Bonriki Inundation Vulnerability Assessment

Oceanographic Data Acquisition

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Australian Government

SPC Secretariat of the Pacific Community

Australian Aid

Bonriki Inundation Vulnerability Assessment (BIVA)

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Acknowledgements

The BIVA project is part of the Australian Government's Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP), within the International Climate Change Adaptation Initiative. The project was developed by the Secretariat of the Pacific Community's (SPC) Geoscience Division (GSD) in partnership with the Australian Government and the Government of Kiribati (GoK).

Key GoK stakeholders that contributed to the implementation of the project were:

- Ministry of Public Works and Utilities (MPWU), in particular the Water Engineering Unit with the MPWU
- The Public Utilities Board (PUB), in particular the Water and Sanitation Division and the Customer Relations Division within the PUB
- The Office of the President, in particular the Disaster Management Office
- The Ministry of Environment, Lands and Agricultural Development (MELAD) Lands Division
- The Ministry of Fisheries and Marine Resources Development (MFMRD) Minerals Division
- Members of the Kiribati National Expert Group on climate change and disaster risk management (KNEG)

The Bonriki Village community members also played a key role in the implementation of the project. Community members participated in the school water science and mapping program, assisted with construction of new piezometers and data collection for the groundwater component, and shared their knowledge and experiences with regards to historical inundation events and coastal processes.

Key technical advisors involved with implementation of the project included:

- Flinders University, Adelaide, Australia
- University of Western Australia, Perth, Australia
- The University of Auckland, Auckland, New Zealand
- United Nations Educational, Scientific and Cultural Organization, Institute for Water Education (UNESCO-IHE), Delft, the Netherlands
- Technical advisors Tony Falkland and Ian White

List of Abbreviations

AWAC	acoustic wave and current meter (Nortek)
BIVA	Bonriki Inundation and Vulnerability Assessment Project
PACGEO	Pacific Island Marine Spatial Information System
RBR	Richard Brancker Research Ltd
SPC	Secretariat of the Pacific Community
TWR	tide and wave recorder

Executive Summary

The Geoscience Division of the Secretariat of the Pacific Community (SPC) completed an oceanographic assessment of Bonriki, South Tarawa in Kiribati from April 2013 to July 2014. This campaign was in conjunction with the University of Western Australia and was funded through Australian Aid. The objective of this component was to collect oceanographic data that would be utilised for numerical modelling and in the assessment of wave impacts on the groundwater resource of Bonriki

The Richard Brancker Research Ltd (RBR) tide and wave recorders TWR-2050P pressure sensors were deployed in the atoll's lagoon, mid-lagoon, Betio Passage, ocean side and on the reef flat. The TWRs' measured surface wave parameters and water elevation. Two RBR Virtuosos were also deployed to collect water pressure data that was then used to derive water levels.

Current velocities (speed and direction of water flow) were measured *in situ* using the Nortek acoustic wave and current (AWAC) meter. The AWAC was deployed both in the lagoon and on the ocean side of Bonriki. Data from the AWAC in the lagoon show the predominant direction of water flow as towards the northwest at a mean speed of between 0.01 m/s to 0.15 m/s. The AWAC deployed offshore shows that the predominant direction of water flow is towards the southeast at mean speeds of 0.1 m/s to 0.4 m/s.

All the oceanographic raw data files are available on PACGEO web portal (http://www.pacgeo.org/), which is an open access geospatial data repository for the Pacific Islands region.

1. Introduction

1.1 Background

The Bonriki Inundation Vulnerability Assessment (BIVA) project is part of the Australian government's Pacific–Australia Climate Change Science and Adaptation Planning Program (PACCSAP), within the International Climate Change Adaptation Initiative. The objectives of PACCSAP are to:

- improve scientific understanding of climate change in the Pacific;
- increase awareness of climate science, impacts and adaptation options; and
- improve adaptation planning to build resilience to climate change impacts.

The BIVA project was developed by the Geoscience Division (GSD) of the Secretariat of the Pacific Community (SPC) in partnership with the Australian government and the Government of Kiribati (GoK).

1.1.1 Project objective and outcomes

The BIVA project aims to improve our understanding of the vulnerability of the Bonriki freshwater reserve to coastal hazards and climate variability and change. Improving our knowledge of risks to this freshwater resource will enable better adaptation planning by the GoK.

More specifically, the project has sought to use this knowledge to support adaptation planning through the following outcomes:

- Improved understanding and ability to model the role of reef systems in the dissipation of ocean surface waves and the generation of longer-period motions that contribute to coastal hazards.
- Improved understanding of freshwater lens systems in atoll environments with respect to seawater overtopping and infiltration, as well as current and future abstraction demands, recharge scenarios and land-use activities.
- Enhanced data to inform a risk-based approach in the design, construction and protection of the Bonriki water reserve.
- Increased knowledge provided to the GoK and the community of the risks associated with the impact of coastal hazards on freshwater resources in response to climate change, variability and sea-level rise.

1.1.2 Context

The Republic of Kiribati is located in the Central Pacific and comprises 33 atolls in three principal island groups. The islands are scattered within an area of about 5 million square kilometres. The BIVA project focuses on the Kiribati National Water Reserve of Bonriki. Bonriki is located on Tarawa atoll within the Gilbert group of islands in Western Kiribati (Figure 1). South Tarawa is the main urban area in Kiribati, with the 2010 census recording 50,182 people of the more than 103,058 total population (KNSO and SPC 2012). Impacts to the Bonriki water resource from climate change, inundation, abstraction and other anthropogenic influences have potential for severe impacts on people's livelihood of South Tarawa. The Bonriki water reserve is used as the primary raw water

supply for the Public Utilities Board (PUB) reticulated water system. PUB water is the source of potable water use by at least 67% of the more than 50,182 people of South Tarawa (KNSO and SPC 2012). Key infrastructure including the PUB Water Treatment Plant and Bonriki International Airport and residential houses are also located on Bonriki, above the freshwater lens, making it an important economic, social and cultural area for the Republic of Kiribati.

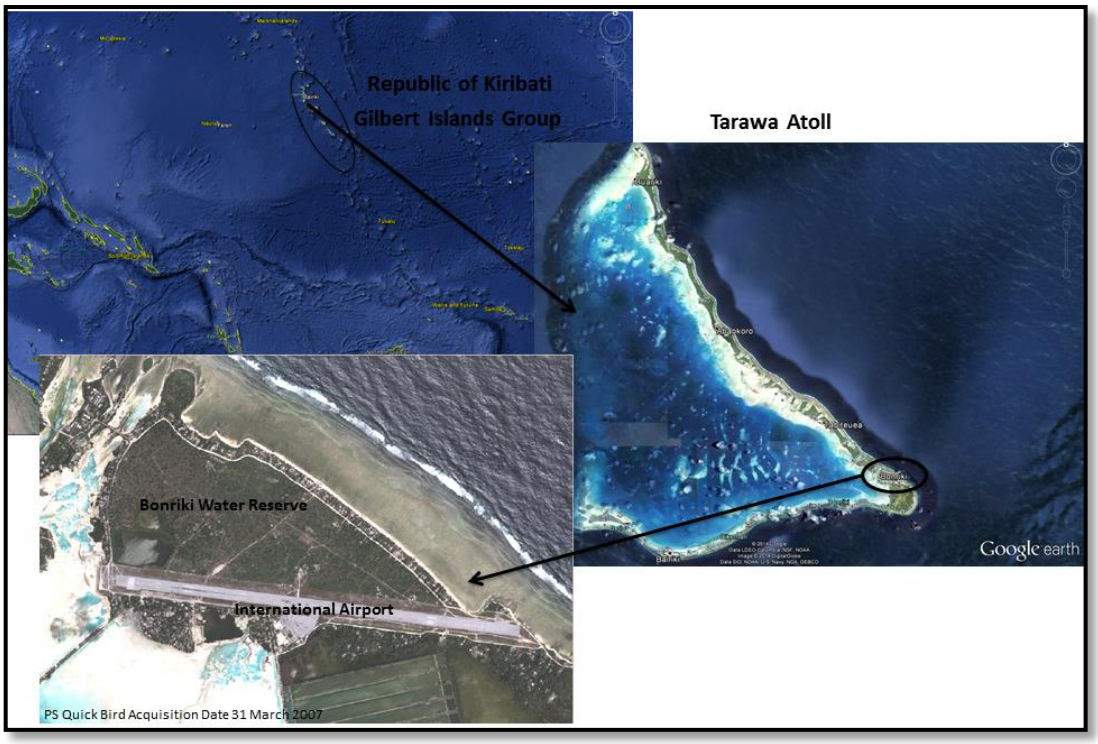

Figure 1. *Bonriki Water Reserve Location.*

1.2 Purpose of this report

This report describes the oceanographic campaign completed in Bonriki, Tarawa, Kiribati. Oceanographic data were acquired from the lagoon and reefal environment surrounding Bonriki. The data will be used in assessing current and wave regimes that impact the groundwater reserve.

