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.
TABLE OF CONTENTS

EXECUTIVE SUMMARY................................................................................................................................. 2

1 INTRODUCTION........................................................................................................................................... 3

2 METHOD.......................................................................................................................................................... 4

2.1 Rangiroa instrument deployments............................................................................................................. 4

2.2 Apataki, Arutua, Kauehi and Manihi instrument deployments................................................................. 7

2.2.1 Kauehi instrument deployments........................................................................................................... 8

2.2.2 Arutua instrument deployments............................................................................................................ 9

2.2.3 Apataki instrument deployments........................................................................................................ 10

2.2.4 Manihi instrument deployments.......................................................................................................... 11

3 RESULTS........................................................................................................................................................ 12

3.1 Rangiroa instruments................................................................................................................................. 12

3.1.1 AQD — Tiputa channel.............................................................................................................................. 12

3.1.2 AQD — Avatoru reef flat.......................................................................................................................... 14

3.1.3 AQD — Tivaru Hoa................................................................................................................................. 14

3.1.4 AWAC — Centre of the lagoon................................................................................................................ 15

3.1.5 AWAC — Avatoru reef slope................................................................................................................ 15

3.1.6 TWR — Avatoru reef flat......................................................................................................................... 16

3.1.7 TWR — Avatoru Lagoon.......................................................................................................................... 17

3.1.8 TWR — Avatoru reef crest....................................................................................................................... 17

3.1.9 TWR — Tivaru Lagoon............................................................................................................................. 18

3.1.10 TWR — Tivaru reef slope....................................................................................................................... 18

3.1.11 TWR — Otupipi Lagoon........................................................................................................................ 19

3.1.12 TWR — Utoto Lagoon........................................................................................................................... 19

3.1.13 TWR — Utoto reef flat.......................................................................................................................... 20

3.2 Kauehi instrument deployments.................................................................................................................. 20

3.2.1 AQD — Kauehi....................................................................................................................................... 20

3.2.2 TWR — Kauehi reef slope......................................................................................................................... 21

3.2.3 TWR — Kauehi reef crest......................................................................................................................... 21

3.2.4 TWR — Kauehi shoreline......................................................................................................................... 22

3.3 Arutua instrument deployments.................................................................................................................. 22

3.3.1 AQD — Arutua....................................................................................................................................... 22

3.3.2 TWR — Arutua reef slope......................................................................................................................... 23

3.3.3 TWR — Arutua reef crest......................................................................................................................... 23

3.3.4 TWR — Arutua shoreline......................................................................................................................... 24

3.4 Apataki instrument deployments................................................................................................................ 24

3.4.1 AQD — Apataki.................................................................................................................................... 24

3.4.2 TWR — Apataki reef slope..................................................................................................................... 25

3.4.3 TWR — Apataki reef crest..................................................................................................................... 25

3.4.4 TWR — Apataki shoreline..................................................................................................................... 26

3.5 Manihi instrument deployments................................................................................................................ 26

3.5.1 AQD — Manihi..................................................................................................................................... 26

3.5.2 TWR — Manihi reef slope..................................................................................................................... 27

3.5.3 TWR — Manihi reef crest..................................................................................................................... 27

3.5.4 TWR — Manihi shoreline..................................................................................................................... 28

4 BIBLIOGRAPHY............................................................................................................................................ 29

5 APPENDICES.................................................................................................................................................. 30

APPENDIX A : INSTRUMENT DEPLOYMENTS............................................................................................. 30

APPENDIX B : GLOSSARY OF TERMS......................................................................................................... 38

