ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION 2011

28th STAR Session is held in conjunction with the
1st SPC Applied Geoscience and Technology Division Meeting (17-21 October 2011)

Hosted by the Government of Cook Islands at the
Tanoa International Hotel, Nadi, Fiji Islands

SPC SOPAC Division Published Report 26

October 2011

*Science, Technology and Resources Network

Compiled and edited by:

John Collen[1] & Lala Bukarau[2]

[1] Victoria University of Wellington & [2] SPC SOPAC Division

Pre-Session Version, for use at the STAR Conference (17-18 October 2011)
A revised and final version of this document will be released after the Nadi conference

In 2010 and again this year (2011), the STAR Session is jointly convened with the Circum-Pacific Council for Energy and Mineral Resources

CONTENTS

Note from compilers

Abstracts included in this volume were received up until the close of business on Wednesday, 13 October 2011.

FOREWORD

As SOPAC moves into a new phase of its existence as a Division of the Secretariat of the Pacific Community (SPC), it is pertinent to review the role that STAR has played in SOPAC's evolution over the past 25 years. STAR (the Science, Technology and Resources Network) was founded in 1985 in collaboration with the International Oceanographic Commission, to facilitate the continuing provision of advice to SOPAC by the international geoscience community. The first Chair of STAR was Charles Helsley, then Director of the Hawaii Institute of Geophysics. He was succeeded in 1992 by Keith Crook from the Hawaii Undersea Research Laboratory and, in turn, John Collen from Victoria University of Wellington became Chair in 1999.

Apart from giving advice, facilitating research in the region and sponsoring workshops and meetings, STAR organised an annual conference each year in conjunction with the annual meetings of SOPAC's Governing Council. The STAR conferences were not simply technical conferences at which individuals presented and discussed scientific papers, as participants had the additional responsibilities of formulating advice to SOPAC about its work program and highlighting technical and scientific issues of particular importance or urgency to the region. This advice, as reports and recommendations from STAR Working Groups and summaries of highlights of STAR technical presentations, was formally presented to Council through an address in Plenary by the Chair of STAR and during the Governing Council/Technical Advisory Group (GC/TAG) segment of the Annual Sessions.

SOPAC's role in the Pacific region evolved continually since its formation. A fundamental and essential strength throughout, though, was its ability to mobilize multidisciplinary science to address the national needs of its island member countries. The long-established working relationship between SOPAC and the international research community was a vital element in this endeavour, and much of this was focussed through STAR. This voluntary association saw the interests of STAR members and the themes of the annual meetings change similarly through time. In earlier years STAR was primarily concerned with "blue-water" marine geoscience, tectonics and resource exploration and evaluation. However, as national needs and priorities changed, the scope of STAR similarly expanded. During the 1990's STAR supported the changes in SOPAC's scope and focus that led to the development of the three major work programmes. From 2005, Programme Monitoring and Evaluation Groups (PMEGs) composed of STAR/TAG scientists met with SOPAC Programme Managers prior to the STAR Meeting and then reported directly to Council as independent advisers during the joint TAG/Council deliberations. This was deliberately intended to allow wider and more detailed participation of international scientists in assisting SOPAC's work.

Now that the future of SOPAC as a Suva-based division of SPC has been formalised, we have the opportunity to put behind us the uncertainties that developed over the past few years during the Regional Institutional Framework (RIF) process. SPC has pledged its full support to STAR, and other regional technical organisations have expressed similar sentiments. Further, in 2010 and again this year, sessions have been held jointly with the Circum-Pacific Council for Energy and Mineral Resources, a relationship that I hope will continue. Thus, we have the opportunity to not only continue our long-term relationship but to widen our endeavours in Pacific science in collaboration with and for the benefit of the SOPAC nations. STAR will continue to support the work of SOPAC and **associated** organisations in the Pacific region and, as in the past at Governing Council meetings, give what support and advice we can to the new Division at its annual meetings. In that respect, the participation of all STAR delegates as technical advisers during the SOPAC Divisional Meeting that follows this conference is welcomed.

The theme of this the 28th STAR Conference is "Adaption to Climate Change and Environmental Change in the Pacific Islands", with a joint STAR-Circum Pacific Council session on the topic "Seabed Minerals". The abstracts in this volume relate to both of those important themes but, as has become traditional at STAR conferences, also cover a wide range of other relevant research.

John Collen
Chair, Science Technology and Resources Network
School of Geography, Environment and earth Sciences
Victoria University of Wellington, Wellington, New Zealand

October 2011

ABSTRACTS OF PAPERS

ANDERSON

Aquatic pollution in Suva, Fiji

Edward P. Anderson
School of Marine Studies, The University of the South Pacific, Suva, Fiji Islands
Email: epasalt@gmail.com

Every year from 2004 through 2011, students at the University of the South Pacific have sampled faecal coliform bacteria (FC), salinity, temperature and oxygen in the creeks, rivers and foreshore of the greater Suva area. This paper focuses on FC, which are the most important measure public health in both drinking and recreational waters. Fiji and World Health Organization standard for water-contact activities is 200 FC colonies/100ml. Most FC are not pathogenic, but they indicate the possible presence of pathogens.

All of the creeks and rivers are above this standard, often by 200x to 500x. Some of the foreshore, including beaches which are commonly used for swimming, are occasionally below this standard in fair weather. Total average range is from 13X to 503x for rivers and from 4x to 52x for foreshore. The most notoriously polluted creek is in the centre of the city, but it is apparently declining in recent years while others are increasing.

FC results are highly variable, thus one count at one station is of doubtful value. Repeated tests are necessary to develop a meaningful database. FC results are influenced by salinity, rainfall, sunlight, and age of the culture medium. They are negatively correlated with dissolved oxygen.

ANTON & KUDUON

Finschafen Earthquake Swarm, Morobe Province, Papua New Guinea

Lawrence Anton[1] and Jonathan Kuduon[2]
[1]Port Moresby Geophysical Observatory, P.O. Box 323, Port Moresby, National Capital District, Papua New Guinea
[2]Rabaul Volcanological Observatory, P.O. Box462, Rabaul, East New Britain Province, Papua New Guinea
Email: lawrence_anton@mineral.gov.pg

Strong shaking and sounds heard from a series of locally generated shallow earthquakes within Finschhafen District was reported to have been ongoing and experienced since the beginning of May 2011, and possibly earlier. Although no major damage was experienced, there had been fear of even bigger events occuring in the near future. The Port Moreby Geophysical Observatory (PMGO) adviced that past experiences have indicated otherwise, but advised that the communities stayed intune to instructions and information emarnating from authorities, at the district, provincial and national levels.

PMGO monitored the situation closely in relation to the possibilities of future continuing acivity. It was adviced that based on past experiences, the series of earthquake activity is known as an "earthquake swarm". The swarm is caused by sustained crustal strain due to the deformation in the upper plate which increases the rate of stress buildup. The stress buildup eventually changes tectonic stress conditions in the area, therefore reactivating nearby geological faults and resulting in the locally generated shallow earthquakes.

