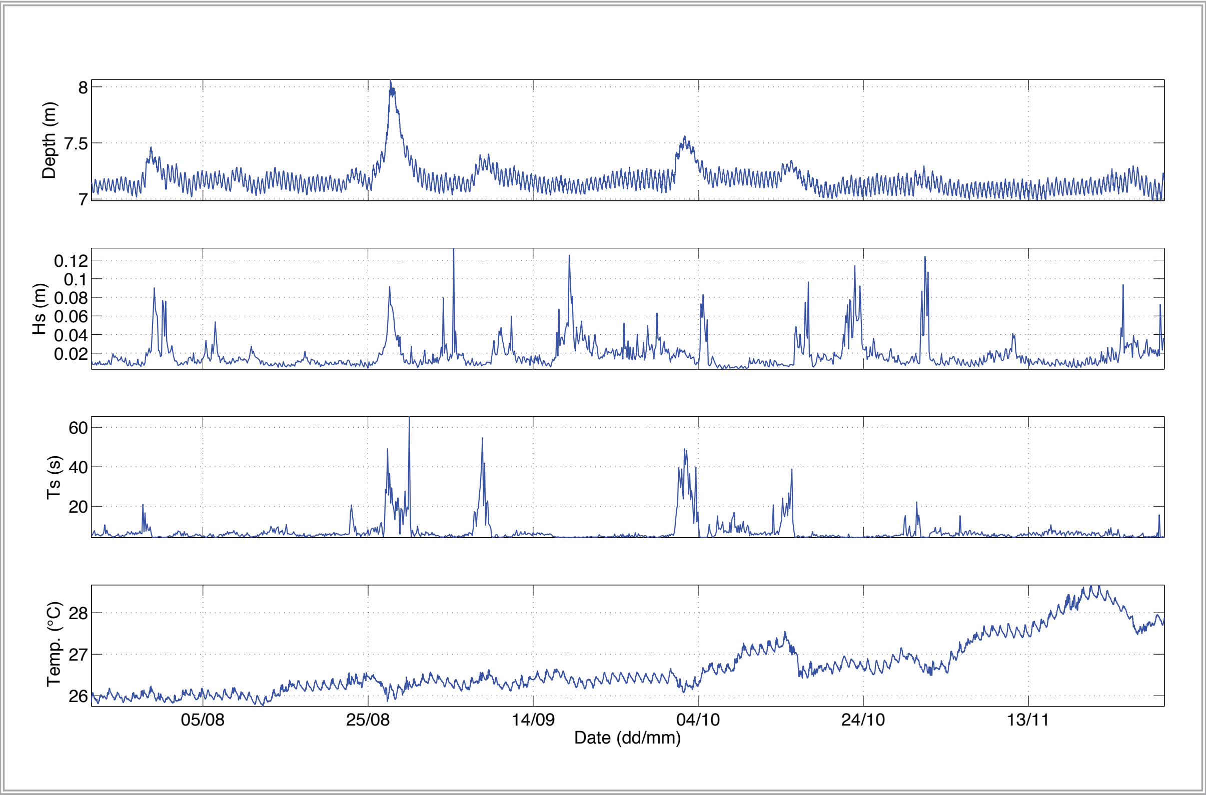

Figure 21: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR in Otupipi Lagoon. Direction is given from true north in oceanographic convention (going toward). Note the maximum water level on 27 August 2011, coinciding with the extreme southerly swell event.

3.1.12 TWR — Utoto Lagoon

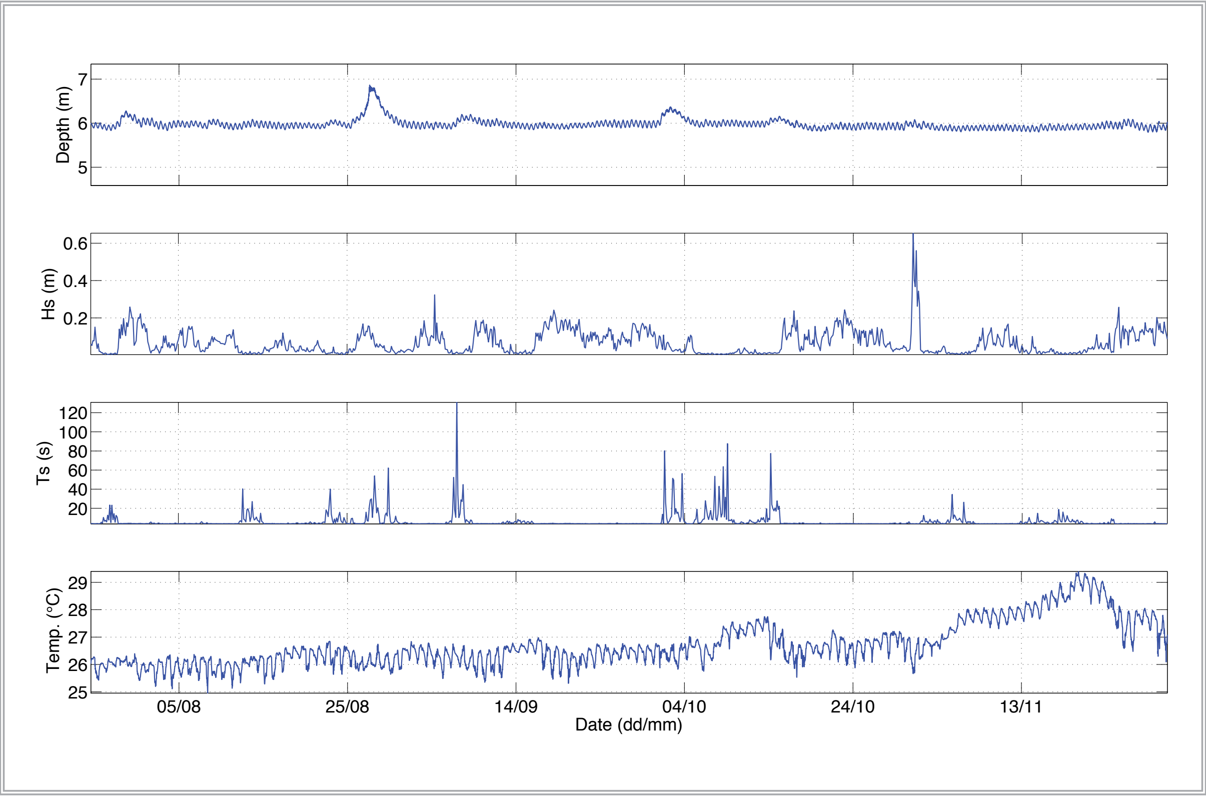

Figure 22: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR in Utoto Lagoon. Direction is given from true north in oceanographic convention (going toward).

3.1.13 TWR — Utoto reef flat

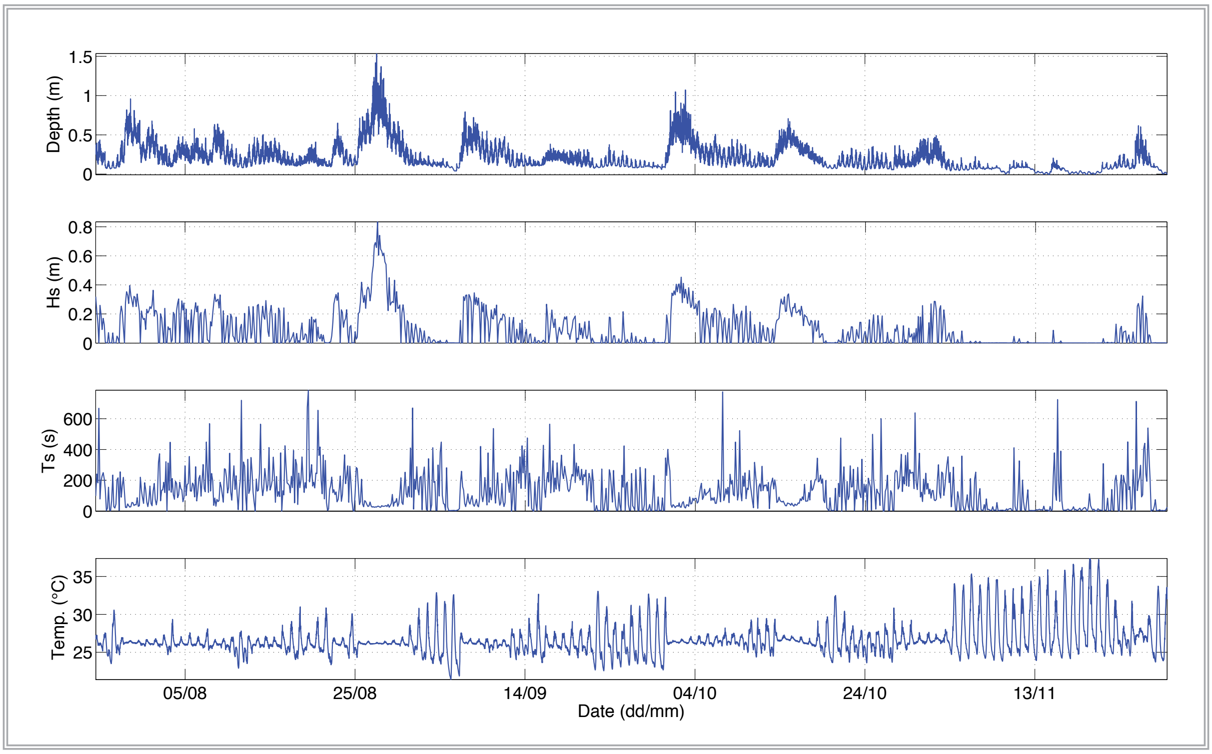

Figure 23: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Utoto reef flat. Direction is given from true north in oceanographic convention (going toward). Note the maximum water level and significant wave height recorded on 27 August 2011, coinciding with the extreme southerly swell event.

3.2 Kauehi instrument deployments

3.2.1 AQD — Kauehi

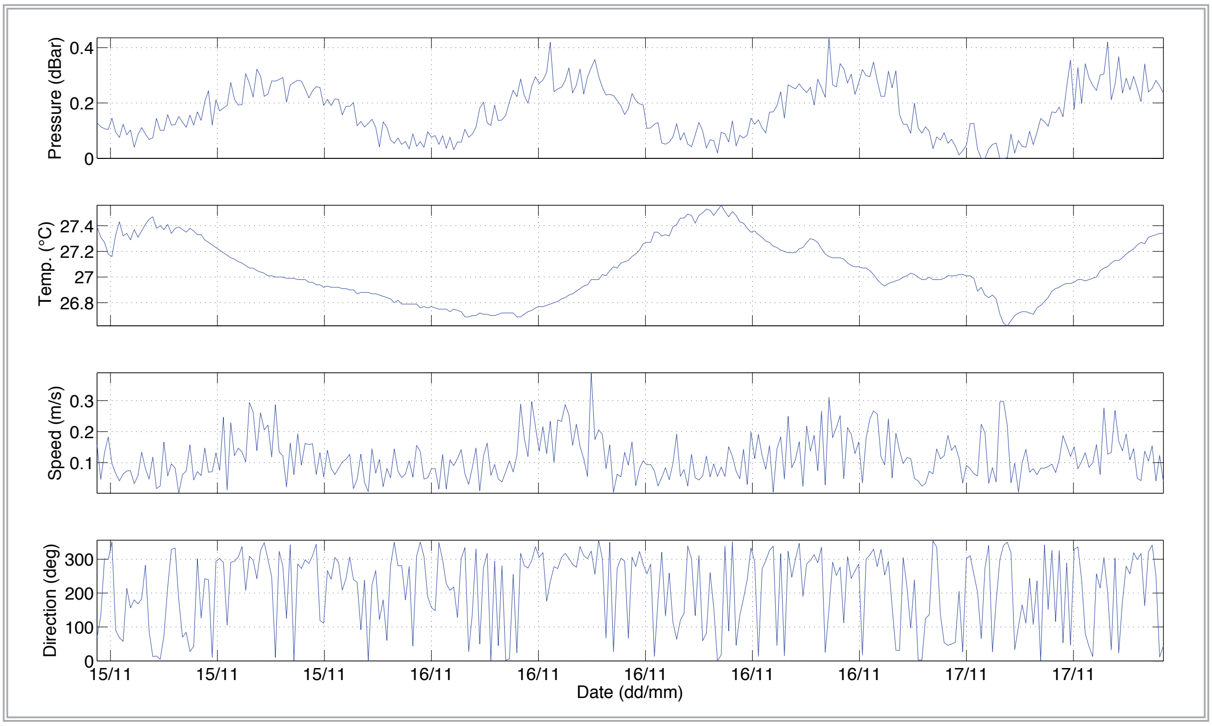

Figure 24: Time series plot of pressure, temperature, current speed and direction, as measured by the AQD on the Kauehi reef flat. Direction is given from true north in oceanographic convention (going toward).

