Preliminary Report

INSTALLATION OF THE WAVERIDER BUOY AND ANCHOR SYSTEM
OFFSHORE APOLIMA ISLAND, WESTERN SAMOA 28-29 August
1989

by

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Prepared for: Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC), Western Samoa Project CCSP/WS.8

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INSTALLATION OF THE WAVERIDER BUOY AND ANCHOR SYSTEM OFFSHORE APOLIMA ISLAND, WESTERN SAMOA

28 - 29 August 1989

SUMMARY

A Waverider anchor system and buoy was deployed in Western Samoa on 28 and 29 August 1989. This was a joint effort between the Government of Western Samoa, NORAD, Norwegian Aid, UN Project RAS/86/125 and CCOP/SOPAC. The P/V Nafanua and crew was made available by the police Department at no cost to the Project to perform the placement.

A telex received from Norway on 30 August 1989 gave the buoy position as 13.804 S 172.195 W. The position determined at time of deployment from three sets of horizontal sextant angles between Tafua, Nuu Lea Lea, and Nu'ulopa gave 13.881 S 172.195W, see Fig 1. The two positions were remarkably close considering the difference in method used to obtain the values.

The ground receiver aboard the P/V Nafanua indicated a 0.6 metre wave at 8.4 seconds following deployment at 0815 hrs on 29 August 1989 (WS time). The Argos Satellite reported a 1.74 metre wave at 5.45 seconds with a peak period of 13.8 seconds 12 hours and 27 minutes later which was consistent with the stronger winds observed following the deployment of the buoy. The installation appears to be quite satisfactory and the buoy is operational.

A previous attempt at deployment of the buoy on 31 July 1989 was aborted when the anchor buoy placed on 28 July could not be located. It was later reported recovered on Savaii. Details regarding its disappearance have not been established.

The buoy should continue to function unattended for about 12 months at which time the batteries will need changing. Boats should avoid any contact with the buoy; however, it is desirable that any change in its position or if the navigation light does not function at night then these facts should be reported immediately to the Apia Observatory. The buoy should be seen on regular bases by either the Fisheries Vessel or the Police Patrol Vessel each time they are in the area, and the sighting should be reported to the Observatory.
While the primary objective for the collection of wave data in Western Samoa is to evaluate the potential for converting wave energy to electrical energy on these islands, the data collected by the Waverider buoy will be of considerable value to future coastal development and coastal protection of Western Samoa. Wave data collected over a period of three years or so should be representative of the area and these data will be of practical value into the future.

**INTRODUCTION AND BACKGROUND**

This activity was undertaken as a part of the Western Samoa Work Program, CCSP/WS.8, "Investigation of the feasibility for use of wave energy for the production of electrical power in Western Samoa."

The work is a part of a continuing programme to collect baseline wave data from the several member countries in the South Pacific Area where use of wave energy by means of existing technology may be feasible. The equipment being deployed was provided by Norwegian Aid, and it is considered to be the most advanced available for this application.

The report contains the details of the anchor system, the available site information, and the methods employed in placing the anchor system and the Waverider buoy.

**OBJECTIVES**

The objective of this report is to document details of the site selection, description of the anchor system, method of installation, and conditions regarding the installation for future reference. The objective for this Wave Measuring Programme was given in Technical Report No. 79, dated 22 June 1987.

**PERSONNEL PARTICIPATING**

The Marine Scientist, Ralf Carter had the support and assistance of the Government of Western Samoa: both the Department of Foreign Affairs and the Department of Agriculture, Forest and Fisheries. The site selected was a result of dialogue between the Norwegian wave experts, the Government of Samoa, CCOP/SOPAC, and the Marine Scientist while working on the site. The final selection, by necessity was made by the Marine Scientist at sea in the general area. Asi Blakelock, the Superintendent of police was of significant assistance in making the P/V Nafanua available to the project. The individuals that assisted in the Projected included:

Terri Toomata, Foreign Affairs  
Poloma Komiri, Foreign Affairs  
Ausetalia Tittimaea, Superintendent Apia Observatory  
Fa'atoia Malele, Observatory  
Ueta Faasili, Chief Fisheries Officer  
Lui Bell, Senior Marine Biologist Mike King, Fisheries
Edward C. White, Resident Representative UNDP
Savali Time, Fishery Officer
Totive Aloaina, Crew Tauti Matapalapaia
Siitia Amituitania, Crew Tauti Matapalapaia
Tavitia Nikolao, Inspector, Commanding Officer, Nafanua
Lorenese Neru, Executive Officer
Maselino Tomeniko, Navigator
Talosaga Time, Coxswain
Iekome Mulumulu, P.O.
Peni Amoufa, C/Eng
Tifaga Paese, Electronic
Mike Enoka, Electrician
Foe Faamausili, C/Nav.
Falaulu Manu, Engl/Diver
Lafaele Iosefo, Engl/Diver
Peni Sio, Cook/Diver
Ervine Brown, Engl
Simaota Ioane, Seaman
Seualu Amuia, Seaman
Sani Tagi, Seaman
Alewi Fepeuai, Hydrological Service
Kuatemawi Tuapola, Hydrological Service
Leota Faasuaga, Geophistic Service Samuelu
Taaape
Tana Sua

Others participating in the Programme included the crew of the
Fisheries vessel, Tautai Matapalapaia, Observatory driver Tana Sua,
and other members of the Observatory Staff.

**EQUIPMENT, FACILITIES AND METHODS**

The following equipment were provided by the Norwegian Aid
and shipped to Western Samoa by the Project Office in Suva:

- Waverider buoy with new batteries installed
- Two sets of Components for the anchor systems
- Two Plastic marker buoy, 0.7 metre diam. Ground
- receiver for buoy signal

Items provided by the Project Office in Suva:

- Danfort anchor with chain and 300 Ibs mono-filament line
- Electrical and rubber tape, serving line, etc.
- Measuring tapes, 100 ft and 12 ft
- Stop watch, Charts, tide data, and maps
- Sextant, field glasses, and bearing compass
- Reel with 300 metres sounding line and weight
- Various safety equipment
- 3.5 cum shipping container
- Hand tools, falls; miscellaneous lines etc.
- Various shackles, chains, blocks, etc.
- Sketches of the anchor system etc.
Items provided by the Government of Western Samoa:

- Fisheries vessel, TAUTI MATAPALAPAIA and crew for site, selection and buoy deployment
- Patrol vessel, NAFANUA and crew for deployment of two clump anchors and the placement of the Waverider buoy
- Cast iron for two clump anchors
- Dock and Storage facilities
- Ground transport for equipment and personnel
- Office and staging space
- Support staff for preparation and site work
- Echo-sounders, Radar, Sat-Nav, etc.
- Transport of buoy container from the Wharf
- Two Marker buoys and cast iron weights for anchors

Method of Operation:

The operation was done in steps. The first step was to locate a favourable site having a water depth of less than 300 and greater than 100 metres, good exposure to the southern swell, minimum wave reflection from the coast, mild bottom slope, and agreeable to all parties concerned. The second step was to confirm the depth and mark the location with a small buoy. The third step was to design the anchor system to suit the observed depth. The fourth step was to place the anchor at the marked site, and the fifth and final step was to activate the Waverider system, and replace the temporary buoy with the Waverider buoy.