Amongst the earthquake swarm the four events that were of magnitude >5.0 have occurred. The largest of the earthquakes, a magnitude 5.6 occurred on the night the temporary seismic network was being deployed. Many other earthquakes of lesser magnitudes (those of magnitude < 5.0) have occurred, almost all not recorded. The activity has decrease but is expected to continue. Thirty smaller earthquakes were detected by the three seismic station configuration deployed during the day of 2nd July 2011. The

monitoring instruments of the Global Seismic Network in PNG and the neighbourhood recorded fifty earthquakes of magnitude 4 and 5. The four earthquakes of magnitude 5 are listed in Table 1 below.

Table 1. Magnitude 5 and above earthquakes within the swarm, from April to July 2011.

YEAR	MO DA	ORIG TIME	LAT (◦S)	LONG (◦E)	DEP (Km)	MAG	SOURCE
2011	05 11	152126.06	6.52	147.80	44	5.0	mbGS
2011	05 18	185126.58	6.63	147.89	52	5.5	MwGCMT
2011	06 10	001123.39	6.62	147.87	51	5.2	mbGS
2011	07 01	162550.30	6.68	147.85	52	5.6	MwWCMT

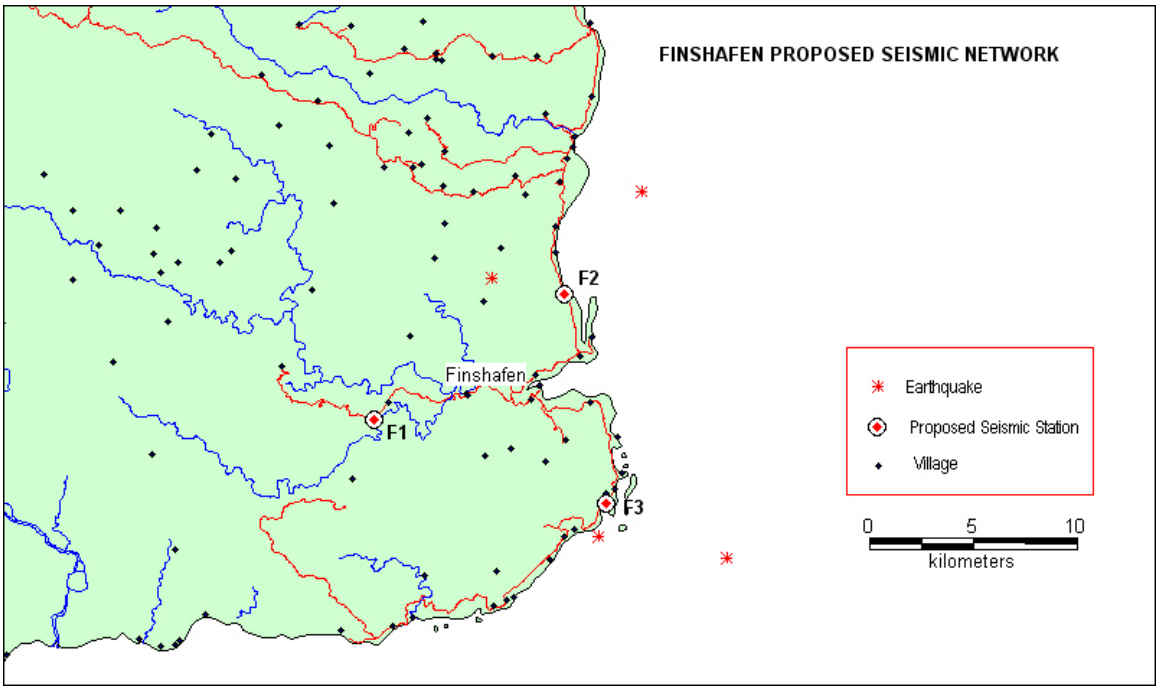


Figure 1. Proposed locations of the seismic stations in relation to Finschhafen township, and a few earthquakes at the beginning of the earthquake swarm. This seismic station configuration was altered during the time of deployment, and followed the one shown in Figure 2.

The activity is not volcanic as the area is not near active volcanoes, nor the earthquakes big enough to generate tsunamis. Tsunamigenic earthquakes are those of magnitudes above, or greater than magnitude 6.0, but lower sized earthquakes may be able to. The ongoing activity can result in the gradual disturbilising and dislodgement of sediments offshore, due to continuing shaking by the earthquake swarm, especially by those of reasonable size (those above magnitude 5.0).

The focal mechanisms of the two magnitude 5 earthquakes are normal fault solutions shown in Figure 3, indicating extension or opening of the crustal upper plate (Bismarck Plate) as a result of flexing or stretching over/above the subducting Solomon Plate.

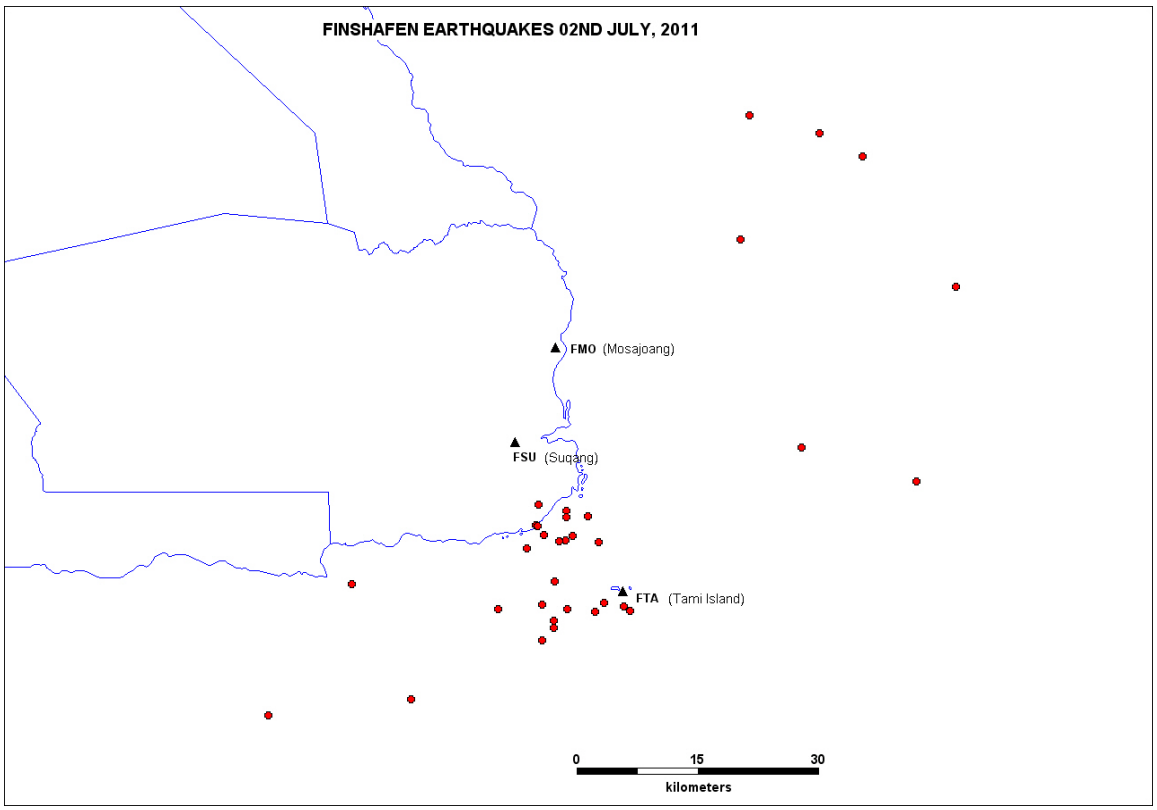


Figure 2. Seismicity recorded by the seismic stations FMO, FSU and FTA, during the 2nd July 2011. The stations are marked by black triangles and located in the villages of Mosajoang, Suquang and on Tami Island.