3.2.2 TWR — Kauehi reef slope

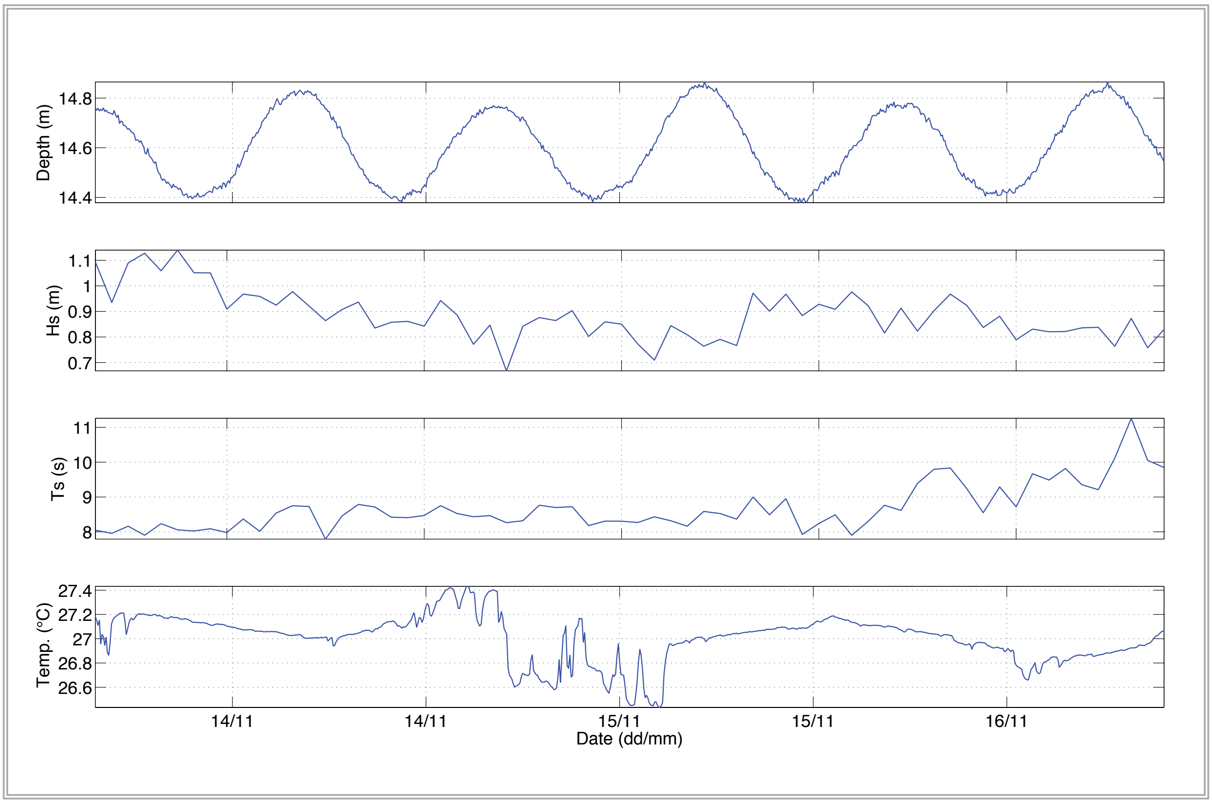

Figure 25: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Kauehi reef slope. Direction is given from true north in oceanographic convention (going toward).

3.2.3 TWR — Kauehi reef crest

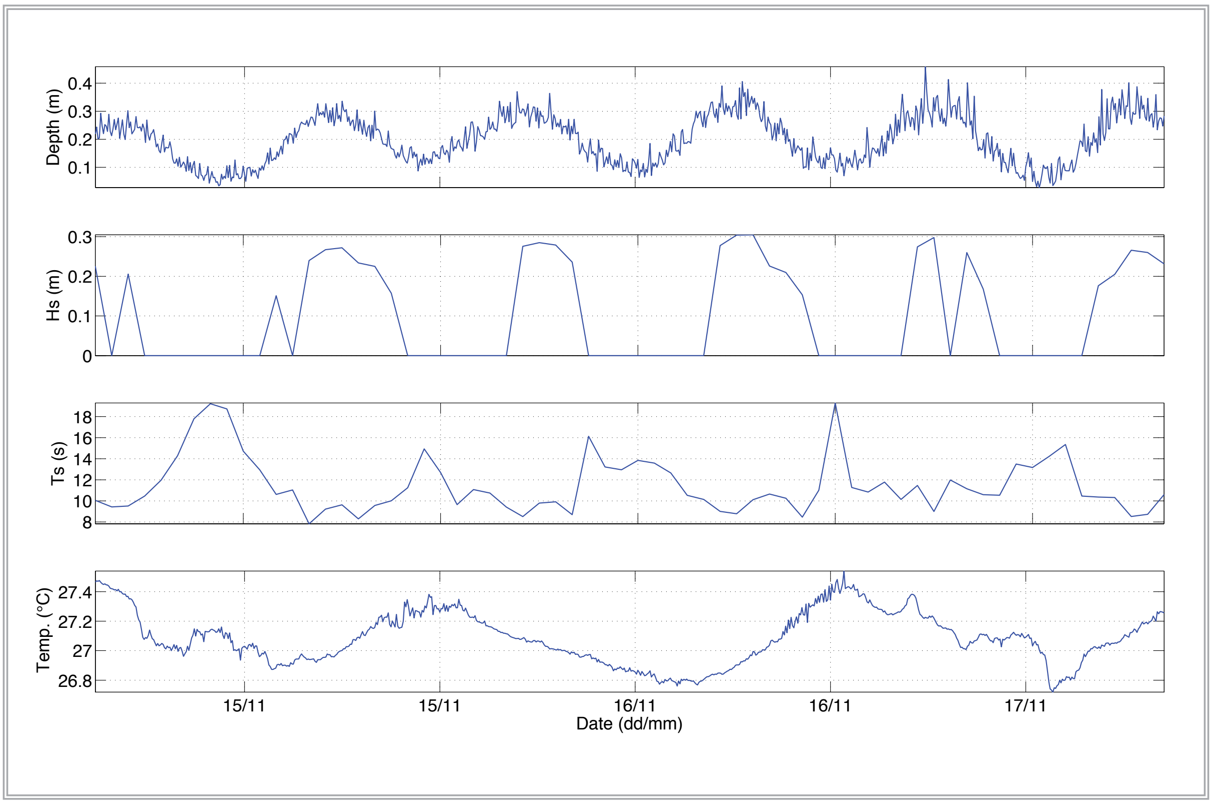

Figure 26: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Kauehi reef crest. Direction is given from true north in oceanographic convention (going toward).

3.2.4 TWR — Kauehi shoreline

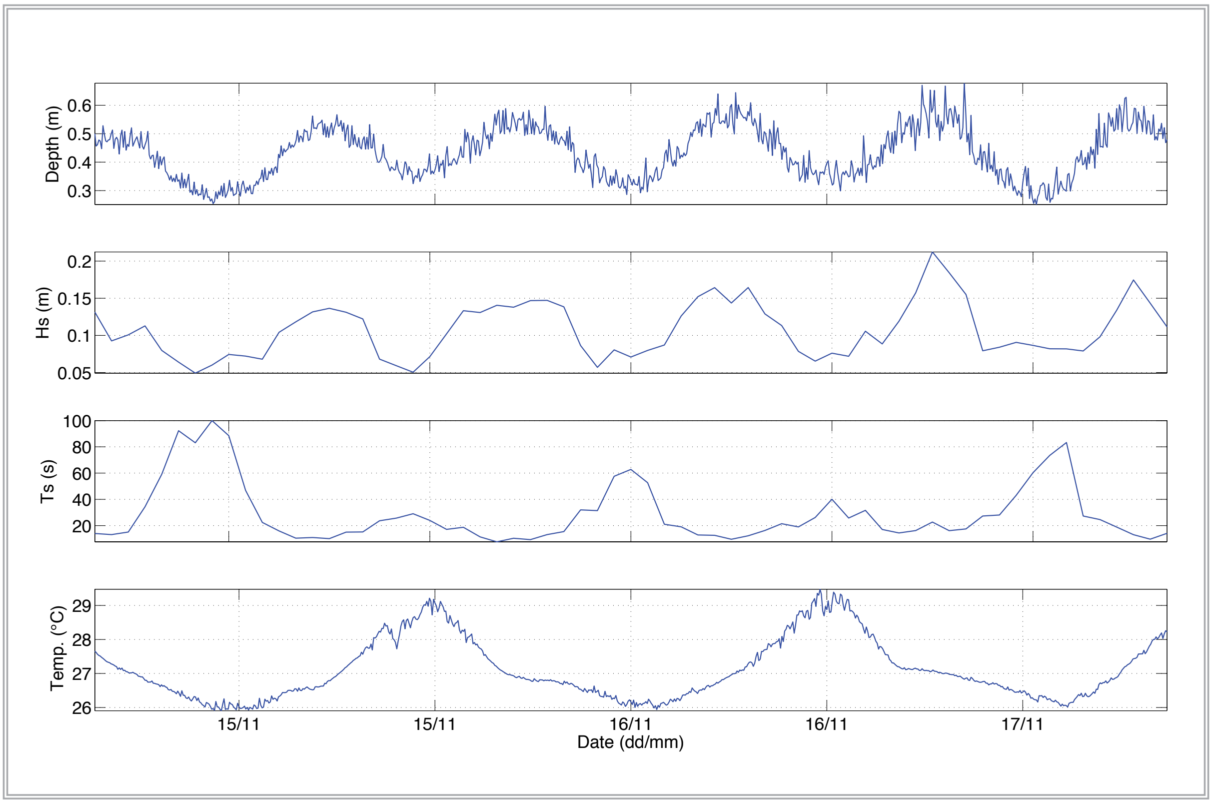

Figure 27: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Kauehi shoreline. Direction is given from true north in oceanographic convention (going toward).

3.3 Arutua instrument deployments

3.3.1 AQD — Arutua

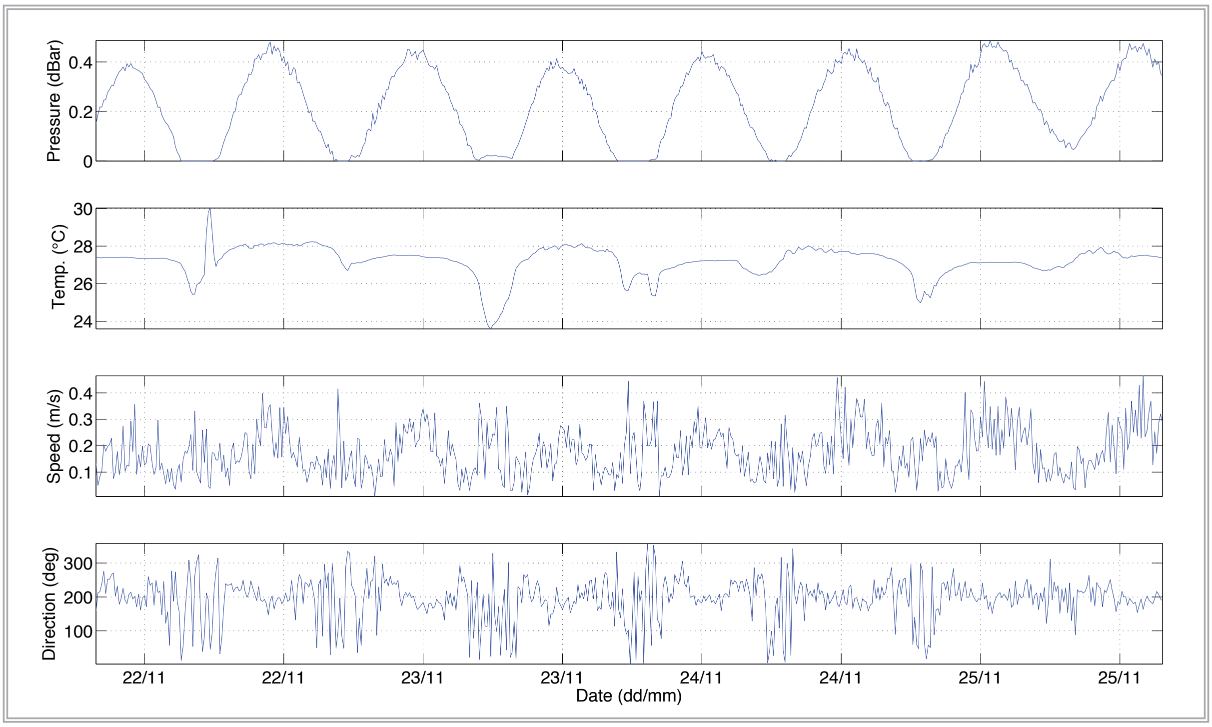

Figure 28: Time series plot of pressure, temperature, current speed and direction, as measured by the AQD on the Arutua reef flat. Direction is given from true north in oceanographic convention (going toward).