**TECHNICAL DETAILS**

**Anchor String**

The following characteristics for the materials used in the anchor string are given for future reference. The weight per unit length was determined by weighting each individual piece and measuring its length. The length were stretched to tension equal to approximately 200 times line diameter squared (lbs tension and inches diameter). The line sizes and best estimate of allowable working load are given in Table I below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Diam mm</th>
<th>kg/m</th>
<th>s.g.</th>
<th>Wt in Sea % air Wt</th>
<th>Working Load N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chain</td>
<td>12</td>
<td>3.737</td>
<td>7.85</td>
<td>87</td>
<td>17,800</td>
</tr>
<tr>
<td>Nolaro</td>
<td>12</td>
<td>0.128</td>
<td>1.41</td>
<td>29.1</td>
<td>9,300</td>
</tr>
<tr>
<td>Nylon</td>
<td>18</td>
<td>0.1935</td>
<td>1.14</td>
<td>12.6</td>
<td>5,800</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>18</td>
<td>0.1935</td>
<td>0.92</td>
<td>-8.7</td>
<td>5,200</td>
</tr>
<tr>
<td>Shackle</td>
<td>11</td>
<td>0.36 ea</td>
<td>7.85</td>
<td>87</td>
<td>17,800</td>
</tr>
</tbody>
</table>
The anchor string beginning with the clump anchor of cast iron (one 710 Ib transmission and one 1210 Ib engine block) and 7.8 m of anchor chain was passed about the mid-section of the transmission portion and through the cylinder of the block portion of the two piece anchor. The chain was secured after passing through the block so the two pieces would not separate during the drop. About 4 metres of chain were free to act as anchor line. The Nolaro line was shackled onto the chain and moused with no. 9 wire. The chain, shackles, and wire were galvanized iron.

The 73 metre length of Nolaro line was shackled to the bottom of the Nylon pennant with the eight 28 cm diam floats. The float pennant terminated with platted splices, and a double man knot formed a large ball on the line to act as a jam for the floats. The 3.5 metre float section was shackled onto the 55 metre, 18 mm diam platted float line, see the photos at the end of the report. All shackles and eyes above the anchor chain were stainless steel and were moused with stainless steel wire.

The float line connects onto the 62 metre 18 mm diam. Nylon safety line. During anchor launch the rubber snubber and Waverider buoy are not connected to the anchor string for safety. After a tidal cycle, and the stability of the anchor is established the rubber snubber and Waverider are collected to the anchor chain. The Nylon pennant would normally be removed when the Waverider buoy is exchanged for the marker buoy used when the anchor is dropped; however, due to strong currents the end of the float line could not be hauled aboard when the buoy exchange was being made, so the Nylon pennant was left attached to the float line, and it was connected to the 17 metre long 38 mm diam rubber snubber attached onto the 1.5 m heavy ballast chain on the bottom of the Waverider buoy.

Description of Vessels

Tauti Matapaiapaia - 40 ft low, 13 ft beam, 6 ft draft, Detroit Diesel 671, speed 7.5 at 1500 rpm, 16 NM Radar, JFV-90 200 or 50 KHz 0-1200 fathom echo sounder, Sat-Nav, and FE-881 MK-11 Furuno 0-200 fathom echo-sounder with strip chart.

Nafanua - 31.5 metre steel hull patrol vessel, 3 metre draft, and 10 metre beam, 2-3516 V-16 Cats, cruz 12 to 15 knots and top speed - 25 knots, fuel 12000 imperial gallons, two 50 cal mounted on the flying bridge main-ship, 75 NM radar, MK-II Furuno 0-200 fathom echo-sounder, Sat-Nav, and 1000 kg jib crane port aft.
ANCHOR LOCATION

The entire shoreline of Savaii between Tafua and Cape Asuisui was sounded parallel and 3.7 km offshore. Parallel to the shore, the bottom was more or less a uniform 400 fathoms (730 metres) deep. Not finding a slope flatter than 2.05:1 the site was abandoned.

A site was located 3.6 nautical miles SSW of Apolima Island between Savaii and Upolu and approximately 4.1 nautical miles from Tafua on Savaii; however, this site could not be used as the anchor line was lost when the marker buoy disappeared.

A second site 4.7 nautical miles SSW of Apolima Island was used. A marker buoy was placed at 1750 hours on 28 August in 109 metre depth. Depth profiles were run in a cross at the site and the marker was circled at a radius of about 100 metres. A more or less uniform depth of between 95 and 110 metres was found.

