

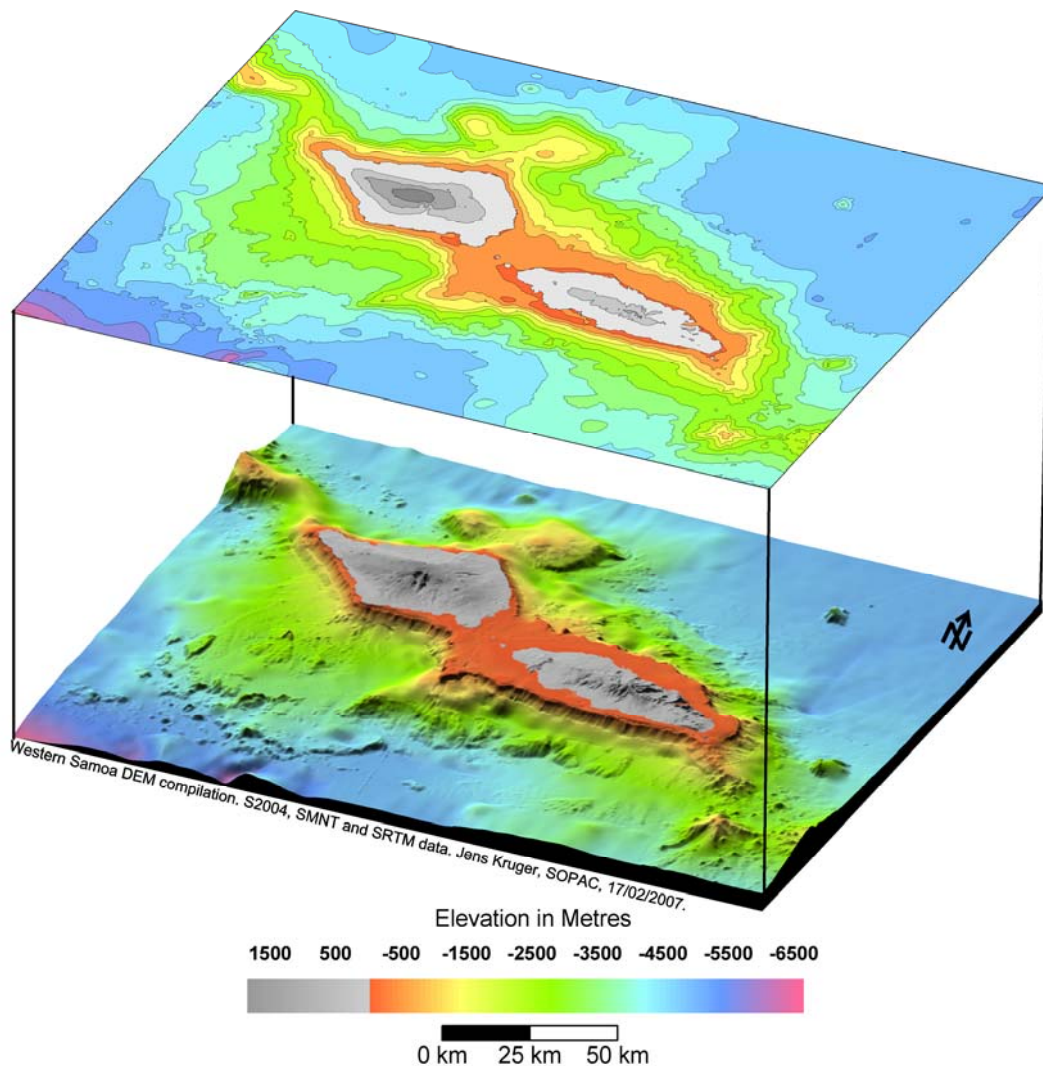


SOPAC

EU-SOPAC Project Report 112
Reducing Vulnerability of Pacific ACP States

SAMOA TECHNICAL REPORT
High-Resolution Bathymetric Survey
Fieldwork Undertaken from 27 January to 1 March 2004

October 2008



Western Samoa three-dimensional Digital Elevation Model

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
1. INTRODUCTION.....	2
1.1 Background	2
1.2 Geographic Situation.....	2
1.3 Geological Setting	3
1.4 Previous Bathymetry Compilations.....	4
2. RESULTS AND DISCUSSION.....	6
2.1 Multibeam Bathymetry.....	6
2.2 Composite Grid	7
2.3 Morphological Features.....	10
3. DATA ACQUISITION AND PROCESSING	12
3.1 Survey Particulars	12
3.2 Field Personnel	12
3.3 Geodetic Reference System	12
3.4 Vessel Description and Static Offsets	13
3.5 Positioning Control	15
3.6 Survey Computer	15
3.7 Multibeam Echosounder.....	15
3.8 Multibeam Echosounder Data Processing	16
3.9 Multibeam Backscatter	16
3.10 Tidal Information.....	17
3.11 Sound Velocity Profiling	18
3.12 Composite DTM Model.....	20
4. REFERENCES.....	22
APPENDICES.....	24
Appendix 1 – Equipment Performance, Statement of Uncertainty, Suitability for Charting	24
Appendix 2 – CTD profiles.....	28
Appendix 3 – High-resolution A0 charts, Western Samoa Bathymetry	32
Appendix 4 – Data supplement: Multibeam Log Sheet.....	33

LIST OF FIGURES

Figure 1.	Location map of Pacific Island countries and territories constituting SOPAC. . v
Figure 2.	Presumed formation of the Samoan chain by movement of the Pacific crustal plate over a stationary hotspot of rising magma from the underlying mantle. ..3
Figure 3.	Plate tectonic map of the major submarine tectonic features in the region. 4
Figure 4.	MBES bathymetry coverage acquired during the survey. 7
Figure 5.	Digital elevation model (DEM) of Samoa compiled for this report. 8
Figure 6.	Three-dimensional perspective image of the DEM of Samoa. 8
Figure 7.	Shaded relief map of the 250 m compiled grid of Upolu and Savai'i. 9
Figure 8.	Slope angle map of Samoa based on the 250 m compiled grid..... 9
Figure 9.	The chartered survey vessel <i>Turagalevu</i> 13
Figure 10.	Diagrams and measurements of the vessel <i>Turagalevu</i> 14
Figure 11.	Tidal elevations as measured by the Apia tide gauge and referenced to lowest astronomical tide (LAT); and tidal elevations predicted by Wxtide. 17
Figure 12.	Definition of levels for the tide gauge at Apia, Samoa (NTC, 2006). 18
Figure 13.	Map showing the location of CTD profiles with cast numbers for Samoa. 20
Figure 14.	Coverage map for the datasets summarised in the section above. 21
Figure A1.1.	Conceptual illustration of bathymetric data acquisition with an MBES. 25

LIST OF TABLES

Table 1.	Summary geography of Samoa. 2
Table 2.	Public multibeam datasets for Samoa. 5
Table 3.	MBES bathymetry grid files for the 2004 survey. 6
Table 4.	Definition of common morphological terms. 10
Table 5.	Description of morphological features on the new bathymetric charts. 11
Table 6A.	Geodetic datum – WGS 72 (local determination). 12
Table 6B.	Geodetic datum – Universal Transverse Mercator Zone 2 South. 13
Table 7A.	Post-processing sequence and Table 7B. Chart production sequence. 16
Table 8.	CTD profile details. 19
Table A1.1.	Recommended accuracy of survey orders. 24
Table A1.2.	Values for calculating error limits for depth accuracy. 25
Table A1.3.	Projected footprint size under varying water depths. 27

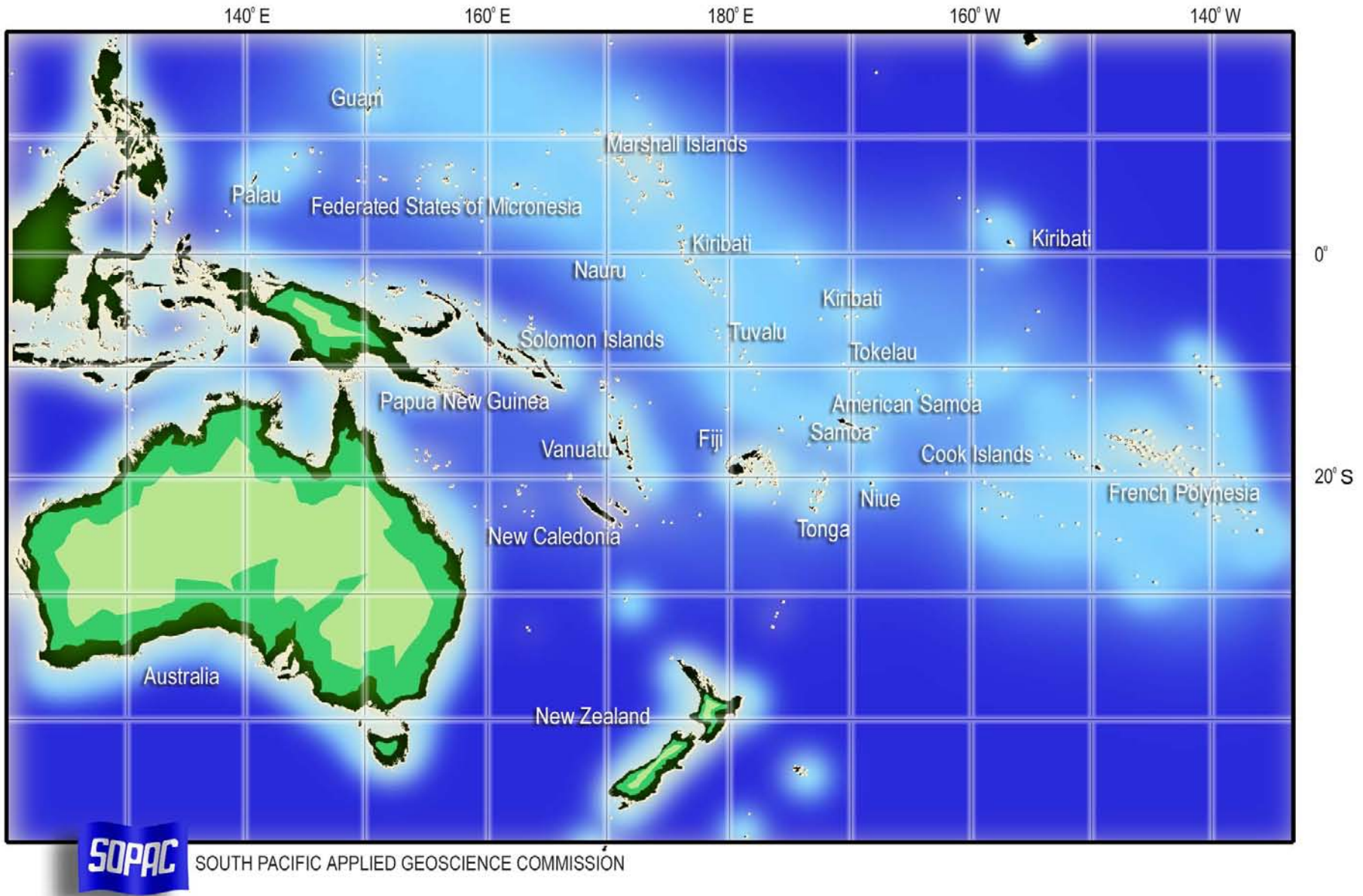


Figure 1. Location map of Pacific Island countries and territories constituting SOPAC

Acronyms and their meaning

ACP	African, Caribbean, and Pacific
ADCP	Acoustic Doppler current profilers
ARGO	Array for real-time geostrophic oceanography
ASCII	American standard code for information interchange
CD	Chart datum
CTD	Conductivity – temperature – depth
DEM	Digital elevation model
DTM	Digital terrain model
EEZ	Exclusive economic zone
GDEM	Generalised digital environmental model
GEBCO	General bathymetric chart of the oceans
GPS	Global positioning system
LAT	Lowest astronomical tide
MBES	Multibeam echosounder
MRU	Motion reference unit
MSL	Mean sea level
NTC	National Tide Centre
PI-GOOS	Pacific Islands global ocean observing system
RTK	Real-time kinematic GPS (centimetre accuracy)
SMNT	Seamount catalogue
SOPAC	Pacific Islands Applied Geoscience Commission
SPCZ	South Pacific convergence zone
SRTM	Shuttle radar topography model
TAO	Tropical atmosphere ocean array
UTM	Universal transverse Mercator
WGS	World geodetic system

EXECUTIVE SUMMARY

Krüger, J. and Kumar, S. 2008: High-Resolution Bathymetric Survey of Samoa. *EU EDF 8 & 9 – SOPAC Project Report 112*. Pacific Islands Applied Geoscience Commission: Suva, Fiji. vi + 50 p. + 9 charts.

The Pacific Islands Applied Geoscience Commission (SOPAC) carried out a marine survey for Samoa around the islands of Savai'i and Upolu. The objective was to investigate the seabed and provide information about water depths around the islands using a Multibeam echosounder (MBES).

This report describes the high-resolution bathymetric mapping survey carried out over a period of five weeks from 27 January to 1 March 2004, resulting in the acquisition of over 2754 line-km of MBES data.

The survey achieved 100% coverage of the seafloor from approximately 50 m depth in the nearshore area to an average offshore distance of 10 km, reaching water depths of some 1500 m. Coverage was significantly less in some areas such as Apolima Strait.

The resultant data compilation was used to produce nine bathymetry charts for Samoa at a scale of 1 : 50 000. These new bathymetric maps provide a descriptive picture of the ocean bottom terrain, vividly revealing the size, shape and distribution of underwater features. They serve as the basic tool for scientific, engineering, marine geophysical and environmental studies, as well as for marine and coastal resource management.

1. INTRODUCTION

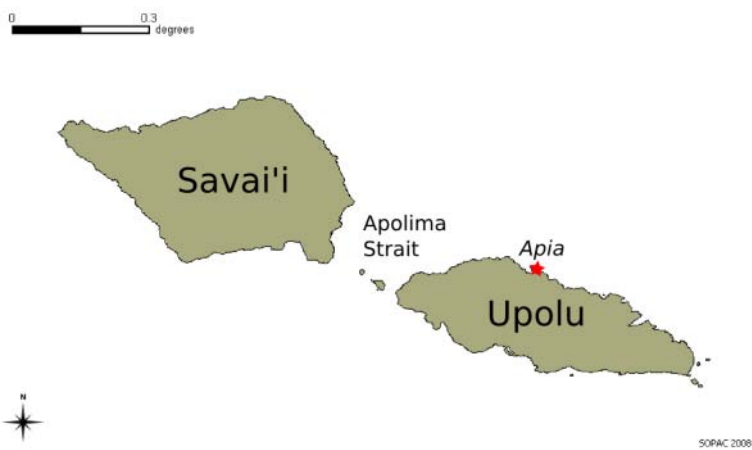
1.1 Background

A marine survey for Samoa was carried out around the island of Savai'i and Upolu. The objective was to investigate the seabed and provide information about water depths around the islands using a multibeam echosounder (MBES). The wave and current regime at three main locations mainly in the passage between the two islands (Apolima Strait) was also investigated using acoustic Doppler current profilers (ADCP). The strength of the magnetic field was also continuously logged during the survey using a towed magnetometer. The present report presents the results of the MBES survey (data collected by the ADCPs and magnetometer are covered elsewhere). This work was initiated by the SOPAC/EU Reducing Vulnerability of Pacific ACP States Project, under the European Development Fund.

1.2 Geographic Situation

Key geographic characteristics of independent (previously Western) Samoa are provided in Table 1.

Table 1. Summary geography of Samoa

Location (Apia)	13° 35' S, 172° 20' W
	
Population	214 265 (July 2007 estimate, source: http://www.wikipedia.org)
Land area	2 935 km ²
Coastline	Samoa has 403 km of coastline with coastal features such as fringing reefs, lagoons, natural beaches and mangroves. Systematic mapping of the geology and geomorphology of Savai'i Island is currently underway (Talia et al. 2007)
Tides	Tides are semi-diurnal
Climate	The climate of Samoa is tropical, and is dominated by the south-easterly trade winds and the South Pacific Convergence Zone (SPCZ). The rainy season (October to March) and a dry season (May to October) temperatures are consistently warm, around 30°C
EEZ	Approximately 120 000 km ²

1.3 Geological Setting

The Samoan volcanic chain lies near the north-northeast portion of the Tonga Trench. From west to east, the principal volcanic islands of independent Samoa are Savai'i and Upolu, and of American Samoa are five volcanic islands (Tutuila, Anunu, Ofu, Olosega, and Ta'u) as well as two coral atolls, Rose and Swain (Figure 2). The islands comprise a chain of predominantly basaltic volcanic domes and cones forming a central ridge along the island. This chain has been attributed either to volcanism along a seafloor fracture (Dana 1849; Kear and Wood 1959; Hawkins and Natland 1975; Natland 1980), or to a mantle plume (Farley et al. 1992; Hart et al. 2000; Courtillot et al. 2003), as illustrated in Figure 2.

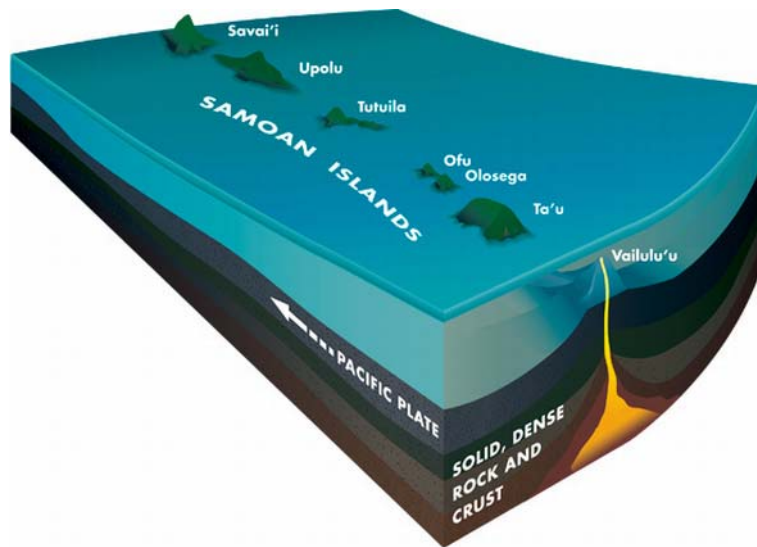


Figure 2. Illustration showing the presumed formation of the Samoan chain by movement of the Pacific crustal plate over a stationary hotspot of rising magma from the underlying mantle (Source: <http://www.who.edu/oceanus>).

The Samoan chain lies just east and 100 km north of the subduction of the Pacific plate beneath the northeastern corner of the Australian Plate at the Tonga Trench (Figure 3). The estimated westward convergence of the Australian Plate at the Tonga Trench is approximately 15 cm/yr (Lonsdale 1986). The Samoan chain is also unusual in that the islands are largest at the western end (Savai'i, Samoa), and deeply eroded in the middle (Tutuila, American Samoa); the easternmost feature (Rose Atoll, American Samoa) is a coral atoll that breaches the surface of the ocean and not an active underwater seamount (Hawkins and Natland 1975).

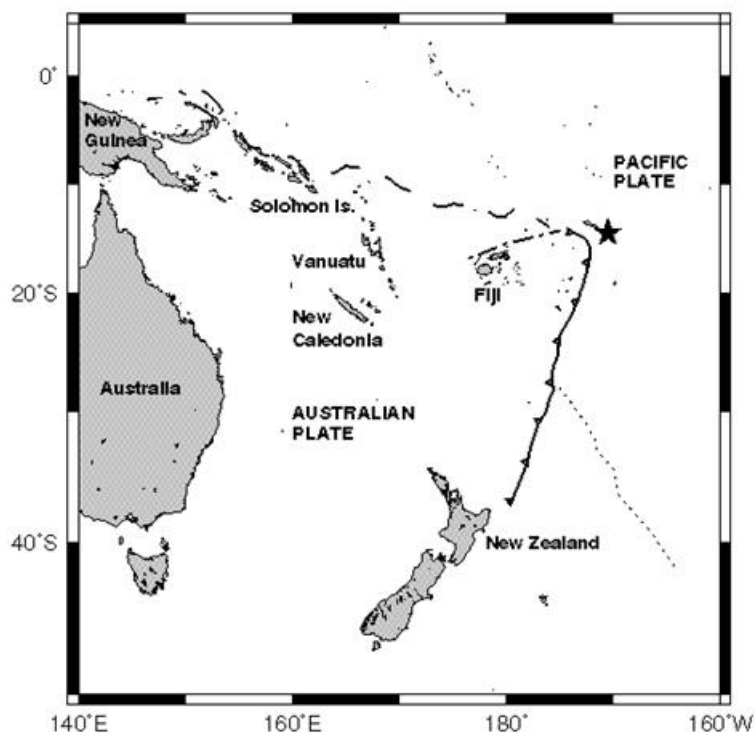


Figure 3. Plate tectonic map showing the major submarine tectonic features in the region (after Wright et al. 2000): the Samoan archipelago is marked by star, the Tonga Trench by a solid line with barbs on the overriding plate, the Fiji Fracture Zone and Vitiāz Trench Lineament by dashed lines, and the Louisville Ridge by a dotted line.

1.4 Previous Bathymetry Compilations

Bathymetric maps are topographic maps of the seafloor, giving a descriptive picture of the ocean bottom terrain. With an exclusive economic zone (EEZ) of approximately 120 000 km², the available bathymetric data is limited and the exact nature of seafloor is poorly known. Most available bathymetric data originates from sparse single-beam soundings from oceanographic cruises, and since the early 1970s, from MBES systems, as well as satellite-derived predicted depth (e.g. see http://topex.ucsd.edu/marine_topo/).

A bathymetry map at a scale of 1 : 375,000 at 200 m contour interval for Western Samoa was compiled by Hill and Tiffin (1991). The datasets used for this compilation are:

- Seabeam bathymetry and GLORIA images of the 1989 SOPAC cruise.
- SeaMARC II and 3.5 kHz echo sounder data of the 1987 RV Moana Wave cruise.
- A 12-kHz echo sounder survey of Western Samoan waters conducted in 1985 by the Royal Australian Navy Detached Survey Unit aboard MV Cape Pillar.
- MGD77-format geophysical data collected by oceanographic research institutions and held by the US National Geophysical Data Center in Boulder, Colorado, as well as by the SOPAC Technical Secretariat in Suva.
- Soviet 1982 RV Kallisto survey (Pushchin et al. 1983) conducted over the northern Tonga Trench and adjacent area.
- Data from SOPAC-Japanese joint survey on RV Natsushima (Honza et al. 1985) 1986 Tripartite II HMNZS Tui cruise (Glasby et al. 1986; Meylan 1986) office of the Royal New Zealand Navy for the General Bathymetric Chart of the Oceans (GEBCO) British Admiralty Chart 1730 “Samoa Islands”, 1988 edition.

- Seabeam data collected by RV *Sonne* (cruise SO67a) while in transit through the Western Samoan EEZ (Beiersdorf et al. 1990; Hill and Utanga 1990).

A search for public multibeam data on NOAA's national geophysical data centre (<http://map.ngdc.noaa.gov>) and the Seamount Catalogue, SMNT (earthref.org) in February 2007 produced the scientific cruises for the area of interest show in Table 2.

Table 2. Public multibeam datasets for Samoa

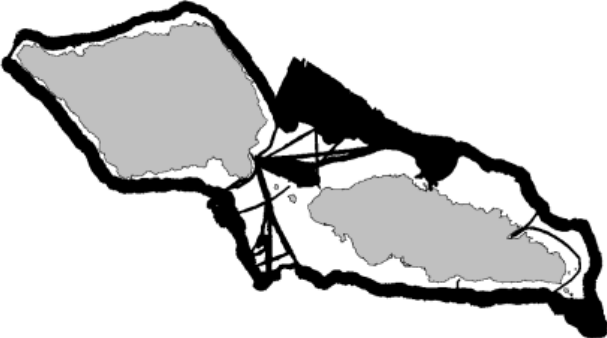


Ship	Survey ID	Year
RV <i>Washington</i>	RNDB15WT	1989
RV <i>Revelle</i>	KIWI10RR	1998
RV <i>Melville</i>	BMRG08MV	1996
RV <i>Melville</i>	AVON05MV	1999
RV <i>Melville</i>	COOK14MV	2001
RV <i>Melville</i>	COOK20MV	2002
RV <i>Kilo Moana</i>	KM0506	2005

2. RESULTS AND DISCUSSION

2.1 *Multibeam Bathymetry*

The multibeam echosounder (MBES) bathymetry data acquired during this survey are available as grid files shown in Table 3 below. These grid files, as well as charts, metadata, and report, are available through the SOPAC GeoNetwork site. The report and full-size charts are also available from the SOPAC virtual library.