3.3.2 TWR — Arutua reef slope

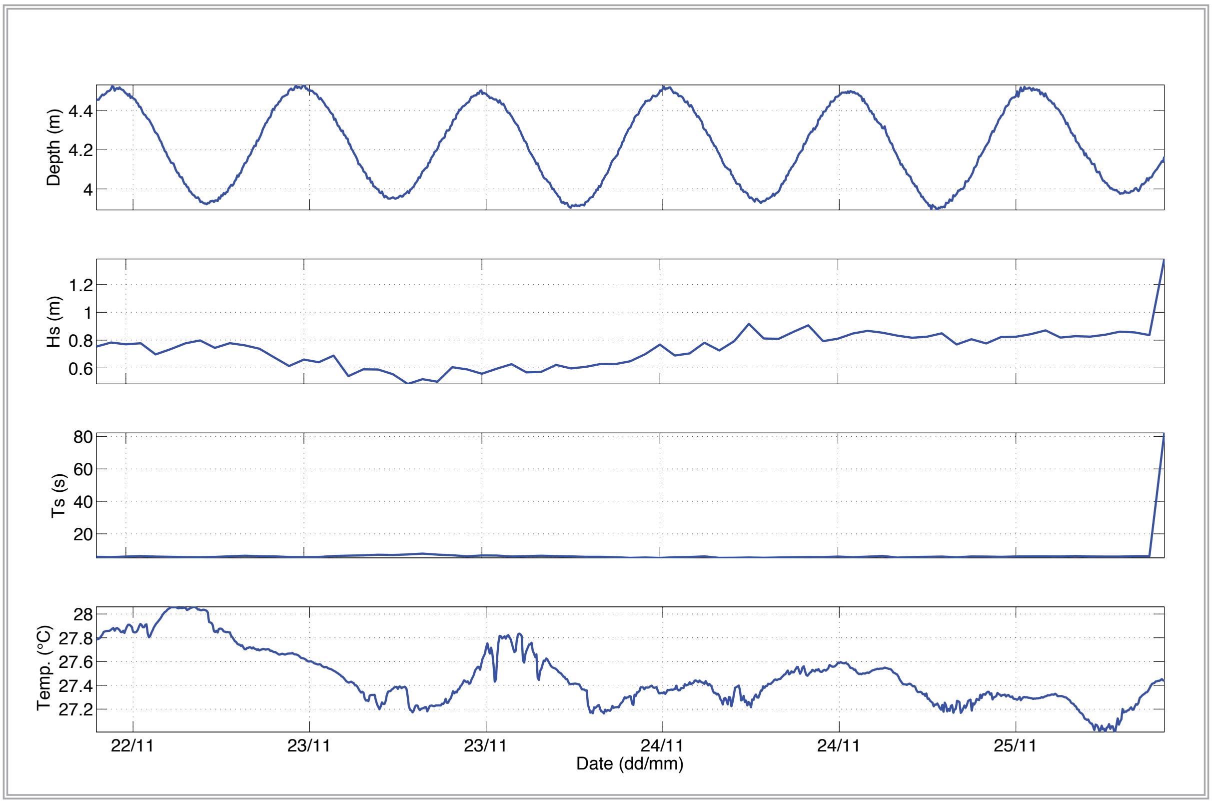

Figure 29: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Arutua reef slope. Direction is given from true north in oceanographic convention (going toward).

3.3.3. TWR — Arutua reef crest

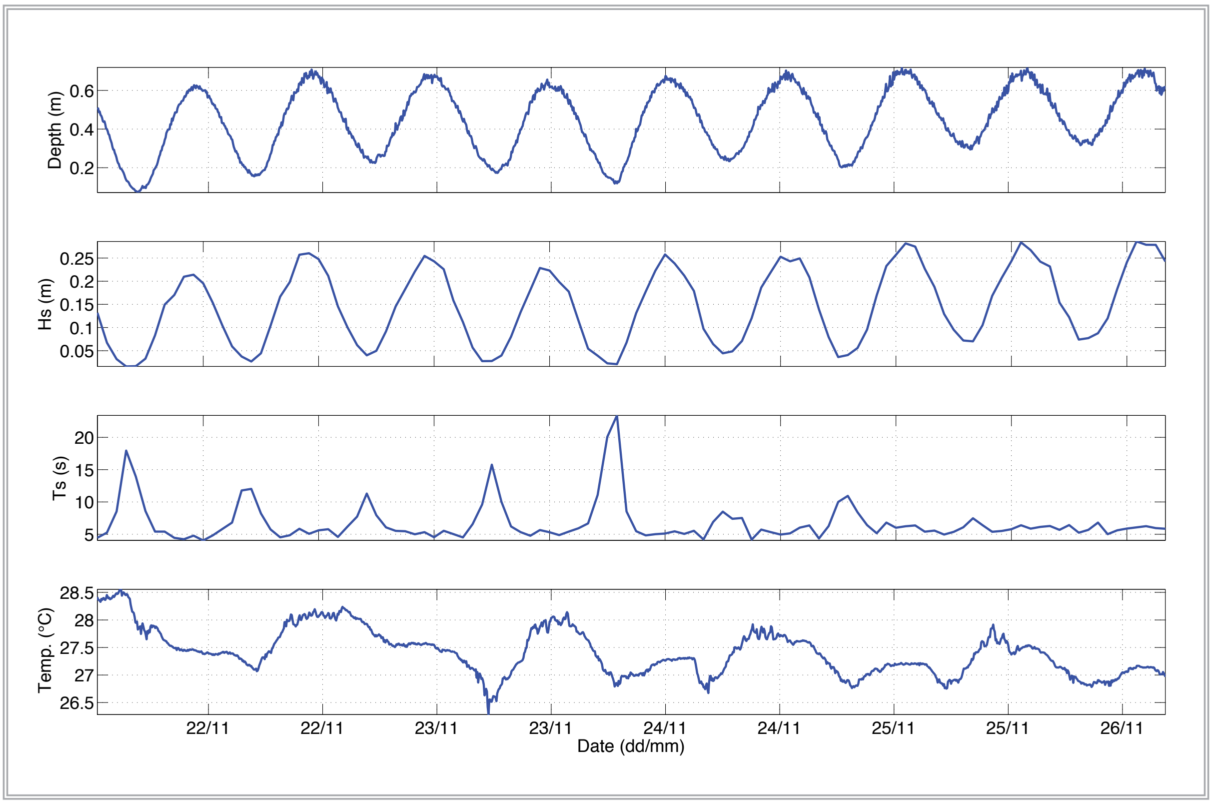

Figure 30: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Arutua reef crest. Direction is given from true north in oceanographic convention (going toward).

3.3.4 TWR — Arutua shoreline

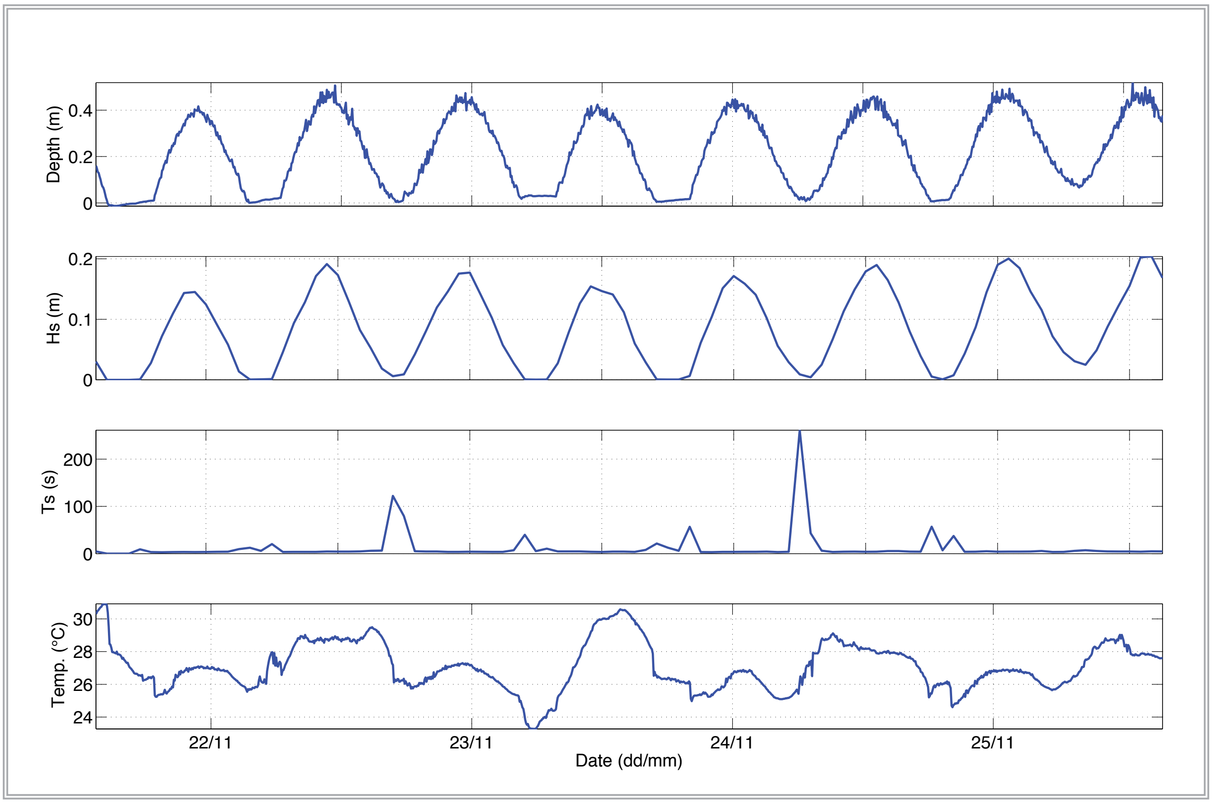

Figure 31: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Arutua shoreline. Direction is given from true north in oceanographic convention (going toward).