Bathymetry map no. 3 of the N.Z.G.S. Bulletin No. 63 (Kear and Wood, 1959) show the depth to be between 50 and 60 fathoms at this location, see Fig 2. Map no. 3 shows 60 fathom depth 0.4 NM distance on all four sides of this location. The 60 fathom contour to the east best fits the site observations. The bathymetry data was from the 1953-56 HMNZS Lachlan survey (Hunt, 1956).

The reasons for selection of this site were: it satisfied the depth requirements, it is located in line with Apolima Island with respect to the normal ship route through Apolima Strait so ships would normally pass either to the west or east of it, the site is as far south as possible and have the protection of Apolima Island. Being this far south it would be exposed to waves from 105 to 280 degrees true, waves reaching this area should be the same as those that reach the south side of Savai'i, and the bottom appeared to be safe with respect to slope, coral heads, channels etc.

The running time was 6 hr 30 min between Apia fishing wharf and Cape Asuisui. The calculated ship speed was 7.5 knots at 1500 revolutions per minute.

ANCHOR PLACEMENT

The vessel anchored in the lee of nearby Apolima Island overnight, and returned to the marker at first light. The marker was found on a bearing 234 degrees true from Nuu Lea Lea rock at a range of 4.72 NM.

The free drop method was employed to place the anchor. The anchor string was run out astern the vessel, and the anchor was cast over as the vessel came abeam the marker buoy. A sounding of the bottom along side the marker float indicated a depth of 109 metres (60 fathoms) with some angle in the line.

The drop was made at 1827 hours just as the sun reached the horizon. The anchor required 35.8 seconds (3.05 ms) to reach the bottom. The current set to the southwest.
WAVERIDER BUOY PREPARATION

The Waverider buoy was removed from its shipping cradle and hoisted on a sling. The hatch was removed with the top PC container. The antenna shipped inside the buoy was attached to the navigation light. The battery voltage was checked on 3 July 1989 from the breakout box and found to be 20.5 volts on A, B, C, & D to +Bat. During operation B+ to B- was 9.86 volts. The power cable was connected at 1030 hrs Western Samoa time (2130 hrs Zulu) on 29 July 1989. Fresh desiccant was placed inside the buoy along with the antenna blank cover. The hatch "0" ring was checked for cuts, cleaned, and fresh lubricant added. The hatch was secured. The ground receiver indicated contact with ID 5626 (15AH) on channel 32. The buoy remained at the Apia Observatory following an attempt to place in on 31 July until 28 August when it was placed aboard the P/V Nafanua for transport to the site for deployment on 30 August 1989.

DEPLOYMENT OF THE WAVERIDER BUOY

The Waverider buoy aboard the P/V Nafanua was brought to the anchor site on the morning of 29 August from an overnight anchorage at Apolima Island. The anchor buoy was heaved aboard on the port side, the marker buoy was removed, and an attempt was made to haul the float line to the surface, but it could not be done by four men. The white safety line was secured to the vessel. A significant current set to the southwest was present at 1827 hrs on 28th August 1989 during a flood time. The anchor held the vessel, and it swung free of the line which was secured to the vessel port aft. Again at 0815 hrs when the buoy was cast over on the 29 August there was a south west set to the current. It was at the start of ebb tide at that time, and the trade winds were present but very light (the winds increased through the day and were in excess of 12 knots in the afternoon).

The rubber snubber already connected to the Waverider buoy was attached to the white nylon line and all were set adrift. The location was photographed and sextant angles shot between Tafua Savaii, Nuu Lea Lea, and Nu'ulopa rock. The location was determined from one of three sets of angles to be 13 degrees 52.8 minutes south 172 degrees 11.2 minutes west using the split fix technique. This location was confirmed by telex from Norway on 30 August 1989, and found to be 13 degrees 53 minutes south 172 degrees 11.4 minutes west at 2146 hrs on the 29th December (Samoa Time).