Table 3. MBES bathymetry grid files for the 2004 survey

Savai'i and Upolu, MBES coverage, 70 m grid.	
Five-mile reef north of Apia, 10 m grid.	
Apolima Strait, 10 m grid.	

The bathymetry data contained in the 70 m grid file is presented on nine separate charts at a scale of 1 : 50 000 and contoured at intervals of 100 m. Reduced versions of these charts are appended to this report; an overview diagram with chart boundaries is shown in Figure 4.

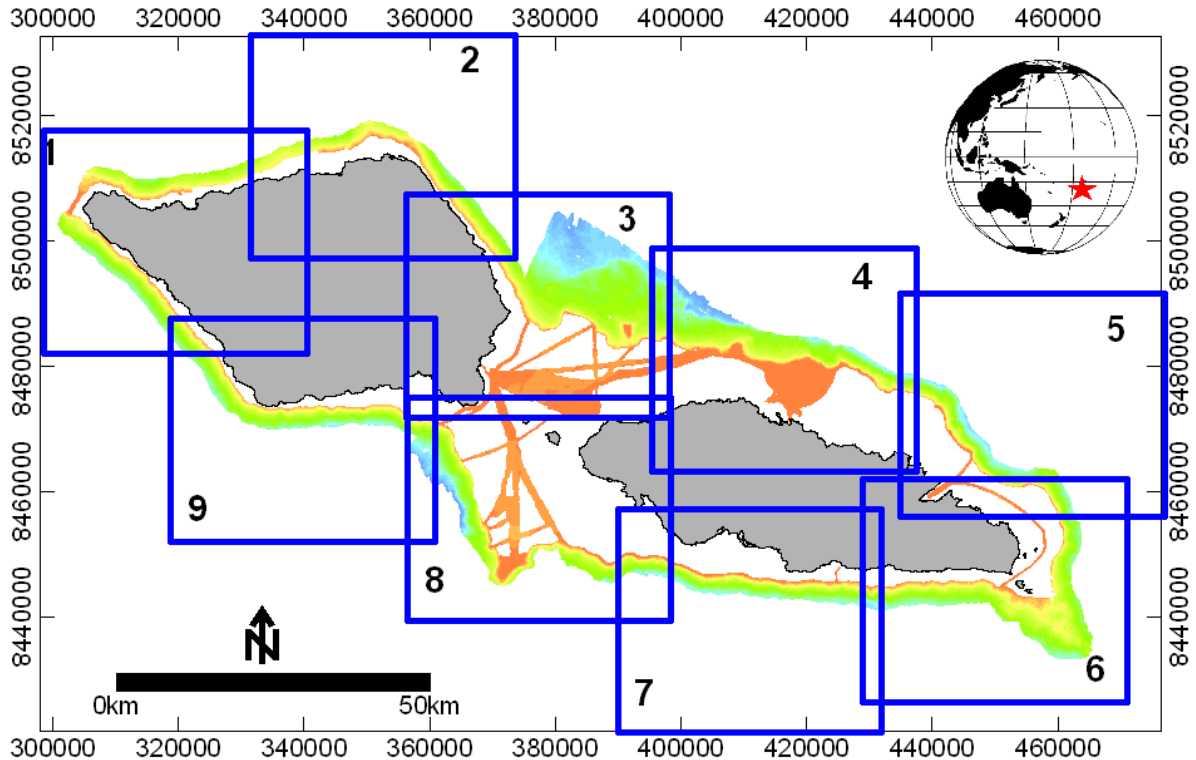


Figure 4. Overview map showing the MBES bathymetry coverage acquired during the survey (blue colours indicate deep water areas, and red shallow water). Blue boxes are the chart bounds of the charts appended to this report.

The surveyed area generally extended from the inshore area to approximately 10 km offshore. Water depths within the surveyed area ranged from 5 to 80 m in the Apolima Strait to a maximum of 2000 m offshore, as dictated by the operational limit of the MBES system. Minimum water depths were measured near the coast on the outer slope of the fringing reef with depths becoming greater in a general seaward direction with irregular slope angles ranging from 0° to 83° and a mean slope angle of 31°.

2.2 Composite Grid

Merging of the nearshore MBES data acquired during this survey with publicly available offshore grids (see Section 3.12 for detailed description) resulted in a 250 m grid shown in Figure 5 and Figure 6 below. This grid has been published as an A0-sized map at a scale of 1 : 250 000 by Krüger (2007), and is available through the SOPAC virtual library (chart PDF) and the SOPAC GeoNetwork site (grid file and metadata). The grid compilation is also shown as a shaded relief and slope angle maps in Figure 7 and Figure 8, respectively.

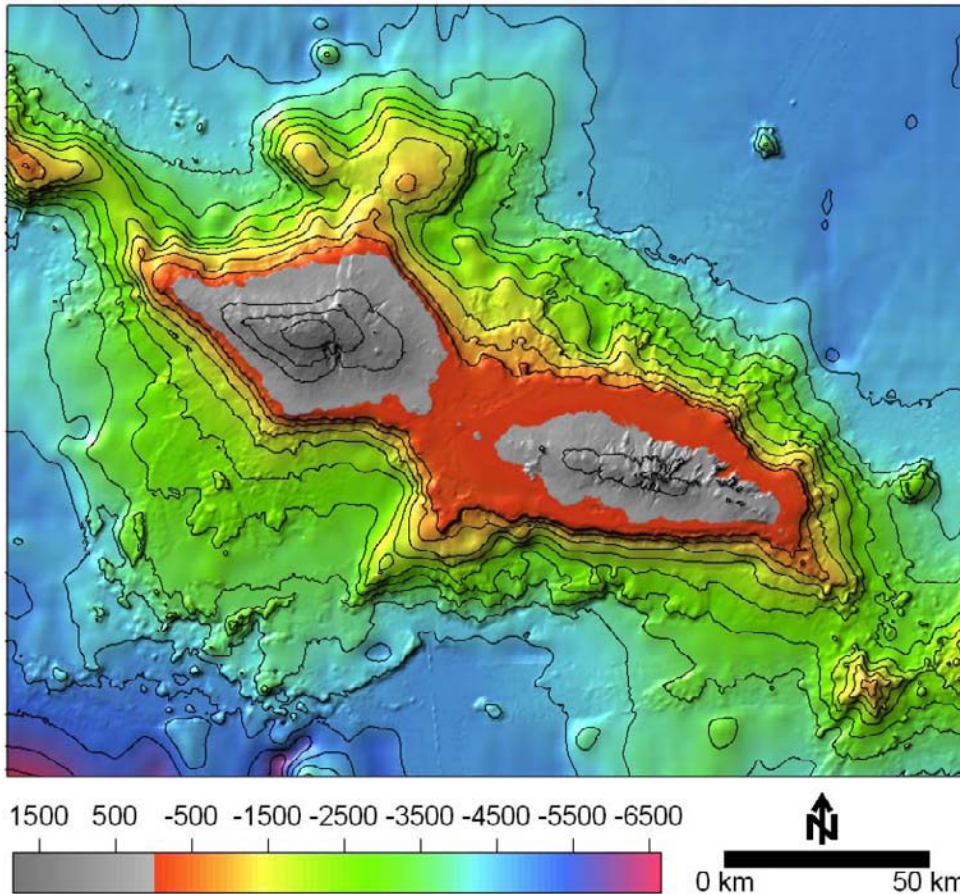


Figure 5. Digital elevation model (DEM) of Samoa compiled for this report. Land elevation (grey scale) and water depth (coloured scale) are referenced to sea level. Contour interval is 500 m. See text for details. The image shows some linear artefacts near the northern and northeastern edge of the image which are a result of the sparse data in these areas.

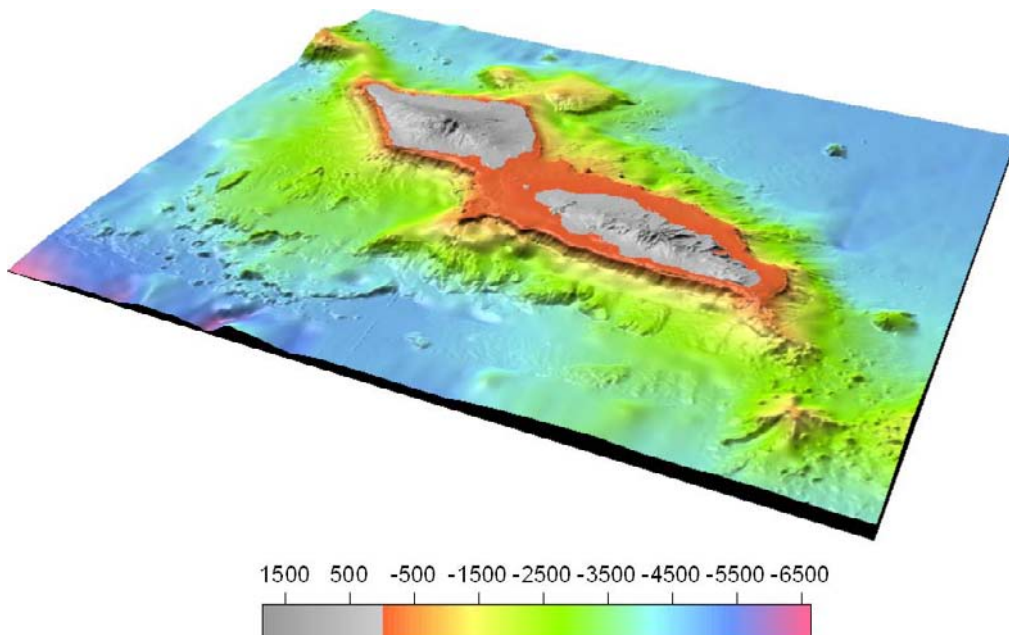


Figure 6. Three-dimensional perspective image of the digital elevation model of Samoa compiled for this report. The view is toward the NNW with an illumination from the NW. Elevation and depth values are in metres relative to sea level with a two-times vertical exaggeration. Scale varies in this perspective view.

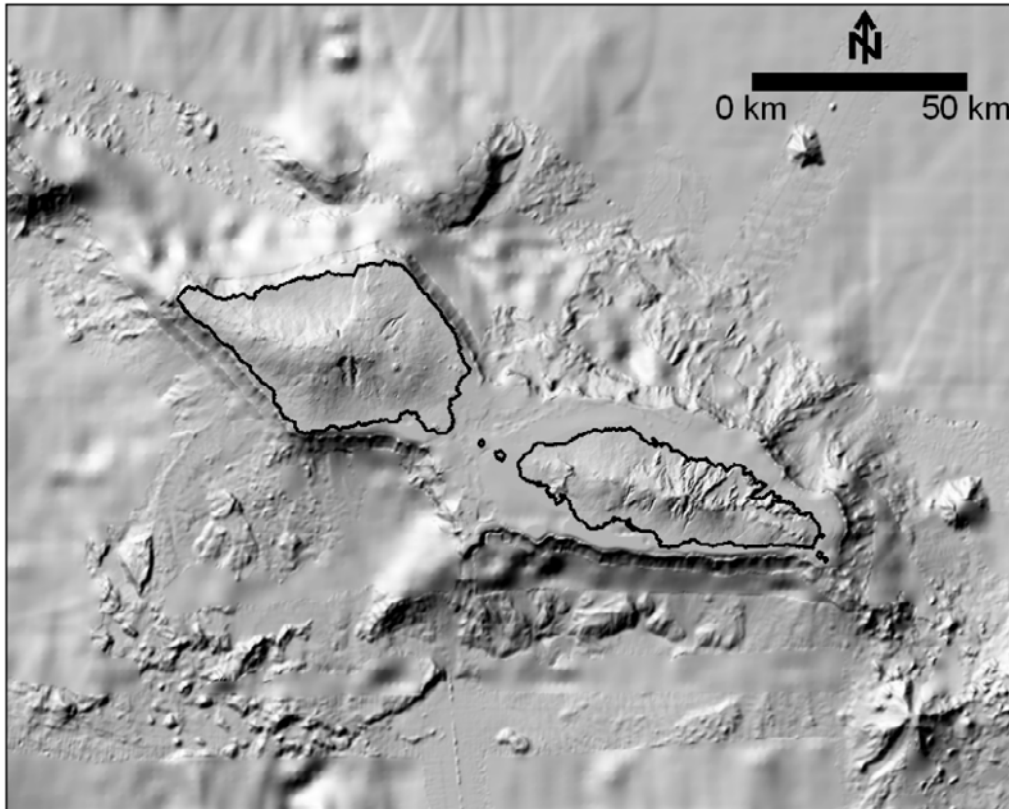


Figure 7. Shaded relief map of the 250 m compiled grid of Upolu and Savai'i. The sun illumination angle is from the northwest, and the coastline is shown as a solid black line. Note the high detail in areas of multibeam echosounder (MBES) coverage.

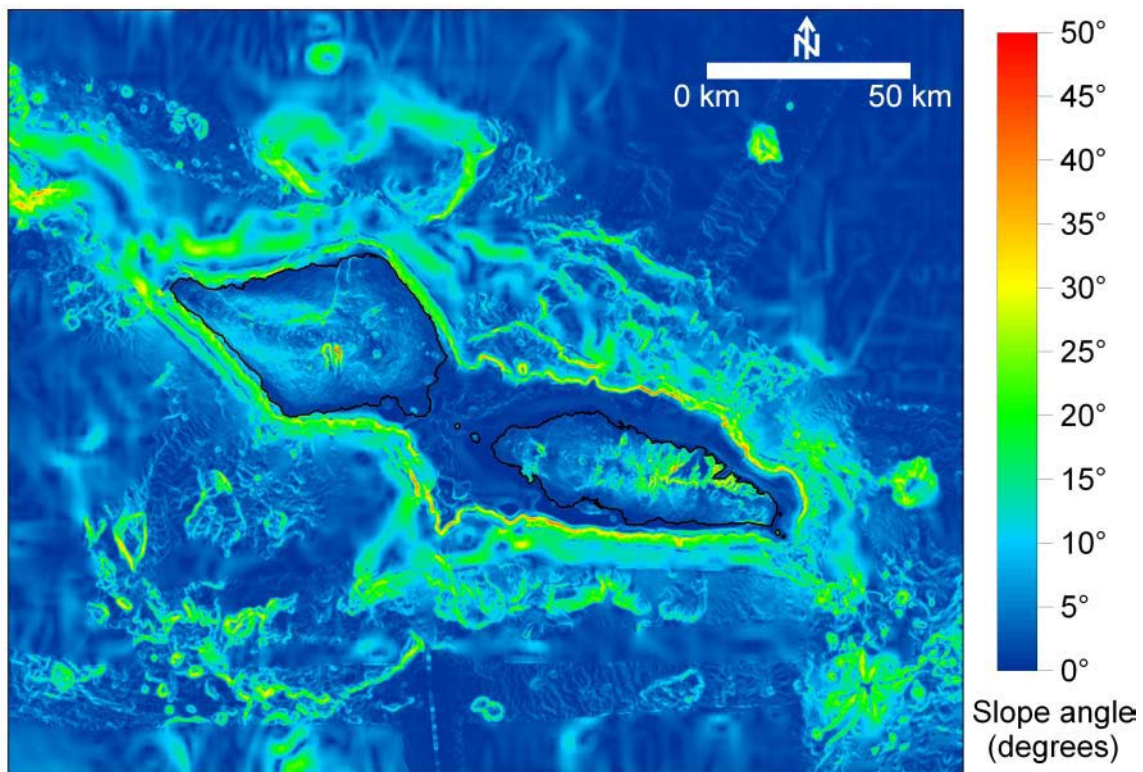


Figure 8. Slope angle map of Samoa based on the 250 m compiled grid. Angles are shown from 50° to near-horizontal, red to blue, respectively. The striations to the north and northeast are artefacts resulting from grid interpolation in areas of poor MBES coverage.

2.3 Morphological Features

Common scientific terms used to describe seabed morphology are outlined in Table 4.

Table 4. Definition of common morphological terms (adapted from IHO 2001)

Reef	A ridge or mound comprised primarily of hard coral that is consolidated into limestone.
Ridge	A feature of positive relief with long narrow elevation and steep sides. A ridge may comprise a line of isolated or joined pinnacles.
Pinnacle	A high tower-shaped rock or coral outcrop that may be alone or close together to form a ridge like feature.
Terrace	A relatively flat horizontal or gently inclined surface, which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.
Plateau	A flat or nearly flat area of considerable extent, dropping off abruptly on one or more sides.
Canyon or channel	A relatively narrow, deep depression with steep sides, the bottom of which generally has a continuous slope, developed characteristically on some continental slopes.
Saddle	A broad pass, resembling in shape a riding saddle, in a ridge or between contiguous seamounts.
Escarpment or Scarp	An elongated and narrow area of comparatively steep slope separating near-horizontal or gently sloping areas.
Shelf	A zone around the island extending from the low water line to a depth at which there is a shelf break usually accompanied with a marked increase of slope toward the oceanic depths
Shelf break	The line where the nearshore shelf and slope meet that marks the point of increasing seafloor gradient
Slope	The area seawards of the shelf break to the upper edge of the abyssal plains

Generally, and with reference to the DTM model shown in Figure 5, Figure 6, and Figure 8, a shelf surrounds the islands of Savai'i and Upolu in water depths of approximately 100–200 m. This shelf is relatively narrow south of Savai'i and Upolu, and extends to a maximum offshore distance of 12 km northeast of Apia. The shelf occupies the broad Apolima Strait between Savai'i and Upolu. The Apolima Strait is interpreted as a drowned carbonate platform, which presumably interconnected the two islands of Savai'i and Upolu during the last glacial maximum (about 21 000 years ago) when sea level was approximately 120 m lower than today. Beyond the shelf edge, the flanks of the edifices vary greatly from place to place both in gradient and roughness. A terrace is evident in water depths of approximately 500–1200 m, exhibiting maximum widths of some 12 km (north of Apolima Strait). There are saddles that connect the terrace to the Tuapi'o and Taumatau seamount, west and north of Savai'i, respectively. A third saddle lies between the southeast of Upolu and the Tisa seamount.

The limited coverage and absence of any additional ground-truthing data prevents a detailed description of the seabed morphology, which is also beyond the scope of this survey report. The deeper submarine morphology of Savai'i and Upolu is described in more detail from sidescan sonar studies in Keating et. al. (2000), and Hill and Tiffin (1993). However, a brief summary of the dominant morphological features on each chart (see overview in Figure 4) as interpreted from the MBES data is presented in Table 5.

Table 5. Description of morphological features on the new bathymetric charts

Chart 1	A narrow shelf runs along the northern and southern coasts of Savai'i island, terminating at a shelf break in approximately 150 m water depths. The break exhibits an average slope angle of around 40°. Note that the vessel surveyed across the shelf in a water depth of around 100 m at the western extent of the island. The seafloor is relatively featureless except for a few bathymetry highs at the southwestern corner.
Chart 2	The MBES coverage shows the shelf break at water depths of 200 m, with some minor channels originating at the headscarp. The seafloor is predominantly featureless except for a saddle at 500 m that extends to the Taumata seamount.
Chart 3	This chart shows a large extent of the Apolima Strait at water depths of generally 100–200 m, with predominantly featureless seabed. A shelf break is well defined at depths of 200–700 m, before leveling off into a deeper terrace that extends into water depth of 1200 m. One of the dominant features is a plateau approximately 27 km north of Leulumoega, rising to about 100 m below sealevel from the surrounding terrace in 600 m water depths. Slope angles of the plateau are between 55° to 65° with a maximum of 70°. At its peak in water depths of 100 m, the plateau has an areal extend of 1.3 km ² . An escarpment that terminates the terrace is evident at water depths of approximately 1200 m running for approximately 8 km in a seaward convex arc subparallel to the shoreline.
Chart 4	This chart shows good coverage of the shelf and its termination at the shelf break in water depth of 100 m water depth with an average slope angle of 65°. A continuation of the subparallel escarpment is also evident in water depths of 1200–1700 m. The terrace bound to the south by the shelf break and by the escarpment to the north exhibits numerous channels, predominantly in the area situated 20 km to the north of Apia.
Chart 5	The shelf and shelf break continues as described above. The escarpment described from Charts 3 and 4 above is less pronounced in the area shown in Chart 5. Numerous small channels are seen originating from the base of the terrace.
Chart 6	The area shown in this chart covers the southeastern extend of Upolu island. The shelf is at its maximum width at some 8 km to the northeast of Amaile. The dominant feature is the highly irregular seabed with numerous pinnacles to the southeast of Nu'ulua Island, forming a saddle to the Tisa seamount. The southern inshore area of Upolu has a shelf width of approximately 2 km, with a ridge protruding into the slope approximately 3.5 km south of Matavai.
Chart 7	The shelf break is narrow and occurs at approximately 2 km offshore in the east of the chart, widening toward the west to 7 km offshore. Numerous small channels originate at the base of the shelf break scarp.
Chart 8	The predominantly flat and featureless Apolima Strait shown to the north of Chart 8 drops off at slope angles locally exceeding 60°. A 2–3.5 km wide terrace lies below the shelf break in water depths of 600–1200 m. The terrace is incised by numerous channels that continue into 2000 m water depths.
Chart 9	The shelf south of Savai'i is relatively narrow, with the break occurring approximately 2 km offshore. The shelf slope exhibits an average angle of around 35°, and is incised by some minor channels.

3. DATA ACQUISITION AND PROCESSING

Fieldwork can be summarised as follows:

3.1 Survey Particulars

Survey vessel: RV *Turangalevu*

Fieldwork date: 27/01/04 to 01/03/04. All dates and times in this report are given in the local Samoa time zone (11:00h GMT = 23:00h local).

Equipment used: Reson 8160, deep water MBES.

3.2 Field Personnel

SOPAC: Quan Chung (Project Technician) and Ed Saphore (Marine Consultant)

Vessel: Steven Hay (Captain), Jon Tikokandavu (Engineer), Edward Smith (Crew).

Observers: Dean Solofa (Officer), Ausementia Titimaea (Head of Meteorology Department), Lameko Talia (Geological Dept), Happy Valley Patu (Geological Dept), Isoposeta Upuse (Hydrology Dept), Faigame Sale (Geological Dept), Mafutaga Sela (Hydrology Dept), Pitone Taulia (Hydrology Dept), Mulipolu Antonio (Acting Director Fisheries).

3.3 Geodetic Reference System

The survey was conducted in the Western Samoa Integrated Grid as defined in Table 6A. The final grid ASCII files were converted to UTM2S for charting purposes using the Blue Marble Geographic Calculator v3.01 software. Therefore, the resulting charts are defined in the coordinate system shown in Table 6B:

Table 6A. Geodetic datum – WGS 72 (local determination)

Ellipsoid	WGS 72	
	Semi-major axis (a)	6378135.0000
	Semi-major axis (b)	6356750.5200
	Flattening	1/298.26
Origin	Observation Doppler (011)	
	Latitude	13 48 52.98 (S)
	Longitude	171 46 51.33 (W)
	Height (MSL)	0.91 m
Projection name	Western Samoa Integrated Grid (WSIG)	
	Longitude of origin	172 degrees West
	Latitude of origin	equator
	False easting	700000 m
	False northing	7000000 m
	Central scale factor	1.0000
	Zone width	2 degrees

Table 6B. Geodetic datum – Universal Transverse Mercator Zone 2 South

Ellipsoid	WGS84	
	Semi-major axis (a)	6378137.000
	Semi-major axis (b)	6356752.314
	Inverse flattening (1/f)	298.257223563
	Eccentricity sq. (e2)	0.0066943800
Projection	UTM Zone 02 South	
	Projection type	Transverse Mercator
	Origin latitude	00° 00' 00.000" South
	Origin longitude	171° 00' 00.000" West
	Origin false easting	500000.0000
	Origin false northing	1000000.0000
	Scale factor	0.9996000000
	Grid unit	metres

3.4 Vessel Description and Static Offsets

Details regarding the survey vessel are shown in Figure 9 and Figure 10.



Figure 9. The chartered survey vessel Turagalevu. Note the portside pole mount with fore and aft stabilisers.