As illustrated in Figure 2, the project consisted of three interlinked components, stakeholder engagement, groundwater investigations and analysis, and coastal investigations and analysis.

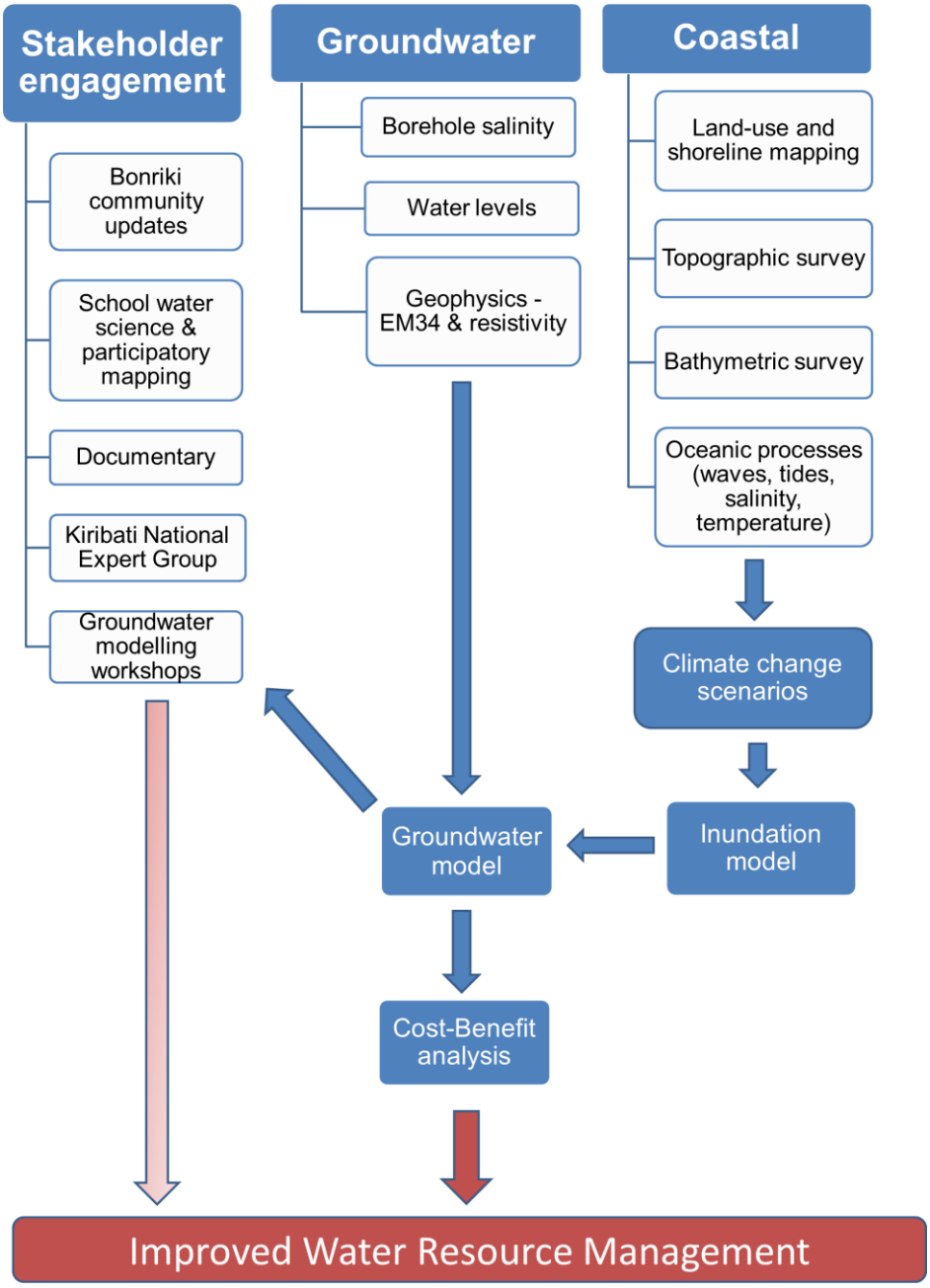

Figure 2: *Bonriki Inundation Vulnerability project components.*

1.3 Scope of this report

Oceanographic data were collected over a 14-month period with a major exercise in December 2013 that was in conjunction with the University of Western Australia. This report provides instrumentation summary and technical details and is structured as below:

- Section 2 provides a detailed methodology with instrument type, capabilities and settings;
- Section 3 illustrates results for the various instruments in their respective locations; and
- Section 4 provides a conclusion.

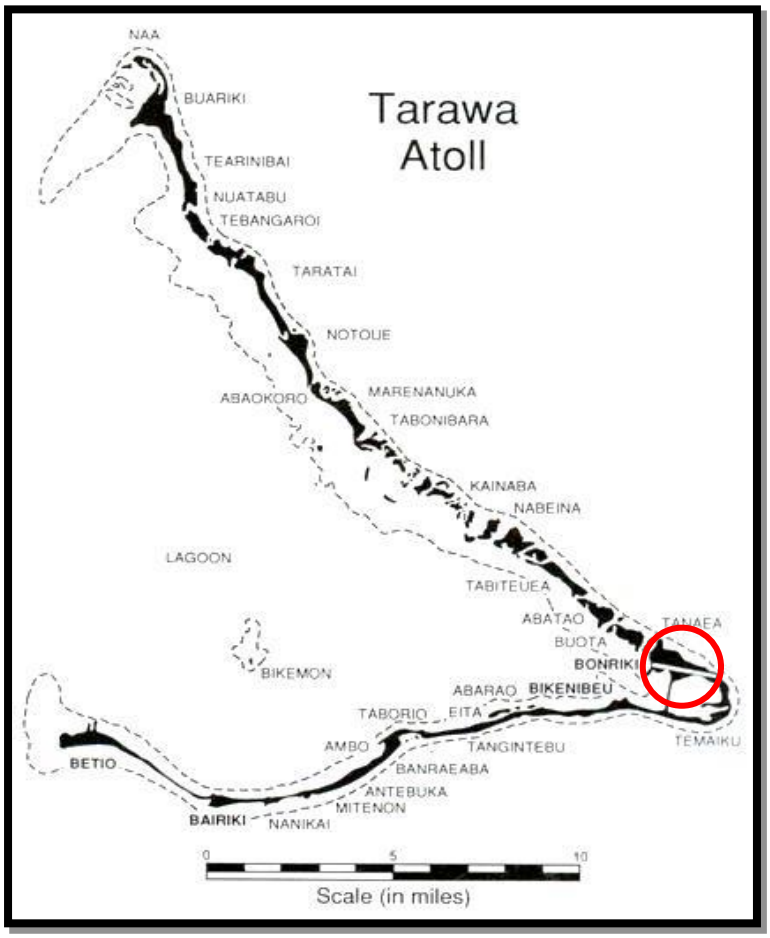

Figure 3: *Tarawa Atoll. The project site is marked by a red circle.*

2. Methodology

Current velocities were measured using an acoustic wave and current (AWAC) meter by Nortek (a scientific instruments company). Two locations were selected, one in the lagoon west of Bonriki, and the other on the outer reef slope east of Bonriki.

The AWAC was programmed to profile current speed and direction and to record directional waves, water temperature and pressure.

Three RBR tide and wave recorders (TWRs) were used to measure *in situ* surface wave parameters and elevation. These were deployed in the lagoon and the reef slope, east of Bonriki.

Details of the instrument operating parameters are listed in the tables below and typical deployment frames are shown.