The ground receiver was used to check the output of the Waverider buoy. It locked onto channel 32 ID# 5626 and indicated a 0.6 m wave at 8.4 seconds.

The buoy hull number is 68379-6A. It has a Cunifer-10 hull, bronze in colour. The anchor appears to have about 100 metres scope. The eight 28-cm diameter floats appear to be set about 29 metres from the surface. The navigation light was observed to have five rapid amber/white flashed every 10 seconds.
CONCLUSIONS

The conclusions presented in this report are based upon the experience of this operation and other similar operations. Some modification of these conclusions can be expected after the buoy has operated at the location for a time.

1. The sub-surface currents at the anchor site were some stronger than anticipated. The weight of the anchor is sufficient to hold the buoy at this location; however, strumming of the lines may attract fish bite.

2. It would be desirable to remove the 204 ft 3/4-inch white nylon pennant from the string, to reduce the hydraulic drag and angle on the line to the anchor. This could be done during a period of less current.

3. The anchor held the 31.5 metre Police Vessel, Nafanua against the currents without any apparent shift in relative position with the marker buoy along side. The marker buoy was not removed and should survive for several months.

4. The current set to the southwest during both ebb and flood tides while the anchor was being placed and while the Waverider buoy was attached.

5. The bottom is quite irregular, and it has what appears to be north and south uniform bottom channels that have almost vertical walls. The elevation of the channel bottoms are typically 20 to 30 metres deeper than the general surface that is around 100 metres deep.

6. Several coral heads or other chimney like structures occur in groups on the bottom. They rise 15 or so metres above the general 100 metre deep surface.

7. Ships navigating Apolima Strait should pass well to the west of the buoy anchorage. Ships to the east of Apolima Island bound for Australia will come to the east but close to the site. Local fishermen should be familiar with the buoy location and avoid contact with it.

8. The Notice to Mariners should bring the buoy location to the attention of both yacht and commercial ship masters. The flashing navigation light should aid in the avoidance of the buoy as well as assisting overflying pilots in checking its location.

9. The buoy should be exposed to waves approaching Western Samoa between 110 to 280 degrees true. The exposure is almost as favourable as the proposed location on southern Upolu Island at Sapo'e (Carter, 1988), and the greater depth at Apolima is an advantage.
10. The greater exposure to ship traffic and the stronger currents make the Apolima site less attractive than the Sapo'e site. The much shorter distance to the Apolima site from Apia is a significant advantage. Domestic airlines overfly the site frequently at Apolima.

11. The police vessel, Nafanua is well suited for the deployment of the Waverider buoy. The experience gained by the crew in this exercise will likely serve them well with future similar activities.

12. The Police Department is to be commended for their contribution to this activity. Without their most capable assistance the operation would have been much more difficult and costly.

13. The split fix method of determining the buoy location from horizontal sextant angles to nearby islands proved to be most useful during this exercise.

14. The location of the buoy given by the Argos Satellite confirmed that the anchor was stable and the buoy was holding position.

15. The Superintendent of Police is to be commended for providing the P/V Nafanua for this most significant activity, and the vessel Master and crew are to be congratulated on a job well done.

16. The position of the buoy should be monitored for some time in the event fish bit becomes a problem. The currents appear to be such that if the buoy was cut free that it would drift onto the south coast of Savaii, probably within 12 to 18 hours.

17. The waves reaching the Waverider buoy site should be representative of the waves that approach the southern coast of Savai'i.

18. The Waverider buoy should be exposed to waves approaching from about 175 degrees. The exposure is primarily from the southern direction. Some wave diffraction will occur over the nearshore region of southern Upolu Island, and this effect will tend to increase the exposure.

REFERENCE


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1. The views expressed in this report are those of the Author and do not necessarily reflect those of the United Nations.

2. Mention of any firm or licenses process does not imply endorsement by the United Nations.