3.4 Apataki instrument deployments

3.4.1 AQD — Apataki

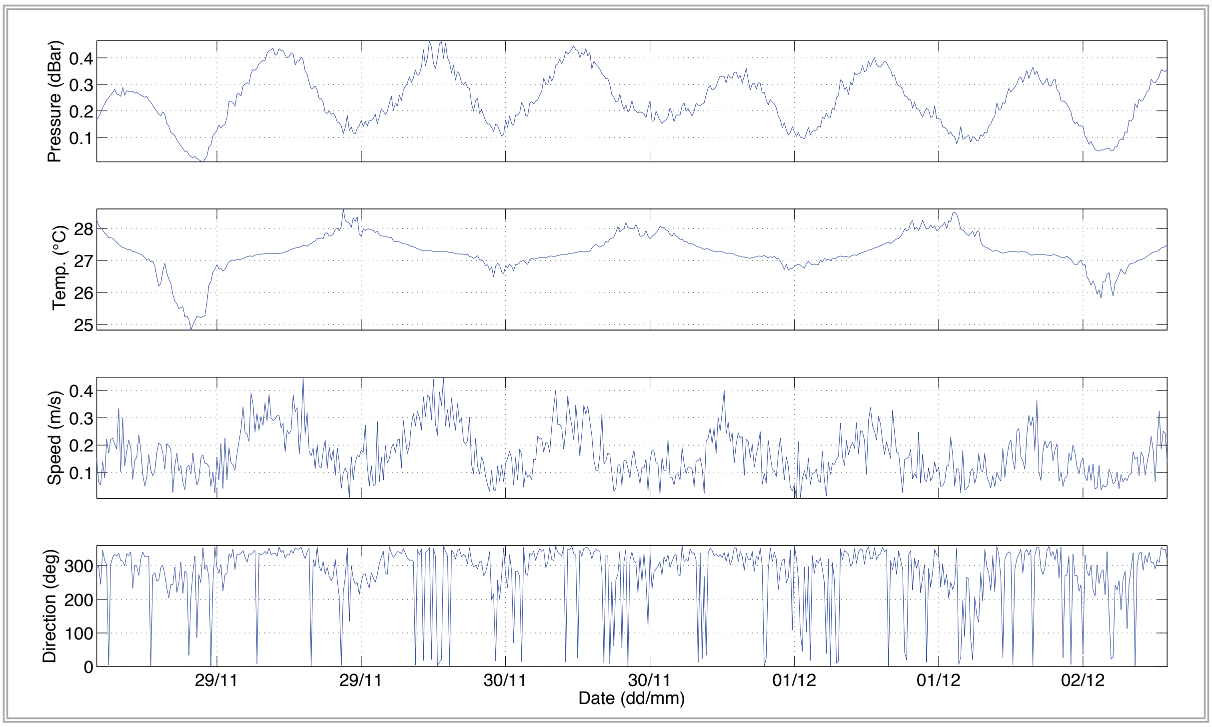

Figure 32: Time series plot of pressure, temperature, current speed and direction, as measured by the AQD on the Apataki reef flat. Direction is given from true north in oceanographic convention (going toward).

3.4.2 TWR — Apataki reef slope

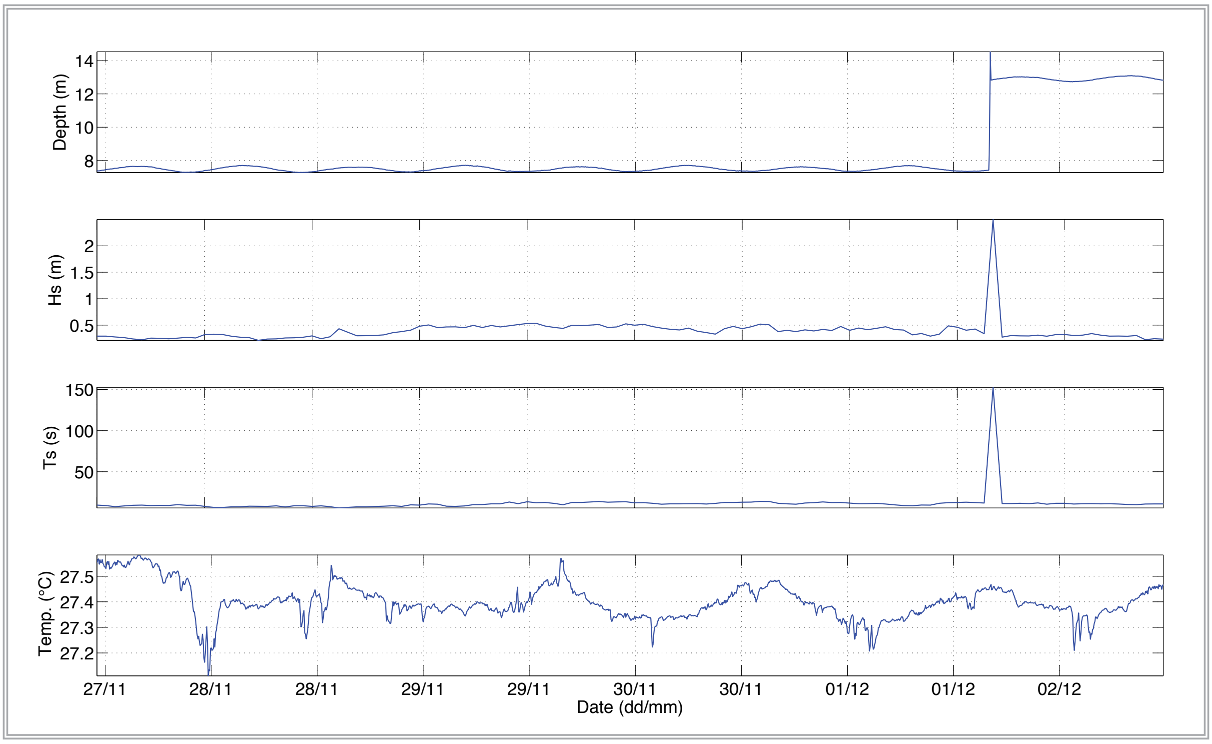

Figure 33: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Apataki reef slope. Direction is given from true north in oceanographic convention (going toward). Note the peaks in the plots on 1 December 2011 resulting from villagers moving the instrument. (It was moved from a depth of 7 m to a depth of 9 m, then to 14 m, and finally left at a depth of 12 m.)

3.4.3 TWR — Apataki reef crest

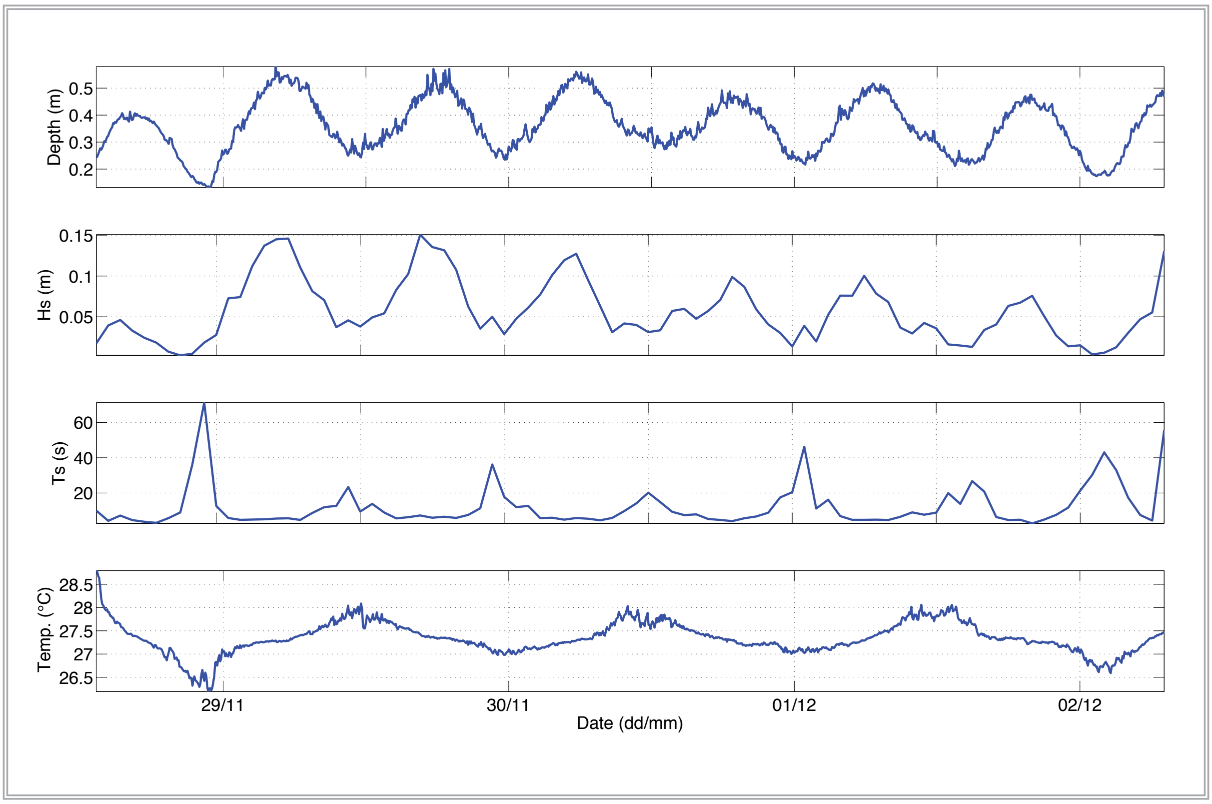

Figure 34: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Apataki reef crest. Direction is given from true north in oceanographic convention (going toward).

3.4.4 TWR — Apataki shoreline

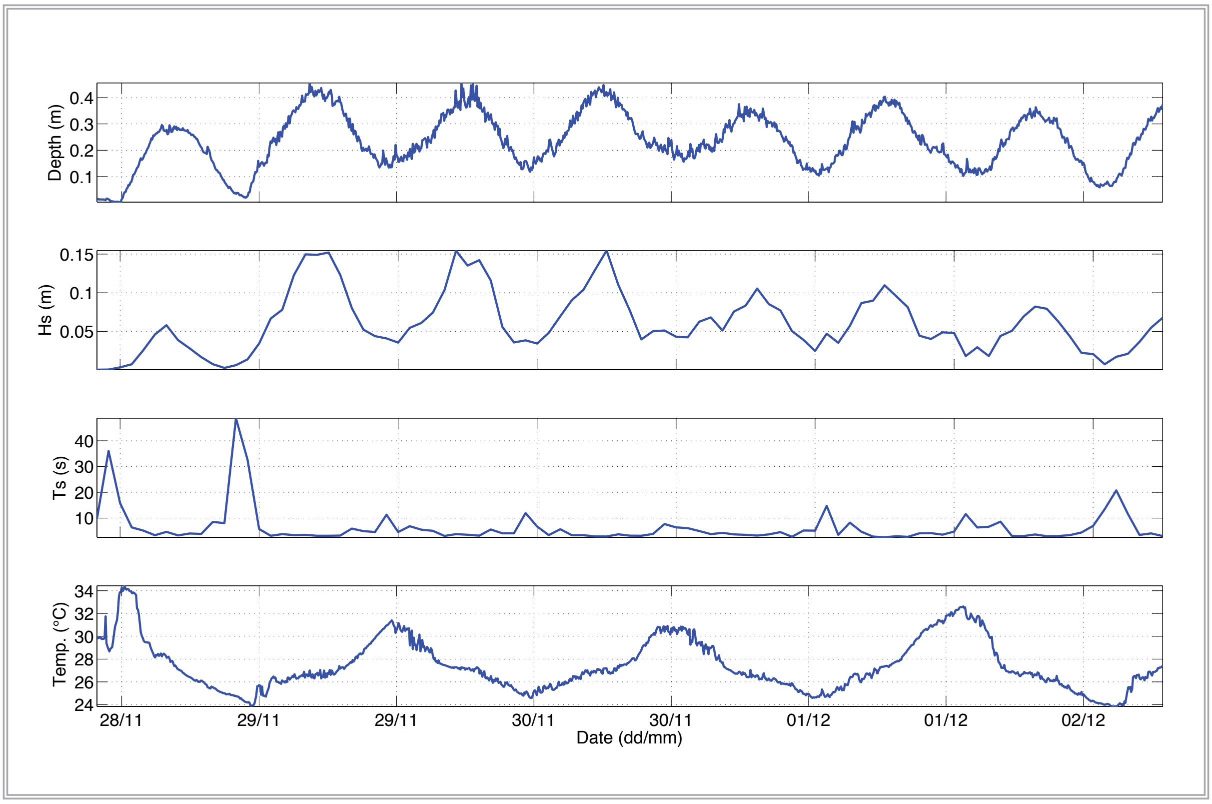

Figure 35: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Apataki shoreline. Direction is given from true north in oceanographic convention (going toward).