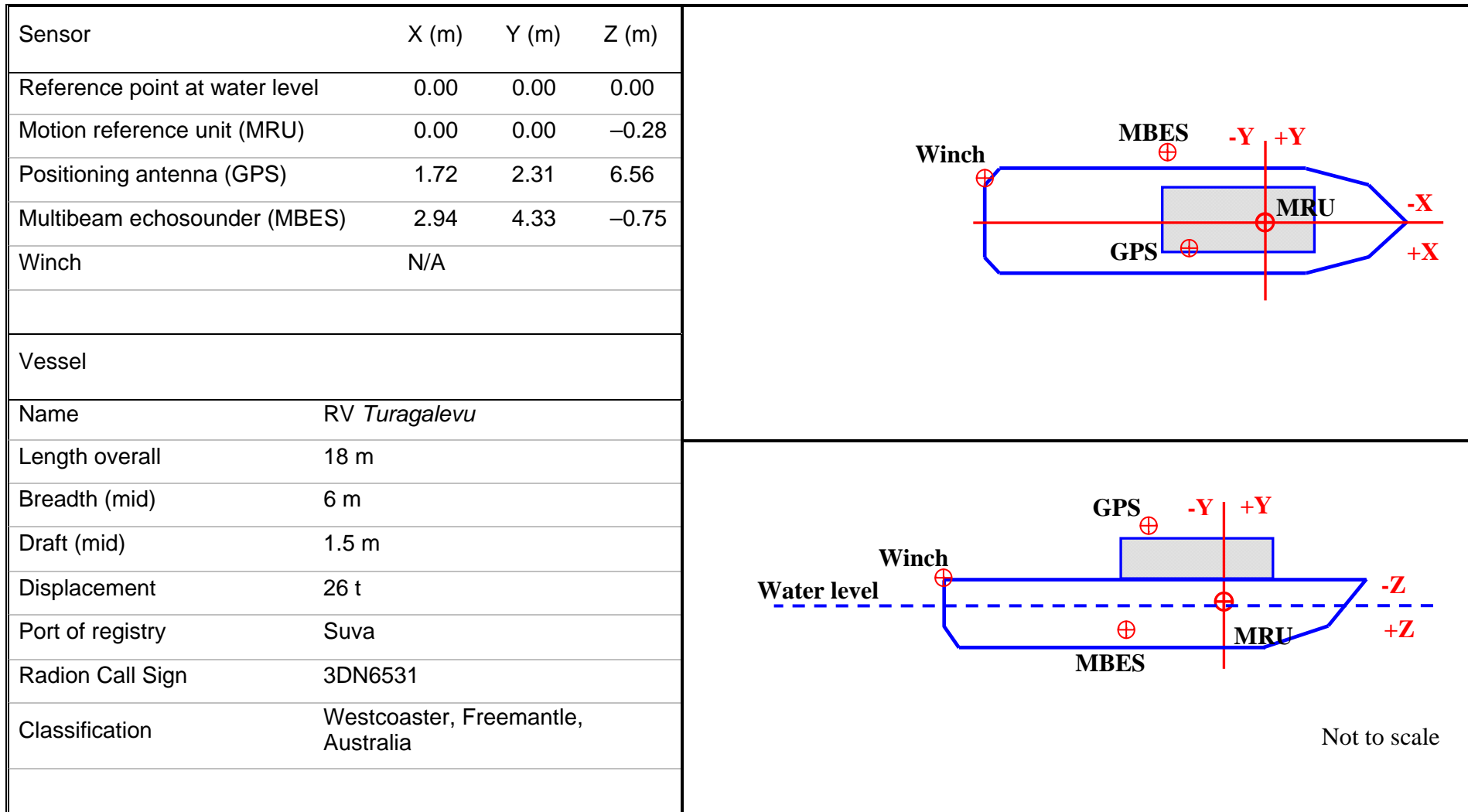


Figure 10. Diagrams and measurements of the chartered survey vessel *Turagalevu*.

3.5 Positioning Control

The vessel's reference point (X=0, Y=0, Z=0) was the motion reference unit (MRU) position at the waterline. Positioning was by stand-alone GPS, using an Ashtech Aquarius dual-frequency receiver. A good satellite constellation status was observed throughout the survey. The patch test was conducted in Suva, Fiji, using RTK GPS.

3.6 Survey Computer

The survey computer was a Windows 2000 PC running Navisoft 2.2.2. This computer was used for continuous on-line data logging and computation of positioning and digital bathymetry. The package also provided a line control display for the helm. The on-line operator continuously monitored a range of quality control parameters.

An off-line Navisoft 2.2.2 package was used in the office for replaying and post-processing of track data and bathymetry. An A0 plotter was available for the production of charts.

3.7 Multibeam Echosounder

A Reson SeaBat 8160 multibeam echosounder (MBES) was temporarily installed on MV Turangalevu (Figure 9 and Figure 10), and used to provide swath bathymetry data. A MBES provides high-resolution information about the depth of water from the surface to the seafloor in a water body. The main instrumental and operating parameters are:

3.7.1 Instrumentation

Multibeam echosounder	Reson SeaBat 8160
Transducer mount	Port side pole-mounted
Motion reference unit	TSS DMS 2-05 Dynamic Motion Sensor
Gyro	SG Brown Meridian Surveyor Gyro Compass
Sound velocity probe at transducer	Installed

3.7.2 Operating Parameters 8160

Transducer Frequency	50 kHz
General water depth	10–2000 m
Average ship's speed	7 knots (3.6 m/s)
Transmit Power	Variable 1–16
Pulse length	Variable 0.5–10.0 ms
Horizontal coverage	Approximately two times water depth
No of beams / beam spacing	126 / 1.2°
Ping rate	Variable

3.7.3 Dynamic Offset Calibration Suva, Fiji, 27 January 2004

Roll correction	–0.79
Pitch correction	10.45
Yaw correction	2.87
GPS Latency correction	4070
Gyro correction	Not determined

3.8 *Multibeam Echosounder Data Processing*

On return to the SOPAC office in Suva a combination of Navisoft Sweep 2.2.2 and Terramodel / Terravisualiser 10.30 software was used for the post-processing of the MBES survey data. Post-processing is a form of data reduction which involves checking, calibration, cleaning and preparation necessary to convert raw measurements into a form suitable for analysis, application and presentation. The product of post-processing is in the form of ASCII listings of gridded easting, northing, and depth (XYZ) points. Gridded XYZ points were used in Surfer 8.05 to produce final charts and figures. The post-processing and chart production sequences are listed in Tables 7A and 7B.

Table 7A. *Post-processing sequence*

Phase 1	Correct for sound velocity, tide, and patch test parameters using the Navisoft Sweep 'Calculate' program. This process converts RAW files into PRD files.
Phase 2	Editing and de-spiking of soundings in PRD files using the Navisoft Sweep 'Data Edit' module.
Phase 3	Deleting, interpolation, and manual editing of single and multiple points using the editor's interactive tools.
XYZ output	Cleaned PRD files are recorded on to a grid file in the Navisoft Sweep 'Data Exchange' Module, and exported as an ASCII XYZ file (easting, northing, depth) in the project coordinate system. The exported ASCII XYZ file is imported in Trimble's Terramodel Terravisualiser where a final data cleaning process for outliers was carried out.

Table 7B. *Chart Production Sequence*

XYZ to grid	XYZ data are reduced and gridded to approximately 1 mm (0.1%) at the charting scale. In the case of this survey, the final grid was created at a resolution of 70 m or less (see Figure 4).
Digital terrain model (DTM)	A surface model is created from the grid. A search radius of approximately three times the grid spacing is used to fill data gaps. The DTM is also blanked against regions that contain no valid data such as land and shallow reef areas.
Chart output	Various levels of smoothing are applied to the DTM and contours to give a realistic impression of the seabed, without removing any real features from the data set.

3.9 *Multibeam Backscatter*

The MBES records echo strength data (reflected energy) that can be presented as seabed backscatter maps, similar to sidescan sonar mosaic, or backscatter image, shows information on the composition of the seafloor. The backscatter signal recorded during this survey was either faulty or not present, and is thus not presented here.

3.10 Tidal Information

Observed soundings were reduced to chart datum using water level elevations for the port of Apia as predicted by the computer software Wxtide (freely available at www.wxtide32.com). Predicted amplitudes were found to be accurate when compared to official tidal water levels as reported by the United Kingdom Hydrographic Office (easytide.ukho.gov.uk), with a minimal difference in phase, as Wxtide lags the Admiralty predictions by two minutes. This seems to suggest that Wxtide makes use of the full harmonic dataset available for Apia.

The Wxtide predictions were also compared to measured water elevations downloaded from the National Tidal Centre (NTC), Bureau of Meteorology in digital format (www.bom.gov.au). The results are plotted in Figure 11, showing a ten-day period from 30 January to 8 February 2004. There is a consistent difference between the two measurements, with predicted tide levels as given by Wxtide consistently lower by approximately 0.26 m than observed tide gauge records. The Apia tide gauge was deployed by the NTC in 1993, as part of the South Pacific sea level and climate monitoring program, and has well established levels shown in Figure 12. The tidal value reported by the tide gauge is relative to the lowest astronomical tide (LAT), which is also tide gauge zero (NTC 2006). Harmonic analysis of tide gauge data shows the zero frequency level to be 0.75 m above tide gauge zero (NTC 2008). The predicted tidal values for Apia are very closely aligned to those published in the US Tidal Tables for the Central and Western Pacific Ocean, and are given relative to chart datum, which is approximately the level of Mean Lower Low Water, 0.49 m below Mean Sea Level (personal communication John Page, Head of Tides, UKHO). Soundings in this report are therefore relative to chart datum, which is 0.26 m above tide gauge zero, or 3.20 m below BM48.

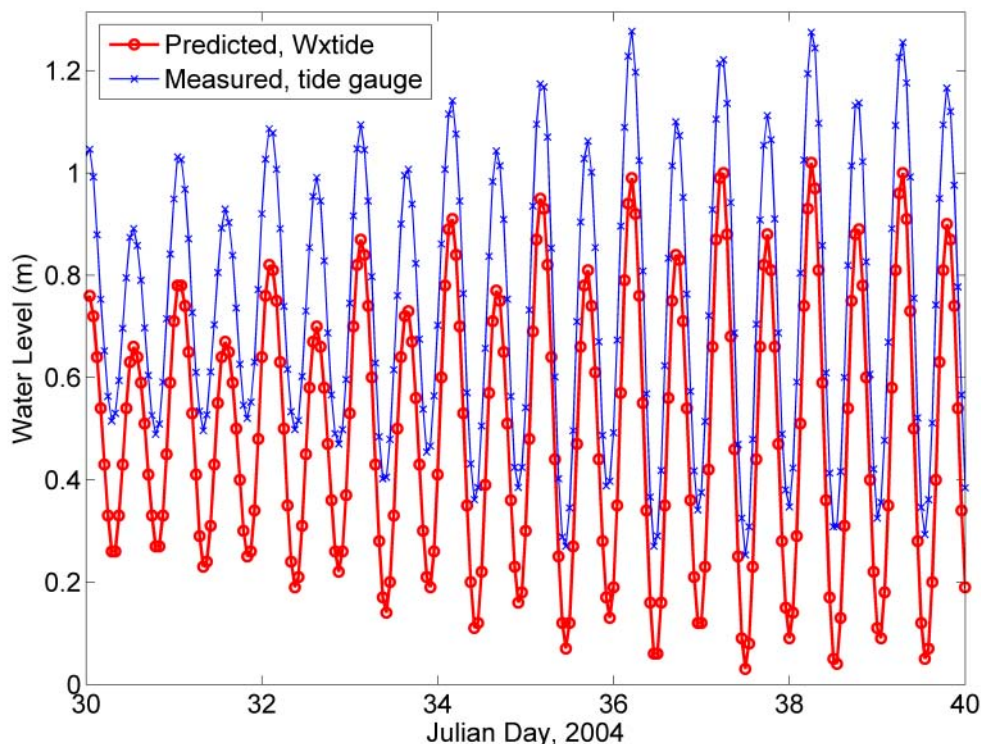


Figure 11. Tidal elevations as measured by the Apia tide gauge (blue line marked with x) and referenced to lowest astronomical tide (LAT); and tidal elevations predicted by Wxtide (thick red line marked with o) above chart datum, for a period of 10 days in 2004. The two curves show good agreement with an average residual of 0.26 m (see text).

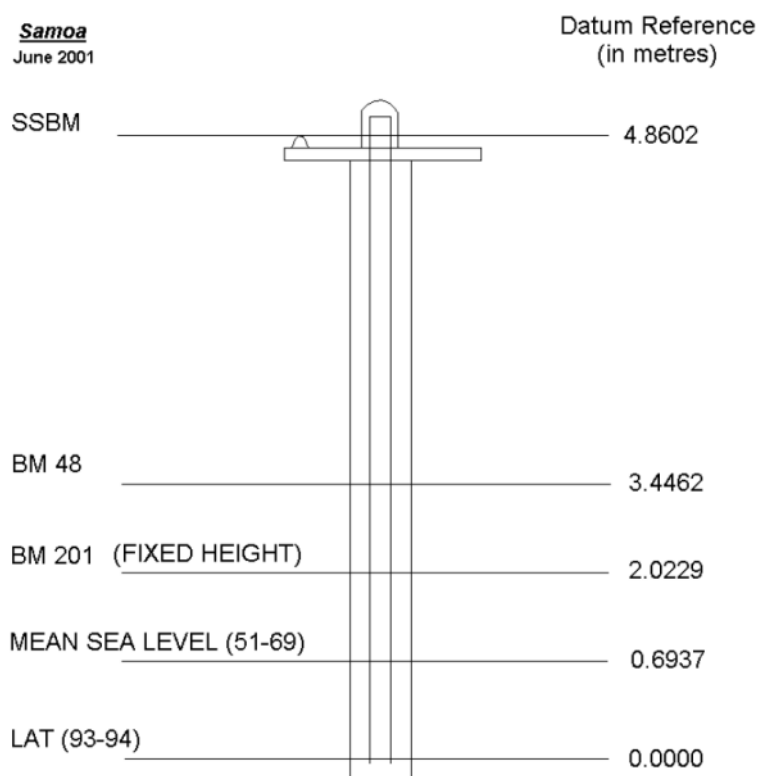


Figure 12. Definition of levels for the tide gauge at Apia, Samoa (NTC, 2006).

3.11 Sound Velocity Profiling

The accuracy of the depth soundings depends in part on the variation of the speed of sound with water depth. Sound velocity profiles are therefore required in order to find the correct depth and location of water depth soundings. The speed of sound in seawater varies with temperature, salinity and depth, and was determined by measuring the conductivity, temperature and depth (CTD) through the water column. The main instrumental, operational, processing parameters are listed below.

3.11.1 CTD Instrumentation

Make	SeaBird Electronics
Model	SeaCat 19+ (self-powered, self-contained)
Serial number	4172
Depth rating	3000 m

3.11.2 Operating Parameters

Sample rate	1 scan every 0.5 s
Maximum depth	Limited to 400 m due to wire rope length
Data recorded	Profiles of conductivity, temperature, and pressure

3.11.3 Data Processing

Positioning	The profile position was taken at the GPS antenna near the start of the downcast. No allowance was made for instrument or vessel drift over the duration of the profile, which may be significant (>500 m).
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Data conversion Convert raw data (.hex) to a .cnv file. The following values are output from the recorded data:

- Pressure, dbar
- Depth, m (derived using salt water at local latitude)
- Temperature, °C (ITS-90)
- Salinity, psu (derived)
- Density, kg m⁻³ (derived)
- Sound velocity, m s⁻¹ (derived using Chen and Millero 1977)

Bin average Average data into 1 m depth bins. No filtering was applied.

Output Processed data is saved in ASCII text format with the file name date_location_bin.cnv.

The CTD profile details are listed in Table 8, and locations are shown in Figure 13. The summaries of the CTD profile data in graphical form are shown in Appendix 2.

Table 8. CTD profile details

Open water Profile	Date	Time	Easting	Northing	Total Water Depth (m)
CTD cast 1	04/02/04	14:45	413209.94	8481471.71	600
CTD cast 2	08/02/04	15:30	385674.43	8477374.19	100
CTD cast 3	15/02/04	12:42	379258.04	8489393.16	800
CTD cast 4	17/02/04	06:31	425348.55	8447873.59	15
CTD cast 5	17/02/04	08:25	447067.76	89443917.7	900
CTD cast 6	17/02/04	13:57	461912.81	8455694.62	1000
CTD cast 7	17/02/04	16:09	445479.40	8469799.87	1000
CTD cast 8	19/02/04	13:28	380965.06	8504165.98	2000
CTD cast 9	23/02/04	10:49	364286.00	8460542.41	1300
CTD cast 10	29/02/04	13:53	310366.38	8509406.56	600

The on-board CTD probe could only be operated to maximum depth of 400 m due to restrictions on the wire rope length. The ship-based profile data were not complemented with external sources of sound velocity data, and corrections were therefore not applied for depths exceeding 400 m.

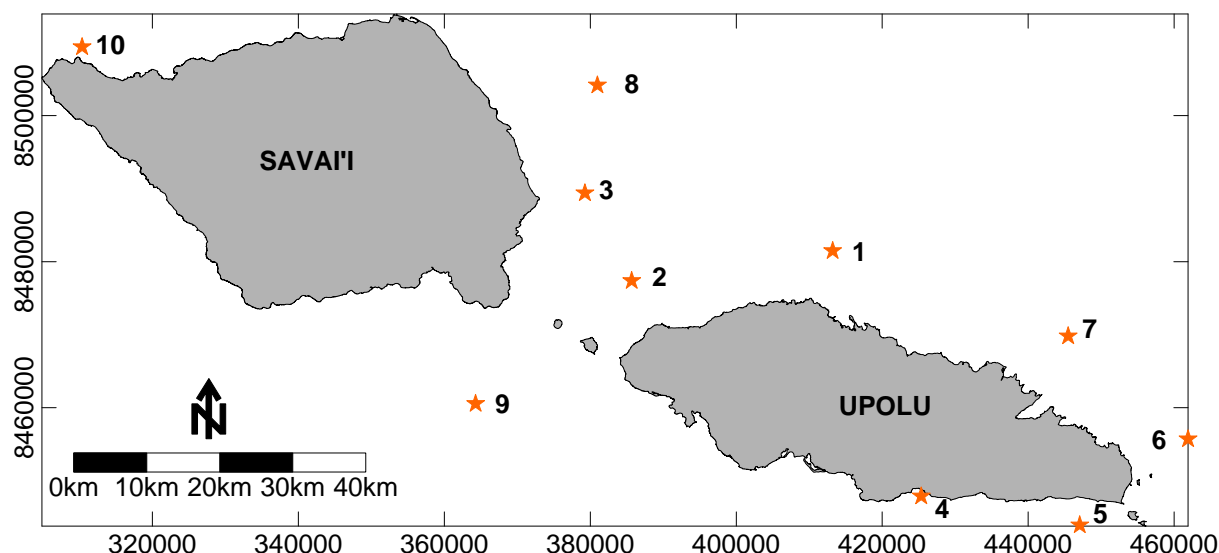


Figure 13. Map showing the location of CTD profiles with cast numbers for Samoa.

3.12 Composite DTM Model

Publicly available bathymetry and topography data for the area on interest, approximately 230 x 190 km centred on Savai'i and Upolu, was collated as summarised below and in Figure 14.

- S2004 This global grid is a blend of Smith and Sandwell (1997) bathymetry derived from satellite altimeter measurements below 1000 m depth, and General Bathymetric Chart of the Oceans (GEBCO) data in shallow water. Grid spacing is approximately 2 km (as referenced in Marks and Smith, 2006). (source: ftp://falcon.grdl.noaa.gov/pub/walter/Gebco_SandS_blend.bi2, accessed February 2007).
- SOPAC/EU MBES data acquired under EU funding as documented in this report.
- SMNT The Seamount Catalogue (SMNT) is a digital archive for seamount maps, containing multibeam data files collected by oceanographic survey vessels. Public MBES bathymetry for Savai'i and Upolu were obtained from the Seamount Catalogue (source: <http://earthref.org>, accessed February 2007). This data consisted of raw data files gridded at 180 m from the scientific cruises listed in section 1.4. The data contained considerable noise and many outliers, and was therefore manually cleaned using the hydrographic software package Hypack before being integrated into the dataset as described below.
- SRTM Global land elevation data from the Space Shuttle Topography Mission, 2000. Global elevation data are available at a grid spacing of 90 m (source: <http://seamless.usgs.gov>, accessed February 2007).

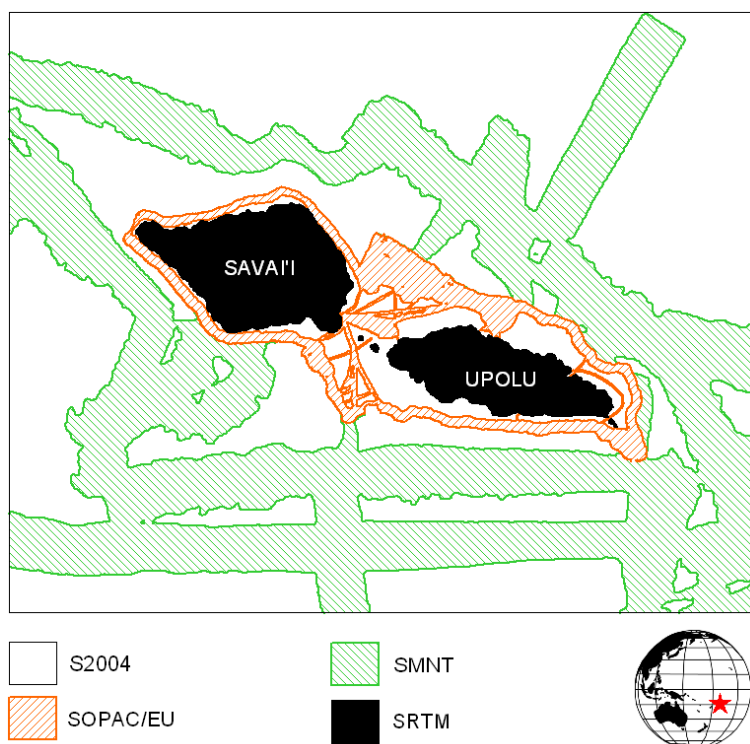


Figure 14. Coverage map for the datasets summarised in the section above.

The datasets outlined above were merged using Golden Software Surfer 8.05, at a grid spacing of 250 m through the following method:

- (1) Created multibeam grid by mosaicing SMNT and SOPAC/EU data.
- (2) Calculated residual surface between S2004 and grid (1).
- (3) Applied low-pass filter to grid (2) in areas with no multibeam coverage.
- (4) Added residual grid from step (3) to S2004 grid.
- (5) Replaced land areas with SRTM values in final grid.

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APPENDICES

Appendix 1 – Equipment Performance, Statement of Uncertainty, and Suitability for Charting

Bathymetric maps are topographic maps of the sea floor. The bathymetric map serves the basic tool for performing scientific, engineering, marine geophysical and environmental studies. The information presented in this report and enclosed charts are intended to assist persons and authorities engaged in recreation, tourism, marine resource related industries, hydrographic mapping, coastal development, trade and commerce, sovereignty and security, and environmental management. It is therefore important that users be informed of the uncertainties associated with the data and with products constructed from it. The following is an outline of the survey equipment used and the operating principles, including limitations and estimates regarding the data accuracy.

A1.1 Horizontal positioning

The methods used to acquire survey data will affect the final product accuracy. The global positioning system, GPS, uses radio signals from satellites that orbit the earth to calculate the position of the GPS receiver. Standalone GPS has an estimated accuracy as good as approximately 10 m, depending on satellite configuration and atmospheric conditions. In addition to this, equipment and measurements errors also need to be considered.

A general rule of thumb is that surveys should be conducted with a positioning accuracy of 1 mm at the scale of the chart. Therefore, at a scale of 1 : 10 000, the survey would be required to be accurate to 10 m.

The present S-44 4th Edition Standard of the International Hydrographic Office (IHO) includes a depth-dependent factor that takes into account the added uncertainty of the positions of soundings from multibeam echo sounder systems as depth increases. The relevant survey orders are listed in Table A1.1, with multibeam surveys conducted by SOPAC generally falling into orders 2 and 3.

Table A1.1. Recommended accuracy of survey orders

Survey order	Application	Recommended accuracy
Order 1	Harbours and navigation channels	5 m + 5% of depth
Order 2	Depths < 200 m	20 m + 5% of depth
Order 3	Depths > 200 m	150 m + 5% of depth

For the purpose of this survey, it was assumed that the use of GPS provided adequate precision in terms of horizontal position. Therefore, it is not recommended to interpret nearshore data at scales larger than 1 : 10 000, or a grid size smaller than 10 m. For areas with water depths greater than 200m, a charting scale of least 1 : 50 000 is recommended.