It is now established the zone of origin of the earthquake swarm, and for the reasonable sized earthquakes it is advisable that people stay away from coastlines when they feel strong shaking. The earthquakes are originating mainly offshore, in line with a feature that is known to have become active during the 1987 magnitude 7.8 Siassi Earthquake and aftershock sequence. Figure 2 show the earthquakes that were recorded during the deployment on 2nd July, while Figure 3 shows the overlay of these earthquakes, those in the magnitude range 4.0 – 5.9, on the plot of the 1987 Siassi Earthquake and it's aftershock sequence.

The fact that noises are heard accompanying the earthquakes indicates their nearness to Finschhafen and their shallow depths origin.

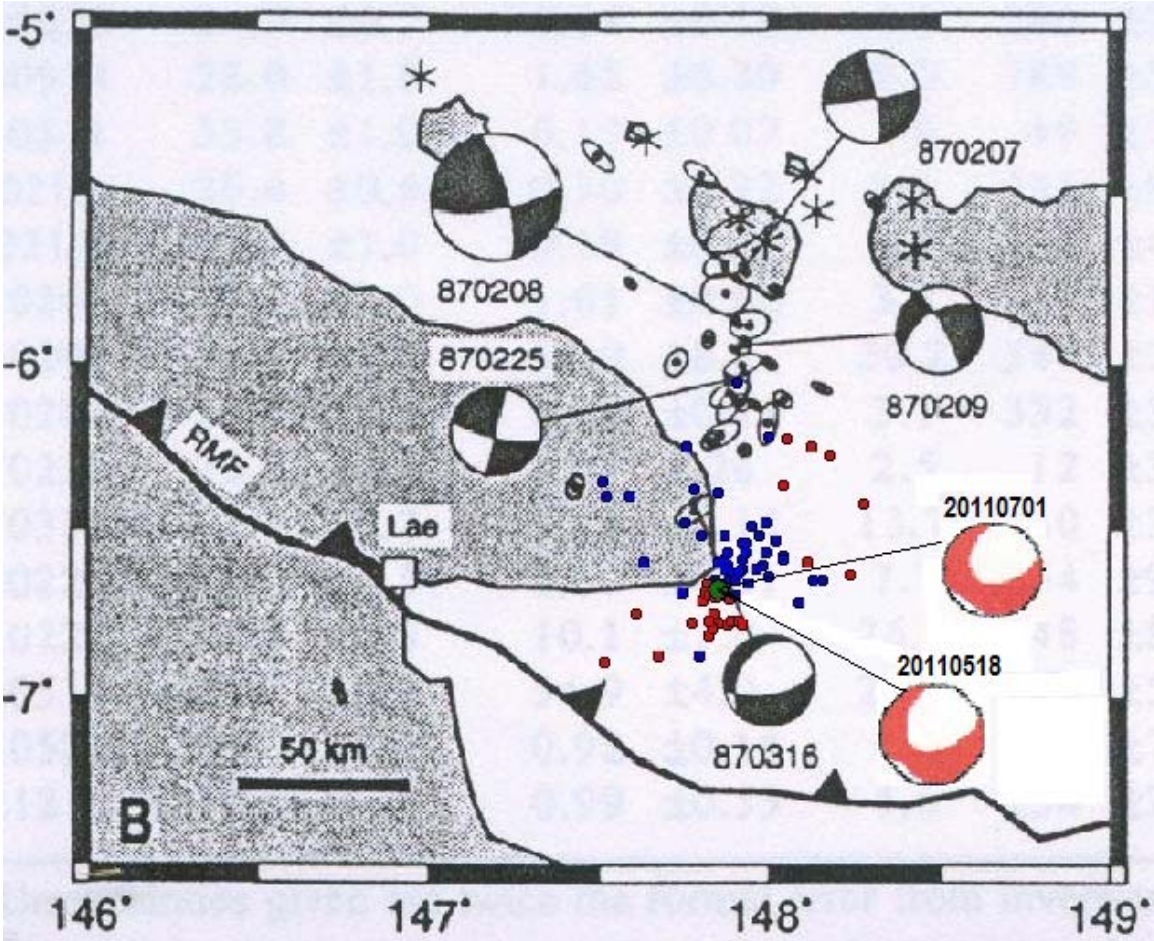


Figure 3. The 1987 Siassi Earthquake and aftershock sequence (from Abers and McCaffrey, 1994), overlain on the seismicity recorded during the 2nd July 201, in red while the earthquakes in the magnitude range 4.0 to 5.9 are in blue (located by USGS/NEIC, 2011). The earthquakes recorded during the 2nd July and the aftershock sequence of the 1987 earthquake coincides around the Finschhafen area where the earthquakes of magnitude 5.5 (20110518) and 5.6 (20110701) occurred.

References

Abers, G. A., and McCaffrey, R., 1994. *Active arc-continent collision: Earthquakes, gravity anomalies, and fault kinematics in the Huon-Finisterre collision zone, Papua New Guinea,* Tectonics, 13(2), 227–245.

United States Geological Survey, 2011. *Preliminary Determination of Epicenters, monthly listings*, U.S. Department of Interior/Geological Survey, National Earthquake Information Center, Denver, Colorado.

ARTACK & OTHERS

Successful progress of the PICs national efforts relating to the Maritime Boundaries Sector activities in the Pacific

Emily Artack, Arthur Webb & Andrick Lal
SOPAC / SPC, Private Mail Bag, GPO, Suva, Fiji
Emails: Emily@sopac.org, Arthur@sopac.org, andrick@sopac.org

The AusAID-funded Maritime Boundaries Sector within the SOPAC Division provides technical advice and training to the SOPAC member countries relating to the definition of national baselines and the outer limits of the maritime zones under the United Nations Law of the Sea Convention (UNCLOS).

Every year, the Maritime Boundaries team has been reporting on its activities relating to the mapping systems, surveying technology and field work used by the project team. This year significant work has been undertaken by the project team in close collaboration with its project partners (Geoscience Australia and the Australian Government's Attorney General's Office) in reviewing and updating the national maritime legislation of two Pacific Island countries, Niue and Tuvalu. The Project team visited the two countries earlier this year and held high level Government briefings and consultations with the relevant Government departments, and task-forces in both countries. The purpose of the visits were to discuss the progress of the technical work that the Project has achieved since 2002, and to work with the technical and legal representatives in-countries in updating the national maritime acts and legislation to reflect the updated baseline and maritime limits information developed by SOPAC.