3.5 Manihi instrument deployments

3.5.1 AQD — Manihi

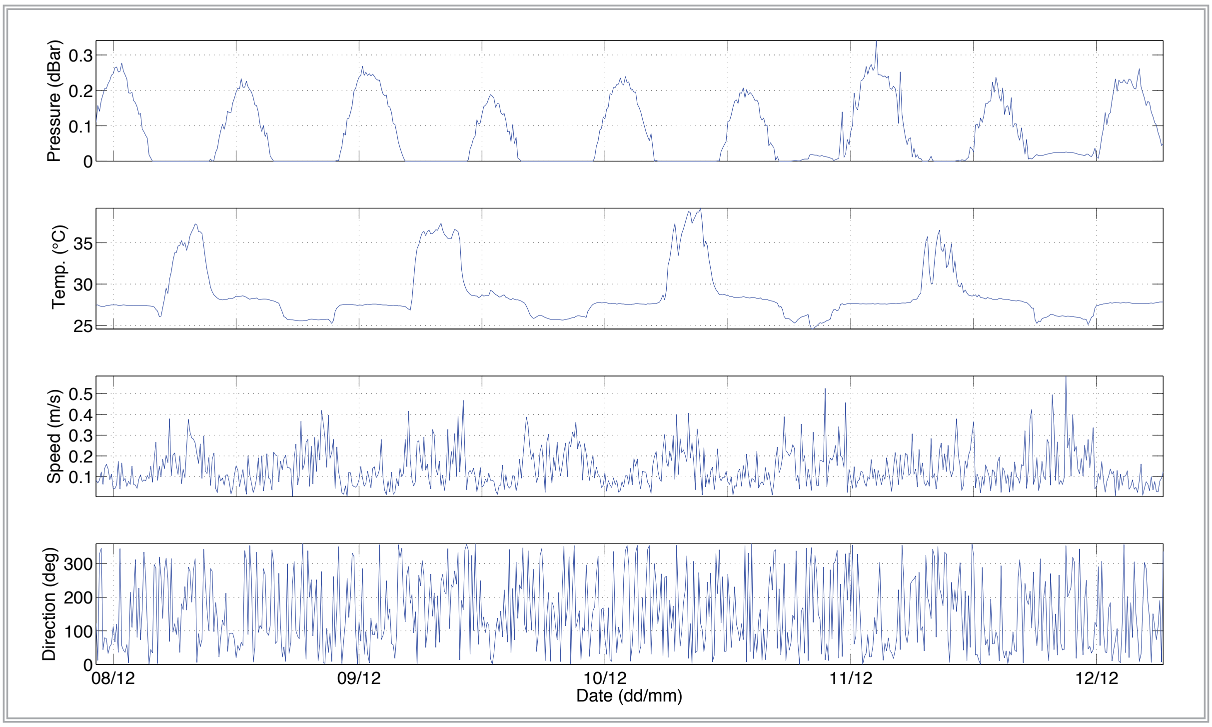

Figure 36: Time series plot of current speed and direction, temperature and pressure as measured by the AQD on the Manihi reef flat. Direction is given from true north in oceanographic convention (going toward).

3.5.2 TWR — Manihi reef slope

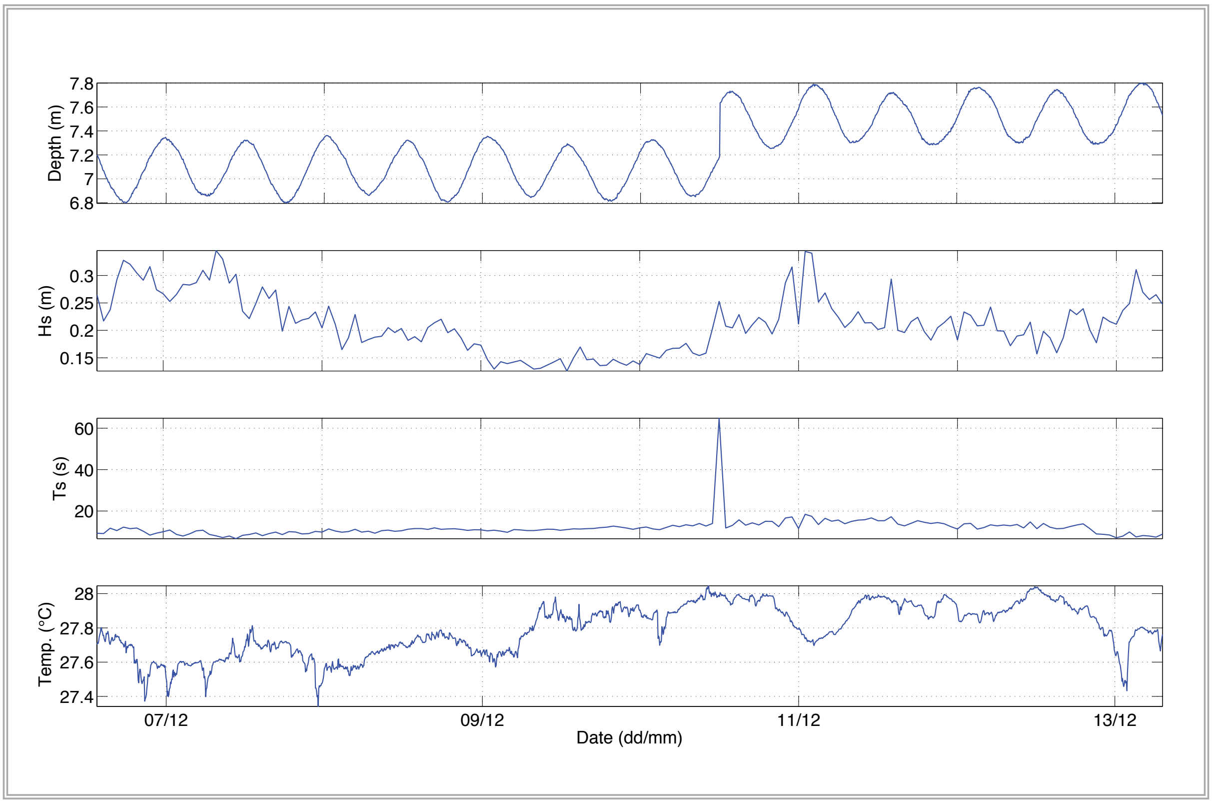

Figure 37: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Manihi reef slope. Direction is given from true north in oceanographic convention (going toward).

3.5.3 TWR — Manihi reef crest

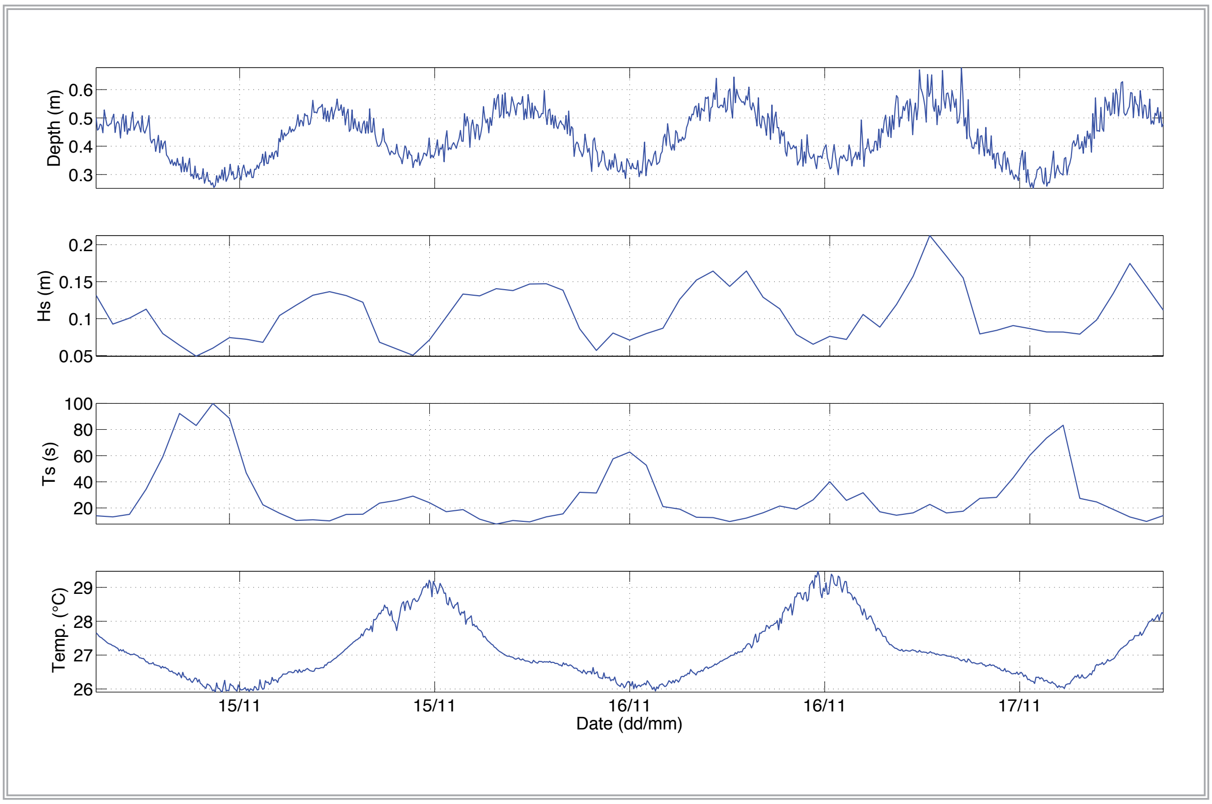

Figure 38: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Manihi reef crest. Direction is given from true north in oceanographic convention (going toward).

3.5.4 TWR — Manihi shoreline

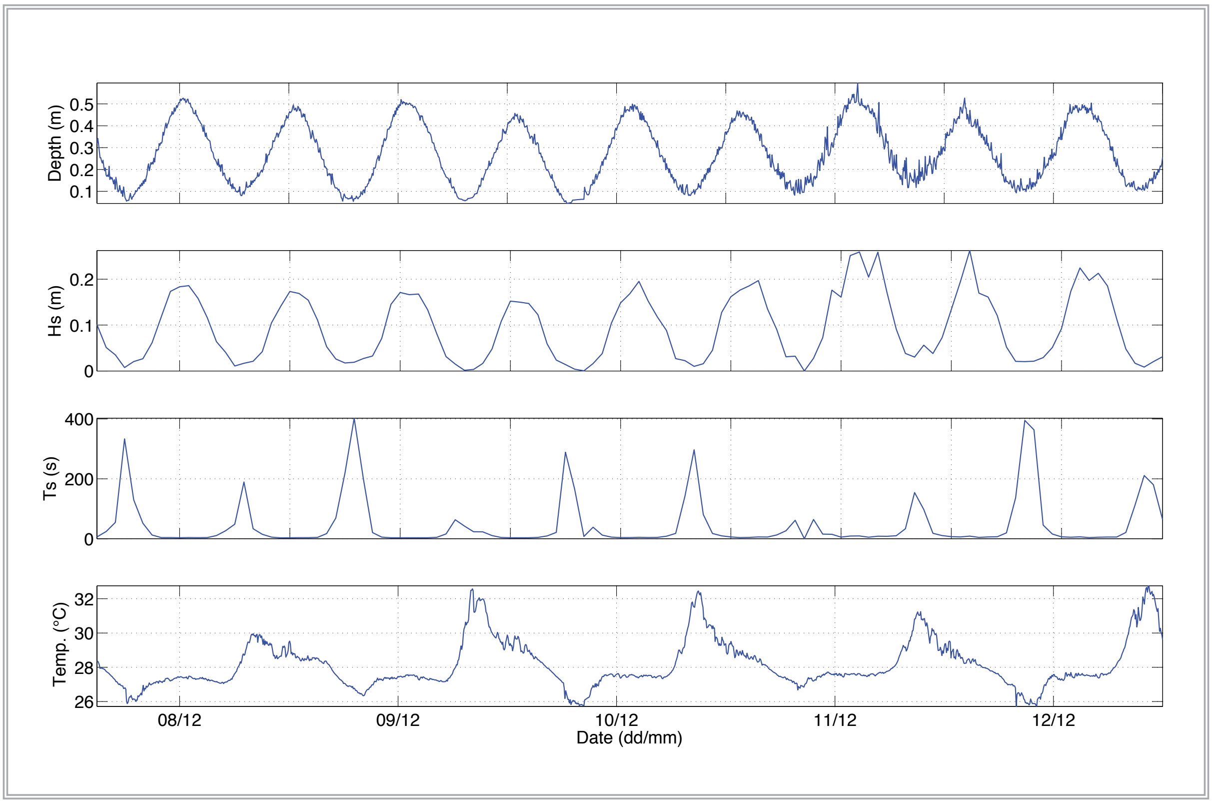

Figure 39: Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the TWR on the Manihi shoreline. Direction is given from true north in oceanographic convention (going toward).