A1.2 Depth measurements

Bathymetric maps provide information about the depth of water from the water surface to the seabed. Through the use of detailed depth contours and full use of bathymetric data, the size, shape and distribution of underwater features are clearly revealed. The depth is measured using a ship-mounted Multibeam echo sounder (MBES). The MBES transducer produces an acoustic pulse designed as a fan that is wide in the across-track and narrow in the along-track direction (Figure A1.1). The seabed covered by this beam typically returns good data over a swath that is two to three times the water depth. The pulse of sound emitted from the MBES travels through the water column and is reflected back as an echo and received as numerous narrow beams by the receiving elements of the MBES. The measurements are time-based, and by using the speed of

sound in seawater each time is converted first to a range and then, knowing the beam angle, to a depth. The distance to the seabed is then combined with the movement of the vessel to stabilise it into a real-world framework. The framework is then positioned to provide XYZ soundings for each beam’s interaction with the seabed. A series of these swaths are then combined to produce a three-dimensional representation of the seafloor topography.

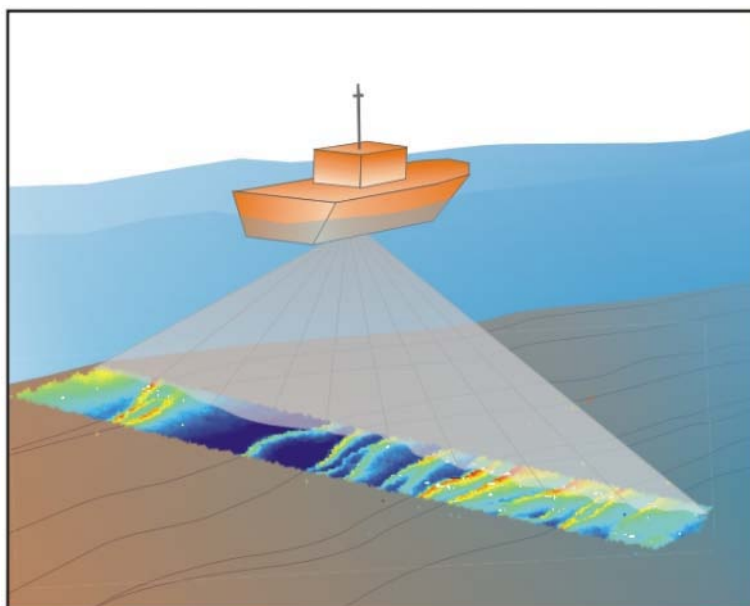


Figure A1.1. Conceptual illustration of bathymetric data acquisition with a Multibeam echosounder, MBES (source: <http://www.rcom.marum.de>, accessed 10/01/2007).

The accuracy of the MBES system is critically dependent on the corrections applied for vessel motion (heave, pitch, roll, yaw, and heading). However, the absolute accuracy of single-beam and multibeam bathymetry depends on several factors that are not easy to determine. For single beam data, probably the principal errors that may be introduced are due to topographic features falling between survey lines. Multibeam systems give far better coverage.

The S-44 4th Edition Standard of the IHO lists values “a” and “b” (Table A1.2) that should be introduced into the following equation to calculate the error limits for depth accuracy:

$$\pm \sqrt{a^2 + (b \times d)^2} , \text{ where } d = \text{depth.}$$

Table A1.2. Values for calculating error limits for depth accuracy

Survey order	Application	Constants
Order 1	Harbours and navigation channels	a = 0.5 m, b = 0.013
Order 2	Depths < 200 m	a = 1.0 m, b = 0.023
Order 3	Depths > 200 m	a = 1.0 m, b = 0.023

For example, the IHO recommends that a near-shore coastal survey (Order 2) in water depths of 20 m should have a maximum error of ±1.1 m.

A MBES has, as any other measuring instrument, an inherent limit in its achievable accuracy. The total measurement accuracy, i.e. the uncertainty in the depth and location of the soundings, also depends upon the errors of the auxiliary instruments such as the motion reference unit, the gyro compass, and the measurements of the speed of sound through the water column. The sea state at the time of the survey also contributes significantly to the quality of the data. The possible accuracy of the measured depths may be estimated by considering the following main error sources.

A1.3 Error budget analysis for depths

Measurement	The nadir-beam bottom detection range resolution of the multibeam system has a maximum limit of 0.1 m (Reson, 2002). However, multibeam systems are particularly susceptible to errors in the far range (outer beams), and detection is estimated at ± 0.3 m plus 0.5 % of the depth. Errors also include the detection of the sea floor due to local variations of depth within the beam footprint, especially in the outer beams, and a varying density of the bottom material. This may be significant if a relatively low frequency transducer is used on soft marine muds in shallow water.
Transducer draft	The transducer depth may be accurate to ± 0.1 m. However, the draft of the vessel due to the variability in vessel loading, e.g. fuel and fresh water storage, was not determined. It is estimated that this introduced a water depth independent error of up to ± 0.2 m. Dynamic draft errors, e.g. vessel squat, may also be significant.
Sound velocity	The sound velocity profiles measured by the conductivity-temperature-depth sensor (CTD) probe did not reach full survey depths in waters exceeding 400 m water depths. An inaccurate sound path from the transducer to the bottom and back will affect not only the observed depth of water, but also the apparent position of the observed sounding. This error is presumed to exceed 0.5% of the water depth beyond the direct CTD measurements. In order to minimise this error, ARGO and GDEM data may be used to supplement the CTD data.
Heave	This error is directly dependent on the sea state and the sensitivity of the motion sensor and installation parameters. The MRU installation did not account for the offset distance between MRU, the centre of gravity, and the MBES transducer mount. The software was able to perform lever arm calculations and heave compensation during post-processing, and the vertical error is assumed to be significant only in heavy seas.
Tide/water level	Uncertainties due to tides may be significant, especially where predicted tides some distance from the survey area are used. Perhaps ± 0.3 m for uncertainty in tidal datum need to be considered.

From the listing above, it is estimated that the measured depths in 20 m have an uncertainty of ± 1.5 m. However, the complete bathymetric model, or digital terrain model (DTM), is based on some form of interpolation between the sampled depths from several survey lines. Consequently, the total uncertainty associated with a bathymetric model will include uncertainties due to horizontal positioning, and uncertainties introduced by the interpolation process, and will therefore be larger than the depth sounding uncertainty.

A1.4 Multibeam echosounder data density

The density of data used to construct a bathymetric grid is an important factor in its resolution – the denser the data, the higher the resolution that can be achieved. Sounding density is critical in terms of seabed feature detection and delineation. The two main factors that control the potential bathymetric target resolution capability of a multibeam echosounder are the distance between individual soundings (both in the cross-track and along-track dimensions), and the footprint size. The footprint is the area on the bottom covered by the sound pulse. Footprint size is a function of range, beam angle, and receiver and transmitter beam widths. A high sounding density and small footprint will result in higher-resolution data. Conversely, the target detection capability is going to decay as a result of a growing projected beam footprint and decreasing data density.

The along-track spacing is controlled by the ping rate, which in turn is limited by the two-way travel time from the source to the furthestmost point imaged. The maximum across-track spacing depends

again primarily on the range, but also on the equiangular beam spacing. The size of the beams received by the MBES system is between one and one-and-a-half degrees. This means that a system mounted on a ship will have a larger projected footprint as the water depth increases. The footprint will also be larger at the outer beams than at the centre of the swath, as the range and incident angles increase with distance from the nadir beam. It is possible to have local variations of depth within the beam footprint, causing vertical error and affecting amplitude detection.

Table A1.3 shows a summary of the projected beam footprint size under varying water depths for the two MBES systems currently in use by SOPAC. It should be noted that the higher frequency system (SeaBat 8101) is not appropriate for applications in waters deeper than 200 m. Due to the constant beam width; the sounded area varies according to the depth and slope, which results in a variable data density in the survey area.

Table A1.3. Projected footprint size under varying water depths

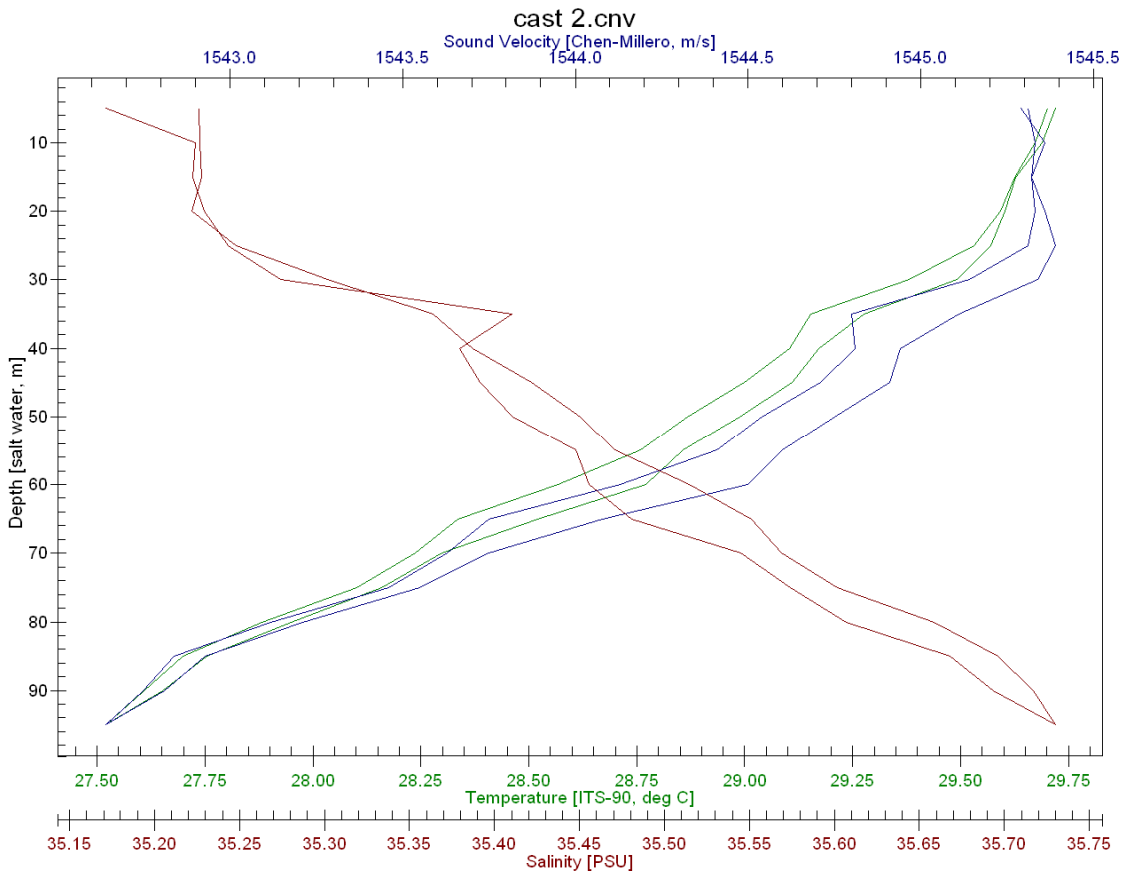
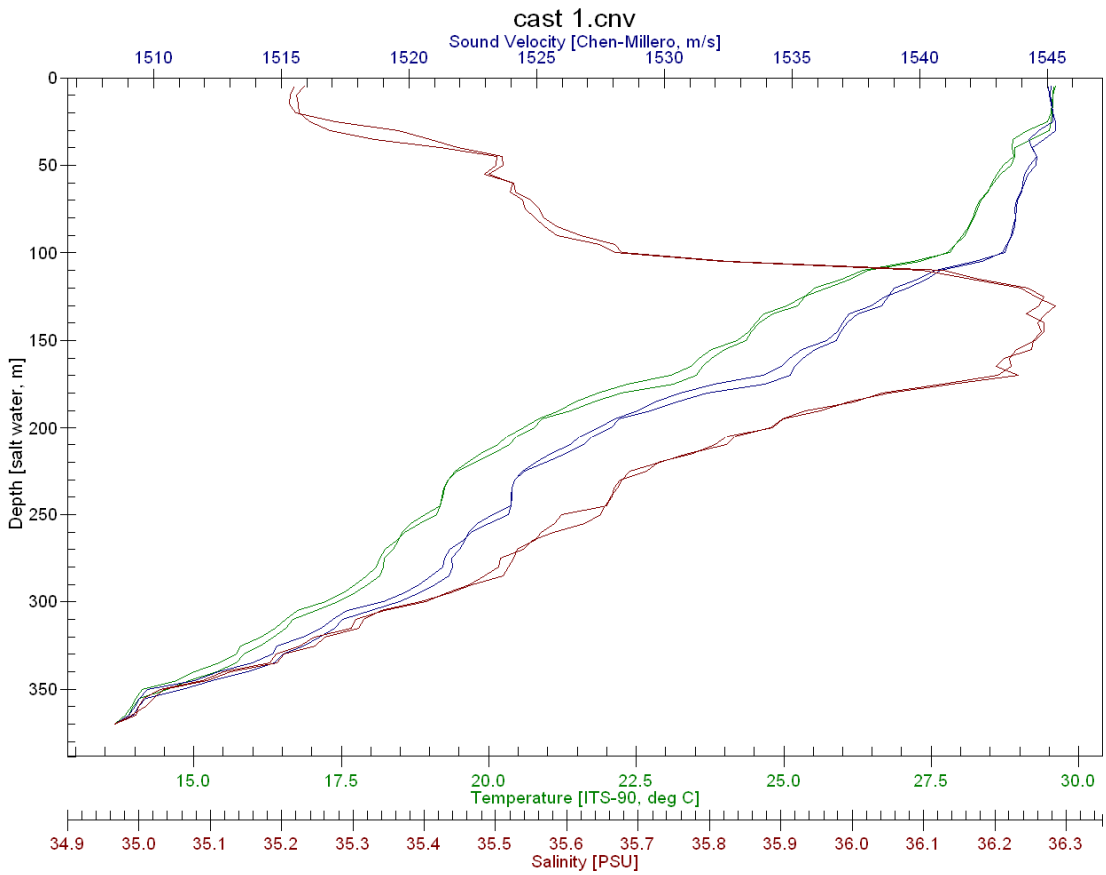
Water depth (m)	SeaBat 8160 (deep water) 50 kHz, 126 beams at 1.5 °		SeaBat 8101 (shallow water) 240 kHz, 101 beams at 1.5 °	
	Inner footprint at nadir (m)	Outer footprint at 65° (m)	Inner footprint, nadir (m)	Outer footprint (m)
20	0.5	2.8	0.5	3.5
50	1.3	7.0	1.3	17.6
100	2.7	14.0	2.6	35.3
200	5.3	28.0	5.2	70.6
500	13.3	69.9	N/A	N/A
1000	26.7	139.8	N/A	N/A
1500	40.0	209.8	N/A	N/A
2000	53.4	279.7	N/A	N/A

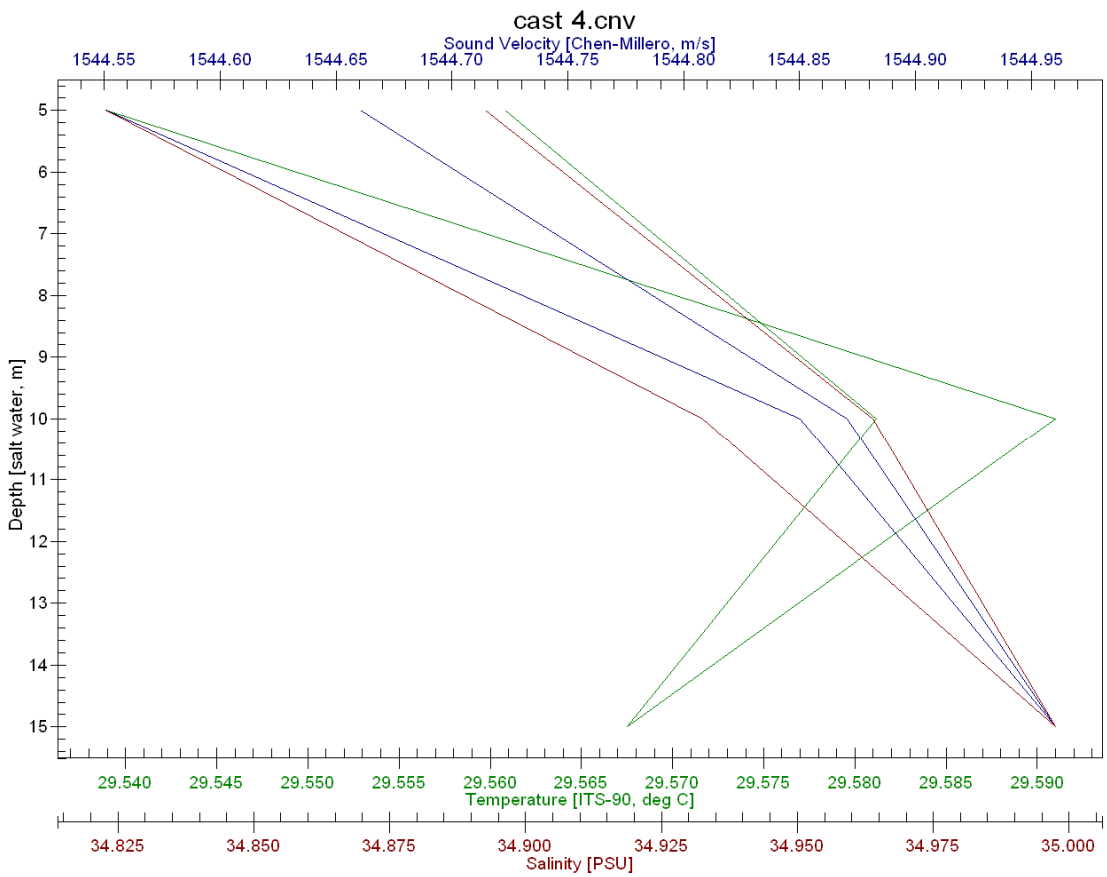
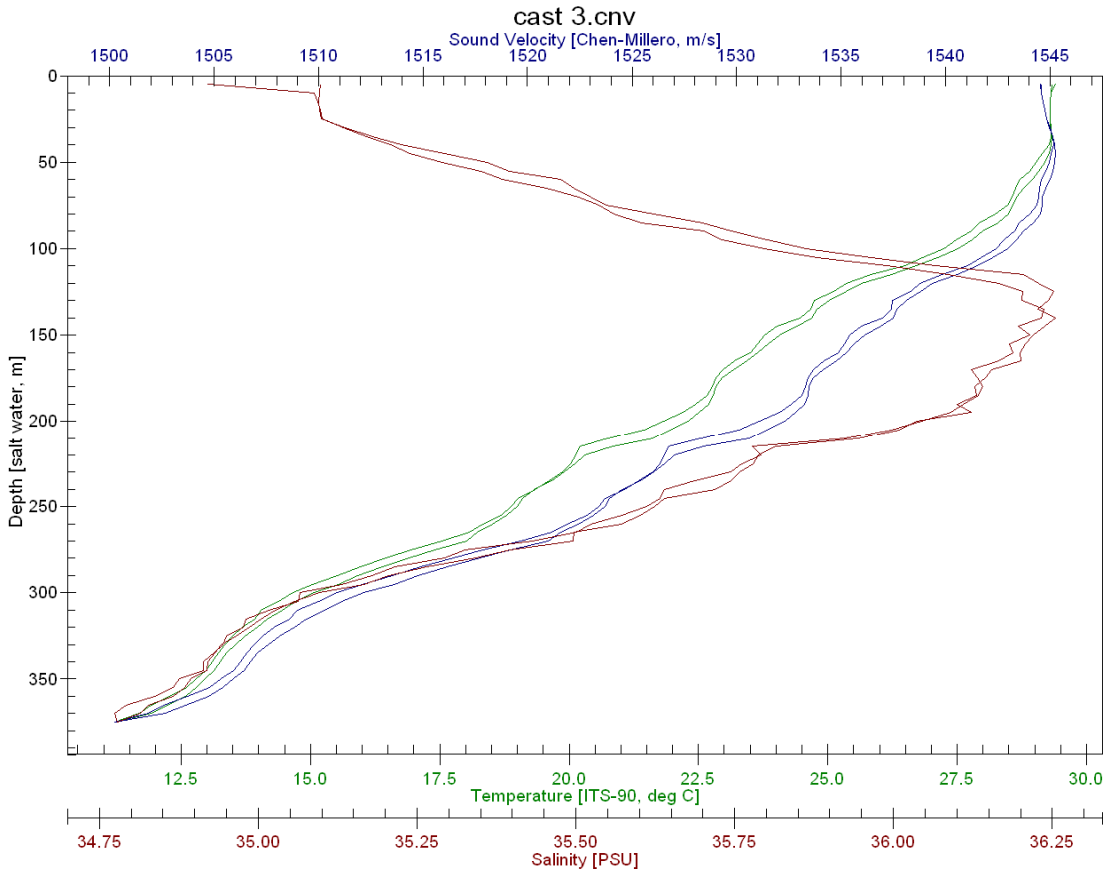
Table A1.3 assumes a horizontal seabed, and shows the variation in across-track footprint size with water depth and beam angle. The sounding density and swath width will also vary when surveying steep slopes, or highly incised margins, as the footprint size varies strongly with topography. Therefore, deeper sections have larger projected footprints and fewer data point. This has the effect that a bathymetric feature whose lateral dimensions are less than the beam footprint size will not be resolved.