APPENDIX C : INSTRUMENT BROCHURES.................................................................................................. 39
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, Aapataki, 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.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>AOD</th>
<th>AWAC</th>
<th>TWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Acoustic Doppler Profiler</td>
<td>Acoustic Wave and Current Meter</td>
<td>Tide and Wave Recorder</td>
</tr>
<tr>
<td>Make</td>
<td>Nortek</td>
<td></td>
<td>RBR</td>
</tr>
<tr>
<td>Model</td>
<td>AQD</td>
<td>AWAC-AST</td>
<td>TWR-2050</td>
</tr>
<tr>
<td>Type</td>
<td>Acoustic, 1000 Hz (Tiputa channel) and 2000 Hz (Avatoru reef flat and Tivaru Hoa)</td>
<td>Acoustic, 600Hz</td>
<td>Pressure sensor</td>
</tr>
<tr>
<td>Digital recorder</td>
<td>Internal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data recorded</td>
<td>Current speed and direction, temperature, pressure</td>
<td>Current speed and direction, temperature, pressure (mid lagoon), directional waves, temperature, pressure (reef slope)</td>
<td>Tides, temperature, waves</td>
</tr>
</tbody>
</table>
Table 2: Rangiroa instrument settings.

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

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.

<table>
<thead>
<tr>
<th>Location name</th>
<th>Instrument</th>
<th>Serial No</th>
<th>Easting (m)</th>
<th>Northing (m)</th>
<th>Water depth (m)</th>
<th>Height above seabed (m)</th>
<th>Date, local time, number of first good sample</th>
<th>Duration (days)</th>
<th>Date, local time, number of last good sample</th>
<th>Raw data filename</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiputa (Rangiroa NE) Shipping channel</td>
<td>AQD</td>
<td>9161</td>
<td>432346</td>
<td>8344526</td>
<td>21</td>
<td>0.21</td>
<td>22/07/2011, 11:40:00 AM, 398</td>
<td>134</td>
<td>3/12/2011, 12:10:00 PM, 19698</td>
<td>TIP_ch01.prf</td>
</tr>
<tr>
<td>Avatoru Village reef flat</td>
<td>AQD</td>
<td>9471</td>
<td>424549.5</td>
<td>8348375</td>
<td>1</td>
<td>0.10</td>
<td>19/07/2011, 13:30:00 PM, 85</td>
<td>140</td>
<td>6/12/2011, 8:00:00 AM, 13500</td>
<td>AVA_RF01.prf &amp; AVA_RF01.wpb</td>
</tr>
<tr>
<td>Tivaru Hoa</td>
<td>AQD</td>
<td>9440</td>
<td>404662.7</td>
<td>8341918</td>
<td>1</td>
<td>0.23</td>
<td>23/07/2011, 19:00:00 PM, 191</td>
<td>131</td>
<td>1/12/2011, 12:45:00 PM, 12767</td>
<td>Tiv_Ho01.prf</td>
</tr>
<tr>
<td>Centre of Rangiroa Lagoon</td>
<td>AWAC-AST</td>
<td>WPR 1532</td>
<td>426121.3</td>
<td>8332630</td>
<td>24</td>
<td>0.55</td>
<td>15/07/2011, 10:40:00 AM, 252</td>
<td>140</td>
<td>2/12/2011, 9:00:00 AM, 20400</td>
<td>RGL_L01.wpr &amp; RGL_L01.wpb</td>
</tr>
<tr>
<td>North of Avatoru reef slope</td>
<td>AWAC-AST</td>
<td>WPR 0301</td>
<td>424583.4</td>
<td>8348552</td>
<td>40</td>
<td>0.55</td>
<td>14/07/2011, 12:00:00 PM, 107</td>
<td>144</td>
<td>5/12/2011, 6:00:00 AM, 20838</td>
<td>RGL_R01.wpr &amp; RGL_R01.wpb</td>
</tr>
<tr>
<td>Avatoru village reef flat/shore</td>
<td>TWR-2050</td>
<td>21577</td>
<td>424534.6</td>
<td>8348328</td>
<td>0.3</td>
<td>0.50</td>
<td>20/07/2011, 14:00:00 PM, 117</td>
<td>139</td>
<td>6/12/2011, 7:45:00 AM, 13435</td>
<td>Avatoru shoreline_021577_20111126_1110.hex</td>
</tr>
<tr>
<td>Avatoru lagoon</td>
<td>TWR-2050</td>
<td>15484</td>
<td>427691</td>
<td>8346589</td>
<td>7</td>
<td>0.20</td>