The in-country visits by the SOPAC Maritime Boundaries Sector and the Australian AG's Office provided valuable outcomes as the countries were given information detailing the necessary steps on how to declare their maritime boundaries, how to draft public notices and in the preparation for bilateral negotiations with their neighbouring countries. This presentation will discuss the Project achievements to date and highlight the need for PICs Governments to consider the legislative aspects of declaration as well as the technical input. In cases like Niue and Tuvalu, the technical solutions adequate for declaration have been available since 2005. However, neither country could take advantage of this data due to outdated maritime acts which did not serve well the needs of the country or facilitated the use of the more accurate maritime boundaries data.

BACA & OTHERS

PCRAFI: Better Information Smarter Investments

Abigail Baca[1], Paolo Bazzurro[2], Litea Biukoto[3], Michael Bonte-Grapentin[1], Phil Glassey[4], David Heron[4], Mereoni Ketewai[3], Olivier Mahul[1], Joy Papao[3], Amrit Raj[3], Jay Roop[5], Sachindra Singh[3], Susan Vocea[3]

[1] World Bank
[2] AIR WORLDWIDE
[3] SPC SOPAC Division
[4] GNS
[5] Asian Development Bank

The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) is providing for the first time quantitative and probabilistic risk information for all Pacific island countries. The Pacific Region is prone to many natural hazards that threaten populations and cause significant economic losses due to damages to the built environment and crops. An extensive study has been conducted to analyze the risk from tropical cyclones, earthquakes, and tsunamis. This included the generation of detailed exposure information to locate and characterize over 3.5 million buildings and infrastructure in 15 island countries . The impact that historical events have had on the people and assets of these countries has been investigated to understand the extent of adverse consequences that possible future events may bring. Ten thousand simulations of potential future annual tropical cyclone and earthquake activity in the Pacific Region have been carried out to estimate risk in terms of monetary loss and casualties. The country risk profiles derived from this study can be used to improve the resilience of Pacific island countries to natural hazards. The initiative has been implemented jointly by the Applied Geoscience and Technology Division of the Secretariat of the Pacific Community (SOPAC), the World Bank and the Asian Development Bank, with technical inputs from AIR Worldwide, GNS Science, Geoscience Australia and national technical agencies.

BAKER & OTHERS

Blue Carbon – Management of coastal ecosystems to support Millennium Development Goals

Elaine Baker, Anissa Lawrence & Steven Lutz
UNEP/GRID Arendal, School of Geoscience University of Sydney, NSW 2006, Australia
Email: elaine.baker@sydney.edu.au

Many Pacific islands are extremely vulnerable to climate change. Coastal ecosystems, in particular mangroves, seagrasses and saltwater marshes provide ecosystem services, including coastal protection from climate change associated hazards such as erosion, flooding and storm waves and surges. In addition to providing a measure of resistance and resilience to coastal communities, these blue carbon sinks sequester and store carbon from the atmosphere at rates that have been estimated to be up to 50 times greater than tropical forests. Increased understanding and acknowledgment of the role of blue carbon in climate change mitigation, may see the development of a market based payment for ecosystem services, which could support the sustainable management of these coastal ecosystems.

COLLEN & OTHERS

In-situ measurements of H_2S concentrations in euxinic atoll lagoon waters

J.D. Collen[1], D.W. Garton[2] & J.P.A. Gardner[3]
[1]School of Geography, Environment & Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand
[2]School of Biology, Georgia Institute of Technology, Atlanta, Georgia 30332, USA
[3]School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand
Emails: john.collen@vuw.ac.nz; david.garton@biology.gatech.edu; jonathan.gardner@vuw.ac.nz

Previous studies have shown the waters of the lagoon system of Palmyra Atoll in the northern Line Islands to be strongly stratified, with extensive dysoxia and anoxia in the bottom layers (Gardner *et al.*, 2011). Here we present *in situ* measurements of the hydrogen sulphide content of these waters by amperometric microsensing. pH, dissolved oxygen, temperature, density, salinity and chlorophyll a were measured simultaneously with H_2S, and bisulphide calculated from pH and H_2S values. Results confirm the presence of oxygen-saturated surface waters and very strongly sulfidic, anoxic bottom waters separated by a narrow but well-defined suboxic zone. High H_2S levels are associated with elevated ammonia, and decreased pH, temperature and chlorophyll a. The high H_2S and associated bisulphide values result from the activity of sulphate-reducing bacteria, stimulated by the abundant descending organic matter in the nutrient-rich lagoons. The system is unusual in that, despite the marked changes through the water column of dissolved oxygen and H_2S, there is only an extremely weak pycnocline. These are the first such results from an atoll setting, and the high concentrations of toxic material together with a potentially unstable stratification argue for a precautionary approach to any land modifications here that may alter surface water flow and possibly disturb lower water layers.

Reference:

Gardner, J.P.A., Garton, D.W., Collen, J.D. 2011. Near-surface mixing and pronounced deep-water stratification in a compartmentalised, human-disturbed atoll lagoon system. *Coral Reefs*, 30: 271–282.

FISHER

Vulnerability and resilience of the hydrothermal vent communities to polymetallic sulfide deposit mining

Chuck Fisher
Biology Department, The Pennsylvania State University, 208 Mueller Lab, University Park, PA 16802-5301, USA
Email: cfisher@psu.edu

Compared to the stable, cold, dark, and food limited "normal" deepsea, hydrothermal vents are highly productive patchy and ephemeral environments, characterized by fluctuations in temperature and chemistry that range from ambient to levels inhospitable to life. Although these environments are not suitable for most animals on Earth, quite a few animals have evolved adaptations that not only allow them to survive in this hostile environment, but to flourish there in very large numbers. This requires special adaptations, and as a result the animals that live around hydrothermal vents are often metabolically unique animals with specialized life history strategies, and the communities exhibit a high degree of endemism and low diversity. Globally, one finds different animals and communities in different biogeographic regions. Throughout the West Pacific the communities found on spreading centers are quite similar to one another, although there is also a substantial amount of regional variation as well as site-to-site differences on even smaller scales.

The absolute reliance of many of the animals on quite specific microhabitats within the vent environment, coupled with the sessile habit of many species, will result in mortality of most individuals associated with any active vent area mined. On the other hand, most of the species must be adapted at the population level to catastrophic events, because hydrothermal vents exist in tectonically and volcanically active environments. As species they can and do survive the regular (natural) events that wipe out local populations. Current data suggests that in general, the metapopulations (the populations that constitute an interbreeding group) of the most common fauna, and likely most of the less common fauna, are relatively large and include at least multiple vent sites. In most cases the metapopulations occupy larger regions. As a result, mining activities that are planned with consideration of conservation of the regional gene pool may have little long-term effect on the hydrothermal vent fauna of the region. On the other hand, poorly planned or regionally intense mining activities could have devastating effects on the fauna, especially on relatively rare species or isolated populations. Although our knowledge about these fauna allows the kinds of predictions indicated above, careful monitoring before, during and after the impending mining of hydrothermal vents in the West Pacific will provide the hard data that will guide the responsible hydrothermal vent mining practices of the future.