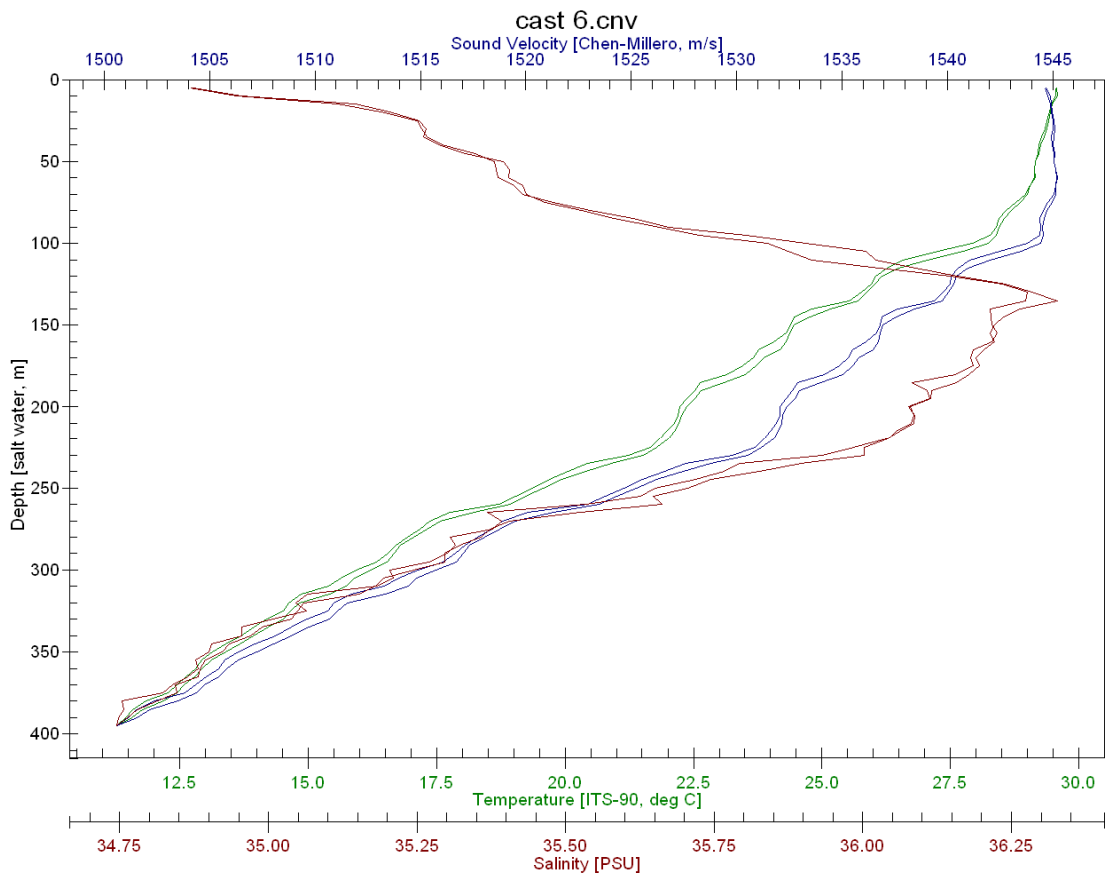
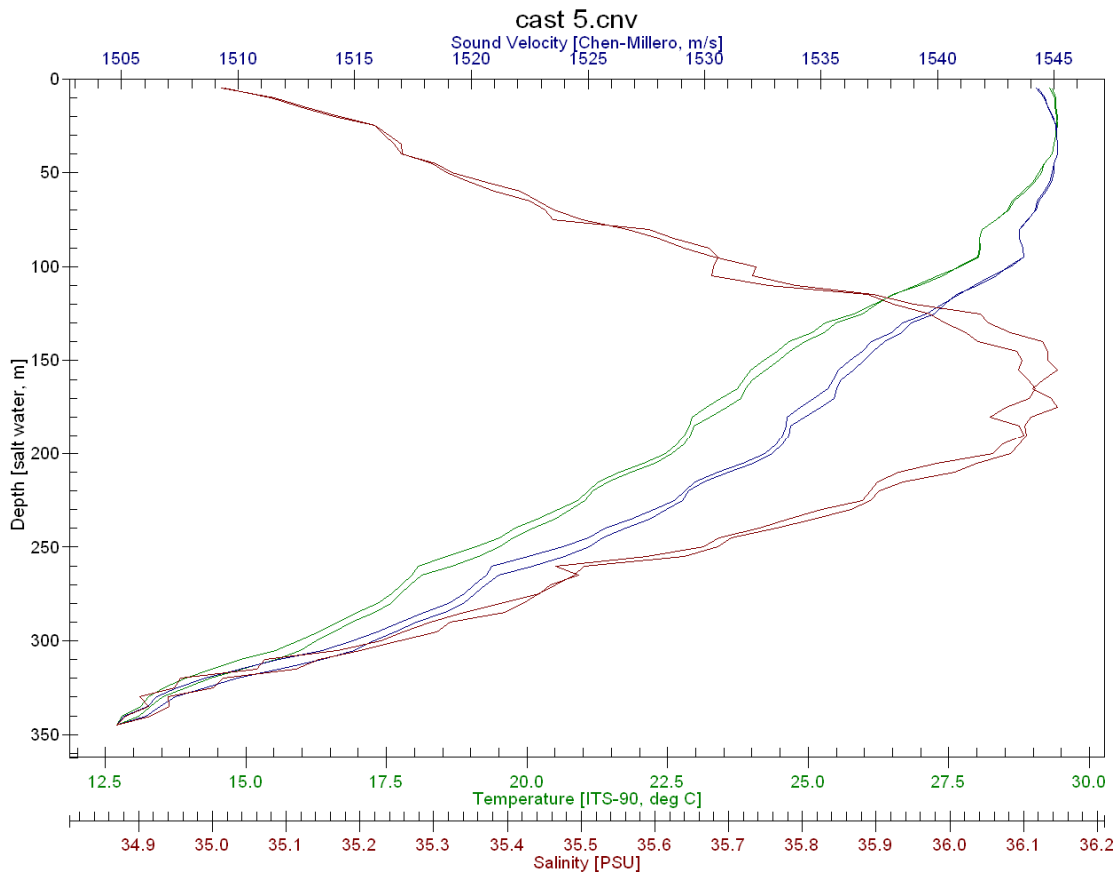
It should also be noted that the along-track resolution usually exceeds the across-track resolution due to ping rates, especially in deep water. Since ping rates are limited by the two-way travel time, rates for water depths of 20 m and 1500 m are 12.9 and 0.2 pings per second, respectively. Using maximum ping rates, or when surveying in deep water, the same area may be measured with the outer beams for several pings, which may give inconsistent sounding data due to the poor repeatability on uneven seabed.

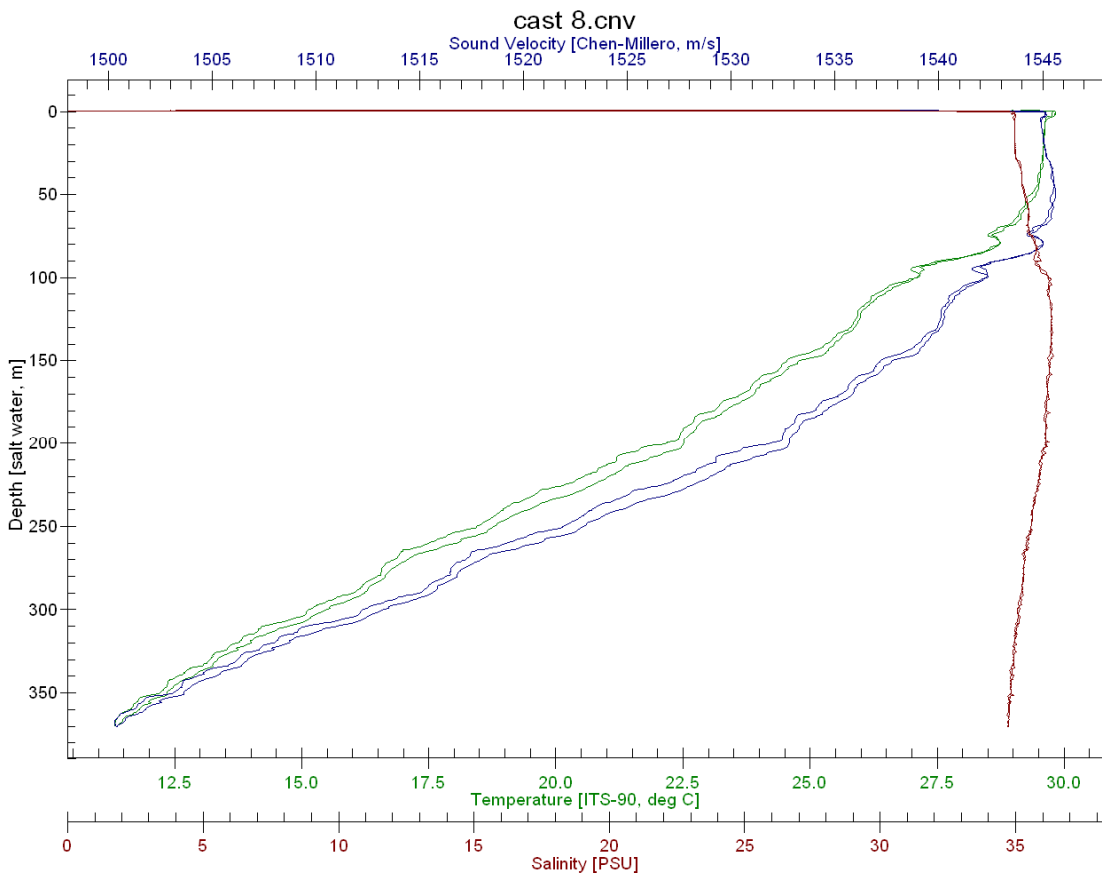
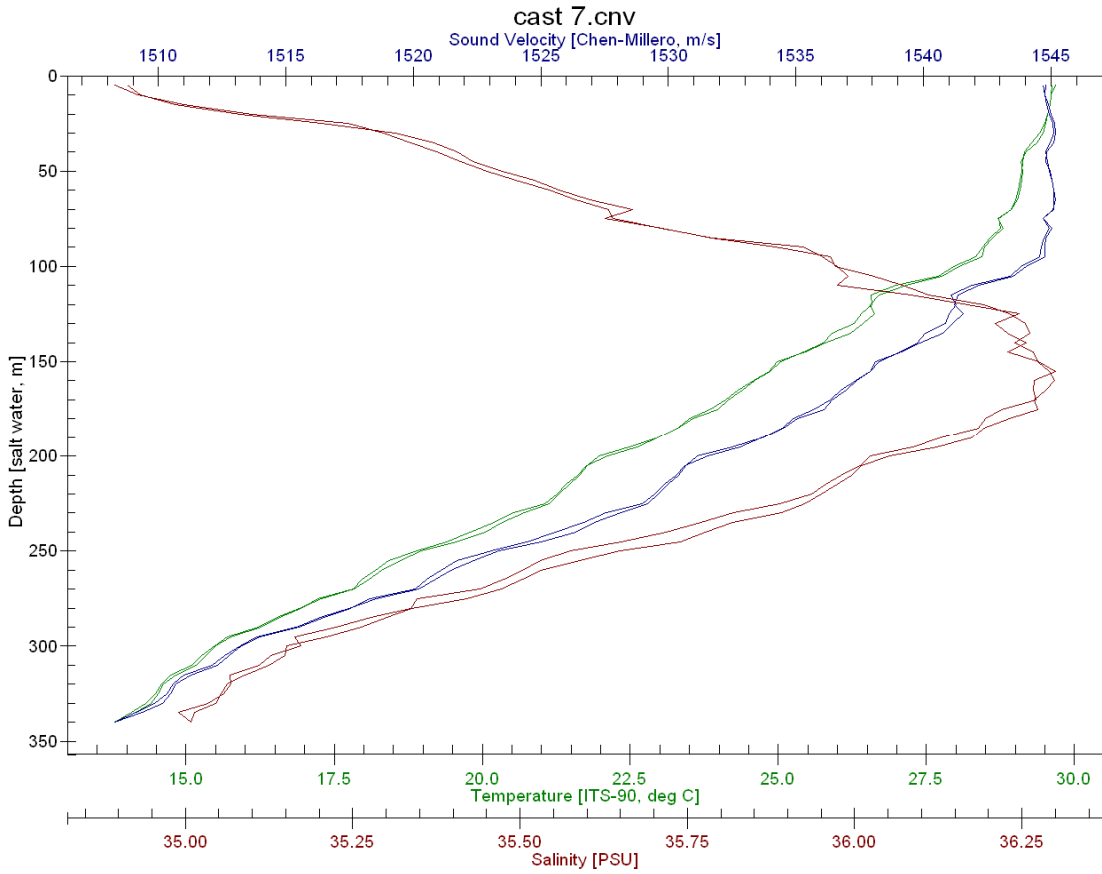
In order to take into account depth-dependent point density, it is generally accepted to grid bathymetric data at a resolution that is on the order of the average beam footprint size, typically 10% of the water depth.

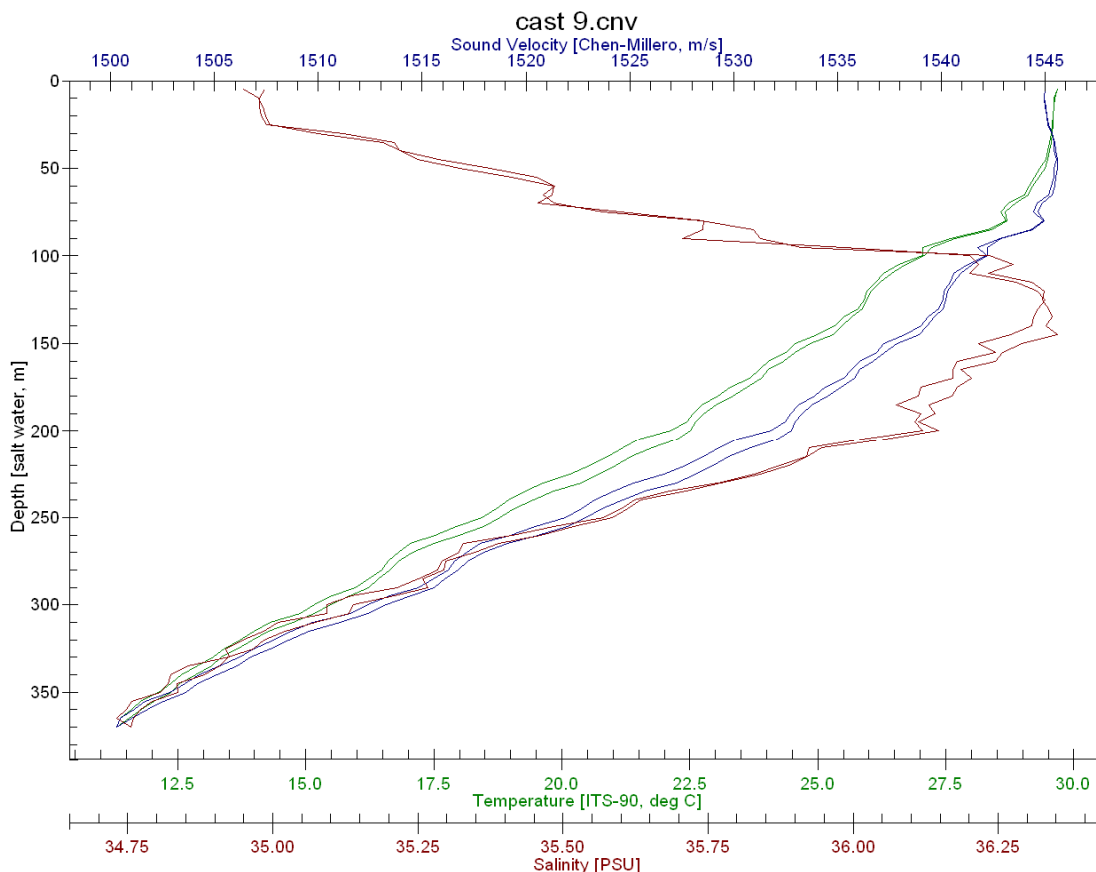
Appendix 2 – CTD profiles











Appendix 3 – High-Resolution A0 Charts, Western Samoa Bathymetry

Charts are available from SOPAC, and can be downloaded from its website (www.sopac.org). Full size is 841 x 1189 mm. (Low-resolution A4 representations follow.)

Chart No	Title	Scale	Drawing No.
1	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.1
2	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.2
3	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.3
4	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.4
5	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.5
6	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.6
7	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.7
8	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.8
9	Western Samoa, Upolu and Savai'i Bathymetry	1 : 50 000	ER112.9

Appendix 4: SOPAC/EU/EDF8 Marine survey Samoa Multibeam Log sheet.

Annex #04F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	01-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
010204.0001	S Apolima	068	7.9	09:00	10:19	In transit to Apia
010204.0002	Apolima	046	8.0	10:17	11:32	In transit to Apia
010204.0003	N Upolu	075	8.0	11:32	n/a	In transit to Apia
Annex #04F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	04-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
040204.0004	N Upolu	012	8.5	05:50	07:12	Heading for Mulifanua Harbour approach
040204.0005	N Upolu	253	7.8	07:12	08:24	Heading for Mulifanua Harbour approach
040204.0006	Mulifanua	217	8.0	08:24	08:45	Down leadin lights Mulifanua
040204.0007	Apolima Strait	290	8.0	09:34	n/a	Set course for Salelolaga
040204.0008	Salelolaga approach	098	n/a	12:15	12:24	Lost C-Map and reset GPS
040204.0009	Apolima Strait	093	8.9	12:30	13:22	C-Map back on line
040204.0010	NW Upolu	076	8.2	13:23	15:17	Discover that Navisoft / C-map is off-set
040204.0011	N Upolu	119	7.5	15:17	15:49	Discover that Hypack / C-map is off-set
ADCP #1 data						
040204	X 694796.41, Y 5473553.38			08:52		Deploy ADCP #1 at Mulifanua approach
240204	Retrieved on 24 Feb 04				13:00	Retrieve ADCP #1 at Mulifanua
ACDP #2 data						
040204	X 678113.08, Y 5478717.99			11:21		Deploy ADCP #2 at Salelolaga approach
240204	Retrieved on 24 Feb 04				10:45	Retrieve ADCP #2 at Salelolaga
Annex #05F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	05-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
050204.0012	Apia Harbour approach	328	8.2	12:59	13:32	Head for ADCP #3 site
050204.0013	N Upolu	109	8.0	13:40	08:24	Head for CTD #1 Site

CTD #1 data

X 721317.92, Y 5481000.15

13:32

13:46

Cast CTD #1 North Upolu @ Z=370m

ADCP #3 data

X 725394.18, Y 5472096.16

15:25

08:00

Deploy ADCP #3 at Apia Harbour approach

Retrieved ADCP #3 on 5 March 2004

06-Feb-04

Annex #06F

Apia

SOPAC**EU****EDF8****PROJECT****/ SAMOA**

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
060204.0014	N Upolu	313	8.2	06:00	06:50	Depart Apia Harbour and head west
060204.0015	NW Upolu	314	7.9	06:52	07:27	Bound for Apolima Strait
060204.0016	Apolima Strait	297	6.7	07:27	08:26	
060204.0017	Apolima Strait	264	8.9	08:26	10:00	Line 4 Magnetometer on / lines @ 200m
060204.0018	Apolima Strait		7.4	10:12	11:02	Line 36 Changed line spacing to 150m
060204.0019	Apolima Strait	218	8.3	11:03	11:46	Line 37
060204.0020	Apolima Strait	042	6.8	11:46	12:10	Line 38
060204.0021	Apolima Strait	231	7.2	12:11	12:43	Line 39
060204.0022	Apolima Strait	044	6.6	12:43	13:03	Line 40
060204.0023	Apolima Strait	242	7.3	13:04	13:23	Line 41
060204.0024						Error, Started file by mistake
060204.0025	Apolima Strait	085	6.5	13:24	13:45	Line 42
060204.0026	Apolima Strait	234	7.1	13:47	14:06	Line 43
060204.0027	Apolima Strait	042	6.4	14:07	14:29	Line 44
060204.0028	Apolima Strait	240	6.7	14:30	14:49	Line 45
060204.0029	Apolima Strait	047	6.1	14:50	15:13	Line 46
060204.0030	Apolima Strait	231	6.9	15:14	15:33	Line 47
060204.0031	Apolima Strait	038	6.2	15:33	15:54	Line 48
060204.0032	Apolima Strait	239	7.7	15:55	16:12	Line 49
060204.0033	Apolima Strait	050	6.1	16:13	16:33	Line 50
060204.0034	Apolima Strait	216	7.6	16:35	16:52	Line 51
060204.0035	Apolima Strait	046	6.6	16:53	17:11	Line 52
060204.0036	Apolima Strait	141	8.2	17:14	17:44	Line 01 Head for Mulifanua Harbour
060204.0037	Mulifanua	329	1.6	18:05	18:30	Line 02 Anchor at Mulifanua Harbour

MAG #1 Data 060204 Annex #07F	Apolima Strait SOPAC	EU	EDF8	08:26 PROJECT	17:15 / SAMOA	MAGLOG Samoa Survey2 07-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
070204.0038	Mulifanua	263	7.7	06:47	07:33	Line 1 To where we ended yesterday
070204.0039	Apolima Strait	049	6.7	07:33	07:58	Line 53 Start 150m spacing survey
070204.0040	Apolima Strait	049	7.0	07:58	08:00	Line 53 Traffic close to magnetometer
070204.0041	Apolima Strait	221	8.3	08:01	08:17	Line 54
070204.0042	Apolima Strait	042	6.5	08:18	08:38	Line 56 Skip to 2 line spacing
070204.0043	Apolima Strait	223	8.5	08:39	08:55	Line 58
070204.0044	Apolima Strait	038	6.7	08:57	09:16	Line 60
070204.0045	Apolima Strait	239	7.9	09:17	09:33	Line 62 Run line 25m off to port
070204.0046	Apolima Strait	049	6.5	09:35	09:51	Line 64
070204.0047	Apolima Strait	220	8.4	09:52	10:07	Line 65
070204.0048	Apolima Strait	023	6.6	10:08	10:24	Line 67
070204.0049	Apolima Strait	228	7.2	10:26	10:40	Line 69
070204.0050	Apolima Strait	050	7.0	10:42	10:57	Line 71
070204.0051	Apolima Strait	230	7.9	10:59	11:16	Line 73
070204.0052	Apolima Strait	042	7.4	11:18	11:35	Line 76 Skip 3 lines
070204.0053	Apolima Strait	237	7.6	11:36	11:53	Line 78 Skip 2 lines
070204.0054	Apolima Strait	040	9.5	11:54	12:11	Line 80
070204.0055	Apolima Strait	223	7.2	12:12	12:29	Line 82
070204.0056	Apolima Strait	024	7.6	12:31	12:49	Line 85 Skip 3 lines
070204.0057	Apolima Strait	229	7.0	12:51	13:10	Line 87
070204.0058	Apolima Strait	045	8.0	13:12	13:26	Line 89
070204.0059	Apolima Strait	209	7.3	13:28	13:36	Line 91 Stop for traffic
070204.0060	Apolima Strait	208	7.1	13:39	13:48	Line 91
070204.0061	Apolima Strait	054	7.5	17:50	14:08	Line 93
070204.0062	Apolima Strait	229	7.2	14:10	14:24	Line 95
070204.0063	Apolima Strait	160	7.3	14:26	14:39	Line 97
070204.0064	Apolima Strait	204	6.3	14:41	14:56	Line 99
070204.0065	Apolima Strait	043	7.6	14:57	15:10	Line 101

070204.0066	Apolima Strait	209	7.2	15:12	15:25	Line 103
070204.0067	Apolima Strait	044	8.5	15:27	15:38	Line 105
070204.0068	Apolima Strait	212	7.1	15:39	15:50	Line 106
070204.0069	Apolima Strait	034	8.3	15:52	16:01	Line 107
070204.0070	Apolima Strait	218	7.0	16:01	16:13	Line 108
070204.0071	Apolima Strait	043	8.4	16:13	16:22	Line 109
070204.0072	Apolima Strait	243	7.9	16:23	16:33	Line 110
070204.0073	Apolima Strait	055	7.7	16:34	16:42	Line 112
070204.0074	Apolima Strait	227	7.1	16:43	16:52	Line 113
070204.0075	Apolima Strait	040	7.6	16:52	17:02	Line 114
070204.0076	Apolima Strait	n/a	n/a	17:02	17:19	Line 115 Hiway to Salelolaga anchorage

MAG #2 Data

070204 Apolima Strait 07:30 17:00 MAGLOG Samoa Survey2
SOPAC EU EDF8 PROJECT / SAMOA 08-Feb-04

Area	Azimuth	Speed	Start	Stop	COMMENTS
Salelolaga	134	6.4	07:09	07:22	Line 1 Depart Salelolaga for line area
Apolima Strait	045	6.6	07:22	07:33	Line 115 Start 150m line spacing
Apolima Strait	222	7.9	07:34	07:41	Line 116
Apolima Strait	045	6.0	07:42	07:51	Line 117
Apolima Strait	219	7.6	07:52	08:00	Line 118
Apolima Strait	045	6.8	08:00	08:08	Line 119
Apolima Strait	216	8.9	08:08	08:14	Line 120
Apolima Strait	043	7.2	08:15	08:22	Line 121
Apolima Strait	224	8.3	08:23	08:28	Line 122
Apolima Strait	047	6.8	08:30	08:35	Line 123
Apolima Strait	222	8.0	08:36	08:40	Line 124
Apolima Strait	112	7.3	08:43	09:53	Run line across to Upolu side of strait
Apolima Strait	229	7.9	10:00	10:22	Line 33 Running line on Upolu side
Apolima Strait	086	7.6	10:23	10:52	Line n/a
Apolima Strait	169	7.4	10:52	11:07	Line n/a
Apolima Strait	053	7.0	11:07	11:26	Line n/a
Apolima Strait	221	7.9	11:32	11:37	Line 18

Apolima Strait	040	6.8	11:38	11:42	Line 19	
Apolima Strait	275	8.2	11:43	12:02	Line 20	
Apolima Strait	040	6.5	12:02	12:08	Line 21	
Apolima Strait	043	7.7	12:10	12:18	Line 21	
Apolima Strait	221	7.4	12:19	12:32	Line 22	
Apolima Strait	041	7.2	12:32	12:47	Line 23	
Apolima Strait	230	7.4	12:48	13:03	Line 24	
Apolima Strait	047	7.4	13:05	13:21	Line 26	Run approx 25m stb of line
Apolima Strait	220	7.9	13:23	13:39	Line 27	
Apolima Strait	044	7.2	13:40	13:59	Line 28	
Apolima Strait	215	7.3	14:00	14:18	Line 29	
Apolima Strait	043	7.0	14:19	14:39	Line 30	
Apolima Strait	226	8.8	14:41	15:01	Line 31	
Apolima Strait	045	7.1	15:03	15:20	Line 32	Bring in magnetometer
Apolima Strait	049	7.4	15:23	15:30	Line 25	
N UPOLU	070	7.6	15:51	16:17		Gyrocompass "crashes"
N UPOLU	076	7.6	16:32	17:26		Gyrocompass is back on line
N UPOLU	088	7.0	06:14	18:21		Deep drop off to N Upolu L. L.