Table 1: *Deployed instrument survey.*

Instrument	AWAC	Virtuoso	TWR
Description	Acoustic wave and current meter	Single channel logger	Tide and wave recorder
Make	Nortek	RBR	RBR
Model	AWAC-AST	RBR virtuoso D	TWR-2050
Type	Acoustic, 600 kHz	Pressure sensor	Pressure sensor
Digital recorder	Internal		
Data recorded	Current speed and direction, directional waves, temperature and pressure	Pressure	Tides, temperature, waves

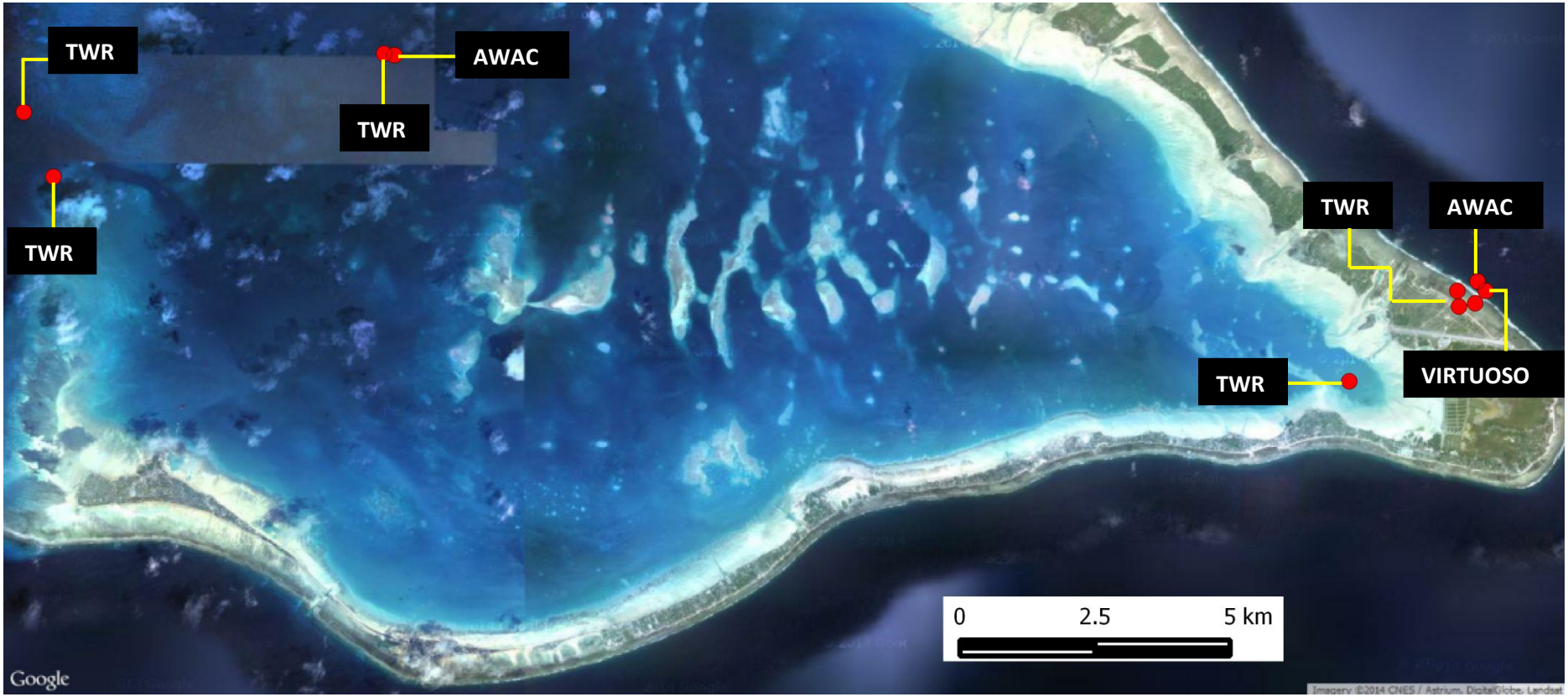

Figure 4: *Locations of oceanographic instruments plotted on Google backdrop.*

Figure 5: *Deployment of a tide and wave recorder on the reef slope east of Bonriki.*

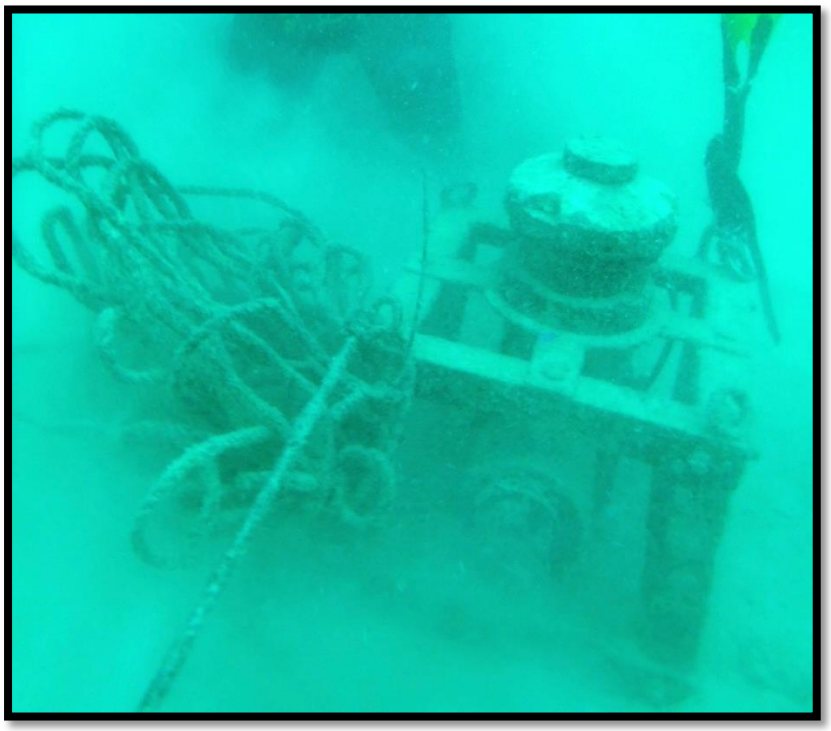

Figure 6: *Deployment of acoustic wave and current meter in lagoon west of Bonriki. At the time of deployment, visibility in the lagoon was very poor.*

Figure 7: *Tide and wave recorder deployed on the reef flat east of Bonriki.*

Figure 8: *Virtuoso deployed on the reef flat east of Bonriki.*

Table 2: *Deployed instruments and their settings.*

Instrument	Default temperature (°C)	Default salinity (ppt)	Magnetic declination (deg)	Sampling interval (s)	No. of samples/ bursts	Averaging interval (s)	Record interval (s)	Number of cells in profile	Blanking distance (m)	Cell size (m)
TWR west of Bonriki (lagoon) SN:15485 SN:21576	Measured	N/A	N/A	1 Hz	2048	120 for tides	600 for tides and 10800 for waves	N/A	N/A	N/A
TWR Betio Passage SN:21576	Measured	N/A	N/A	1 Hz	2048	480 for tides	600 for tides and 10800 for waves	N/A	N/A	N/A
TWR east of Bonriki (ocean) SN:21575 SN:15484	Measured	N/A	N/A	1 Hz	2048	480 for tides	600 for tides and 10800 for waves	N/A	N/A	N/A
TWR Betio Passage SN:21575 SN:15484	Measured	N/A	N/A	1 Hz	2048	120 for tides	600 for tides and 10800 for waves	N/A	N/A	N/A
TWR east of Bonriki (reef flat, nearshore) SN:15484	Measured	N/A	N/A	1 Hz	2048	600 for tides	1200 for tides and 3600 for waves	N/A	N/A	N/A
TWR Betio Passage SN:21575	Measured	N/A	N/A	1 Hz	4096	600 for tides	600 for tides and 7200 for waves	N/A	N/A	N/A
TWR east of Bonriki (reef flat, north) SN:21576	Measured	N/A	N/A	1 Hz	4096	2400 for tides	600 for tides and 10800 for waves	N/A	N/A	N/A
TWR west of Bonriki (lagoon) SN: 21583	Measured	N/A	N/A	1 Hz	4096	600 for tides	600 for tides and 7200 for waves	N/A	N/A	N/A
Virtuoso D (east of Bonriki, end of reef flat transect) SN:52935	Measured	N/A	N/A	1 Hz	N/A	Continuous	N/A	N/A	N/A	N/A
Virtuoso D (west of Bonriki, mid-lagoon)	Measured	N/A	N/A	1 Hz	N/A	Continuous	N/A	N/A	N/A	N/A

Instrument	Default temperature (°C)	Default salinity (ppt)	Magnetic declination (deg)	Sampling interval (s)	No. of samples/ bursts	Averaging interval (s)	Record interval (s)	Number of cells in profile	Blanking distance (m)	Cell size (m)
SN:52937										
AWAC (west of Bonriki, mid-lagoon) SN: WPR 1532	Measured	35	9.28	1 Hz	2048	10800 for waves 60 for currents	600	25	0.50	1.00
AWAC (east of Bonriki, ocean) SN: WPR 1532	Measured	35	9.28	1 Hz	2400	3600 for waves 60 for currents	300	20	0.50	1.00
AWAC (east of Bonriki, ocean) SN: WPR 1532	Measured	35	9.28	1 Hz	2048	10800 for waves 60 for currents	300	25	0.50	1.00

The raw binary files from the AWACs were converted to readable ASCII listings from the AWAC v1.41 software. These raw files were then loaded into the Nortek Storm v1.09 software and processed. The processed files were exported and uploaded into Matlab. Various Matlab scripts were used for analysing and plotting data.

For the TDRs, the downloaded raw data (.hex files) were opened in the RBR software Ruskin v1.8.1 and exported to readable ASCII listings. Various Matlab scripts were used to generate plots from these data.