<td>16/07/2011, 10:45:00 AM, 151</td>
<td>135</td>
<td>28/11/2011, 12:15:00 PM, 13118</td>
<td>North_lagoon_015484_20111228_1821.hex</td>
</tr>
<tr>
<td>Tivaru reef slope</td>
<td>TWR-2050</td>
<td>15485</td>
<td>404249.4</td>
<td>8342017</td>
<td>16</td>
<td>0.20</td>
<td>18/07/2011, 9:30:00 AM, 64</td>
<td>136</td>
<td>1/12/2011, 13:30:00 PM, 13134</td>
<td>Tivaru reefslope_015485_20111201_1708.hex</td>
</tr>
<tr>
<td>Avatoru village reef crest</td>
<td>TWR-2050</td>
<td>21578</td>
<td>424556</td>
<td>8348384</td>
<td>2</td>
<td>0.50</td>
<td>21/07/2011, 11:00:00 AM, 11</td>
<td>138</td>
<td>6/12/2011, 1:00:00 AM, 13438</td>
<td>Avatoru reeforest_021578_20111206_1047.hex</td>
</tr>
<tr>
<td>Tivaru Lagoon</td>
<td>TWR-2050</td>
<td>21573</td>
<td>405400.4</td>
<td>8341359</td>
<td>6</td>
<td>0.15</td>
<td>23/07/2011, 2:15:00 PM, 71</td>
<td>131</td>
<td>1/12/2011, 12:30:00 PM, 12638</td>
<td>Tivaru_Lagoon_021573_20111201_1648.hex</td>
</tr>
<tr>
<td>Otupipi Lagoon</td>
<td>TWR-2050</td>
<td>21575</td>
<td>455070.1</td>
<td>8308945</td>
<td>7</td>
<td>0.20</td>
<td>22/07/2011, 11:15:00 AM, 59</td>
<td>130</td>
<td>29/11/2011, 12:30:00 PM, 12542</td>
<td>Otupipi-Lagoon_021575_20111209_1820.hex</td>
</tr>
<tr>
<td>Utoto reef flat</td>
<td>TWR-2050</td>
<td>21572</td>
<td>433441.1</td>
<td>8314877</td>
<td>0.3</td>
<td>0.50</td>
<td>25/07/2011, 11:30:00 AM, 59</td>
<td>127</td>
<td>29/11/2011, 9:15:00 AM, 12167</td>
<td>Utoto reefflat-021572_20111229_1841.hex</td>
</tr>
<tr>
<td>Utoto Lagoon</td>
<td>TWR-2050</td>
<td>21571</td>
<td>433391.2</td>
<td>8315791</td>
<td>6</td>
<td>0.20</td>
<td>25/07/2011, 12:30:00 PM, 64</td>
<td>128</td>
<td>30/11/2011, 9:00:01 AM, 12337</td>
<td>Utoto_lagoon_021571_2011130_1745.hex</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>AQD</th>
<th>TWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Acoustic Doppler Profiler</td>
<td>Tide and Wave Recorder</td>
</tr>
<tr>
<td>Make</td>
<td>Nortek</td>
<td>RBR</td>
</tr>
<tr>
<td>Model</td>
<td>AQD</td>
<td>TWR-2050</td>
</tr>
<tr>
<td>Type</td>
<td>Acoustic, 2000 Hz</td>
<td>Pressure sensor</td>
</tr>
<tr>
<td>Digital recorder</td>
<td>Internal</td>
<td></td>
</tr>
<tr>
<td>Data recorded</td>
<td>Current speed and direction, temperature, pressure</td>
<td>Tides, temperature, waves</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Instrument</th>
<th>AQD</th>
<th>AOD</th>
<th>TWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default temperature (°C)</td>
<td>Measured</td>
<td>35.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Default salinity (ppt)</td>
<td>35.0</td>
<td>35.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Sampling interval (s)</td>
<td>1 Hz</td>
<td>2 Hz</td>
<td>2 Hz</td>
</tr>
<tr>
<td>No. of samples/bursts</td>
<td>N/A</td>
<td>1024 for waves</td>
<td>2048 for waves</td>
</tr>
<tr>
<td>Averaging interval (s)</td>
<td>60</td>
<td>60 for currents and 600 for waves</td>
<td>60 for tides</td>
</tr>
<tr>
<td>Record interval (s)</td>
<td>600</td>
<td>600</td>
<td>3,600 for waves and 300 for tides</td>
</tr>
<tr>
<td>Number of cells in profile</td>
<td>20</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>Blanking distance (m)</td>
<td>0.1</td>
<td>0.1</td>
<td>N/A</td>
</tr>
<tr>
<td>Cell size (m)</td>
<td>0.1</td>
<td>0.1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
2.2.1 Kauehi instrument deployments