Apolima Strait 07:30 08:43 MAGLOG Samoa Survey2

Apolima Strait 11:30 15:20 MAGLOG Samoa Survey2

X 693758.06, Y 5477015.81

Annex #11F	SOPAC	EU	EDF8	PROJECT	Cast CTD #2 in NE Apolima Strait / SAMOA	11-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
110204.0112	5 Mile Reef	042	7.6	15:02	15:25	Line 40
110204.0113	5 Mile Reef	196	8.3	15:26	15:46	Line 38
110204.0114	5 Mile Reef	090	7.1	15:48	16:10	Line 36
110204.0115	5 Mile Reef	183	8.4	16:10	16:32	Line 34

110204.0116	5 Mile Reef	011	7.8	16:33	16:53	Line 32
110204.0117	5 Mile Reef	193	8.3	16:54	17:13	Line 30
110204.0118	5 Mile Reef	028	7.6	17:14	17:34	Line 28
110204.0119	5 Mile Reef	197	7.5	17:35	17:54	Line 26
110204.0120	5 Mile Reef					Line 24 Do Not Use This Line
110204.0121	5 Mile Reef	011	7.3	17:54	18:13	Line 24
110204.0122	5 Mile Reef	188	7.7	18:14	n/a	Line 22

MAG #5 Data

110204	5 Mile Reef			14:57	18:30	MAGLOG Samoa Survey2
SOPAC	EU	EDF8	PROJECT	/ SAMOA	12-Feb-04	

Area	Azimuth	Speed	Start	Stop	COMMENTS
In transit to 5 Mile Reef	288	7.9	07:02	07:19	Line 1 MBES mapping to line 1
5 Mile Reef	183	7.8	07:20	07:34	Line 3 Side Scan sensor light blinking
5 Mile Reef	021	7.6	07:35	07:49	Line 5
5 Mile Reef	188	7.6	07:50	08:04	Line 7
5 Mile Reef	012	7.8	08:06	08:21	Line 9
5 Mile Reef	185	7.4	08:22	08:38	Line 11
5 Mile Reef	019	7.3	08:39	08:56	Line 13
5 Mile Reef	184	7.5	09:02	09:15	Line 15
5 Mile Reef	024	7.4	09:16	09:35	Line 17
5 Mile Reef	184	7.2	09:36	09:55	Line 19 Side Scan on
5 Mile Reef	018	7.5	09:57	10:15	Line 20 Side Scan off at end of line
5 Mile Reef	261	7.2	10:17	10:27	Line 2
5 Mile Reef	181	7.6	10:27	10:41	Map over drop off to define reef area
5 Mile Reef	023	7.9	10:42	10:53	n/a
5 Mile Reef	218	7.6	10:53	10:57	n/a
5 Mile Reef	331	8.1	10:58	11:04	n/a
5 Mile Reef	200	6.9	11:05	11:15	n/a
5 Mile Reef	013	7.7	11:26	11:32	Line 2
5 Mile Reef	216	8.2	11:33	11:37	Line 2 Fill in gaps and Line 2
5 Mile Reef	033	7.9	11:37	11:44	Line 4
5 Mile Reef	022	7.4	11:45	11:49	Line 6

5 Mile Reef	178	6.7	11:50	11:55	Line 8	
5 Mile Reef	171	7.7	11:56	12:03	Line 10	
5 Mile Reef	181	7.7	12:04	12:08	Line 12	
5 Mile Reef	012	7.6	12:09	12:15	Line 14	
5 Mile Reef	197	7.5	12:16	12:24	Line 16	Problem w helmsman video cable
5 Mile Reef	020	7.4	12:25	12:29	Line 18	
5 Mile Reef	199	7.4	12:32	13:34	Line 0	
5 Mile Reef	010	7.5	12:37	12:45	Line 23	
5 Mile Reef	188	8.3	12:46	12:55	Line 25	
5 Mile Reef	017	7.5	12:56	13:05	Line 27	Fill in shallow areas
5 Mile Reef	185	8.0	13:06	13:15	Line 29	
5 Mile Reef	013	8.1	13:16	13:27	Line 31	
5 Mile Reef	193	7.1	13:28	13:38	Line 33	
5 Mile Reef	021	7.6	13:39	13:57	Line 35	
5 Mile Reef	194	8.6	14:02	14:13	Line 37	
5 Mile Reef	077	7.4	14:14	14:22	Line 38	
5 Mile Reef	275	8.2	14:23	14:31	Line 37	Follow reef to find shallow areas
5 Mile Reef	300	7.9	14:32	14:35		
5 Mile Reef	358	7.6	14:35	14:45		
5 Mile Reef	121	7.9	14:45	14:54		
5 Mile Reef	027	7.6	15:01	15:25	Line 41	Restart Line 5
5 Mile Reef	193	7.6	15:28	15:49	Line 43	
5 Mile Reef	012	7.2	15:50	16:15	Line 45	Problem w helmsman video cable

5 Mile Reef 06:50 10:13 MAGLOG Samoa Survey2

5 Mile Reef 15:25 16:15 MAGLOG Samoa Survey2
Annex #14F SOPAC EU EDF8 PROJECT / SAMOA

14-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
140204.0167	5 Mile Reef	020	7.9	07:10	07:32	Line 47
140204.0168	5 Mile Reef	174	7.5	07:32	07:56	Line 49

140204.0169	5 Mile Reef	028	7.8	07:58	08:19	Line 51 Sighted floating drum
140204.0170	5 Mile Reef	194	8.3	08:20	08:43	Line 53
140204.0171	5 Mile Reef	015	8.1	08:45	09:06	Line 55
140204.0172	5 Mile Reef	189	7.9	09:07	09:28	Line 57
140204.0173	5 Mile Reef	018	7.8	09:30	09:51	Line 59
140204.0174	5 Mile Reef	192	8.2	09:52	10:12	Line 61
140204.0175	5 Mile Reef	018	7.6	10:14	10:35	Line 63
140204.0176	5 Mile Reef	189	8.0	10:36	10:56	Line 65
140204.0177	5 Mile Reef	018	8.0	10:57	11:19	Line 67
140204.0178	5 Mile Reef	197	8.3	11:20	11:40	Line 69
140204.0179	5 Mile Reef	018	7.7	11:42	n/a	Line 71
140204.0180	5 Mile Reef	198	7.7	n/a	12:24	
140204.0181	5 Mile Reef	021	7.6	12:30	12:32	Fill in gaps in data
140204.0182	5 Mile Reef	213	7.9	12:33	12:38	Fill in gaps in data
140204.0183	5 Mile Reef					Do not use this line
140204.0184	5 Mile Reef	034	7.0	12:40	12:43	
140204.0185	5 Mile Reef	200	7.7	12:45	12:50	Fill in gaps in data
140204.0186	5 Mile Reef	195	7.5	12:51	12:56	Fill in gaps in data
140204.0187	5 Mile Reef	016	7.5	12:59	13:01	Fill in gaps in data
140204.0188	5 Mile Reef	022	7.6	13:08	13:10	Fill in gaps in data
140204.0189	5 Mile Reef	198	7.4	13:11	13:14	Fill in gaps in data
140204.0190	5 Mile Reef	010	7.1	13:14	13:17	Fill in gaps in data
140204.0191	5 Mile Reef	207	7.1	13:18	13:20	Fill in gaps in data
140204.0192	5 Mile Reef	010	6.8	13:21	13:22	Fill in gaps in data
140204.0193	5 Mile Reef	187	6.7	13:23	13:27	Fill in gaps in data
140204.0194	5 Mile Reef	187	8.2	13:31	13:35	Fill in gaps in data
140204.0195	5 Mile Reef	012	7.0	13:36	13:40	Fill in gaps in data
140204.0196	5 Mile Reef	195	7.2	13:40	13:45	Fill in gaps in data
140204.0197	5 Mile Reef	068	6.4	13:45	13:51	Fill in gaps in data
140204.0198	5 Mile Reef	190	7.3	13:52	13:54	Fill in gaps in data
140204.0199	N of Apia	277	8.1	14:31	14:40	Fill in area W of 5 Mile Reef
140204.0200	N of Apia	173	8.5	14:41	14:51	Fill in area SW of 5 Mile Reef
140204.0201	N of Apia	359	8.0	14:51	14:58	Fill in area SW of 5 Mile Reef
140204.0202	N of Apia	144	7.2	14:58	15:07	Fill in area SW of 5 Mile Reef
140204.0203	N of Apia	171	7.2	15:09	15:37	Fill in area SW of 5 Mile Reef

140204.0204	N of Apia	309	7.8	15:38	16:00	Fill in area SW of 5 Mile Reef
140204.0205	N of Apia	115	6.8	16:00	16:24	Fill in area SW of 5 Mile Reef
140204.0206	N of Apia	338	8.0	16:24	16:41	Fill in area SW of 5 Mile Reef
140204.0207	N of Apia	147	6.8	16:43	17:03	Fill in area SW of 5 Mile Reef
140204.0208	N of Apia	026	7.4	17:03	17:16	Fill in area SW of 5 Mile Reef
140204.0209	N of Apia	106	6.8	17:16	17:38	Fill in area SW of 5 Mile Reef

MAG #8 Data

140204	5 Mile Reef			07:05	12:23	MAGLOG Samoa Survey2
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MAG #9 Data

140204	N of Apia			14:40	17:38	MAGLOG Samoa Survey2
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Annex #15F

SOPAC

EU

EDF8

PROJECT

/ SAMOA

15-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
150204.0210	Apia	278	8.4	07:11	08:05	NW of Apia
150204.0211	N Upolu	252	8.0	08:05	08:23	NW of Apia
150204.0212	N Upolu	070	6.8	08:23	08:37	N of Malua lighthouse
150204.0213	N Upolu	033	7.7	08:37	10:18	N of Mulifanua
150204.0214	N Apolima	317	8.3	10:18	11:47	E of Cape Tuasivi, Savaii
150204.0215	N Apolima	089	7.8	11:47	12:42	E of Cape Tuasivi, Savaii
150204.0216	N Apolima	037	6.9	13:01	14:28	E of Cape Tuasivi, Savaii
150204.0217	N Upolu	127	8.0	14:29	15:00	N of Mulifanua
150204.0218	N Upolu	065	7.4	15:01	17:32	N of Mulifanua
150204.0219	N Upolu	180	8.4	17:33	18:12	Head for Apia harbour

CTD #3 data

E687309, N5489064

12:43

12:56

E of Cape Tuasivi @ Z=800m

Annex #16F

SOPAC

EU

EDF8

PROJECT

/ SAMOA

16-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
160204.0220	N Upolu	032	8.1	07:35	07:50	E of 5 Mile Reef
160204.0221	N Upolu	034	7.6	07:50	09:32	

160204.0222	N E Upolu	177	8.3	09:32	11:21	N of Solosolo Village
160204.0223	E Upolu	093	8.4	11:22	12:21	S E of Nu'utele Island
160204.0224	S E Upolu	143	8.9	12:21	13:39	17km from Falealili
160204.0225	S E Upolu	298	7.4	14:08	16:36	Heading for Falealili
160204.0226	S Upolu	351	8.2	16:36	n/a	Map road into Falealili
Annex #17F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	17-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
170204.0227	S Upolu	224	6.0	06:47	08:00	
170204.0228	S E Upolu	094	8.5	08:00	08:24	
170204.0229	S E Upolu	349	8.0	08:41	09:21	
170204.0230	S E Upolu	335	8.1	09:22	09:39	
170204.0231	S E Upolu	079	8.5	09:39	10:37	
170204.0232	S E Upolu	315	8.2	10:37	11:10	
170204.0233	S E Upolu	126	8.5	11:10	11:27	
170204.0234	S E Upolu	288	8.8	11:27	12:56	
170204.0235	N E upolu	240	8.4	12:56	13:56	
170204.0236	N E upolu	304	7.6	14:21	16:07	
170204.0237	N upolu	008	7.4	16:27	18:22	
Grab Sample SAM-170204-1	X 733319.64, Y 544734.43			06:21		Falealili harbour
CTD #4 data	X 733319.64, Y 544734.43			06:31	06:32	Falealili harbour in 15m
CTD #5 data	X 755030, Y 5443291			08:23	08:36	S Upolu in 900m
CTD #6 data	X 769931, Y 5455010			13:57	14:15	Aleipata, Upolu at 1000m
CTD #7 data	X 753550, Y 5469190			16:08	16:15	N Upolu

MAG #10 data
 170204 S E Upolu 09:00 13:53 MAGLOG Samoa Survey3

MAG #11 data
 170204 off coast of Aleipata, Upolu 14:18 15:00 MAGLOG Samoa Survey3
Annex #19F SOPAC EU EDF8 PROJECT / SAMOA 19-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
190204.0238	Apia	033	7.7	07:14	07:55	E of 5 Mile Reef
190204.0239	N Upolu	010	7.4	07:55	09:20	Heading west to N Apolima Strait
190204.0240	N Apolima	273	7.4	09:43	10:41	Deep water area of N Apolima Strait
190204.0241	N Apolima	350	7.2	11:01	12:34	Deep water area of N Apolima Strait
190204.0242	N Apolima	034	7.8	12:34	13:26	Deep water area of N Apolima Strait
190204.0243	N Apolima	126	6.2	13:52	14:56	Deep water area of N Apolima Strait
190204.0244	N Apolima	121	7.0	14:56	16:34	Heading east to Apia

MAG #12 Data
 190204 N Apolima Strait 12:45 13:25 MAGLOG Samoa Survey3

MAG #13 Data
 190204 N Apolima Strait 13:45 16:40 MAGLOG Samoa Survey3

CTD #8 Data
 X 689158, Y 5503833 13:30 13:42 Cast CTD #8 in NW Apolima Strait
Annex #20F SOPAC EU EDF8 PROJECT / SAMOA 20-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
200204.0245	N Apolima	038	8.1	08:37	11:09	Deep water area of N Apolima Strait
200204.0246	N Apolima	129	6.6	11:09	13:05	Deep water area of N Apolima Strait
200204.0247	N Apolima	265	6.7	13:11	14:50	Deep water area of N Apolima Strait
200204.0248	N Apolima	203	6.1	14:53	15:57	Deep water area of N Apolima Strait
200204.0249	N Apolima	185	6.0	15:57	17:22	The vessel is in transit to Apia

MAG #14 Data

200204 Annex #21F	N Apolima Strait SOPAC	EU	EDF8	08:40 PROJECT	17:22 / SAMOA	MAGLOG Samoa Survey3 21-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
210204.0250	Apia	320	8.2	13:00	13:41	In transit to S Apolima Strait
210204.0251	Apolima Strait					Do Not Use This File
210204.0252	Apolima Strait	294	8.0	13:45	15:03	N Upolu
210204.0253	Apolima Strait	235	7.9	15:03	15:34	Mid channel, Apolima Strait
210204.0254	Apolima Strait	101	7.1	15:34	16:01	Mid channel, Apolima Strait
210204.0255	Apolima Strait	069	7.0	16:02	17:00	Near Salelolaga

MAG #15 Data

210204 Annex #22F	Apia to Salelolaga SOPAC	EU	EDF8	13:00 PROJECT	16:48 / SAMOA	MAGLOG Samoa Survey3 22-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
220204.0256	Apolima Strait	139	7.8	06:56	07:32	Depart Salelolaga harbour
220204.0257	Apolima Strait	235	7.3	07:32	07:59	In transit to S Apolima
220204.0258	S Apolima Strait	321	7.3	09:05	10:34	225°, 18km off Apolima Isl
220204.0259	S Apolima Strait	140	7.1	10:34	11:04	220°, 23.8 km off Manono Isl
220204.0260	S Apolima Strait	147	7.5	11:04	11:30	
220204.0261	S Apolima Strait	292	8.1	11:31	11:43	
220204.0262	S Apolima Strait	153	7.6	11:43	13:04	13.5 km off SW Upolu coast
220204.0263	S Upolu	080	7.3	13:04	16:26	7.5km SE off Safata harbour
220204.0264	S Upolu	318	7.6	16:28	17:07	196°, 4km off Falealili harbour
220204.0265	S Upolu	276	7.8	17:07	17:55	178°, 5.5km off Safata harbour
220204.0266	S Upolu	286	7.9	17:55	18:40	150°, 20.6km off Manono Island
220204.0267	S Upolu	273	7.9	18:40	19:28	179°, 13.8km off Manono Island
220204.0268	S Apolima Strait	315	8.3	19:28	20:46	163°, 7.7km off Salelolaga
220204.0269	Apolima Strait	337	7.5	20:46	21:36	Heading for Salelolaga
Annex #23F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	23-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
230204.0270	Apolima Strait	159	8.1	07:15	08:01	Depart Salelolaga harbour
230204.0271	S Apolima Strait	102	7.6	08:22	08:25	In transit to S Apolima
230204.0272	S Apolima Strait	120	6.9	09:52	10:46	196°, 11.5km off Tafua,Savaii
230204.0273	S Apolima Strait	173	6.6	11:03	11:51	198°, 13km off Tafua
230204.0274	S Apolima Strait	052	7.3	11:52	13:04	225°, 7.9km off Tafua Gyrocompass "Crash"
230204.0275	Apolima Strait	016	7.1	13:39	14:20	Heading for Salelolaga harbour
230204.0276	Apolima Strait	016	7.6	14:20	15:05	Heading for Salelolaga harbour
MAG #16 Data						
230204	S Apolima Strait			11:02		MAGLOG Samoa Survey3
CTD #9 Data						
	X 672295, Y 5460275			10:45	11:00	Cast CTD #9 in S Apolima Strait
Annex #24F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	24-Feb-04
MBES data						
240204.0277	Apolima Strait	100	7.0	11:00	11:10	Depart Salelolaga harbour
240204.0278	Apolima Strait	101	7.3	11:19	11:28	Head for Mulifanua
240204.0279	Apolima Strait	351	4.7	13:46	14:40	N Aplolima Strait
240204.0280	Apolima Strait	238	6.7	14:40	16:00	head for Salelolaga
ADCP #2 Data						
240204	Salelolaga				10:45	Retrieve ADCP #2 on 24 Feb 04
040204	X 678113.08, Y 5478717.99			08:52		Deployed on 04 Feb 04
ADCP #1 Data						
240204	Mulifanua				13:00	Retrieve ADCP #1 on 24 Feb 04
040204	X 694796.41, Y 5473553.38			11:21		Deployed on 04 Feb 04
MAG #17 Data						

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
240204	Apolima Strait			11:02	16:00	MAGLOG Samoa Survey3
Grab Sample SAM-240204-3	X 694796.41, Y 5473553.38					Mulifanua 25-Feb-04
Annex #25F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
250204.0281	Apolima Strait	133	8.3	09:53	10:32	Depart Salelolaga harbour
250204.0282	Apolima Strait	140	8.5	10:32	11:42	In transit to S Apolima
250204.0283	S Apolima Strait	148	8.0	11:42	12:14	220°, 15.8km from Apolima Is.
250204.0284	S Apolima Strait	045	7.7	12:14	12:21	191°, 22.6km from Apolima Is.
250204.0285	S Apolima Strait	089	6.6	12:21	12:25	
250204.0286	S Apolima Strait	270	8.1	12:25	12:27	
250204.0287	S Apolima Strait	092	6.8	12:28	12:36	186°, 24.5km from Apolima Is.
250204.0288	S Apolima Strait	270	8.2	12:36	12:44	
250204.0289	S Apolima Strait	075	7.9	12:44	12:57	
250204.0290	S Apolima Strait	272	8.0	12:57	13:08	
250204.0291	S Apolima Strait	090	7.4	13:08	13:22	184°, 23.1km from Apolima Is.
250204.0292	S Apolima Strait	272	8.2	13:22	13:34	
250204.0293	S Apolima Strait	089	7.4	13:34	13:51	184°, 22.6km from Apolima Is.
250204.0294	S Apolima Strait	267	8.0	13:51	14:07	
250204.0295	S Apolima Strait	091	7.3	14:07	14:27	184°, 22.5km from Apolima Is.
250204.0296	S Apolima Strait	270	8.0	14:27	14:45	
250204.0297	S Apolima Strait	086	7.6	14:45	15:08	180°, 22km from Apolima Is.
250204.0298	S Apolima Strait	268	8.3	15:08	15:23	
250204.0299	S Apolima Strait	072	8.8	15:23	15:43	183°, 21.6km from Apolima Is.
250204.0300	S Apolima Strait	274	7.7	15:43	15:52	
250204.0301	S Apolima Strait	068	7.5	15:52	16:01	180°, 20.8km from Apolima Is.
250204.0302	S Apolima Strait	270	7.6	16:01	16:07	
250204.0303	S Apolima Strait	006	6.0	16:07	17:27	207°, 4.7km from Apolima Is.
250204.0304	Apolima Strait	010	7.0	17:27	18:18	154°, 4.7km from Salelolaga.
Annex #26F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	26-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS

MBES data						
260204.0305	Apolima Strait	084	8.5	07:17	08:27	Depart Salelolaga harbour
260204.0306	Apolima Strait	082	7.9	08:27	09:33	341°, 7.5km NE of Malua
260204.0307	N Apolima Strait	180	8.0	11:14	11:23	337°, 7.2km NW of Apia
Annex #27F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	27-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
270204.0308	Apia	038	7.0	12:11	12:21	South of 5-Mile Reef
270204.0309	Apia	113	6.3	12:21	12:31	032°, 4.3km from Apia
270204.0310	Apia	071	6.8	12:31	12:42	
270204.0311						DO NOT USE THIS LINE
270204.0312	Apia	168	7.4	12:43	12:50	
270204.0313	Apia	061	6.6	12:50	12:58	
270204.0314	Apia	105	6.6	12:58	13:06	
270204.0315	Apia	088	7.0	13:06	13:15	034°, 5.5km from Apia
270204.0316	Apia	105	6.9	13:15	13:21	
270204.0317	Apia	073	6.9	13:21	13:27	
270204.0318	Apia	166	7.3	13:27	13:36	
270204.0319	Apia	087	6.9	13:46	14:16	042°, 10.1km from Apia
	Apia					Gyrocompass "crash"
270204.0320	Apia	087	6.8	14:16	14:18	040°, 4.5km from Apia
270204.0321	Apia	196	7.6	14:58	15:09	
Annex #28F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	28-Feb-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
280204.0322	Apia	041	7.3	06:56	07:09	044°, 3.5km from Apia
280204.0323	Apia	077	6.9	07:09	07:48	004°, 11.4km from Apia
280204.0324	N Upolu	089	6.9	07:48	08:29	035°, 10km from Cape Utumau'u
280204.0325	N Upolu					Gyrocompass "Crash"
280204.0326	N Upolu	100	7.2	09:03	09:49	033°, 5.1km from Fagaloa Bay
280204.0327	Fagaloa	222	7.4	09:49	10:31	Fagaloa Bay
280204.0328	Fagaloa	030	6.0	10:31	10:51	Fagaloa Bay
280204.0329	Fagaloa	198	7.1	10:51	11:08	Fagaloa Bay

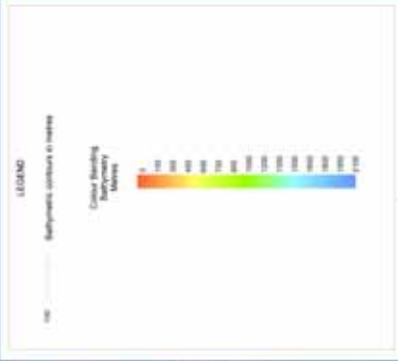
280204.0330	Fagaloa	050	7.2	11:08	11:35	Fagaloa Bay
280204.0331	E Upolu	102	7.2	11:35	12:53	332°, 3.7km from Fanuatapu I.
280204.0332	E Upolu	226	7.9	12:53	13:34	228°, 3.7km from Fanuatapu I.
280204.0333	S Upolu	233	7.7	13:36	15:05	
280204.0334	S Upolu	270	7.8	15:05	17:39	
280204.0335	S Upolu	258	7.6	17:39	18:38	
280204.0336	Apolima	337	6.6	18:38	19:44	
280204.0337	Apolima	n/a	7.6	19:44	20:30	158°, 5.4km from Salelolaga
Annex #29F	SOPAC	EU	EDF8	PROJECT	/ SAMOA	29-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
290204.0338	Apolima	040	8.4	06:56	07:44	173°, 3.8km from Cape Tuasivi
290204.0339	N Savai'i	341	7.9	07:44	09:23	320°, 9.3km from Lesolo Point
290204.0340	N Savai'i	300	7.3	09:23	10:56	070°, 20km from Asau Harbour
290204.0341	N Savai'i	266	7.8	10:56	12:42	Approach to Asau Harbour
290204.0342	N Savai'i	262	8.1	12:42	13:02	Pass by Asau Harbour
290204.0343	N Savai'i	327	7.5	13:02	13:53	280°, 4.7km from Asau
290204.0344	W Savai'i	272	6.4	14:13	15:00	200°, 3.6km from Falealupo
290204.0345	S Savai'i	154	6.0	15:00	16:21	320°, 21.6km from Sala'ilua
290204.0346	S Savai'i	154	7.5	16:21	18:28	200°, 2km from Cape Asuisui
290204.0347	S Savai'i	140	6.0	18:28	20:07	220°, 8km from Satufia
290204.0348	S Savai'i	099	6.8	20:07	21:17	223km, 8.6km from Salelolaga
290204.0349	Apolima	073	7.9	21:25	22:12	Approaching Salelolaga Harbour
MAG #18 Data						
290204	Cape Tuasivi			08:02	12:20	Maglog Samoa-survey3
MAG #19 Data						
290204	Asau			13:05	13:50	Maglog Samoa-survey3
MAG #20 Data						
290204	280°, 4.7km from Asau			14:13	21:21	Maglog Samoa-survey3
CTD #10 Data						