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5 APPENDICES

Appendix A Instrument deployments

Rangiroa deployment photos

AQD in Tiputa channel.

AQD in Avatoru channel.

AQD on Tivaru Hoa.

AQD on Avatoru village reef flat.

AWAC north of Avatoru reef slope.

AWAC in mid-lagoon.

TWR on Utoto reef flat.

TWR in Utoto Lagoon.

TWR on Avatoru shoreline.

TWR on Avatoru reef crest.

TWR in Otupipi Lagoon.

TWR in Tivaru Lagoon.

TWR on Tivaru reef slope.

TWR in Avatoru Lagoon.

Apataki instrument deployment photos

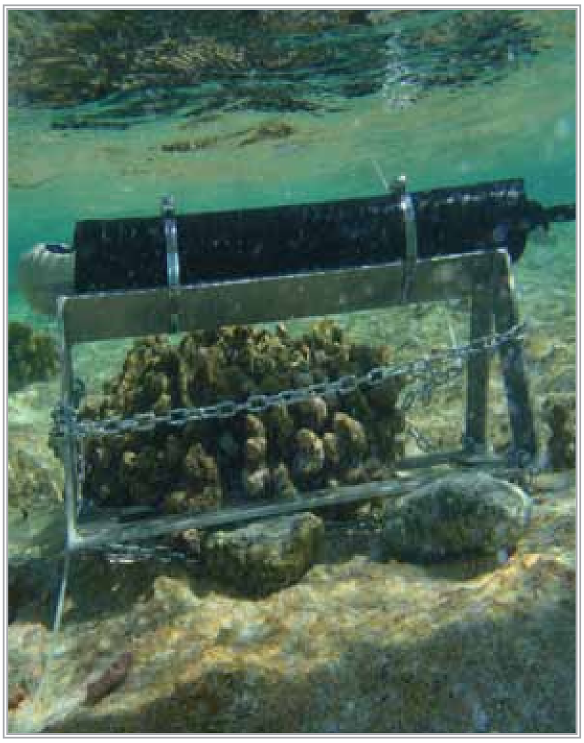
AQD on Apataki village reef flat.

TWR on Apataki shoreline (reef flat).

TWR on Apataki reef crest.

TWR on Apataki reef slope.

Arutua instrument deployment photos



AQD on Arutua village reef flat.

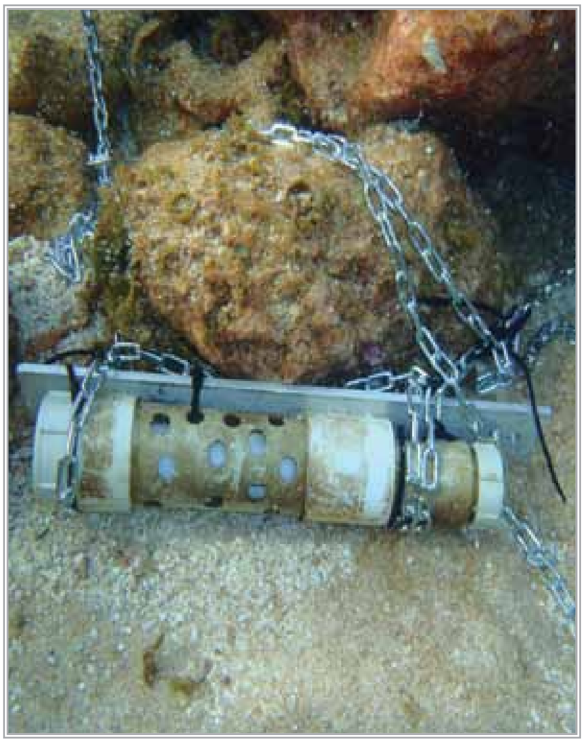
TWR on Arutua shoreline (reef flat).

TWR on Arutua reef crest.

TWR on Arutua reef slope.

Kauehi instrument deployment photos

AQD on Kauehi village reef flat.



TWR on Kauehi shoreline (reef flat).


TWR on Kauehi reef crest.


TWR on Kauehi reef slope.

Manihi instrument deployment photos


AQD on Manihi village reef flat.


TWR on Manihi shoreline (reef flat).


TWR on Manihi reef crest.


TWR on Manihi reef slope.

Appendix B Glossary of terms

Wave statistics	
Significant wave height (H_s, H_m,0, $H_{1/3}$)	Average of the highest one-third of all wave heights (measured from the trough to the crest) over a period of time. Significant wave height Hs can be estimated from a wave-by-wave analysis in which case it is denoted as $H_{1/3}$, but more often is estimated from the variance of the record or the integral of the variance in the spectrum, in which case it is denoted as H_m0. While $H_{1/3}$ is a direct measure of H_s, H_m0 is only an estimate of the significant wave height that under many circumstances is accurate. In general, in deep water, $H_{1/3}$ and H_m0 are very close in value and are both considered good estimates of H_s. All modern wave forecast models predict H_m0 and the standard output of most wave gauge records is H_m0.
Peak wave period (T_p)	The peak wave period (in seconds) associated with the largest wave energy in the total wave spectrum at a specific point.
Peak wave direction ($DirT_p$)	The wave direction at the frequency at which a wave energy spectrum reaches its maximum.
Significant wave period (T_s)	Average period of the one-third highest waves in a wave record.

Ocean properties	
Pressure (dbar)	Force per unit area exerted by water on either side of the unit area. Oceanographic pressure is reported in decibars (dbar). Pressure in decibars is almost equal to the depth in meters; 1,000 dbar is the pressure at a depth of about 1,000m. Nortek instruments were set to read zero pressure at sea level in the ambient air pressure prior to deployment. The RBR TWR instruments recorded absolute pressure, which is the gauge pressure due to the depth of water plus the atmospheric pressure.
Temperature (°C)	A thermodynamic property of a fluid and is due to the activity of molecules and atoms in the fluid. The more the activity (energy), the higher the temperature.
Speed (m/s)	Measured by the distance the wave travels in a certain amount of time (meters per second). It is found by multiplying the wavelength (horizontal distance between cycles) and the frequency (number of wave cycles that are completed in one second).
Direction (deg)	The direction in which a wave travels. Wave directions are defined in degrees clockwise from north to the direction the waves are coming from. Current direction is defined as the direction the water is flowing toward (oceanographic convention). The direction of a current flowing from east to west will be described simply as west. Wave direction (e.g. as measured by the Nortek AWAC instrument), however is given in meteorological convention (coming from).
Depth (m)	The distance from the surface to the sea floor.

Appendix C Instrument brochures

Nortek acoustic wave and current profiler (AWAC)

http://www.nortek-as.com/en/products/wave-systems/awac

AWAC a small revolution in ocean wave measurements

With the Nortek AWAC, you get a current profiler and a wave directional system in one unit. You can measure the current speed and direction in 1-meter thick layers from the bottom to the surface. Waves of all varieties are measureable; this includes long waves, storm waves, short wind waves, or transient waves generated by local ship traffic.

The AWAC is designed as a coastal monitoring system. It is small, rugged, and suitable for multi-year operation in tough environments. The mechanical design is all plastic and titanium to avoid corrosion. The AWAC is available in three transmit frequencies (1 MHz / 600 kHz /400 kHz) which allow for different deployment depths.

The sensor is usually mounted in a frame on the bottom, where it is protected from complications at the surface such as harsh weather, vandalism, and ship traffic. While safely located at the bottom, it is operated in online or in stand-alone mode.

In stand-alone mode, the raw data are stored to the internal data logger and power comes from an external battery pack. A variety of options are available with maximum deployment lengths of 12 months with hourly wave data when using lithium batteries.

Online systems have a variety of possible communication configurations. The most common are long, offshore cables (max. 5 km) or acoustic modems. Online systems can be delivered with backup batteries, protected cables, shore side interface units, and online software.

AST breakthrough

The AWACs extraordinary wave performance has largely to do with the Acoustic Surface Tracking (AST). The AST is based on echo-ranging to the surface with the vertically oriented transducer. The beauty of this method of measuring waves is that it circumvents the depth limitations imposed by bottom mounted pressure and velocity measurements. Long waves (swell) and storm waves are rarely difficult to measure, however waves generated by local winds are challenging without AST. Moreover, the AST also gives you the ability to derive wave parameters based on times series analyses. This means that the AWAC can directly measure wave parameters such as Hmax, H1/10, Tmean, etc. which other bottom mounted systems simply cannot.

Tidal elevation with improved pressure sensor

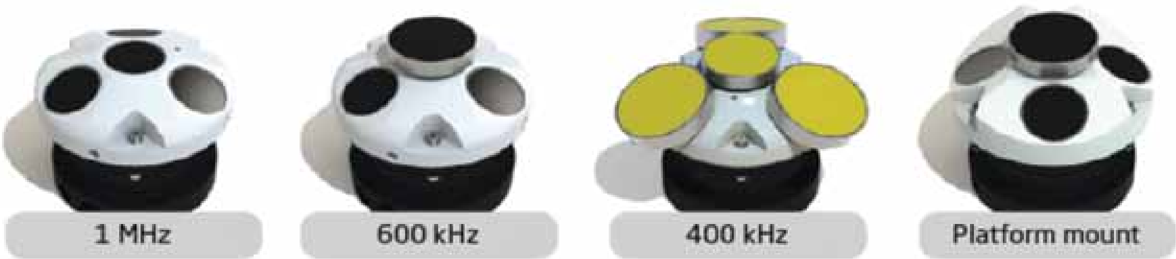
From the spring of 2011, an improved pressure sensor with an absolute accuracy of 0.1% of full scale is available for the AWAC. For a deployment depth of 20 m (and a 50m full scale sensor), this means the absolute accuracy of the sensor is 5 cm, which is within the requirements for many operational harbor systems

Software

The AWAC software is used to configure the instrument for deployment, retrieve the data, and convert all raw data files to ASCII. In order to calculate the wave parameters, you have the choice between the non-graphical QuickWave software and the graphical Storm software. For online systems which require data management and generating content for internet use (e.g. processed results and graphical plots), the SeaState software serves as the link for all your AWAC wave and current data.

New AWAC features

- 400 kHz version of the AWAC
- ProLog Internal Processor
- Special ice detection algorithm
- Improved pressure sensor
- SeaState 2.0 for online data collection



Technical Specifications

System

Acoustic frequency:	1MHz, 600kHz or 400kHz
Acoustic beams:	4 beams, one vertical, three slanted at 25°
Vertical beam opening angle:	1.7°
Operational modes:	Stand-alone or online monitoring

Current Profile

Maximum range:	30m (1MHz), 50m (600 kHz), 100m (400kHz) (depends on local conditions)
Depth cell size:	0.25 – 4.0m (1MHz) 0.5 – 8.0m (600kHz) 1.0 – 8.0m (400kHz)
Number of cells:	Typical 20–40, max. 128
Maximum output rate:	1Hz

Velocity measurements

Velocity range:	±10 m/s horizontal, ±5 m/s along beam
Accuracy:	1% of measured value ±0.5 cm/s

Doppler uncertainty

Current profile:	1cm/s (typical)

Wave measurements

Maximum depth:	35m (1MHz), 60m (600 kHz), 100m (400kHz)
Data types:	Pressure, one velocity along each beam, AST*
Sampling rate (output):	2 Hz velocity, 4 Hz AST* (1MHz), 1 Hz velocity, 2Hz AST* (600kHz), 0.75 Hz velocity, 1.5Hz AST* (400kHz)
No. of samples per burst:	512, 1024, or 2048. Inquire for options

Wave estimates

Range:	-15 to +15m
Accuracy/resolution (Hs):	<1% of measured value/1cm
Accuracy/resolution (Dir):	2° / 0.1°
Period range:	0.5–100s (1MHz), 1 - 100s (0.6MHz), 1.5 - 100s (0.4MHz)

Depth(m)	cut-off period (Hs)	cut-off period (dir)
5	0.5 sec	1.5 sec
20	0.9 sec	3.1 sec
60	1.5 sec	4.2 sec
100	2 sec	6.0 sec