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

Table 6: Kauehi instrument deployment summary.

<table>
<thead>
<tr>
<th>Location name</th>
<th>Instrument</th>
<th>Serial No</th>
<th>Easting</th>
<th>Northing</th>
<th>Water depth (m)</th>
<th>Date, local time, number of first good sample</th>
<th>Duration (days)</th>
<th>Date, local time, number of last good sample</th>
<th>Filename</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kauehi shore</td>
<td>TWR-2050</td>
<td>21574</td>
<td>703189.4</td>
<td>8249219</td>
<td>0.3</td>
<td>13/11/2011, 11:00:00 AM, 339</td>
<td>4</td>
<td>17/11/2011, 3:20:00 PM, 1127</td>
<td>021574_2_0111117_1823.hex</td>
</tr>
<tr>
<td>Kauehi reef slope</td>
<td>TWR-2050</td>
<td>21579</td>
<td>703435.4</td>
<td>8249178</td>
<td>13.5</td>
<td>13/11/2011, 11:00:00 AM, 55</td>
<td>3</td>
<td>16/11/2011, 10:55:00 AM, 850</td>
<td>Kauehi_RBR_reefslope_0_21579_20111116_1210.hex</td>
</tr>
<tr>
<td>Kauehi reef crest</td>
<td>TWR-2050</td>
<td>21576</td>
<td>703232.3</td>
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<tr>
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<td>703210.9</td>
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<td>Aqdp_kauehi.prf</td>
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</tbody>
</table>
2.2.2 Arutua instrument deployments

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

Table 7: Arutua instrument deployment summary.

<table>
<thead>
<tr>
<th>Location name</th>
<th>Instrument</th>
<th>Serial No</th>
<th>Easting</th>
<th>Northing</th>
<th>Water depth (m)</th>
<th>Date, local time, number of first good sample</th>
<th>Duration (days)</th>
<th>Date, local time, number of last good sample</th>
<th>Filename</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arutua shore</td>
<td>TWR-2050</td>
<td>21576</td>
<td>540965.9</td>
<td>8301535.4</td>
<td>0.2</td>
<td>21/11/2011, 11:00:00 AM, 30</td>
<td>4</td>
<td>25/11/2011, 5:55:00 PM, 1208</td>
<td>Reef_shore_arutua.hex</td>
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<tr>
<td>Arutua reef slope</td>
<td>TWR-2050</td>
<td>21579</td>
<td>541083.8</td>
<td>8301445.6</td>
<td>3.2</td>
<td>21/11/2011, 11:00:00 AM, 271</td>
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<td>25/11/2011, 10:40:00 AM, 1142</td>
<td>Reef_slope_arutua.hex</td>
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<tr>
<td>Arutua reef crest</td>
<td>TWR-2050</td>
<td>21574</td>
<td>541051.7</td>
<td>8301518.6</td>
<td>0.4</td>
<td>21/11/2011, 11:00:00 AM, 17</td>
<td>5</td>
<td>26/11/2011, 05:20:00 AM, 1363</td>
<td>Reef_crest_arutua.hex</td>
</tr>
<tr>
<td>Arutua reef flat</td>
<td>AQD</td>
<td>6550</td>
<td>541030.3</td>
<td>8301523.1</td>
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<td>Arutua01.prf</td>
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</tbody>
</table>
2.2.3 Apataki instrument deployments