290204 Annex #01M	X 618572, Y 5509362 SOPAC	EU	EDF8	13:55 PROJECT	14:10 / SAMOA	Cast CTD #10 off Cape Puava 01-Mar-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
010304.0350	Apolima	130	8.5	10:52	11:21	In transit to S Apolima Strait
010304.0351	Apolima	185	9.0	11:26	12:28	196°, 7.3km from Apolima Island
010304.0352	Apolima	285	8.0	12:28	13:12	186°, 18.4km from Apolima Island
010304.0353	Apolima	278	7.2	13:13	13:28	195°, 13.3km from Apolima Island
010304.0354	Apolima	145	8.9	13:28	13:45	
010304.0355	Apolima	197	8.7	13:45	14:15	
010304.0356	Apolima	052	7.8	16:13	16:55	183°, 18.3km from Apolima Island
010304.0357	Apolima	349	7.0	16:55	17:48	176°, 11.6km from Apolima Island
010304.0358	Apolima	010	6.9	17:53	18:46	226°, 3km from Apolima Island
Annex #02M	SOPAC	EU	EDF8	PROJECT	/ SAMOA	02-Mar-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
MBES data						
020304.0361	Apolima	047	7.8	10:45	11:29	Depart Salelolaga/ circumnavigate Savaii
020304.0362	N Savaii	352	8.5	11:35	13:27	119°, 14.3km from Matautu Bay
020304.0363	N Savaii	324	8.4	13:27	14:45	270°, 7km from Matautu Bay
020304.0364	N Savaii	145	8.0	14:45	14:51	
020304.0365	N Savaii	270	8.5	16:23	17:29	261°, 19km from Matautu Bay
020304.0366	N Savaii	139	7.9	17:29	20:06	308°, 3.6km from Asau
020304.0367	S Savaii	204	8.3	20:06	20:25	274°, 2.4km from Falealupo
020304.0368	S Savaii	162	6.5	20:25	21:40	175°, 10.4km from Falealupo
020304.0369	S Savaii	143	7.8	21:40	22:40	154°, 18.4km from Falealupo
020304.0370	S Savaii	135	7.6	22:40	23:40	253°, 3.8km from Salailua Bay
020304.0371	S Savaii	125	7.9	23:40	00:40	206°, 3.9km from Cape Suisui
020304.0372	S Savaii	090	8.2	00:40	01:30	100°, 12.7km from Cape Suisui
020304.0373	SW Apolima	070	8.3	01:35	01:40	264°, 16.8km from Apolima Island
020304.0374	S Apolima	060	8.7	01:45	02:06	Heading for Salelolaga Harbour
Annex #03M	SOPAC	EU	EDF8	PROJECT	/ SAMOA	03-Mar-04
File:	Area	Azimuth	Speed	Start	Stop	COMMENTS

MBES data						
030304.0375	Apolima	088	7.6	11:08	12:13	In transit to Apia
030304.0376	Apolima	082	7.4	12:13	13:31	329°, 7.9km from Malua, N Upolu
Annex #05M	SOPAC	EU	EDF8	PROJECT	/ SAMOA	05-Feb-04

File:	Area	Azimuth	Speed	Start	Stop	COMMENTS
ADCP #3 Data						
50304	X 725394.18, Y 5472096.16 Apia			15:25	08:00	Retreived ADCP #3 on 5 March 2004 Deploy ADCP #3 on 5 February 2004

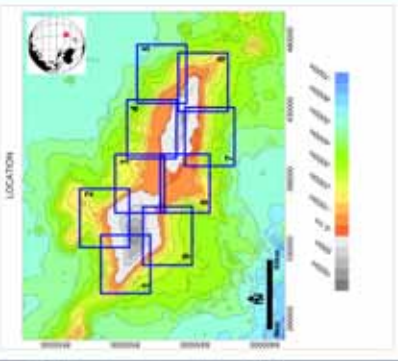


NOTES

Water depths were reduced to chart datum (2.25 m below MHW) from predicted tide heights using WOTM's software (www.wotm2.com)

Chart of Survey
 IHO S-1613(2004)
 Edition Number 1185
 Issue Date 2004
 Collection software
 HydroSW 2.2.2
 Data projection
 Spheroid WGS 84
 Survey method
 RTK / Topographic

Background WGS84 image taken on 03/04/2004



GEODEIC INFORMATION

Geoid datum
 WGS84
 Vertical datum
 UTM Zone 2 South
 Horizontal projection
 Spheroid datum (SRS)

NOT FOR NAVIGATION



PROJECT TITLE

SOPAC

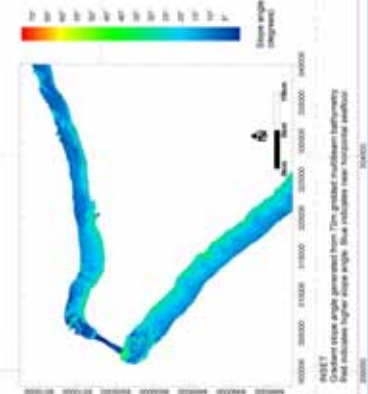
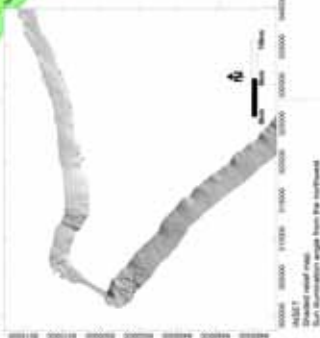
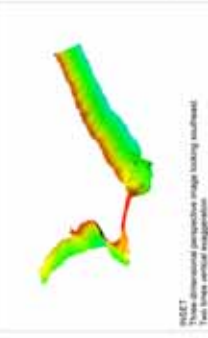
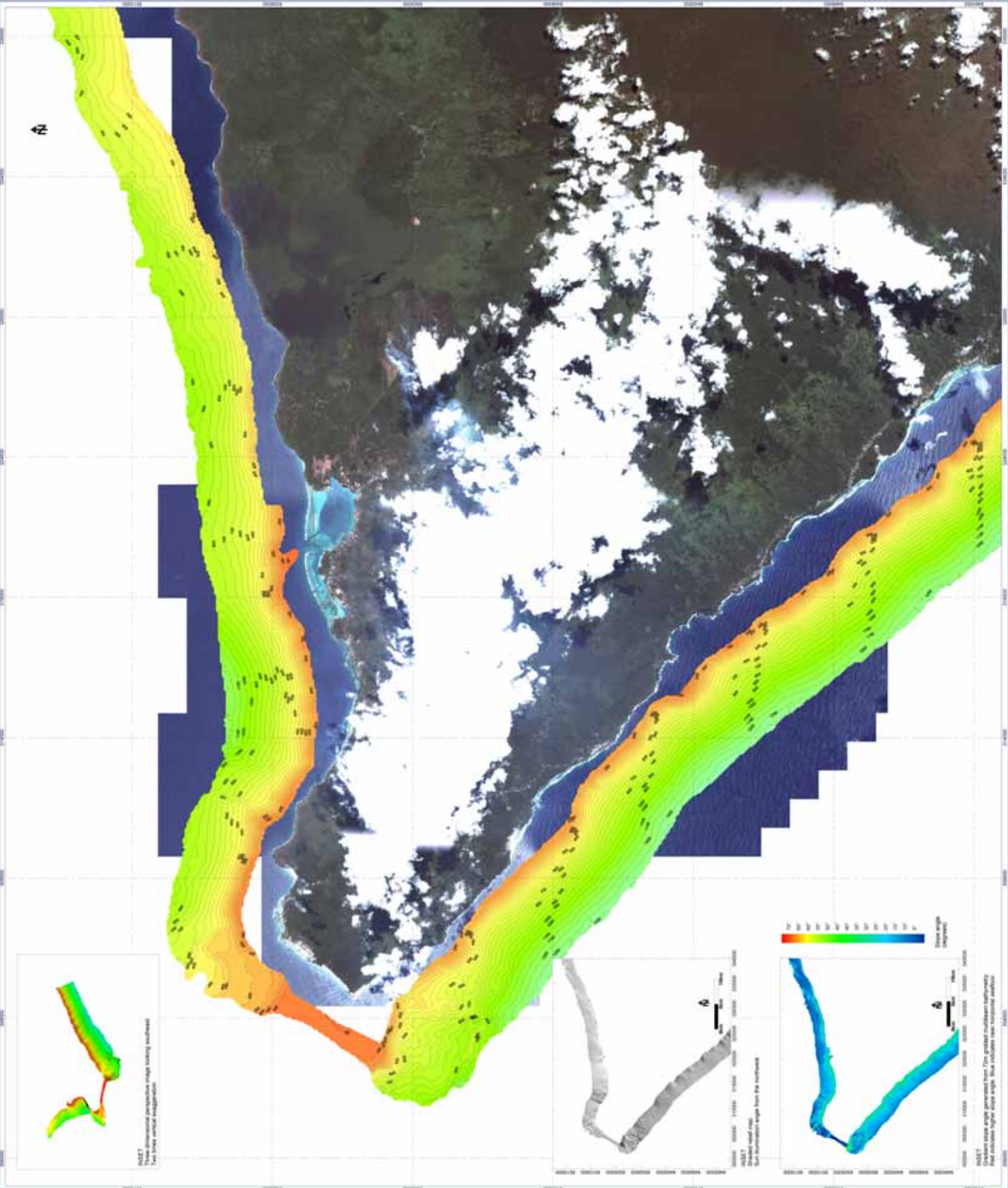
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DRAWING TITLE

SAMOA
UPLOU AND SAVAI
BATHYMETRY
COUNTRY 1

SO PACIFIC Project
 Raising Vulnerability of Pacific IAP States

Drawn by: John Kruger and Sarah Irvine
 Report Reference: BPT12, Drawing No.: BPT12.1



LEGEND

1:000 Bathymetric contours in metres

NOTES

Water depths were reduced to Mean High Water (MHW) from predicted low heights using vertical offsets from charted datum.

DATE OF SURVEY
 01/03 to 03/03/2006

INSTRUMENTS
 National Oceanic and Atmospheric Administration Echosounders
 Processing software: Nacal Sonar 2.2.2
 Chart datum: Mean High Water
 Survey vessel: M.V. 'Tangaroa'

Resampling MCHS03 image taken on 31/04/2004

LOCATION

GEODETIC INFORMATION

Coordinate system: WGS84
 Datum: WGS84
 Vertical datum: ITRF 2005
 Horizontal positioning: Island aware GPS
 Vertical positioning: Island aware GPS

NOT FOR NAVIGATION

SCALE
 Scale 1: 20,000
 Metres

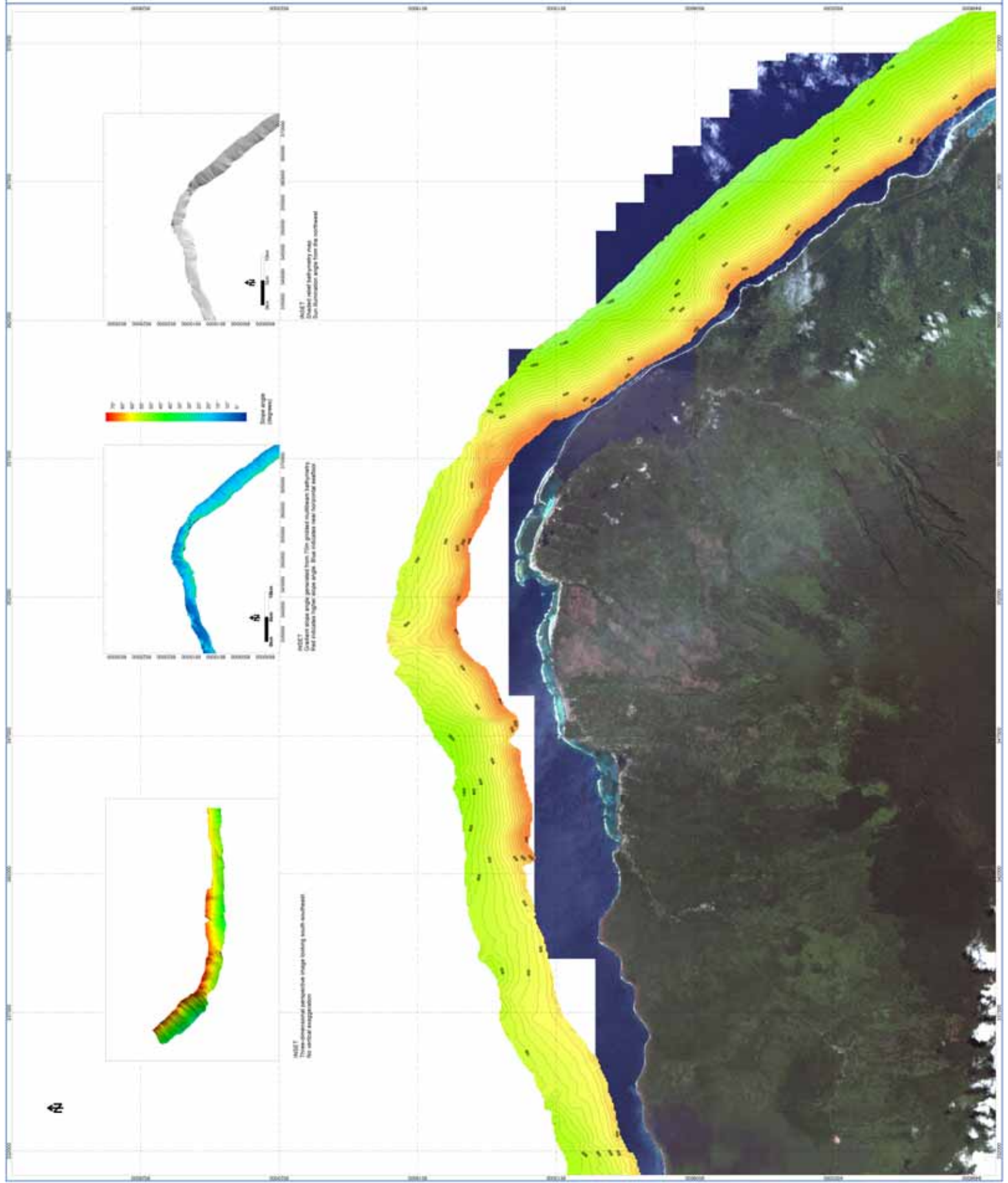
PROJECT TITLE
SOPAC
 PACIFIC ISLANDS APPLIED GEODESY COMMISSION
 Pohna Mall Bldg, GPO, Suva, Fiji Islands
 www.sopac.org

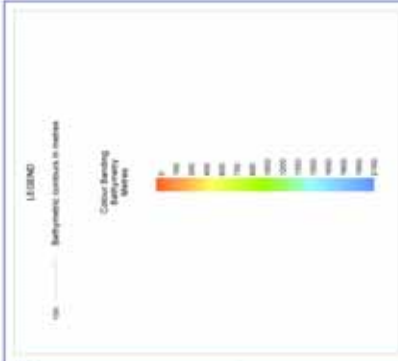
SPONSOR TITLE

 European University of Pacific-ACP States

CLIENT
 SAMOA
 UPOLU AND SAVAI'I
 BATHYMETRY
 CHART 2

Drawn by: John Kruger and Sarah Acosta
 Report Reference: 01/112, Drawing No.: 01/112.2



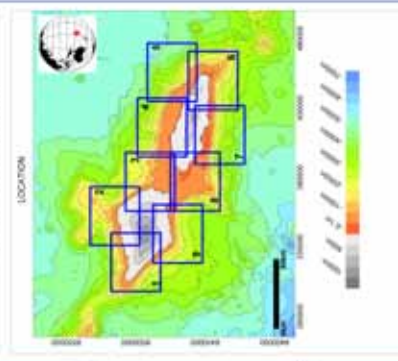


NOTES

Water depths were reduced to Mean Lower Low Water (MLLW) from predicted low tides using SWINEX software (www.swinex32.com).

Date of Survey: 27/01 to 11/02/2007
 Mission Number: 8163
 Acquisition System: Simrad EK60
 Processing Software: Simrad 2.2.2
 Data presentation: 1/4° x 1/4°
 Survey vessel: R/V 'Tougalua'

Background MCHN05 image taken on 15/06/2004



GEOGRAPHIC INFORMATION

Geoidetic datum: WGS84
 Ellipsoid: WGS84
 Projection: UTM Zone 1 South
 Horizontal positioning: Standard GPS

NOT FOR NAVIGATION

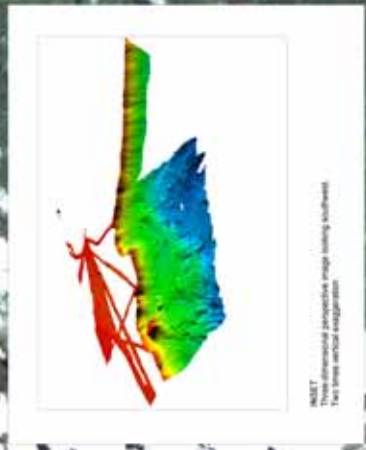
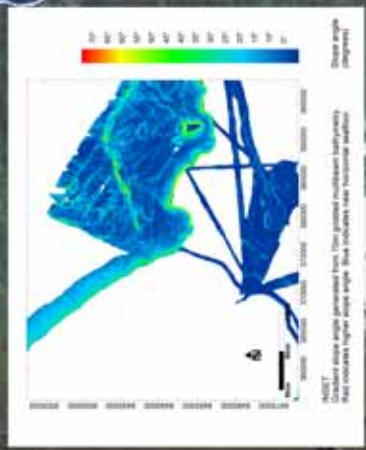
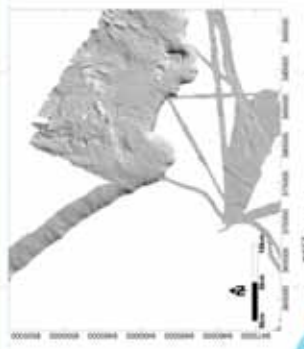
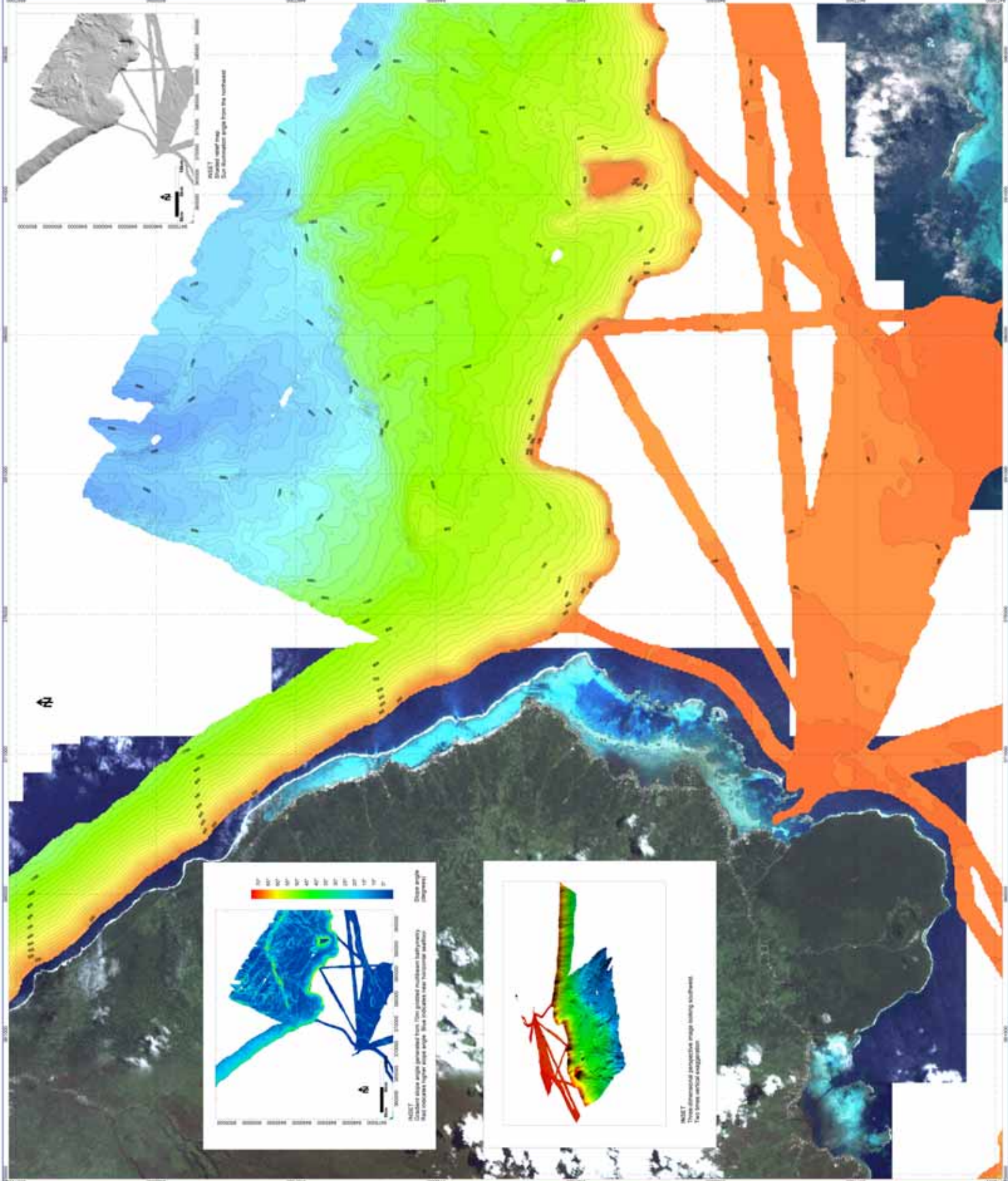


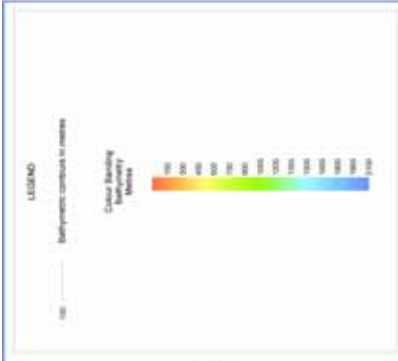
PROJECT TITLE
SOPAC
 PACIFIC ISLANDS APPLIED GEODESY COMMISSION
 Project Man: Ing. GPS, Tom, Pij Islands
 www.sopac.org

SOPAC/EU Project
 Receiving University of Pacific-ICP Samoa

DRAWING TITLE
SAMOA
UPOULU AND SAVAI'I
BATHYMETRY
CHART 3

Drawn by: Jens Kruger and Sarah Kramer
 Report Reference: 2011.02, Drawing No. 2011.12.3





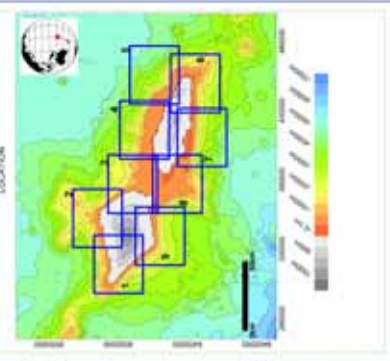
NOTES

Water depths were reduced to chart datum (1.20 m below MSL) for structural low heights using WATERS software (www.waters2.com)

DATE OF SURVEY
 01/02 to 02/02/02

PROJECT
 Pacific Islands Applied Geodesy Commission
 Construction of a new navigation chart for the islands of Samoa
 Survey vessel: M.V. Tuiasavala

Bathymetric image taken on 01/04/2004



GEODETIC INFORMATION

Geoid: datum: WGS84
 Projection: UTM Zone 3 South
 Horizontal datum: World average GRS