FORSTREUTER

Forest change detection in Fiji, results and lessons learned

Wolf Forstreuter
SPC-SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: wolf@sopac.org

Figure 1: *Gallery forest contains dense timber and is of ecological importance. It was only partly counted as forest in the last inventories. For a forest change detection related to REDD is must be included.*

Fiji was the first Pacific Island Country for which a forest mapping as part of a national forest inventory was performed with satellite image data, which was back in 1991. Fiji was also the first Pacific Island Country for which a follow-up inventory was carried with satellite images recorded 10 years later. Now, Fiji needs the change of forest area as part of the REDD preparedness. GIZ financed additional satellite data recorded in 2007 and analysis of all historical and recent image data to calculate the rate of deforestation.

As the mappings of 1991 and of 2001 image data were available as digital layers a computerised overlay process would have produced fast results, but the reality was that both layers were not compatible as the forest definition was different in both mappings (example see Figure 1). Also the definition of forest plantations created problems related legal issues not to any image analysis. Atmospheric correction software helped to reduce the atmospheric differences related to relief and local haze, however, partly forest had still to be mapped from image data affected by haze.

The solution was new visual image interpretation of data recoded in all three mentioned years. The interpretation was carried out for 10 x 10 km map sections subdividing the topographic map sheets which today cover all Fiji. Following classes were separated: Forest, mangrove, pine plantation, hardwood plantation, coconut, non-forest and water where plantation areas and coconut cover was based on external mapping resource not on own classification. The interpretation and delineation was performed with vector based GIS software (MapInfo) while image enhancement and overlay analysis had to be carried out in raster data based image analysis software (ERDAS) and all area calculation was executed in database software (Access). The data was shifted between these products. For every map section the interpretation was also described to document which image data was utilised and where changes were detected.
The deforestation rate of about 1 % is unexpected low. One of the reasons is that forest is still counted as forest even after heavy logging. The current change detection only documents the area converted from forest to non-forest. With image data of 1:50,000 scale level (Landsat) mapping of forest degradation is extremely difficult in Fiji. Even in cases where logging tracks are visible in the image data and indicate serious timber extraction the land cover class "forest" will not change.

The image data utilised did not allow to separate coconut cover from forest cover and the external mapping could not be checked with own interpretation, only logical check could be applied. Also for this purpose very high resolution image data would bring advantage.

Image data of 1991 was partly lost and could not be fully recovered from external data sources. It is essential that a regional organisation provides data backup for such a mapping which is the case now. Even recognising that forest change detection requires a complicated procedure, it is extremely important to build and maintain own capacity otherwise Pacific Island Countries depend with this sensible issue on external consultants.

Land cover mapping of low-lying Pacific Islands baseline for drought mapping?

The Department of Agriculture, the Environment Department and the Lands Department of both countries Tuvalu and Kiribati expressed the need to map their vegetation cover due to their obligation to report to FAO, due to food security issues and to attract alternative fuel related projects.

All outer islands of Kiribati and Tuvalu are currently mapped at 1:10,000 scale using pan-sharpened QuickBird and multi-spectral IKONOS very high resolution (VHR) satellite image data. The delineation between the main land cover or vegetation types is performed as visual image interpretation utilising colour and texture image features. The mapping is carried out at SOPAC by staff from Kiribati and Tuvalu with assistance of the corresponding departments in the countries. The land cover is stratified into: a) forest, b) mangrove, c) dense coconut, d) semi dense coconut, e) scattered coconut, f) shrub, g) bare land, h) settlements, i) water bodies. The coconut density is estimated through statistically sound distributed sample plots for which the number of palms is counted through a semi-automatic process connecting MapInfo GIS software with Access database software. Whenever an island is mapped the report containing the area analysis and coconut palm density figures is sent to all relevant stakeholders. In addition, a customised GIS is established in SPC Land Resource Division allowing the display of all relevant information when clicking on an island (Figure 1).

By today ¾ of all outer islands are mapped which provides the base line of several climate change related questions such as change of sea level or salinity where mangroves are sensitive. It also will provide the base line for mapping drought effects on vegetation due to level or salinity change in the fresh water lens. Where VHR multi-spectral image data is available from the current mapping the ration between the red portion spectrum and the near infrared indicates the healthiness of the plants. This ratio is influenced by cell wall on the leaves and changes before wilted leaves are visible. In case of reported drought new VHR image data has to be recorded and analysed, but the ration can be compared with the ratio image of the historical VHR image data which is a fast semi-automatic image analysis procedure.

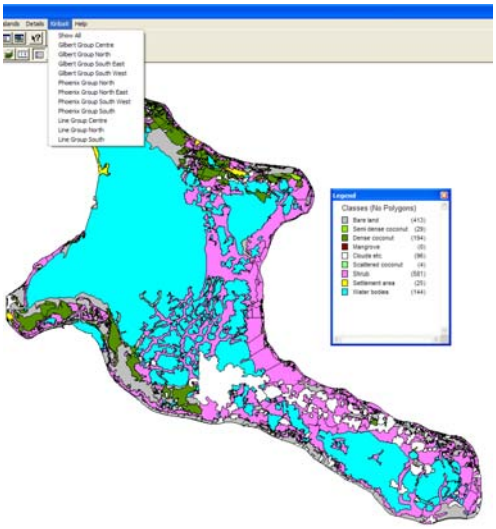


Figure 1: *Display of vegetation cover for Christmas Islands, customised GIS at Land Resource Division SPC*

GARAEBITI & OTHERS

Developing national seismic monitoring capability for regional earthquake and tsunami warning center: the example of New Caledonia-Vanuatu seismic regional network

Esline Garaebiti[1], Sylvain Todman[1] & Pierre Lebellegard[2]
[1] Geohazards Section, Vanuatu Meteorology and Geohazards Department, Port-Vila, Vanuatu
[2] Institut de Recherche et Développement, Nouméa, New Caledonia
Email: gesline@vanuatu.gov.vu

Thirty percent of worldwide earthquakes occur amongst South West Pacific area, however average detection time for local and regional seismic events is one of the lowest times locally. Eighty one percent of the pacific tsunamis are generated by earthquake, increasing the seismic detection response will help to enhance tsunami early warning system. In order to have a succesful local alert system, observatories need to detect as fast as they can the early signs of potential tsunami. Following the UN/IOC recommendations regarding tsunami threats, pacific countries need to have a system fully owned by themselves and based on regional multilateral cooperation with the support of an open and free exchange of data.

One of the possible solution to improve responsiveness and capacity building of National Warning Center is to develop regional cooperation between countries. The example of the New Caledonia – Vanuatu Regional Seismic Network, developed by a dual governmental project since January 2011, show how two countries could mutualize resources, equipments and procedures in order to increase their capacity in earthquake monitoring and then help for better tsunami alert response.