Table 3: *Instrument deployments and their position and placement in the water.*

Location Name	Instrument	Serial No.	Lat-itude	Long-itude	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
West of Bonriki, lagoon	RBR TWR	15485	1.3742	173.1301	7	0.21	13/04/2013 05:20:00PM 267	113	03/08/2013 05:50:00PM 16398	015485_Bonriki lagoon_Apr-Aug.hex
East of Bonriki, Ocean	RBR TWR	21575	1.389221	173.152816	11	0.21	16/04/2013 11:50:00AM 666	44	29/05/2013 10:30:00AM 6850	021575_Bonriki Reef slope_ocean side_Apr-Aug.hex
Betio Passage	RBR TWR	21576	1.408176	172.9146	10.9	0.1	13/04/2013 10:20:00AM 225	43	25/05/2013 05:50:00PM 6318	021576_Betio passage_Apr-Aug.hex
West of Bonriki, lagoon	RBR TWR	21576	1.3742	173.1301	9.0	0.21	19/08/2013 04:30:00PM 28	83	09/11/2013 10:30:00AM 11800	021576_Bonriki lagoon_Aug-Nov.hex
East of Bonriki, Ocean	RBR TWR	21575	1.389221	173.152816	11	0.21	17/08/2013 12:50:00PM 150	58	13/10/2013 08:50:00PM 8406	015484_Bonriki Reef slope_ocean side_Aug-Nov.hex
Betio Passage	RBR TWR	21576	1.408176	172.9146	10.9	0.1	18/08/2013 04:40:00PM 29	84	09/11/2013 03:10:00PM 11972	021575_Betio Passage_Aug-Nov.hex
West of Bonriki, nearshore	RBR TWR	15484	1.38663	173.14836	0.2	0.06	19/11/2013 1:40:00PM 51	20	08/12/2013 7:20:00AM 1400	015484_BONRIKI SHORE_Nov-Dec.hex
Betio Passage	RBR TWR	21575	1.41892	172.9097	16	0.1	14/11/2013 5:00:00PM 277	26	09/12/2013 1:40:00PM 2067	021575_Betio Passage_Nov-Dec.hex
West of Bonriki, lagoon	RBR TWR	21583	1.3742	173.1301	9.0	0.21	09/11/2013 11:20:00AM 08		09/12/2013 6:00:00AM 2152	021583_Bonriki lagoon_Nov-Dec.hex
Betio Passage	RBR TWR	15484	1.41892	172.9097	10.9	0.1	09/12/2013 2:00:00PM 49	115	02/04/2014 12:20:00AM 16378	015484_Betio Passage_Dec-Apr2014.hex

Location Name	Instrument	Serial No.	Lat-itude	Long-itude	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
West of Bonriki, south end of reef flat transect	RBR VIRTUOSO D	52935	1.38716	173.15106	0.7	0.045	18/11/2013 11:17:46AM 656267	21	08/12/2013 04:02:36PM 2401357	052935_South_Transect_Nov-Dec.rsk
West of Bonriki, mid-lagoon	RBR VIRTUOSO D	52937	1.42864	172.96957	21	0.26	14/11/2013 03:10:32PM 324633	26	09/12/2013 12:04:59PM 2473500	052937_Mid_lagoon_Nov-Dec.rsk
West of Bonriki, mid-lagoon	AWAC	WPR 1532	1.42864	172.96957	21	0.355	09/08/2013 09:30:00PM 17180	126	09/11/2013 02:30:00PM 30473	Tarawa lagoon Apr-Nov.wpr
East of Bonriki, ocean transect	AWAC	WPR 1532	1.39079	173.15146	18	0.355	07/12/2013 01:55:00PM 96	235	29/07/2014 03:00:00PM 67501	Tarawa Ocean Dec-Jul.wpr
East of Bonriki, ocean transect	AWAC	WPR 1532	1.39079	173.15146	18	0.355	11/11/2013 02:50:00PM 215	26	06/12/2013 12:55:00PM 7392	Tarawa Ocean Nov-Dec.wpr

3. Results

3.1 RBR tide and wave recorder

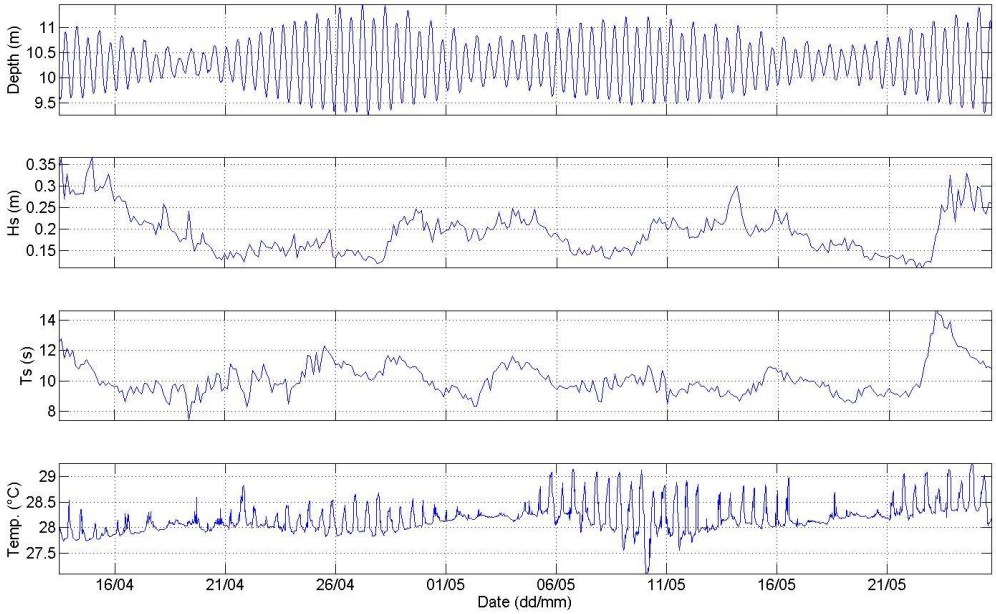

Figure 9: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder near Betio Passage, from April to May 2013.*

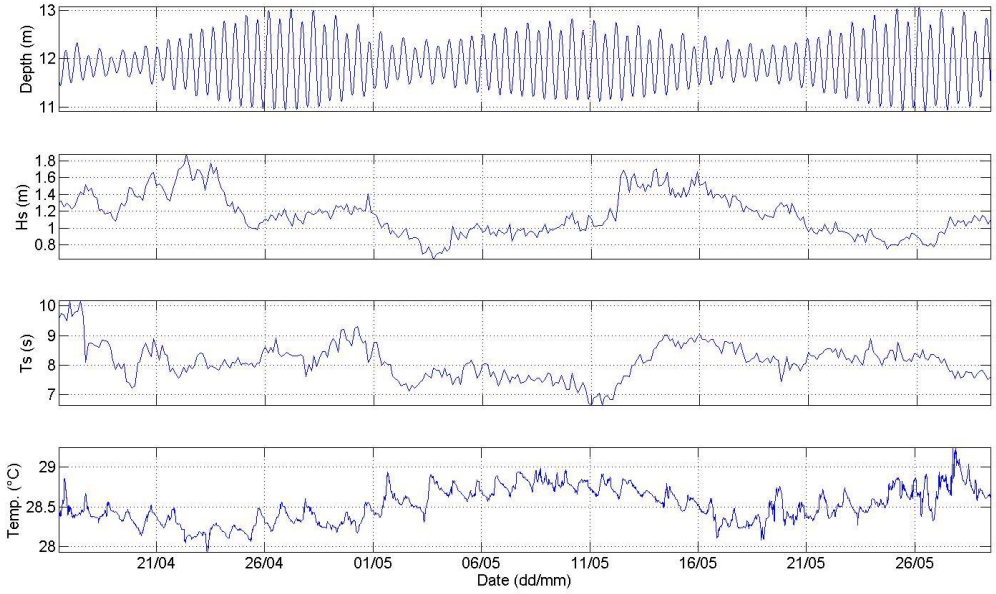

Figure 10: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder east of Bonriki, ocean side from April to May 2013.*