![Apataki IKONOS 2003 satellite image with oceanographic instrument deployment sites.](image)

**Table 8: Apataki instrument deployment summary.**

<table>
<thead>
<tr>
<th>Location name</th>
<th>Instrument No.</th>
<th>Serial No</th>
<th>Easting</th>
<th>Northing</th>
<th>Water depth (m)</th>
<th>Date, local time, number of first good sample</th>
<th>Duration (days)</th>
<th>Date, local time, number of last good sample</th>
<th>Filename</th>
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</thead>
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<tr>
<td>Apataki shore</td>
<td>TWR-2050</td>
<td>21576</td>
<td>562475.5</td>
<td>8278176.5</td>
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<td>3/12/2011, 15:55:00 PM, 1128</td>
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<td>TWR-2050</td>
<td>21579</td>
<td>562293.3</td>
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2.2.4 Manihi instrument deployments

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

Table 9: Manihi instrument deployment summary.

<table>
<thead>
<tr>
<th>Location name</th>
<th>Instrument</th>
<th>Serial No</th>
<th>Easting</th>
<th>Northing</th>
<th>Water depth (m)</th>
<th>Date, local time, number of first good sample</th>
<th>Duration (days)</th>
<th>Date, local time, number of last good sample</th>
<th>Filename</th>
</tr>
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<td>Manihi shore</td>
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</table>
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.](image)

![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).](image)
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

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).
3.1.6 TWR — Avatoru reef flat

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).

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).
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.

3.1.11 TWR — Otupipi 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).

3.1.12 TWR — Utoto Lagoon
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).
4 BIBLIOGRAPHY


5 APPENDICES

Appendix A Instrument deployments

Rangiroa deployment photos

Aquad in Tiputa channel.

Aquad on Tivaru Hoa.

Aquad in Avatoru channel.

Aquad on Avatoru village reef flat.
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

AWAC north of Avatoru reef slope.

AWAC in mid-lagoon.

TWR on Utoto reef flat.

TWR in Utoto Lagoon.
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

- TWR on Avatoru shoreline.
- TWR on Avatoru reef crest.
- TWR in Otupipi Lagoon.
- TWR in Tivaru Lagoon.
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

TWR on Tivaru reef slope.

TWR in Avatoru Lagoon.

Apataki instrument deployment photos

AQP on Apataki village reef flat.

TWR on Apataki shoreline (reef flat).
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

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

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

TWR on Kauehi reef crest.

AQD on Manihi village reef flat.

Manihi instrument deployment photos

TWR on Kauehi reef slope.

TWR on Manihi shoreline (reef flat).
Oceanographic Assessment Rangiroa, Kauehi, Arutua, Apataki and Manihi, French Polynesia

TWR on Manihi reef crest.

TWR on Manihi reef slope.
Appendix B  Glossary of terms

<table>
<thead>
<tr>
<th>Wave statistics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant wave height (Hₜ, Hₘ₀, H₀, H₁/₃)</td>
<td>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 H₁/₃, 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 H₀. While H₁/₃ is a direct measure of Hₛ, H₀ is only an estimate of the significant wave height that under many circumstances is accurate. In general, in deep water, H₁/₃ and H₀ are very close in value and are both considered good estimates of Hₛ. All modern wave forecast models predict H₀ and the standard output of most wave gauge records is H₀.</td>
</tr>
<tr>
<td>Peak wave period (Tₚ)</td>
<td>The peak wave period (in seconds) associated with the largest wave energy in the total wave spectrum at a specific point.</td>
</tr>
<tr>
<td>Peak wave direction (DirTₚ)</td>
<td>The wave direction at the frequency at which a wave energy spectrum reaches its maximum.</td>
</tr>
<tr>
<td>Significant wave period (Tₛ)</td>
<td>Average period of the one-third highest waves in a wave record.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ocean properties</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (dbar)</td>
<td>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.</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>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.</td>
</tr>
<tr>
<td>Speed (m/s)</td>
<td>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).</td>
</tr>
<tr>
<td>Direction (deg)</td>
<td>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).</td>
</tr>
<tr>
<td>Depth (m)</td>
<td>The distance from the surface to the sea floor.</td>
</tr>
</tbody>
</table>
Appendix C  Instrument brochures