Vanuatu Meteorology and Geohazards Department and New Caledonia Institut de Recherche et Développement have decided to join and share their National Seismic Network through common system and procedures. The use of the same software (Seiscomp3) helps both institutes to share knowledge and tools for earthquake monitoring and automatic detection. Procedures, alert system (email and sms) and information give support for decision makers within these observatories. First outcome of this regional network is to decrease the earthquake time detection and to help for the dissemination of the early tsunami alert (common and standardized alert system). Moreover this cooperation complies to the UN/IOC recommendations and it shows how better service observatories could bring to their country.

Positive results of this coordination and the challenges that Pacific Islands Countries are facing with earthquake and tsunami threats force to consider the potential to extend to a larger network between several countries amongst south west pacific area. The Fiji-Tonga network, the Solomon Islands, PNG and Samoa network could all be integrated within a virtual regional tsunami warning center, sharing data regionally and helping locally decision makers regarding tsunami and earthquake threats.

GAUNAVOU

Atmospheric Correction for Rugged Terrain (ATCOR3)

Litia Gaunavou
SPC-SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: litiag@sopac.org

Pacific Island countries are surrounded by huge water areas and cloud build-up already with a few meters of altitude. In Fiji, digital image analysis in 1991 and in 2001 faced serious problems with local haze overlay and relief related atmospheric differences.

To overcome this, GIZ financed an atmospheric correction add-on software for ERDAS; the image analysis software that is being used at SOPAC GIS & RS section.

This paper describes ATCOR3, a method for the radiometric correction of satellite imagery over mountainous terrain to remove atmospheric and topographic effects to retrieve the physical parameters of the Earth's surface. Furthermore, a Digital Elevation Model (DEM) is used to obtain information about surface elevation, slope, and orientation.

ATCOR3 was developed mainly for high spatial resolution satellite sensors with a small field of view such as LANDSAT TM and SPOT HRV, and only the multispectral and panchromatic imagery can be corrected within ATCOR3. Pan-sharpened image data cannot be corrected however; a Haze Removal is only possible for multispectral data.

The result is that it produces sharp and brilliant satellite images and removes the shadow effect in mountainous terrain.

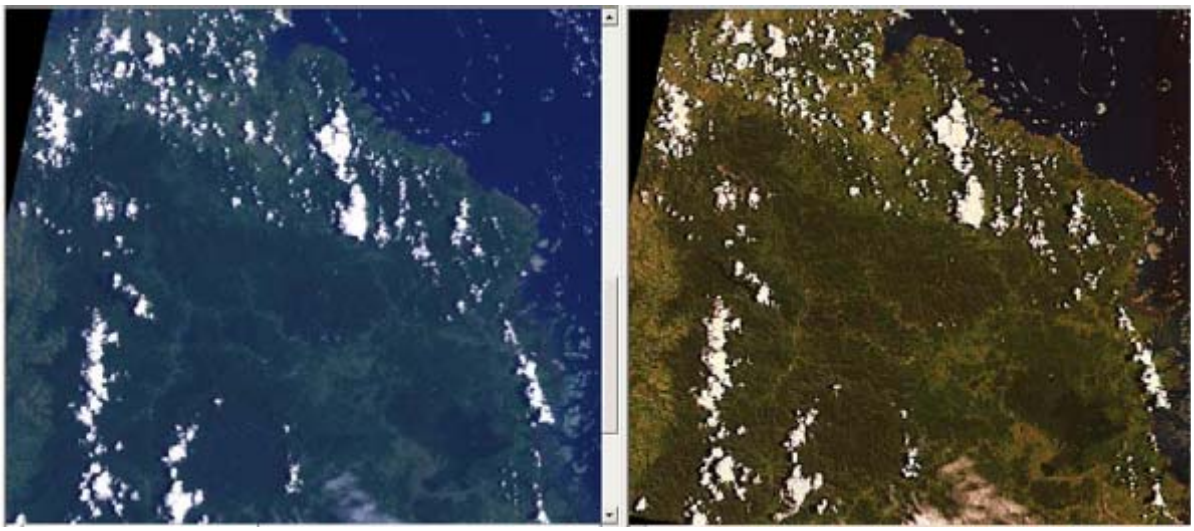


Figure 1: Landsat 4 image data of Viti Levu before (left) and after (right) atmospheric correction.

Image interpretation improved for the forest change detection carried out for Fiji Islands. SOPAC GIS and Remote Sensing Section is now able to enhance multi-spectral image data using ATCOR3 and provides this service for all SPC Member countries.

GERBER

DCCEE-IUCN project: assessing the social and economic value of climate change adaptation in the Pacific Region. Case study: water quality, quantity and sanitation improvements as an adaptation to climate change, Tuvalu

Federica Gerber
SPC-SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: Federica@sopac.org

Water is a critical issue in Tuvalu, a Pacific island atoll nation where groundwater has been declared unsafe for human consumption due to high salinity and pollution. As a result, rainwater is a key water source on the 8 inhabited atoll islands.

Unfortunately, the annual drought, which can last for up to 3 months, results in a scarcity of water with consequent frustrations and health problems in Tuvalu. This is especially the case on the capital atoll of Funafuti where most of the Tuvaluan population resides. Such drought episodes might be worsened by the effects of climate change.

As a result, there are a number of climate change adaptation projects underway to assist Tuvalu build capacity to improve water supplies, including work on rainwater tanks, composting toilets and awareness-raising. These projects are intended to achieve improvements within the next few years. Learning from the experiences of these projects will be crucial in designing climate change adaptation projects in the future. Consequently, SPC/SOPAC Division – on behalf of the IUCN-Oceania Regional Office – is undertaking an economic study of three projects: (i) the SPREP-executed Pacific Adaptation to Climate Change (PACC) project, (ii) the SPC/SOPAC-executed disaster risk management (EU B-Envelope) project, (iii) the SPC/SOPAC-executed GEF-IWRM project. This set of analysis is part of a suite of case studies that IUCN, in collaboration with SOPAC, is undertaking as part of DCCEE funded project on 'Economic and social values of CCA and DRR: strengthening knowledge based climate change adaption.

The economic study will identify key issues that affect the benefits of projects and that can be built in to the design of water adaptation projects in the future.

To collect data for the analysis, Federica Gerber – Natural Resource Economist of SOPAC – visited Tuvalu at the end of April. Following several meetings with community members and government representatives, good data has now been secured in a variety of areas, including health, water supply, rainfall and temperature. A formal economic analysis is now underway and preliminary results are expected in August 2011. The final report is due to be released later in the year.

GLASSEY

The effects of the Canterbury 2010 and Christchurch 2011 earthquakes

Phil Glassey
GNS Science, Private Bag 1930, Dunedin, New Zealand
Email: p.glassey@gns.cri.nz

At 4.36 am on 4 September, 2010, when the M_w 7.1 Darfield earthquake rocked Canterbury. The epicentre was in a rural area almost 40 km away from the centre of Christchurch, New Zealand's second-largest city. There were no deaths and only two people were seriously injured. In coastal areas near Christchurch, widespread liquefaction and associated ground deformation resulted in structural damage to, and in some cases near-collapse, of residences, and extensive breakage of underground water or waste pipe networks. Extensive damage occurred to many unreinforced masonry buildings that had not been structurally

retrofitted. The damage cost from this earthquake was estimated to be at least US$ 3 billion, much of it related to liquefaction and ground deformation. At the time, it was considered that Christchurch had withstood this event well.