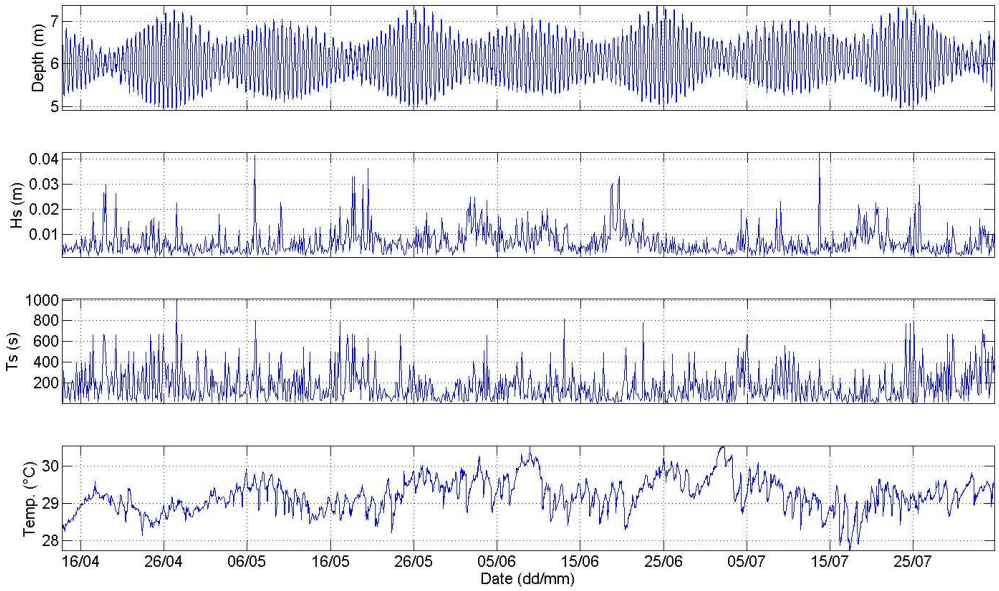

Figure 11: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder west of Bonriki, lagoon side from April to July 2013.*

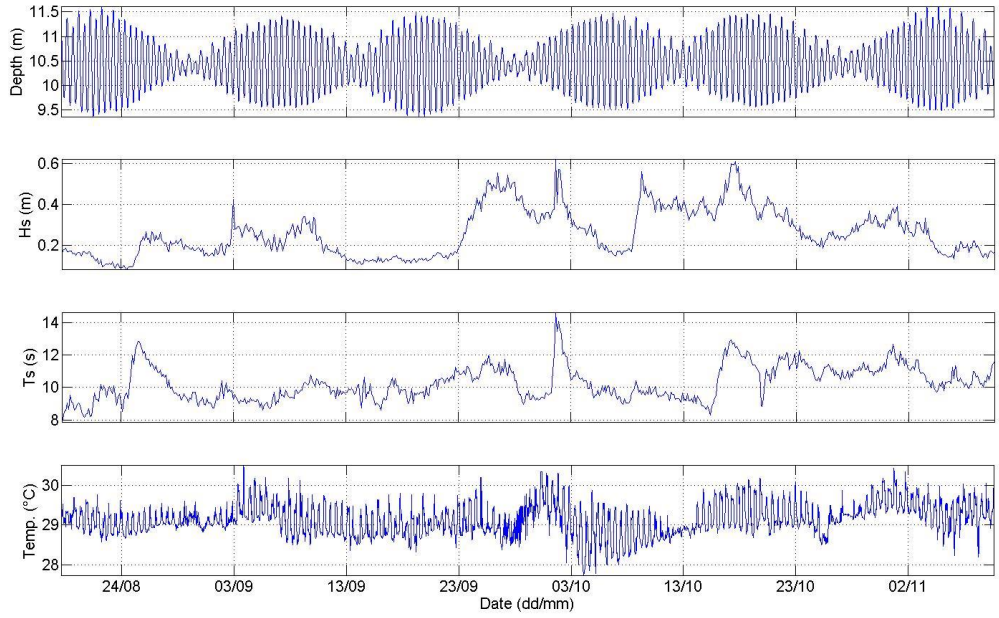

Figure 12: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder near Betio Passage from August to November 2013.*

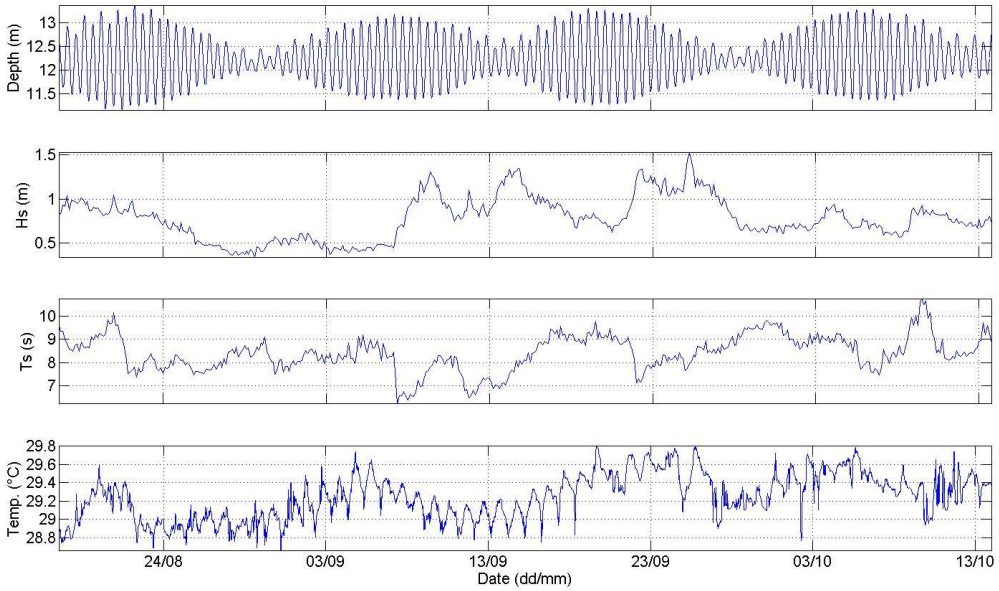

Figure 13: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder east of Bonriki, ocean side from August to October 2013.*

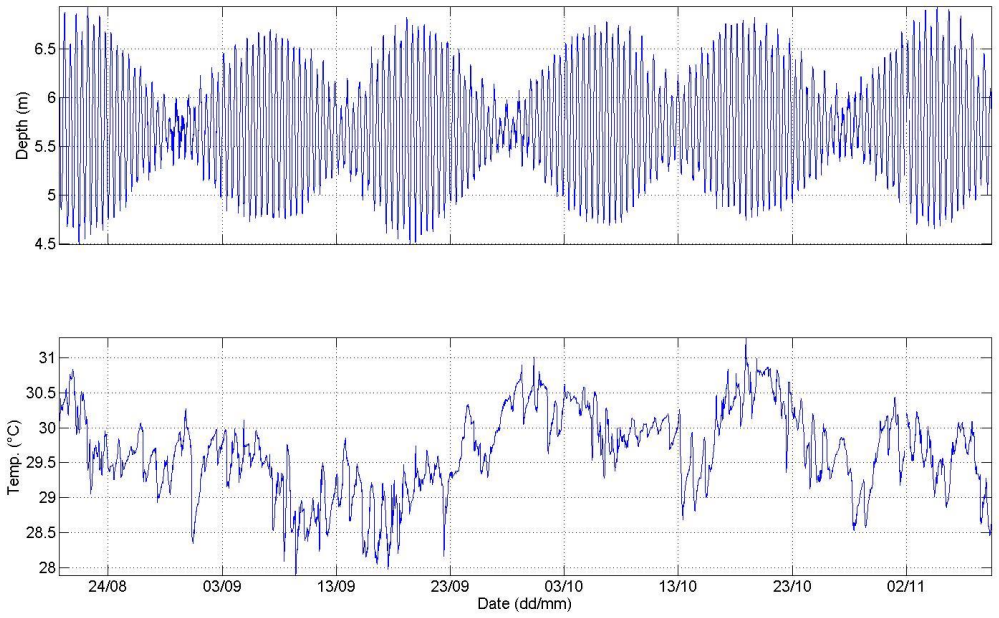

Figure 14: *Time series plot of depth (m) and temperature (°C) as measured by the tide and wave recorder west of Bonriki, lagoon side from August to November 2013.*