Sensors

Temperature:	Thermistor embedded in housing
Range:	–4°C to 40°C
Accuracy/ Resolution:	0.1°C/0.01°C
Time constant:	<5 min
Compass	Magnetoresistive
Accuracy/Resolution:	2°/0.1° for tilt <15°
Tilt:	Liquid level
Maximum tilt:	30°, AST* requires <10° instrument tilt
Up or down:	Automatic detect
Pressure:	Piezoresistive
Standard range:	0–50 m (1MHz) / 0-100m (0.6MHz) / 0-100m (0,4MHz)
Accuracy:	0.5% of full scale. Optional 0.1% of full scale.
Resolution:	0.005% of full scale

Transducer configurations

Standard:	3 beams 120° apart, one vertical
Platform mount:	3 beams 90° apart, one at 5°

Materials

Standard:	Delrin and polyurethane plastics with titanium screws

Connectors:

Bulkhead (Impulse):	MCBH-2-FS
Cable:	PMCIL-6-MP

Environmental

Operating temperature:	–4°C to 40°C
Storage temperature:	–20°C to 60°C
Shock and vibration:	IEC 721-3-2
Depth rating:	300m

Dimensions:

	See drawing on front page
Weight in air:	7.3 kg (0.4MHz), 6.2 kg (0.6MHz), 6.1 kg (1MHz)
Weight in water:	3.6 kg (0.4MHz), 2.9 kg (0.6MHz & 1MHz)

Analog inputs

Number of channels:	2
Supply voltage to analog output devices:	Three options selectable through firmware commands: • Battery voltage/500mA • +5V/250mA • +12V/100mA
Voltage input:	0-5V
Resolution:	16 bit A/D

Data Recording

Capacity(standard):	2 MB, can add: 32/176/352MB or 4GB
Profile record:	Ncells×9 + 120
Wave record:	Nsamples×24 + 1KB

Data Communication

I/O:	RS 232 or RS 422
Communication baud rate:	300–115200
Recorder download baud rate:	600/1200 kBaud for both RS232 and RS422
User control:	Handled via «AWAC» software, or ActiveX® controls. «SeaState» for online systems.
ProLog:	Provides NMEA ASCII or Binary output formats for processed wave and current data.

Power

DC input:	9-18 VDC
Peak current:	3A
Power consumption:	Transmit power: 1–30W, 3 adjustable levels
Sleep consumption:	0.3 mW (RS232) 5 mW (RS422)

Real time clock

Accuracy:	± 1min/year
Backup in absence of power:	1 year

Offshore Cable

The Nortek offshore cable can, when properly deployed, withstand tough conditions in the coastal zone. In RS 422 configuration, cable communication can achieved distances up to 5 km.

Online Projects

Nortek can provide long cables, radio/telephone communication equipment, acoustic modems, etc., that can meet the requirements of your specific project.

*) AST = Acoustic Surface Tracking

Nortek aquadopp profiler (AQD)

http://www.nortek-as.com/en/products/current-profilers/aquadopp-profiler

Aquadopp PROFILER

The Nortek Aquadopp® Profiler is designed with flexibility in mind. It is small, easy to use, and works equally well in ocean, coastal, or river environments. From its introduction in 2000, the Aquadopp® Profiler has represented a completely new generation of current profilers, and remains at the cutting edge still today.

Typical Applications

Small and easy-to-use, the acoustic doppler Aquadopp® Profiler has become a favorite for use in estuaries and shallow coastal water.

It is a cost-effective tool for any shallow water (<100 m) environment, functioning equally well in typical ocean surface waters as high sediment suspension areas near the coast or in rivers. Typical applications include coastal studies as well as studies in rivers, lakes and channels, and online monitoring.

The Aquadopp® Profiler can be deployed on any fixed structure - small, low cost bottom frames, mooring lines, surface buoys, etc.

With a flexible design, options are available for the Aquadopp® Profiler to reduce blanking distance, increase vertical resolution, calculate full directional wave spectra, and profile horizontally in 2D.

The Aquadopp® Profiler Design

The Aquadopp® Profiler measures high-quality, accurate, and unbiased three-component (East, North, Up) current profile data using acoustic Doppler technology. It can measure speed and direction in up to 128 different layers of the water column.

System electronics integrate Doppler velocity with temperature, pressure, tilt, and compass information – all standard with each instrument.

The Aquadopp® Profiler has a built-in solid state data recorder and batteries. State-of-the-art power management and miniaturized electronics combine in a compact single-canister design that is suitable for real-time operation or self-contained deployments. Online telemetry options include cellphone or radio modems and the Nortek AOS.

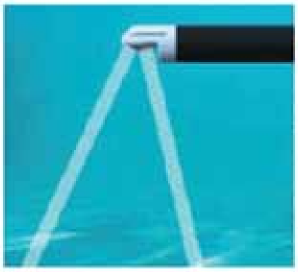
The Aquadopp® Profiler provides significant advantages for your project:

- All plastic and titanium parts eliminate corrosion
- No moving parts that can be blocked or damaged
- Remote sampling volume is not affected by bio-fouling
- Z-Cell option eliminates blanking distance
- Effective directional wave gauge
- Internal compass, tilt, pressure, and temperature sensors
- Online data communication options
- Small and light weight (less than 3.5 kg)
- Log data from external analog sensors, such as OBS or CT sensors

A variety of transducer head designs allow flexibility in deployment and measurement needs:

Sidelooking | 1MHz and 2MHz | 400kHz | 600kHz | Z-Cell 600kHz | Z-Cell 1MHz

HR Profiler



The High Resolution (HR) firmware upgrade turns the Aquadopp® Profiler (1 and 2 MHz models) into a high resolution profiler operating at sub-cm scales with sampling rates as fast as 8 Hz.

Though primarily designed for mean flow studies, the robust computational algorithms of the HR Profiler make it possible to measure conditions with significant flow variations. Whether measuring bottom boundary layers, internal wave generation in lakes, flow under ice, or low energy environments, the HR Profiler is the perfect tool.

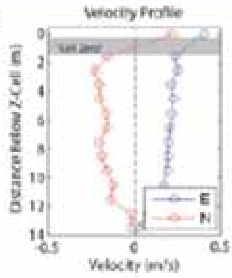
To measure velocity profiles at such a fine vertical resolution (as small as 0.7 cm), the HR firmware implements a pulse-coherent processing technique that provides extremely low noise measurements.

HR Profiler Features:

- Internal data recording (16 GB)
- Reduced blanking distance (5 cm)
- 3D velocity profiles, 0.7 - 5 cm resolution
- Continuous (1 Hz) and burst (max 8 Hz) sampling modes
- Extended velocity range mode for energetic environments
- Configurable for selected beam samplings (1, 2 or 3 beams)
- Measures to within a few cm of the bottom (or ice layer)
- Easily switch between "normal" and HR Profiler modes
- Simultaneous measurements of velocity profiles and acoustic scattering strength

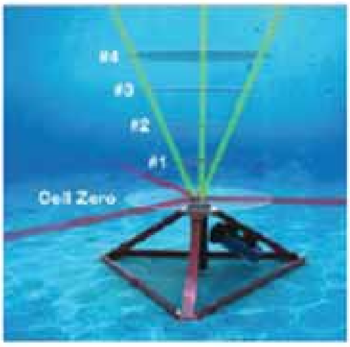
Z-Cell

A standard current profiler cannot measure currents near its transducers. This blanking distance of a few meters can cause the instrument to miss key current velocity data at the boundary layer, either close to the surface or seabed.



Studies show that the surface current can be quite different from what is normally observed 2-3 m below the surface, especially in regions with shallow thermoclines or stong winds.

The Aquadopp® Z-Cell, a hardware and firmware extension to the 1 MHz and 600 kHz Aquadopp® Profilers, eliminates this blanking distance. By adding an extra set of horizontal transducers (2 MHz) to the Aquadopp® Profiler, the Z-Cell is able to measure the 2D current velocity at the level of the instrument or "Cell Zero."



Profilers with the Aquadopp® Z-Cell extension can be mounted on a surface buoy or bottom frame.

The monitoring of near surface currents, enabled by the Aquadopp® Z-Cell, may aid in the study of harmful algal Blooms, sediment plumes, HAZMAT spill tracking, and search and rescue efforts.

PUV Waves

The Aquadopp® Profiler can be configured as a combined wave and current system, collecting (PUV) wave height, period and direction data interleaved (at 1 Hz or 2 Hz) with mean current profiles. Configuring the Aquadopp® Profiler for wave measurement is done through the standard Aquapro software.

The PUV method is used to calculate the full directional wave spectra from the raw data, based on linear wave theory. Pressure is used to estimate non-directional parameters (height and period), and the combination of the pressure and the two horizontal velocity components U and V are used to calculate wave direction.

As a wave sensor, the Aquadopp® Profiler requires extra internal memory and battery capacity, but it is clearly the most cost-effective PUV instrument in the market.

Horizontal Profiling

Some applications require 2D horizontal current profiles rather than the standard vertical 3D profiles. This is possible with all Aquadopp Profilers (except the 400 kHz model) through a special 2D side-looking transducer arrangement.

The 2D side-looking Aquadopp® head can be used to measure 2D (East and North) flow away from walls or boundaries. Typical applications include channel flow monitoring where the Aquadopp® is mounted on the channel wall – protected from floating debris – and measurements are made in the free flow away from the wall.

Additional applications that may benefit from this feature include harbors and port entrances with complex current regimes, as well as loading buoys and offshore platforms where maneuvering of ships is critical.

Technical Specifications

Water velocity measurement				
Acoustic frequency:	0.4MHz	0.6MHz	1.0MHz	2.0MHz
Maximum profiling range*:	60–90m	30–40m	12–20m	4–10m
Cell size:	2–8m	1–4m	0.3–4m	0.1–2m
Beam width:	3.7°	3.0°	3.4°	1.7°
Minimum blanking:	1m	0.50m	0.20m	0.05m
Number of beams:	3			
Maximum # cells:	128			
Velocity Range:	±10m/s (inquire for extended range)			
Accuracy:	1% of measured value ±0.5cm/s			
Max. Sampling rate:	1Hz			
Velocity uncertainty:	Consult software program			

*) The Aquadopp profiler measures the current profile in a user specified number of cells from the instrument out to a maximum range that depends on the acoustic scattering conditions. The lower range should be expected with clear water and small cells and the higher range with large cells and acoustically turbid water.

HR Mode Water velocity measurement		
Acoustic frequency:	1.0MHz	2.0MHz
Maximum profiling range*:	6m	3m
Cell size:	20-300mm	7-150mm
Beam width:	3.4°	1.7°
Minimum blanking:	0.2m	0.03m
Maximum # cells:	128	
Range/velocity limitations:	Product of profiling range and velocity should not exeed 0.5m2/s (2MHz system) or 1.0m2/s for (1MHz system)	
Accuracy:	1% of measured value ±0.5cm/s	
Max. Sampling rate:	1Hz (continous mode), 8Hz (burst mode)	
Velocity uncertainty:	Consult software program	

Cell zero (optional for 0.6MHz and 1MHz transducers)	
Cell zero acoustic frequency:	2Mz
Maximum profiling range*:	0.4-0.9m
Number of beams:	3

Echo intensity	
Sampling:	Same as velocity
Resolution:	0.45dB
Dynamic range:	90dB

Standard sensors	
Temperature:	Thermistor embedded
Range:	–4°C to 30°C
Accuracy/resolution:	0.1°C/0.01°C
Time response:	10 min
Compass:	Magnetometer
Accuracy/resolution:	2°/0.1° for tilt <20°
Tilt:	Liquid level
Accuracy/resolution:	0.2°/0.1°
Maximum tilt:	30°
Up or down:	Automatic detect
Presure:	Piezoresistive
Range:	0–100m (standard), inquire for options
Accuracy/resolution:	0.5%/0.005% of full scale

Analog inputs	
Number of channels:	2
Voltage supply:	Three options selectable through firmware commands: -Battery voltage / 500 mA -+5V / 250 mA -+12V /100 mA
Voltage input:	0–5V
Resolution:	16 bit A/D

Data communication	
I/O:	RS232, RS422. Software supports most commercially available USB–RS232 converters
Communication Baud rate:	300–115200 (baud)
Recorder download baud rate:	600/1200 kBaud for both RS232 and RS422

Data recording	
Capacity:	9 MB, can add 32/176/352MB & 4GB Prolog
Data record:	32 bytes + 9×Ncells
Mode:	Stop when full (default) or wrap mode
Software:	AquaPro
Operating system:	Windows*XP, Windows* 7
Functions:	Deployment planning, data retrieval, ASCII conversion, online data collection, and graphical display

Power	
DC Input:	9-15VDC
Peak current:	3A
Max average consumption at 1Hz:	0.2–1.5W
Sleep consumption:	0.0003 mW (RS232), 0.005 mW (RS422)
Transmit power:	0.3–20W, 3 adjustable levels

Real time clock	
Accuracy:	+/- 1min/year
Backup in absence of power:	4 weeks

Internal batteries	
Type/capacity:	18 AA Alkaline cells/50Wh
New battery voltage:	13.5VDC
Duration (10-minute avg.):	80 days for 2MHz, 0.5m cells 50 days for 1MHz, 1.0m cells

Exact battery consumption and velocity uncertainty are complex functions of the deployment configuration. Please consult the AquaPro software for more exact predictions.