Six months later, at 12.51 pm during lunch-hour on Tuesday 22 February 2011, a shallow-focus aftershock of M_w 6.3 struck 10 km southeast of the Christchurch city centre. The Christchurch Earthquake caused much more severe damage to the city than did the Darfield Earthquake, with the loss of 181 lives, many injuries, and serious social and economic disruption. Many perished in the collapse of two multistorey buildings that were designed and built in the 1960's. Many people also died under an avalanche of bricks and falling facades from the unreinforced masonry buildings. All of these buildings were listed on an earthquake prone building register but unfortunately the earthquake arrived before these buildings have been able to be upgraded. In the residential suburbs many buildings have been severely damaged by a combination of earthquake at greater than design levels and widespread ground deformations caused by liquefaction. Buildings complying with modern earthquake resistant measures have withstood ground motion at or above their design requirements. As of early June 2011, the cost of damage was estimated to be NZ$15 billion. Approximately 23 blocks of the central city business district remain cordoned off due to unsafe multi-story buildings. Almost 500 structurally-unsound commercial buildings are currently scheduled for demolition, and this number may double. An estimated 10,000 residential houses may require rebuilding. The economic and social impacts are large, and ongoing. Full recovery is several years away.

The Pacific Exposure Database, hazard models and risk

The Asian Development Bank (ADB), in association with the World Bank, has funded the development of Pacific Exposure Databases that support greater resilience to climate impacts and natural disasters in the Pacific These databases are input into risk (loss) modelling for earthquake and cyclone hazards that will ultimately support an assessment of options for a regional catastrophe fund as part of the Pacific Island Catastrophic Risk Assessment and Financing Initiative (PCRAFI) project. GNS Science International Ltd, in association with the Pacific Disaster Center (PDC), and SOPAC were contracted to develop these exposure data in 8 Pacific Island Countries: Cook Islands, Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

Attributes describing the buildings and infrastructure have been captured by field survey for about 80 000 features in the eight countries. The data are divided into seven feature classes; Buildings, Footprints, Roads, Bridges, Special Features, Special Infrastructure, and Coastline. Buildings dominate the assets in each country. Additional infrastructure have been captured utilising satellite imagery but not visited in the field, and therefore only have attributes assigned using statistical analysis of the field sample, if any. It is estimated, using a combination of field surveys, satellite imagery and census data, that up to 3.6 million buildings exist in 14 Pacific Island Countries and Timor Leste. The asset and infrastructure inventory is not complete and requires updating and maintenance. The management and upgrade of the data could be embedded within existing day-to-day building control processes and asset management systems.

The data, along with soil types, topography and construction costs form the Pacific exposure database which is used in modelling losses from hazards. At present probabilistic hazards models have been developed for earthquake and cyclone, utilising catalogues of past events and simulation of 10,000 years of events. Hazard information can be used as inputs into building codes, planning, education and determining which key infrastructure are vulnerable and may need to be strengthened or moved. Losses, in terms of cost, have been estimated for all the events. Such information can be utilised for insurance purposes and determining cost- effect mitigation methods. When census data is included, losses in terms of casualties can be estimated, as well as determining how many people may potentially be displaced by an event.

GLEDHILL

The proposed changes to PTWS Tsunami Alerts: using forecast models, threat levels and coastal zones

Ken Gledhill
GNS Science, Avalon, PO Box 30 368, Lower Hutt, New Zealand
Chair, Pacific Tsunami Warning and Mitigation System
Email: k.gledhill@gns.cri.nz

During the next two years the Pacific Tsunami Warning and Mitigation System (PTWS) will be developing new protocols and messaging to alert member states of tsunami threats. Currently a "warning" message is sent to member states in a region based on the occurrence of the earthquake and the expected travel time. The warning zone then expands as time goes on until it is confirmed that a destructive tsunami has or has not been generated. This effectively puts the whole Pacific Ocean into a state of warning following a large earthquake, despite the fact that the tsunami will be minor in most locations.

Over the last decade very good forecast models have been developed and tested which can accurately indicate the possible size of a tsunami at a given location. The plan is to use these modelling tools to provide member states a more realistic estimate of the level of threat they can expect from earthquake induced tsunami. The new alerts will be threat-based rather than based strictly upon magnitude thresholds and time or distance to impact. Several levels of tsunami threat will be established, and forecast threat levels will be assigned to segments of extended coastlines or to island groups. The improvements should greatly reduce the number of areas warned unnecessarily and also provide some advance notice of potential local tsunamis.

PTWS is developing clearer messaging and graphical products which will be used in parallel with current official messaging until ratification at the next Intergovernmental meeting in 2013. Some member states will be trialling the new messages and graphical products during PacWave '11 (see separate talk), the Pacific wide tsunami exercise being held later this year (9-10 November 2011). PTWS encourages all member states to take part in the exercise. Frequent in-depth exercising is very important to ensuring successful responses to real tsunami events.

GLEDHILL & OTHERS

PacWave'11: A Pacific-wide tsunami warning and communications exercise, 9-10 November 2011

Ken Gledhill[1], Laura Kong[2] & Jo Guard[3]
[1]GNS Science, PO Box 30368, Lower Hutt, New Zealand; Chair, Pacific Tsunami Warning and Mitigation System
[2]International Tsunami Information Center, Honolulu, Hawaii, USA.
[3]Ministry of Civil Defence and Emergency Management, Wellington, New Zealand.
Email: k.gledhill@gns.cri.nz

Most of the world's earthquakes and tsunamis occur in the Pacific Ocean and its marginal seas. On average, the Pacific is struck by a locally damaging tsunami every year or two, and by a major Pacific-wide tsunami a few times each century. Over the past three years (2009-2011), the Pacific has witnessed three destructive and deadly tsunamis that have placed Pacific countries in various levels of warning for local and distant tsunamis. Exercise Pacific Wave 2011 (PacWave'11), which will take place on 9 and 10 November 2011, provides an opportunity for Pacific countries to exercise their operational lines of communications, review their tsunami warning and response procedures, and promote emergency preparedness, education, and awareness.

The purpose of PacWave'11 is to improve local and regional source tsunami warning and response capability in the Pacific. PacWave'11 will have multiple scenarios, and be played out in real time. It is

recommended that countries choose one scenario and exercise their response to a destructive regional and/or local source tsunami. The exercise scenarios are:

1. Kamchatka (Kuril-Kamchatka Trench)
2. Ryukyu Islands (Nansei-Shoto Trench)
3. Philippines - South China Sea (Manila Trench)
4. Philippines - Pacific Ocean (Philippines Trench)
5. Vanuatu (New Hebrides Trench)
6. Tonga (Tonga Trench)
7. Northern Chile (Peru-Chile Trench)
8. Ecuador (Colombia-Ecuador Trench)
9. Central America (Middle America Trench)
10. Aleutian Islands (Aleutian Trench)

PacWave'11 will provide the initial exposure to the Pacific Tsunami Warning and Mitigation System's new experimental products (see separate talk) and provide a chance for feedback before they are implemented after 2013.