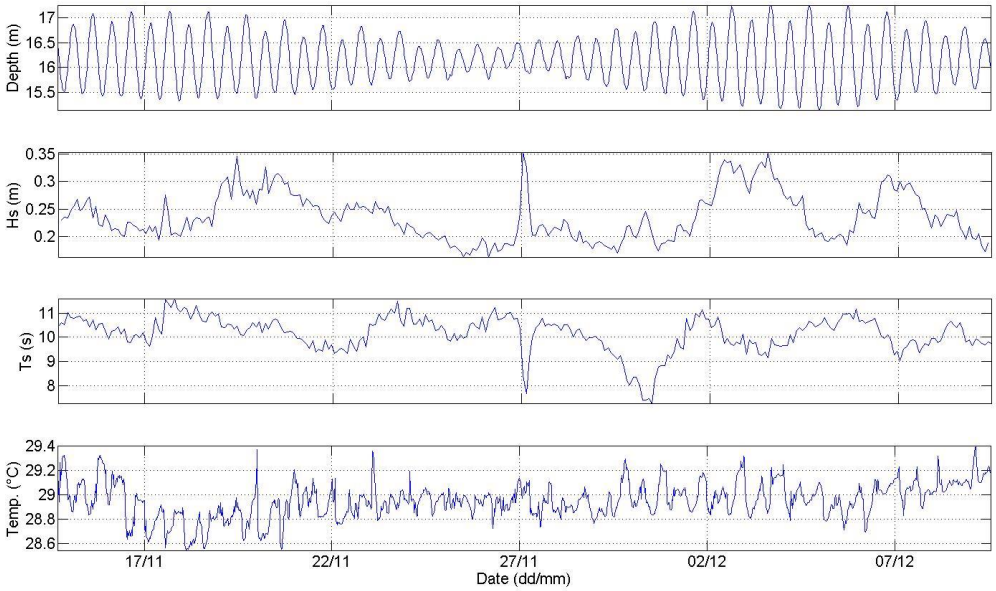

Figure 15: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder near Betio Passage from November to December 2013.*

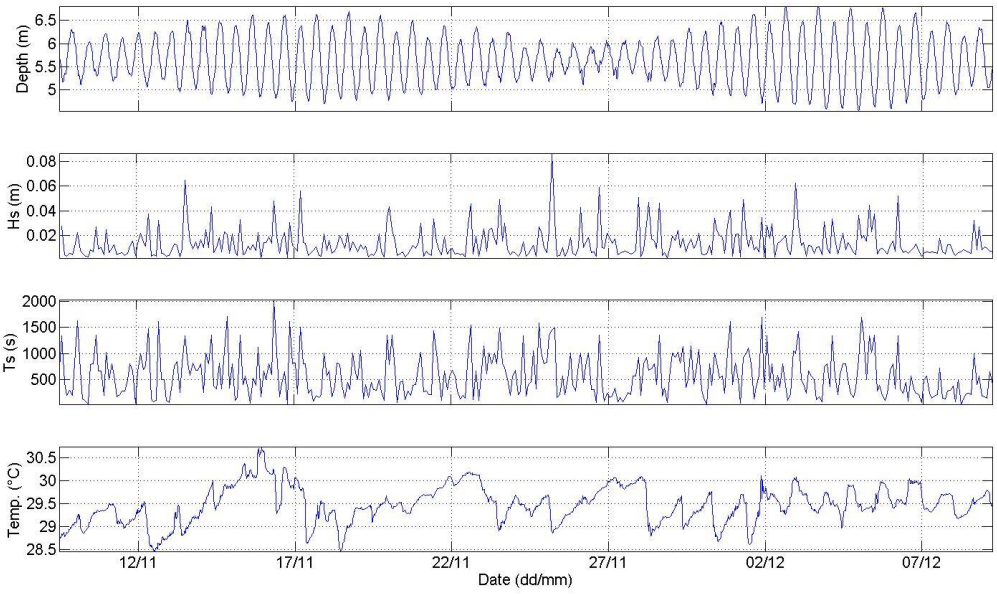

Figure 16: *Time series plot of depth (m) and temperature (°C) as measured by the tide and wave recorder west of Bonriki, lagoon side from November to December 2013.*

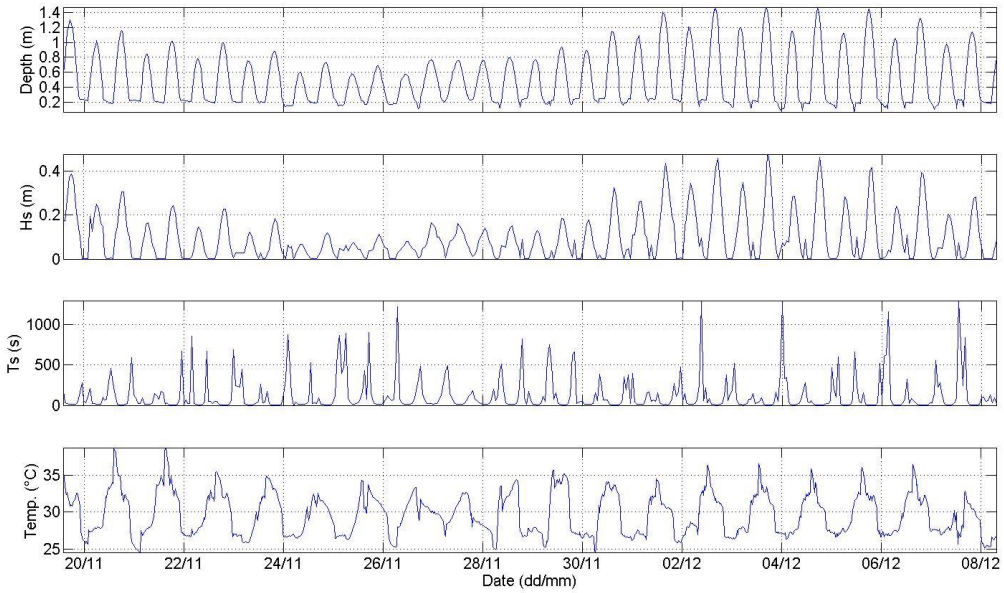

Figure 17: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder east of Bonriki, nearshore on the reef flat from November to December 2013.*

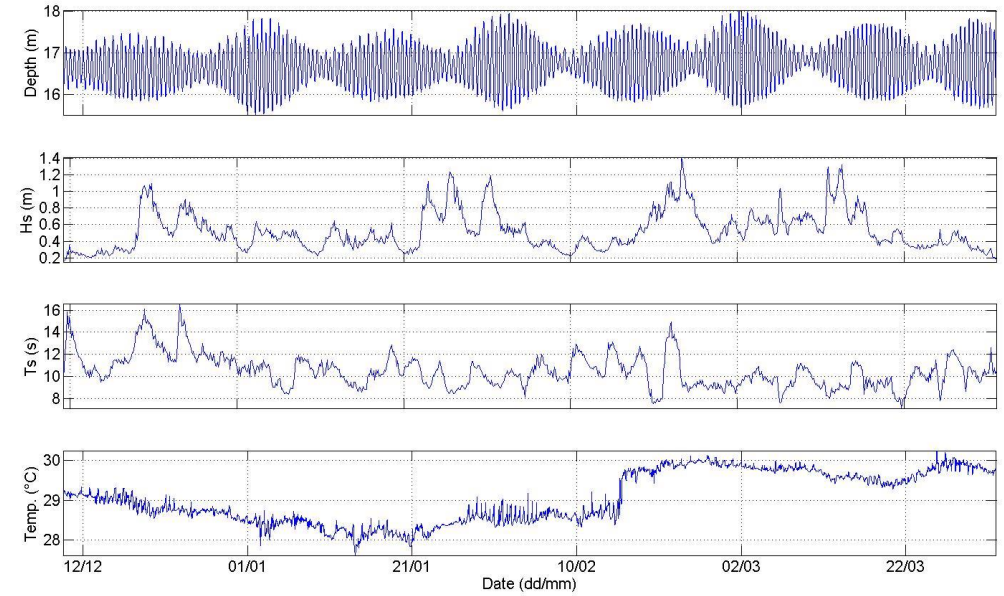

Figure 18: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the tide and wave recorder east of Bonriki, ocean side from December 2013 to March 2014.*

3.2 Virtuoso D

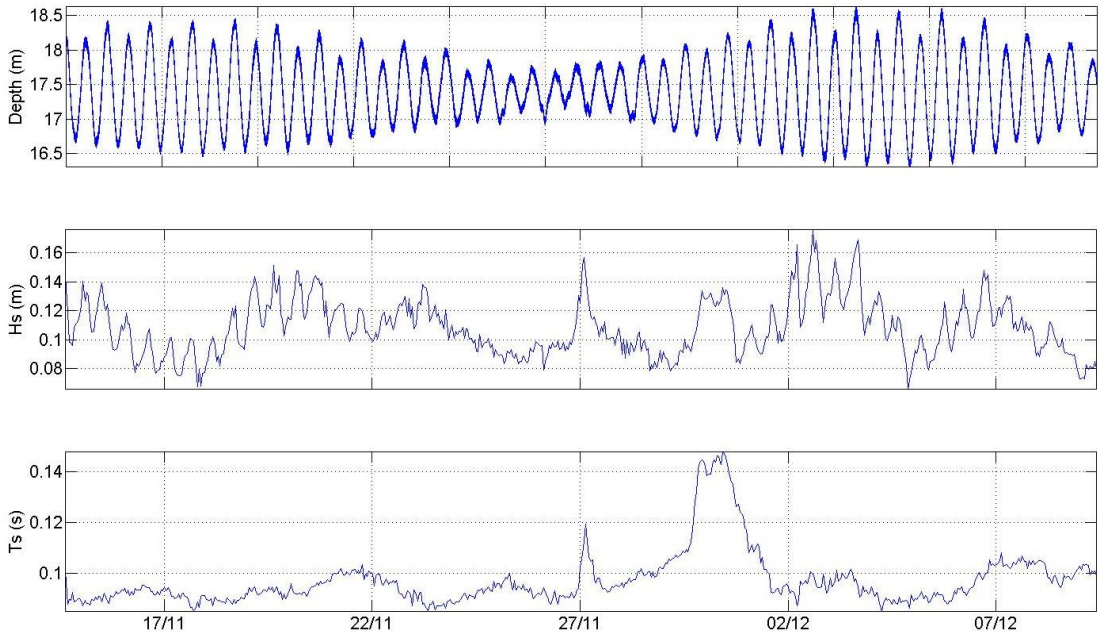

Figure 19: *Time series plot of depth (m), significant wave height (Hs), significant wave period (Ts) and temperature (°C) as measured by the Virtuoso west of Bonriki, mid-lagoon from November to December 2013.*