NOT FOR NAVIGATION

SCALE
 Scale 1:10,000

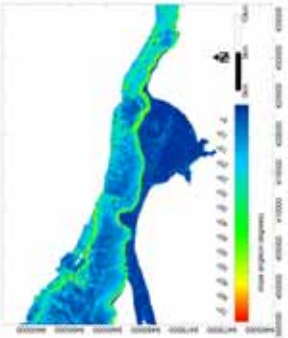
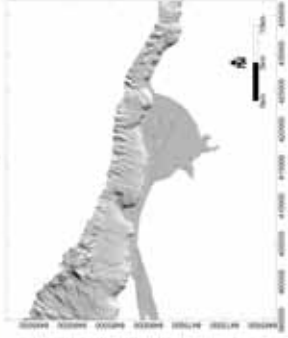
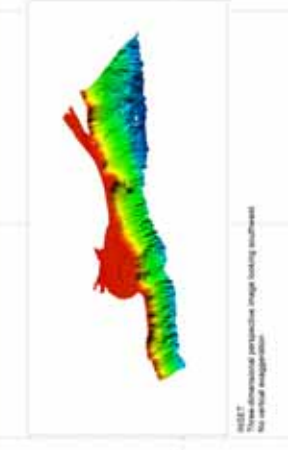
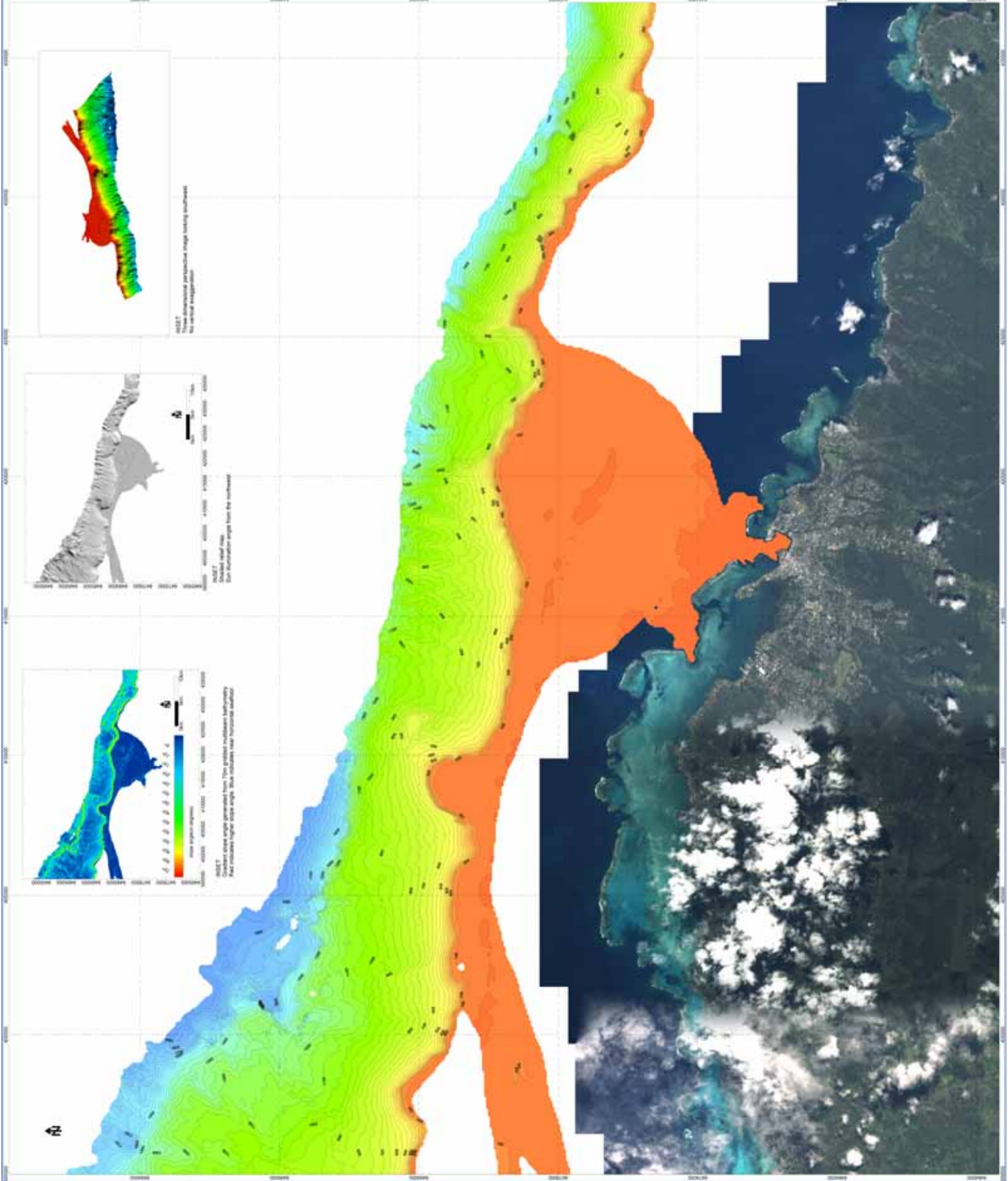
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
 Meters

AS Original

PROJECT TITLE
SOPAC
 PACIFIC ISLANDS APPLIED GEODESY COMMISSION
 Private Mail Bag, GPO, Suva, Fiji Islands

DRAWING TITLE
SAMOA
UPOLU AND SAVAI
BATHYMETRY
CHART 4

Drawn by: James Kuyper and Gert-Jan Kuper
 Report Reference: DITIG Drawing No. 13112.4



LEGEND
Bathymetric contours in metres

Contour Interval
10 metres

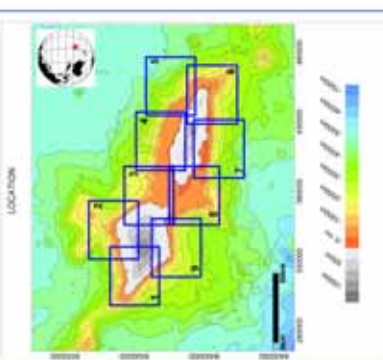
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000

NOTES

Water depths were reduced to chart datum (2.20 m below MHW) from predicted low heights using Ichibayashi software (see exhibit 52) (unit)

Date of Survey: 21/01 to 15/02/2004
 Survey System: Reson SeaSwath 8100 multibeam echosounder
 Navigation System: Garmin 188C GPS
 Processing Software: Surfer 8.2.2
 Data Presentation: Bathymetry
 Survey Method: 8° T-Configuration

Beaching and/or navigation marks are 1:5000 scale
NOT BE USED FOR NAVIGATION



SCALE
Scale 1:10,000

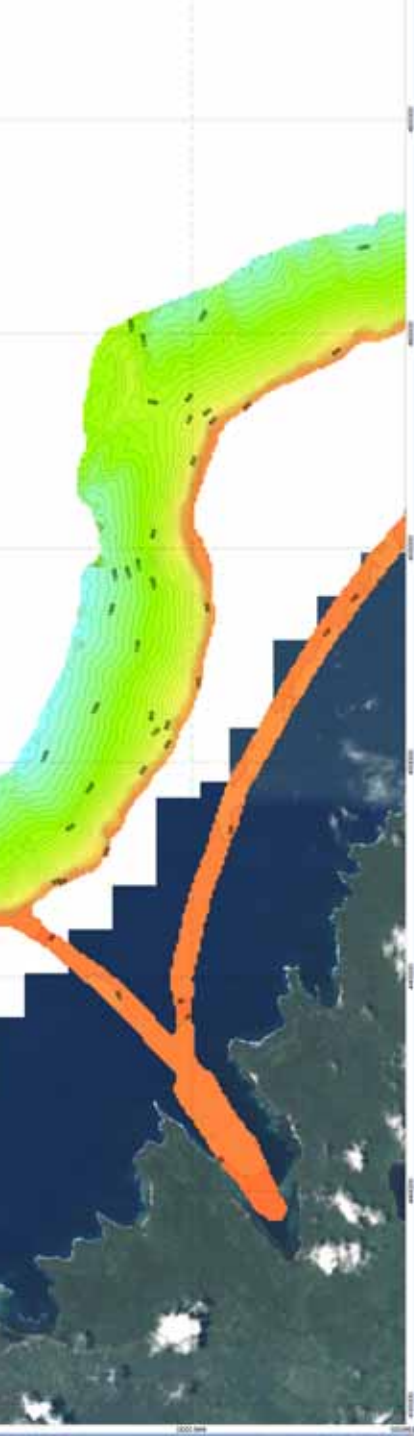
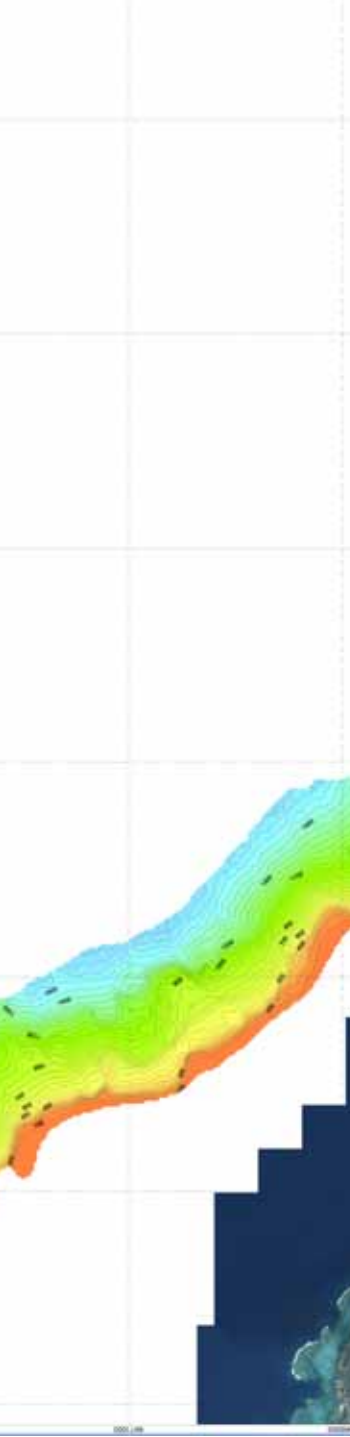
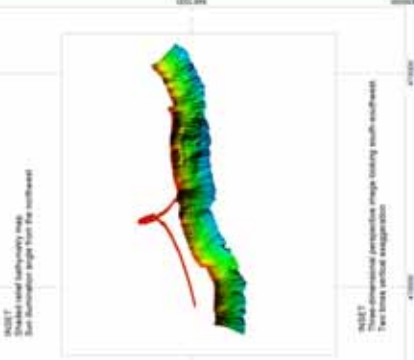
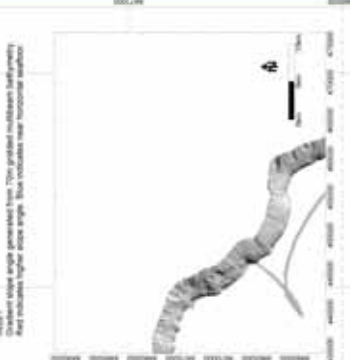
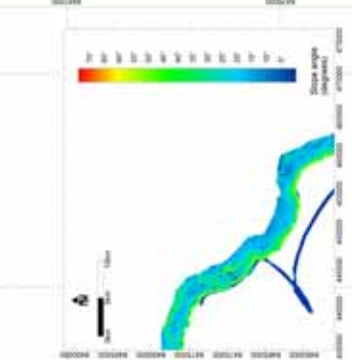
Metres

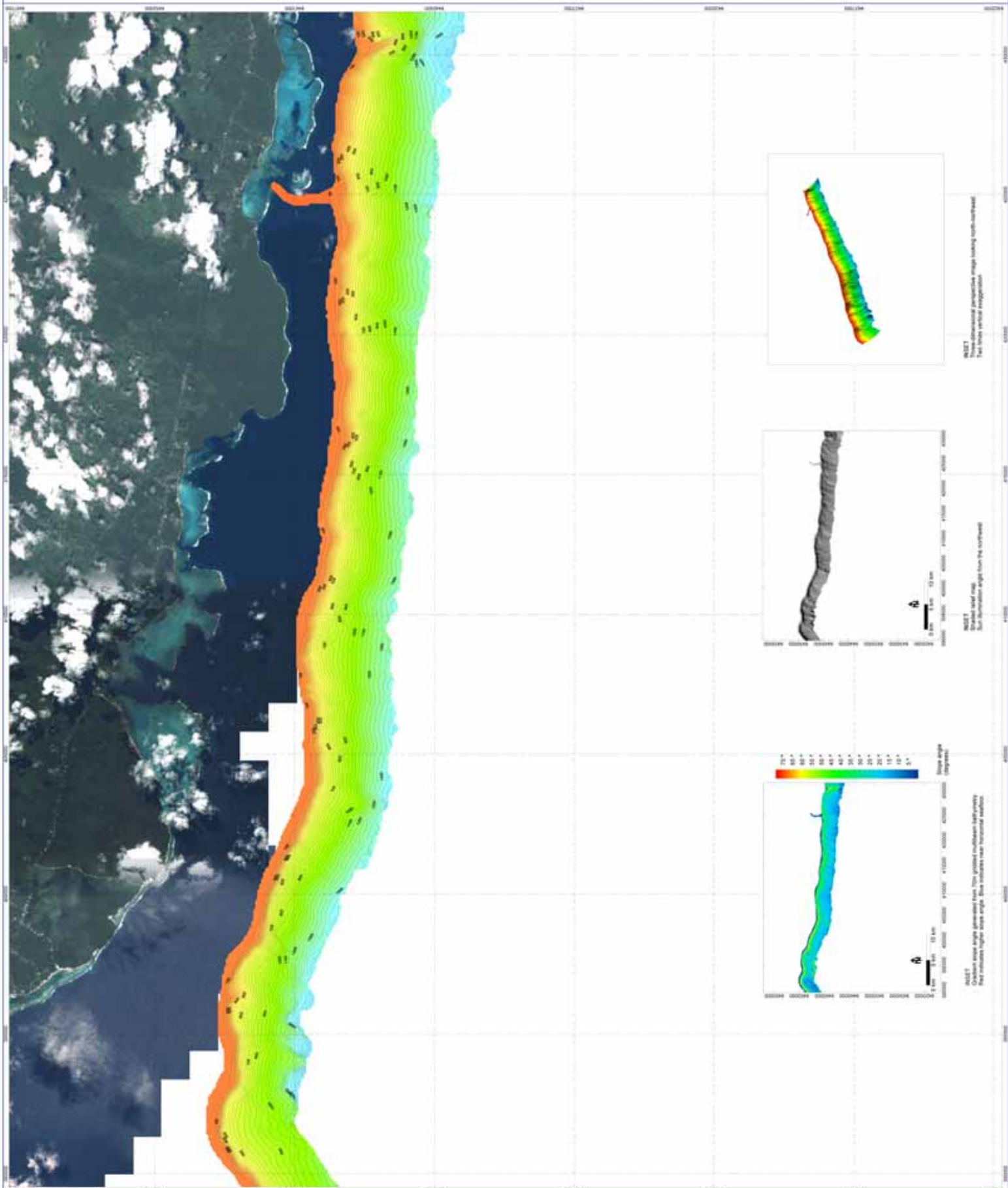
All Original

PROJECT TITLE
SOPAC
PACIFIC ISLANDS APPLIED RESOURCE COMMISSION
Project Area: PNG, GPS, Survey, PLS network
www.sopac.org

DRAWING TITLE
SAMOA
UPOLU AND SAVAITI
BATHYMETRY
CHART 6

Produced by University of Pacific ACP Islands
 Prepared by: JAMES HUGHES AND SARAH KILMER
 August 2004 (revision 1.1) Drawing No. 101113





LEGEND

Bathymetric contours in meters at 10 m intervals

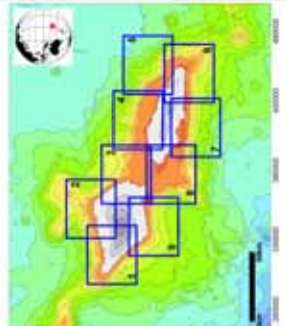


NOTES

Water depths were reduced to chart datum (3.28 m below MHHW) from predicted tide heights using VDatum software (www.vdatum.org)

Date of Survey: 01/12/2015
 Name: Sargol 1105 multibeam echosounder
 Acquisition system: Simrad EK60
 Processing software: HYPACK 4.1.34
 Date processed: June 9, 2017
 Survey vessel: R/V "Toungaloa"
 Sounding: WGS84 image taken on 03/04/2016

LOCATION



GEODETTIC INFORMATION

Geoid datum: WGS84
 Elevation: MGS04
 Projection: UTM Zone 1 South
 Horizontal positioning: Real-time GPS

NOT FOR NAVIGATION

SCALE



All Original

PROJECT TITLE

SOPAC
 PACIFIC ISLANDS APPLIED GEODETIC COMMISSION
 Pohnpei Marine Survey, FY 2016

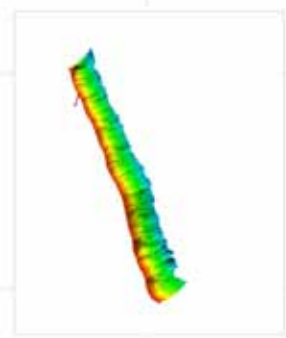


GEOPACELI Project
 National University of Pacific and CP Islands

DRAWING TITLE

SAMOA
 UPOI, SAMANAVI
 BATHYMETRY
 CHART 7

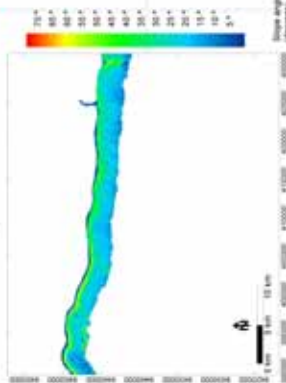
Drawn by: John Kruger and Sarah Kester
 Report Reference: EKI12, Drawing No.: EKI12.1



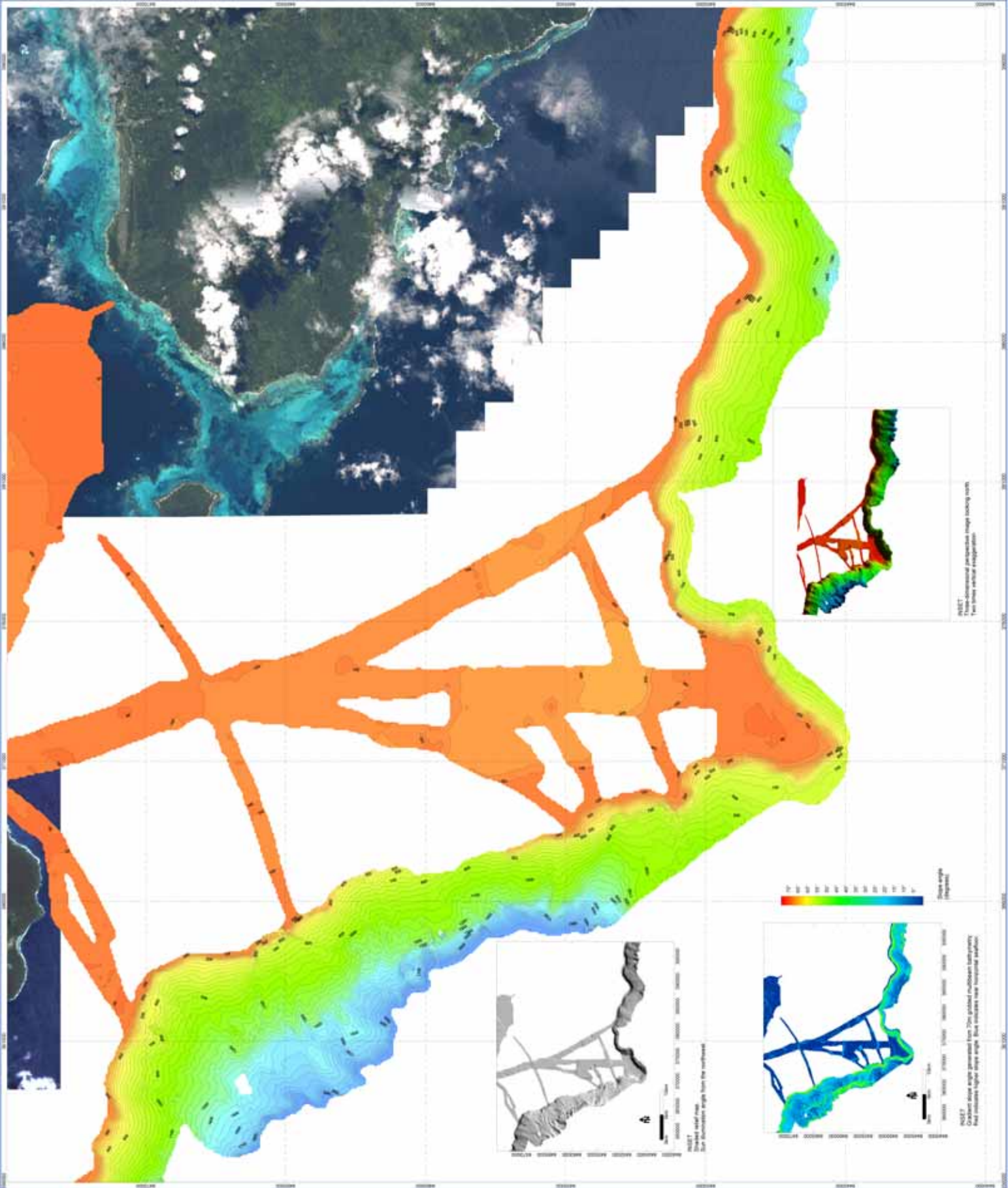
INSET
 Cross-sectional perspective image looking north-south
 Not to be used for navigation



INSET
 Cross-sectional image
 Not to be used for navigation



INSET
 Cross-sectional perspective view. This graphic indicates bathymetry
 but contains higher detail angle. Not to be used for navigation



LEGEND

Bathymetric contours in meters

Contour Interval: 5m

Minimum: 0m

Maximum: 200m

0m 5m 10m 15m 20m 25m 30m 35m 40m 45m 50m 55m 60m 65m 70m 75m 80m 85m 90m 95m 100m 105m 110m 115m 120m 125m 130m 135m 140m 145m 150m 155m 160m 165m 170m 175m 180m 185m 190m 195m 200m

NOTES

Water depth data reduced to least datum (LSD) in Java, MERIT10 projection using WGS84 software (www.wvnet.us).

1:5000 Scale

Date of Survey: 15-05-2012

Area: South of Ulu

Collection software: NGS 2.2

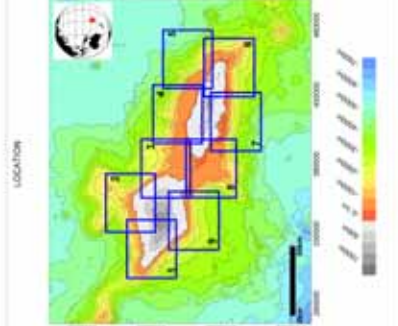
Chart projection: UTM Zone 49S

Chart datum: Mean Low Water

Survey vessel: M.V. Tirtajaya

Backsight: NCHCE image taken on 03/04/2014

NOT TO BE USED FOR NAVIGATION



GEOGRAPHIC INFORMATION

Coordinate system: WGS84

Horizontal datum: UTM Zone 49 South

Horizontal projection: Mercator (UTM)

SCALE

Scale 1 : 50,000

0 100 200 300 400 500 Meters

AS Original

PROJECT TITLE

SOPAC

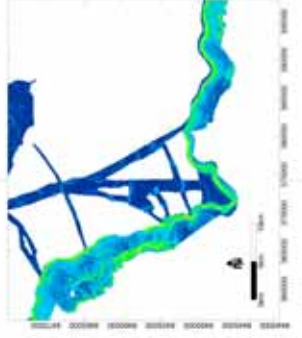
PACIFIC ISLANDS AND ASSOCIATION COMMISSION
 Project for Map UTM Zone 49 South

Reducing Vulnerability of Pacific ACP States

CLIENT TITLE

SAMOA
UPOLO AND SAVAITI
BATHYMETRY
CHART 8

Drawn by: Alex Kogler and Sander Kume
 Report Reference: 81112 Drawing No. 81112B



NET

True-angle perspective image looking north

True angle vertical exaggeration

This is a true-angle perspective image looking north. The vertical exaggeration is 10x. The map shows the lagoon's location relative to the surrounding land.