Nortek acoustic wave and current profiler (AWAC)

Oceanographic Assessment Rangiroa, Kauhia, Apataki and Manihi, French Polynesia

5.3 Instrument brochures
Nortek acoustic wave and current profiler (AWAC)

### Technical Specifications

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

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

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

**Depth uncertainty**
- Depth range: 0 m to 180 m

**Wave measurements**
- Maximum depth: 55 m (1 MHz), 60 m (600 kHz), 100 m (400 kHz)
- Data types: Pressure, one velocity along each beam, AST
- Sampling rate (output): 2 Hz velocity, 4 Hz AST (1 MHz), 1 Hz velocity, 2 Hz AST (600 kHz), 0.75 Hz AST (400 kHz)
- No. of samples per burst: 512, 1024, or 2048. Inquire for options

**Wave estimates**
- Range: ±10 m to ±15 m
- Accuracy/resolution (Hz): ≤1% of measured value ±0.1 m
- Accuracy/resolution (Dry): 2° / 0.1°
- Period range: 0.1–100s (1 MHz), 1–10s (0.6 MHz), 1.5–10s (0.4 MHz)

<table>
<thead>
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<th>Depth (m)</th>
<th>cut-off period (ms)</th>
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<td>5</td>
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<tr>
<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>20</td>
<td>1.8</td>
</tr>
<tr>
<td>50</td>
<td>3.1</td>
</tr>
<tr>
<td>100</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**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: 20°, AST requires <10° instrument tilt
- Up or down: Automatic detect
- Pressure: Piezoresistive
- Standard range: 0–50 m (1 MHz) / 0–1000 m (0.6 MHz) / 0–100 m (0.4 MHz)
- 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: 5 beams 60° apart, one at 9°
- Material: Stainless steel, polyvinyl acetate, or titanium alloy

**Connectors**
- Bulbhead (impulse): MC8H-3-FS
- Cable: PMGIL-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: 300 m

**Dimensions**
- See drawing on front page
- Weight in air: 7.3 kg (0.6 MHz), 4.2 kg (0.6 MHz), 6.1 kg (1 MHz)
- Weight in water: 3.6 kg (0.6 MHz), 2.9 kg (0.6 MHz, 1 MHz)

**Analog Inputs**
- Number of channels: 2
- Supply voltage to analog output devices: Three options selectable through firmware commands
- Battery voltage: 500 mA
- +6V/100 mA
- +12V/100 mA
- Voltage Input: 0–5 V
- Resolution: 16 bit A/D

**Data Recording**
- Capacity (standard): 2 MB, can add: 32/176/352MB or 408
- Profile record: Nvtels=6 + 120
- Verify record: Nvtels=0 + 24 + 1 KB

**Data Communication**
- IPC: RS 232 or RS 422
- Communication baud rate: 300–115200
- Recorder download baud rate: 600–1200 kbaud for both RS322 and RS422
- User control: Handled via AWAAC software, or ActiveX® controls / facsimile for online systems.

**Power**
- DC input: 9–18 VDC
- Peak current: 3 A
- Power consumption: Transmit power: 1–30W, 3 adjustable levels
- Sleep consumption: 0.3 mW (RS322), 5 mW (RS422)

**Real-time clock**
- Accuracy: ±1 min/year
- Backup in absence of power: 1 year

**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.
Nortek aquadopp profiler (AQD)

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-covariant processing technique that provides extremely low noise measurements.

**HR Profiler Features:**
- Internal data recording (1.4 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 samplers (1, 2 or 3 beams)
- Measured 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

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 Aquascope 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.