3.3 Acoustic wave and current meter

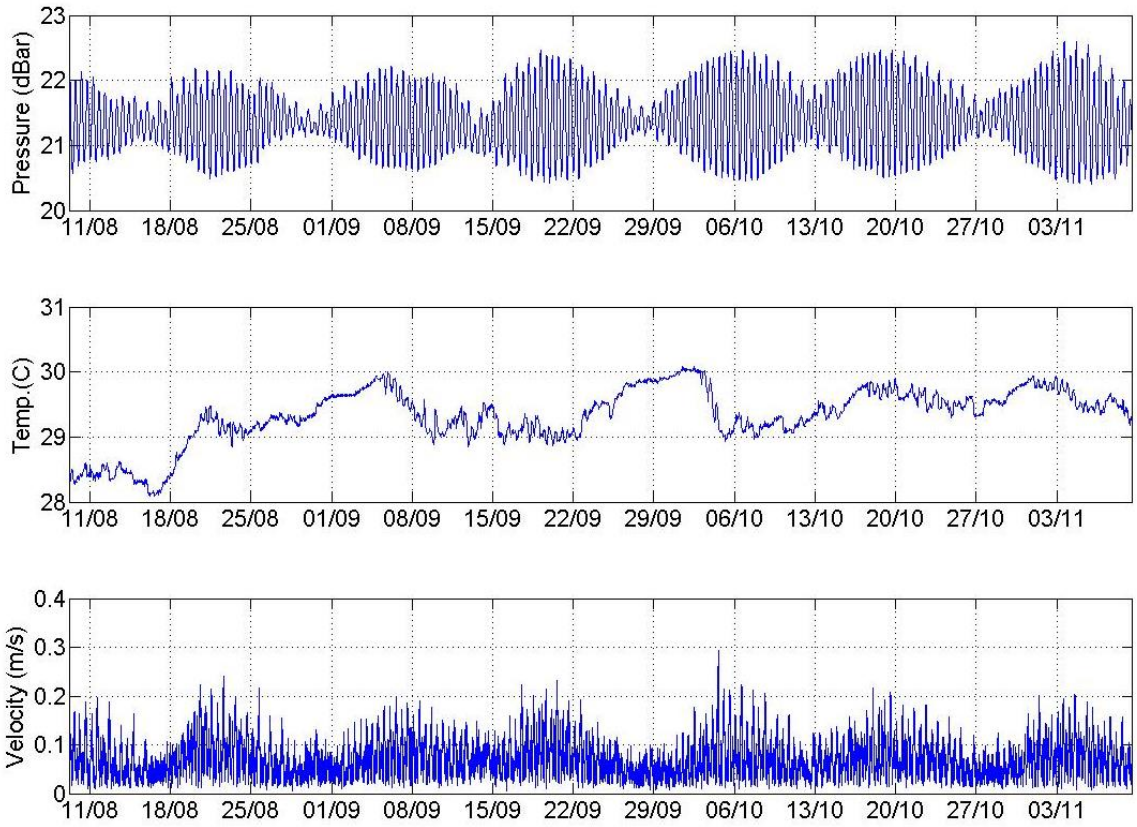

Figure 20: *Time series plot of pressure, temperature, and depth-averaged current speed as measured by the acoustic wave and current meter west of Bonriki, mid-lagoon from April to November 2013. Please note that data collected prior to 11th of August are not shown in the time series as they were erroneous.*

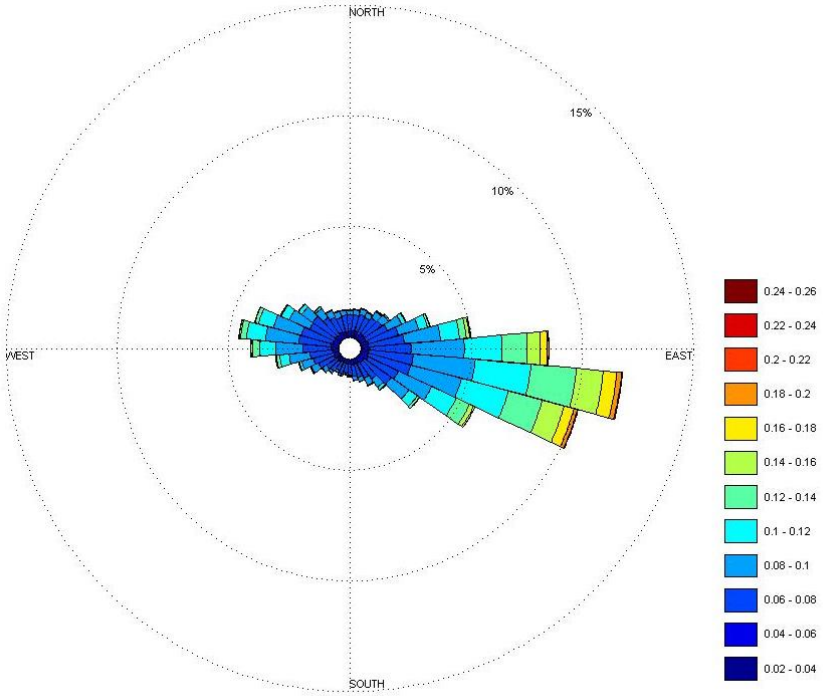

Figure 21: *Rose plot of depth-averaged current direction, as measured by the Acoustic wave and current meter. Direction is given from true north in oceanographic convention (going toward), west of Bonriki, mid-lagoon from April to November 2013.*

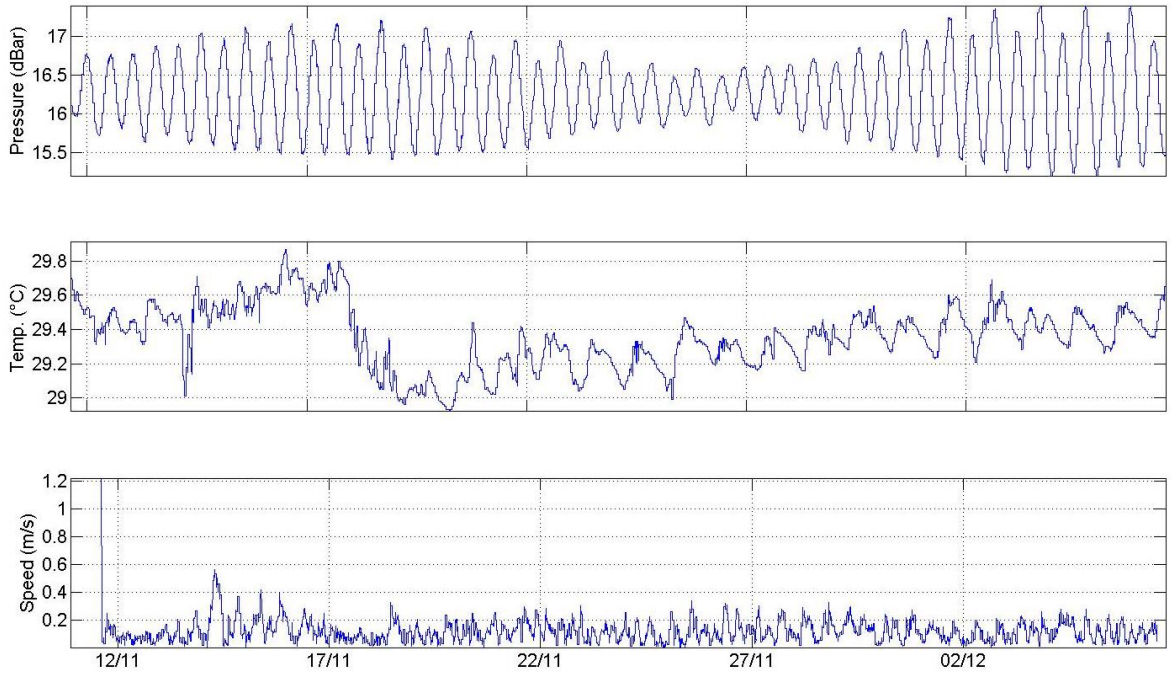

Figure 22: *Time series plot of pressure, temperature, and depth-averaged current speed as measured by the acoustic wave and current meter east of Bonriki, ocean side, from November to December 2013.*