Materials	
Standard:	Delrin and polyurethane plastics with titanium screws
Intermediate and deepwater models:	Titanium and Delrin plastics

Connectors	
Bulkhead (Impulse):	MCBH-8-FS
Cable:	PMCIL-8-MP on 10-m polyurethane cable

Environmental	
Operating temperature:	–5°C to 35°C
Storage temperature:	–20°C to 60°C
Shock and vibration:	IEC 721-3-2
Depth rating:	300m

Dimensions			
	0.4MHz	0.6MHz	1MHz/2MHz
Weight in air:	3.4 kg	2.9 kg	2.2 kg
Weight in water:	0.2 kg	0.4 kg	0.2 kg
Length:	see dimensional drawings		
Diameter:	see dimensional drawings		

Options	
Batteries:	Lithium, Li-Io rechargeable
External batteries:	Alkaline, Lithium or Lithium Ion. See battery brochure for details
Transducer head:	Right angle head for 1 or 2MHz. Inquire for special configurations
Deep water systems:	Inquire for 3000m & 6000m versions
Communication:	Request special harness for RS422

Model TWR-2050
Submersible Tide & Wave Recorder

The TWR-2050 is a self-contained, submersible logger, designed to measure tide and wave data. In addition to averaging capability for tide measurement, the TWR-2050 is capable of measuring bursts of pressure data for wave analysis. The RBR Tide/Wave recorder is very accurate and small (265mm x 38mm OD), and can be mounted on the sea or harbour floor, fastened to an existing structure, or attached to a mooring line.

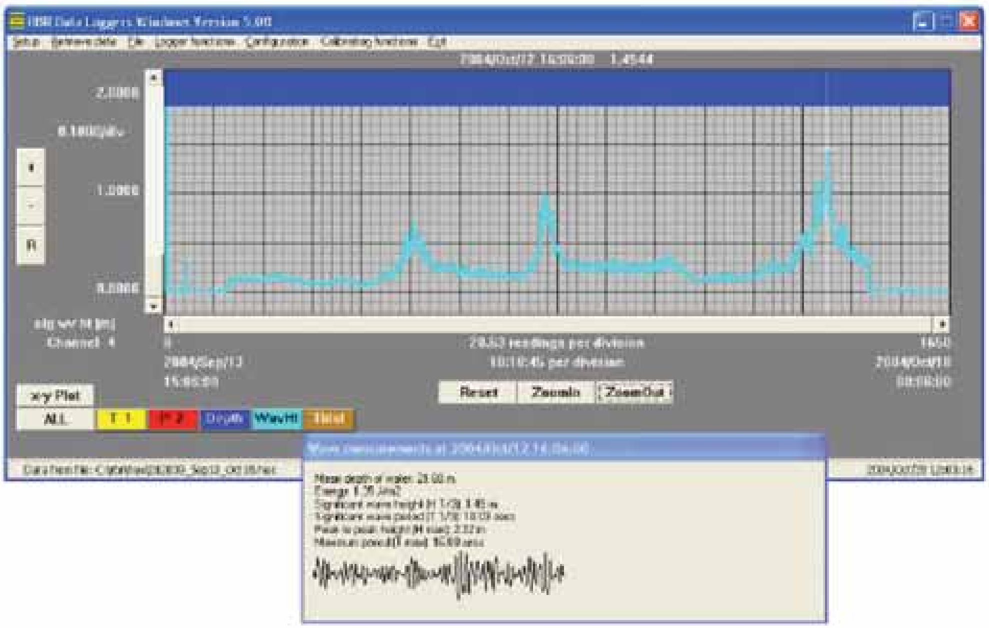
Averaging time is user-selectable from 10 seconds to 9 hours. Burst rates can be 1, 2, or 4Hz. Wave sampling is achieved by taking 512, 1024, or 2048 samples at the selected burst rate. The TWR-2050 can be configured to trigger burst data collection at fixed times.

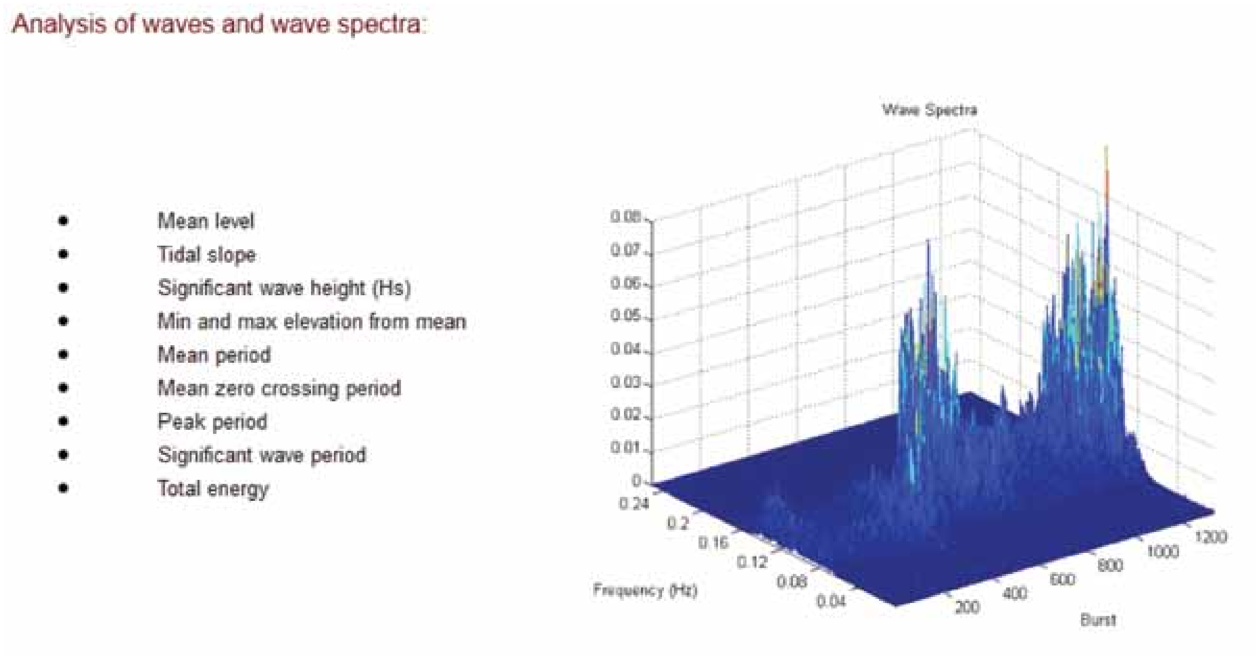
The temperature channel of the TWR-2050 is calibrated to an accuracy of ±0.002°C (ITS-90), with typical annual drift of better than 0.002°C/year. The depth channel is calibrated to an accuracy of 0.05%fs. Calibration constants are stored in the logger and recalibration is possible by the end-user.

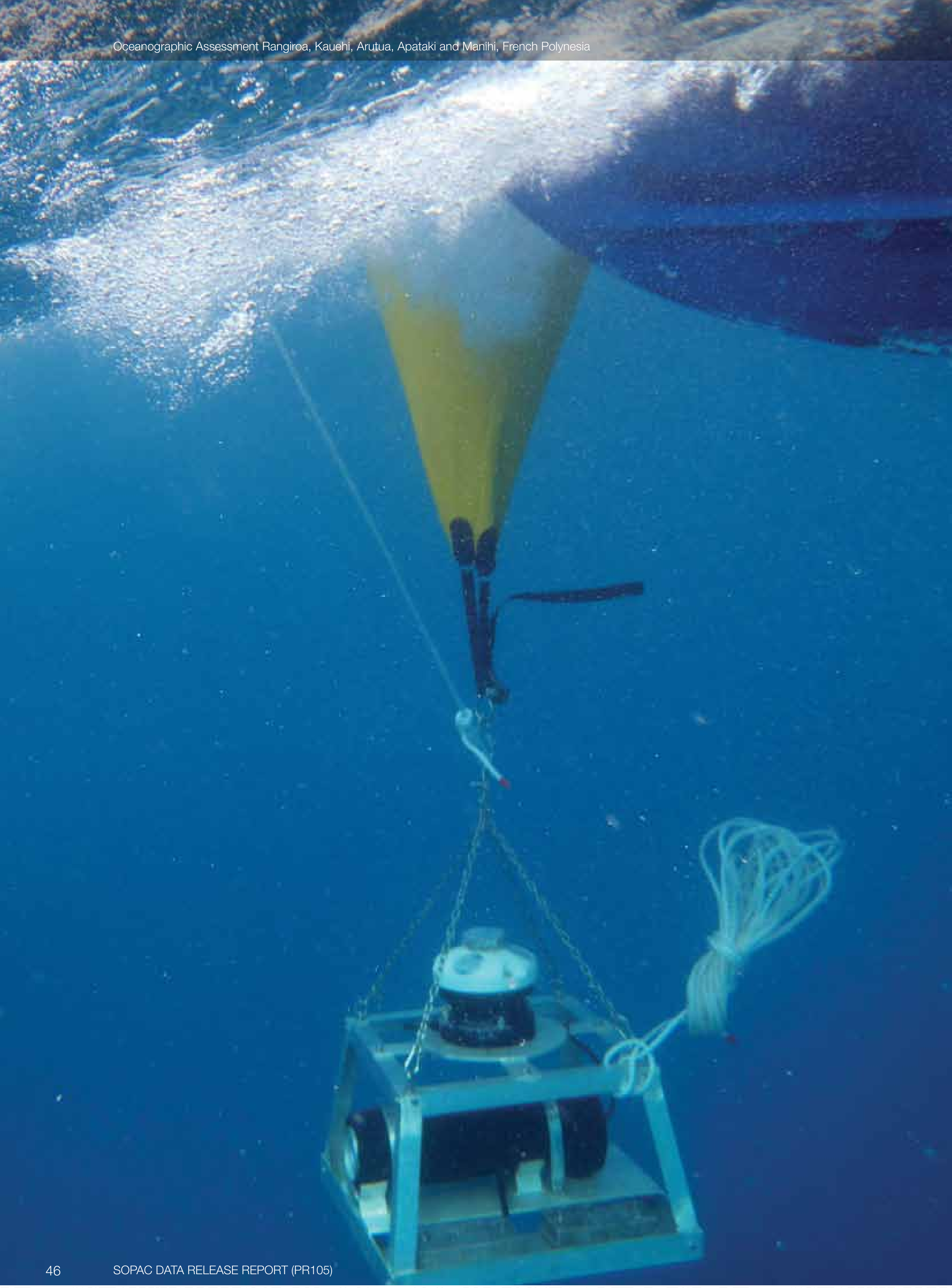
The RBR Windows software package has a straight-forward logger set up display menu, which includes synchronizing the logger to the PC clock, setting the sampling period, setting the averaging burst length, and start and stop logging date selection by means of a graphical calendar. Data can also be saved to a .mat file for import into Matlab® for further analysis and display.

RBR Windows Software is designed to give an indication of:

- Sample rate
- Tide burst duration
- Tide cycle time
- Wave burst duration
- Wave cycle time
- Spectral resolution




Analysis of waves and wave spectra:
• Mean level
• Tidal slope
• Significant wave height (Hs)
• Min and max elevation from mean
• Mean period
• Mean zero crossing period
• Peak period
• Significant wave period
• Total energy
Wave Spectra
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.24
0.2
0.16
0.12
0.08
0.04
Frequency (Hz)
200
400
600
800
1000
1200
Burst



SPC CPS

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SECRÉTARIAT GÉNÉRAL DE LA COMMUNAUTÉ DU PACIFIQUE