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

### Technical Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water velocity measurement</strong></td>
<td></td>
</tr>
<tr>
<td>Acoustic frequency</td>
<td>0.48kHz, 0.69kHz, 1.98kHz, 2.0kHz</td>
</tr>
<tr>
<td>Maximum profiling range*</td>
<td>40-90m, 39-40m, 12-17m, 4-10m</td>
</tr>
<tr>
<td>Cell size</td>
<td>2x4m, 1x4m, 0.3-4m, 0.1-2m</td>
</tr>
<tr>
<td>Beam width</td>
<td>1.7°, 1.0°, 3.4°, 1.7°</td>
</tr>
<tr>
<td>Minimum blanking</td>
<td>0.1m, 0.50m, 0.20m, 0.05m</td>
</tr>
<tr>
<td>Number of beams</td>
<td>3</td>
</tr>
<tr>
<td>Maximum i/cells</td>
<td>128</td>
</tr>
<tr>
<td>Velocity range</td>
<td>±0.1m/s (require extended range)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1% of measured value ±0.5cm/s</td>
</tr>
<tr>
<td>Min Sampling rate</td>
<td>1Hz</td>
</tr>
<tr>
<td>Velocity uncertainty</td>
<td>Consult software program</td>
</tr>
</tbody>
</table>

*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 upper range with large cells and acoustically turbid water.*

### Ultrasonic Profiling Sonar

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic frequency</td>
<td>1.0kHz, 2.0kHz</td>
</tr>
<tr>
<td>Maximum profiling range*</td>
<td>6m, 3m</td>
</tr>
<tr>
<td>Cell size</td>
<td>20-300mm, 7-120mm</td>
</tr>
<tr>
<td>Beam width</td>
<td>2.4°, 1.7°</td>
</tr>
<tr>
<td>Minimum blanking</td>
<td>0.2m, 0.03m</td>
</tr>
<tr>
<td>Maximum i/cells</td>
<td>128</td>
</tr>
<tr>
<td>Range/velocity limitations</td>
<td>Product of profiling range and velocity should not exceed 65m/s^2 (2MHz system) or 1.0m/s^2s for (1MHz system)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1% of measured value ±0.5cm/s</td>
</tr>
<tr>
<td>Min Sampling rate</td>
<td>1Hz (continuous mode), 18Hz (burst mode)</td>
</tr>
<tr>
<td>Velocity uncertainty</td>
<td>Consult software program</td>
</tr>
</tbody>
</table>

### Sound Speed and Attenuation

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell area acoustic frequency</td>
<td>2.0kHz, 3.0kHz</td>
</tr>
<tr>
<td>Maximum profiling range*</td>
<td>2.0kHz</td>
</tr>
<tr>
<td>Number of beams</td>
<td>3</td>
</tr>
<tr>
<td>Echo intensity</td>
<td>Same as velocity</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.4dB</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>90dB</td>
</tr>
</tbody>
</table>

### Standard Sensors

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>-4°C to 70°C</td>
</tr>
</tbody>
</table>
| Accuracy/resolution                  | ±0.5°C/

### Environmental

- **Operating temperature**: -5°C to 35°C
- **Storage temperature**: -20°C to 60°C
- **Shock and vibration**: IEC 72-1-1-2
- **Depth rating**: 300m

### Dimensions

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight in air</td>
<td>3.4 kg, 2.9 kg, 22 kg</td>
</tr>
<tr>
<td>Weight in water</td>
<td>0.2 kg, 0.4 kg, 0.2 kg</td>
</tr>
<tr>
<td>Length</td>
<td>see dimensional drawings</td>
</tr>
<tr>
<td>Diameter</td>
<td>see dimensional drawings</td>
</tr>
</tbody>
</table>

### Options

- **Batteries**: Lithium, Li-ion rechargeable
- **External batteries**: Alkaline, Lithium or Lithium-ion
- **Transducer head**: Right angle head for 1 or 3kHz
- **Communication**: Inquire for special configurations

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**Note**: All specifications are subject to change without notice.
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 2688 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 straightforward logger setup 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