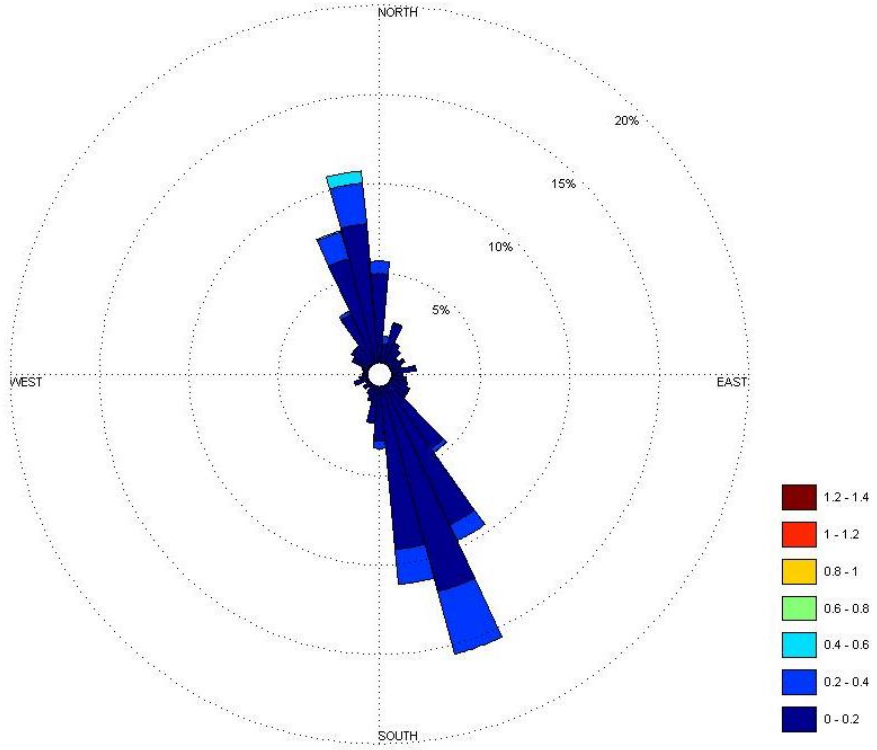

Figure 23: *Rose plot of depth-averaged current direction, as measured by the Acoustic wave and current meter. Direction is given from true north in oceanographic convention (going toward), east of Bonriki, ocean side, from November to December 2013.*

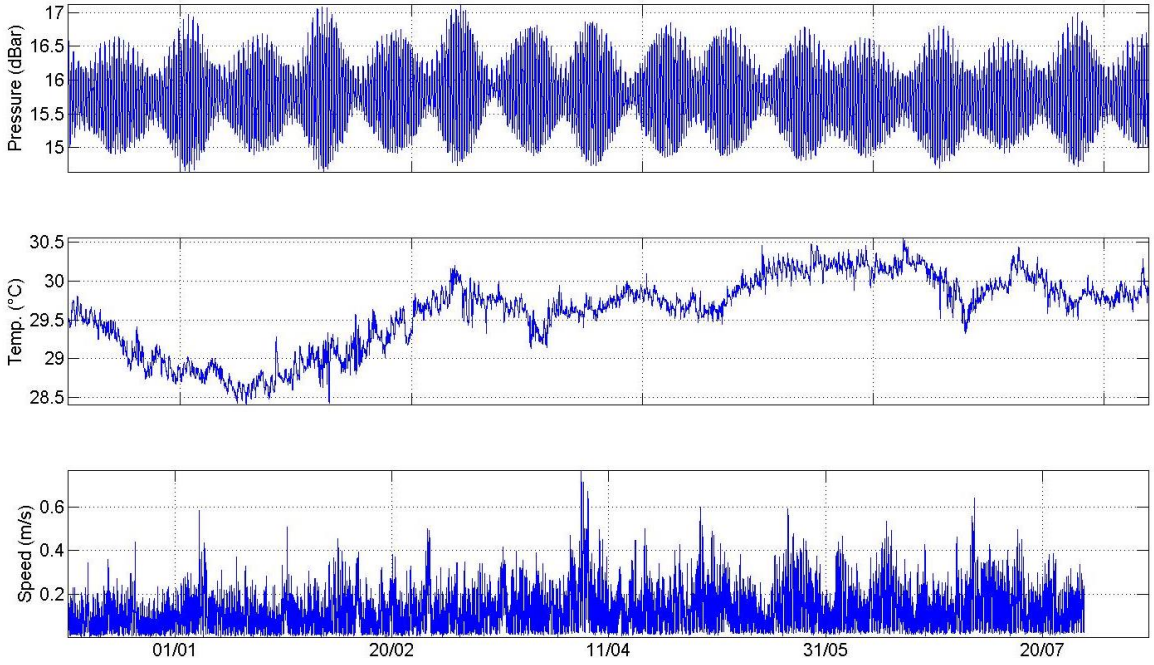

Figure 24: *Time series plot of pressure, temperature, and depth-averaged current speed as measured by the acoustic wave and current meter east of Bonriki, ocean side, from December 2013 to July 2014.*

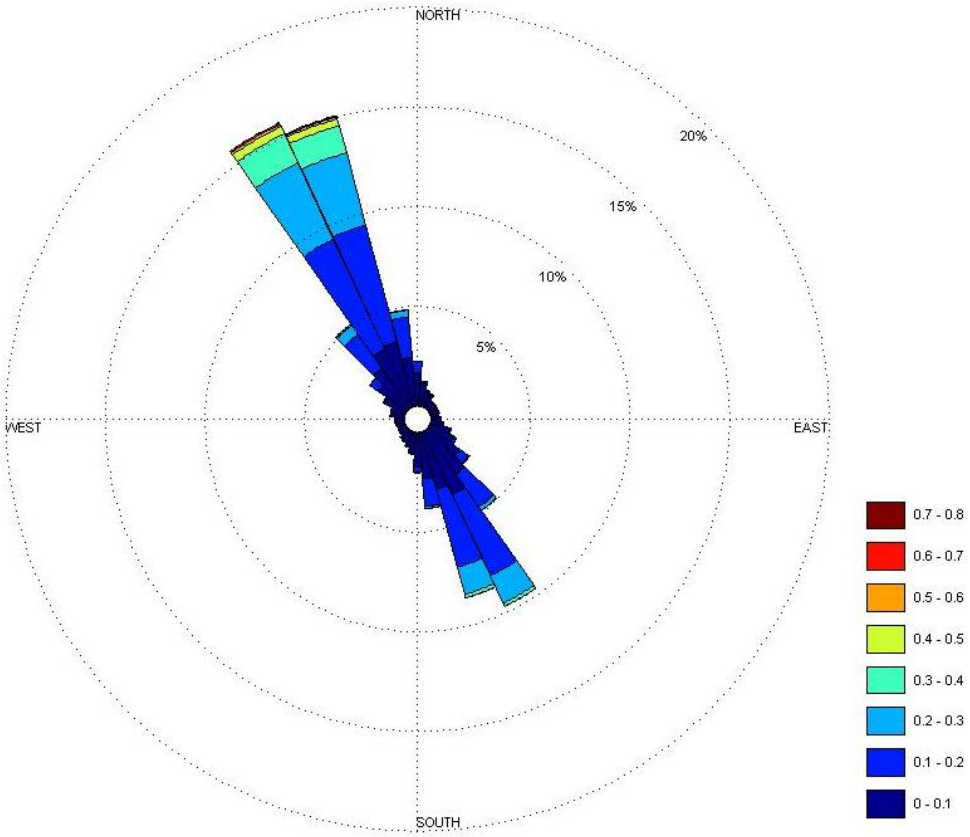

Figure 25: *Rose plot of depth-averaged current direction, as measured by the acoustic wave and current meter. Direction is given from true north in oceanographic convention (going toward), east of Bonriki, ocean side, from November to December 2013.*

4. Conclusion

The oceanographic campaign for this project enabled better understanding of wave and current regimes surrounding Bonriki. Data such as depth, temperature, pressure, direction and velocity were acquired.

Data were recorded for a year with instrument change or reprogramming in between. Two of the TWRs malfunctioned during the deployment period; however, data were successfully retrieved from them with the assistance of the manufacturer (RBR).

The data acquired will be used for numerical and groundwater modelling, which are the other components of the BIVA project.

5. References

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