GREENE

The quest for substrate and habitat knowledge by the renewable energy sector

H. Gary Greene
Center for Habitat Studies/Tombolo, Moss Landing Marine Labs, Moss Landing, CA USA
Email: greene@mlml.calstate.edu

The demand to place tidal, wave and wind energy production systems in the coastal and nearshore areas of maritime nations is creating a demand for knowledge of seafloor conditions at potential power generating sites. Information most in demand relates to the type of seafloor substrate that exist at a site and the ecological environment or marine benthic habitat types. Since most generating systems will be anchored to the seafloor in an extremely dynamic setting it is necessary, both for the engineering of the systems and the evaluation of potential habitat disturbance, to know what lies on and beneath the seafloor. Obtaining this information is not easy as the intensely dynamic nature of the environment produces adverse conditions for seafloor observations and sampling.

A marine benthic habitat characterization study recently undertaken in Admiralty Inlet, Puget Sound, Washington, USA will be discussed. This study involved the collection of multibeam echoesounder bathymetry and backscatter data with validation of the habitat types using an ROV. A detailed ecological analysis was undertaken along with substrate characterization. Results of this study provided the public utility company requesting permission to install a tidal generator with information necessary for the permitting process. Trails and tribulations associated with the collection and interpretation of in situ data will also be discussed.

HARRIS

Global reporting on the state of the marine environment

Peter T. Harris
Marine and Coastal Environment Group, Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia
Email: Peter.Harris@ga.gov.au

In 2002, at the World Summit on Sustainable Development, heads of state who gathered in Johannesburg decided to put the ocean under permanent review. The UN's shorthand name for the project-"Regular

Process" – emphasizes the importance of a regular review of ocean condition every 5 years. This decision was made because the sector-by-sector management of human activities in the ocean has proven insufficient. Land degradation is an accepted technical term in management, and many actions are taken to mitigate its effects, yet ocean degradation, until now, has been invisible. In December 2010, the UN General Assembly appointed a Group of Experts to carry out the first cycle of the assessment from 2010 to 2014. The proposed structure of the first report of the Regular Process includes many topics of geologic interest, such as submarine cables and pipelines, offshore hydrocarbon industries, other marine-based energy industries, offshore mining industries and seamounts, deep-sea banks and plateaus. The role of science (and geoscience in particular) in the "Regular Process" will be discussed.

HARRIS & BAKER

GeoHab Atlas of seafloor geomorphic features and benthic habitats – synthesis and lessons learned

Peter T. Harris[1] & Elaine K. Baker[2]
[1]Marine and Coastal Environment Group, Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia
[2]UNEP/GRID Arendal, School of Geoscience, University of Sydney, NSW 2006, Australia
Emails: Peter.Harris@ga.gov.au; elaine.baker@sydney.edu.au

This paper presents a broad synthesis and overview based on 57 case studies accepted for publication in the "GeoHab Atlas of seafloor geomorphic features and benthic habitats" (the Atlas). The case studies covered areas of seafloor ranging from 0.15 to over 1 million km^2 (average of 26,600 km^2) and a broad range of geomorphic feature types. The mean depths of the study areas ranged from 8 to 2,375 m, with about half of the studies on the shelf (depth <120 m) and half on the slope and at greater depths. Mapping resolution ranged from 0.1 to 170 m (mean of 13 m). There is a relatively equal distribution of studies among the four naturalness categories: near-pristine (n=17), largely unmodified (n = 16), modified (n=13) and extensively modified (n=10). In terms of threats to habitats, most Authors identified fishing (n=46) as the most significant threat, followed by pollution (n=12), oil and gas development (n=7) and aggregate mining (n=7). Anthropogenic climate change was viewed as an immediate threat to benthic habitats by only three authors (n=3).

Water depth was found to be the most useful surrogate for benthic communities in the most studies (n=17), followed by substrate/sediment type (n=14), acoustic backscatter (n=12), wave-current exposure (n=10), grain size (n=10), seabed rugosity (n=9) and BPI/TPI (n=8). Less useful surrogates were water properties (temperature, salinity, DO; n=0) and sediment sorting (n=1). A range of analytical methods were used to identify surrogates, with ARC GIS being by far the most popular method (23 out of 44 studies that specified a methodology).

Of the many purposes for mapping benthic habitats, four stand out as being preeminent: 1) to support government spatial marine planning, management and decision-making; 2) to support and underpin the design of marine protected areas (MPAs); 3) to conduct scientific research programs aimed at generating knowledge of benthic ecosystems and seafloor geology; and 4) to conduct living and non-living seabed resource assessments for economic and management purposes. Out of 57 case studies, habitat mapping was intended to be part of an ongoing monitoring program in 24 cases, whereas the mapping was considered to be a one-off exercise in 33 cases. However, out of the 33 one-off cases, the Authors considered that their habitat map would form the baseline for monitoring future changes in 24 cases. This suggests that governments and regulators generally view habitat mapping as a useful means of measuring and monitoring change. In terms of the perceived clients and users of habitat maps, most Authors considered marine conservation to be the biggest user (n=45), followed by the fishing industry (n=24), government regulators (n=12), the scientific community (n=9), the tourism industry (n=8), navigation (n=6), other industry (e.g. deep sea minerals, wind farms, etc. n=6), oil and gas industry (n=5) and aggregate mining (n=4). However, the overwhelming majority of habitat surveys were funded by government or government funded agencies/institutions (n=49) with only minor funding from private industry (n=7) or non-government organisations (n=4).

A gap analysis (i.e. geomorphic features and habitats not included in the case studies) illustrates that whereas shelf and slope habitats were well represented in the case studies, estuarine and deltaic coastal habitats plus deep ocean (abyssal – hadal) environments were described in only a few case studies. Geographically, about half of the case studies were from waters around western Europe whilst the margins of the continents of Africa, Asia and South America were not represented in any case study. Given the intense pressures facing benthic habitats and broad regional differences in ecosystems, species and habitats, future case studies from these regions should be specifically sought for future editions of the Atlas.

INOUE & OTHERS

Upgrading seismic networks of Fiji and Tonga (2)

Hiroshi Inoue[1], Daisuke Suetsugu[2], Sakaraia Vunisa[3], Rennie Vaiomo'unga[4] , Sefanaia Seru[3], & Siale Vailea[4]

[1] National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan
[2] Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
[3] Seismology Unit, Mineral Resources Department, Suva, Fiji
[4] Geological Survey Unit, Ministry of Lands, Survey and Natural Resources, Nuku'alofa, Tonga
Email: inoue@bosai.go.jp

Japan International Agency (JICA) conducted a four years technical cooperation program of upgrading seismic networks of Fiji and Tonga from 2007 through 2011. The networks consist of satellite-telemetry system of broadband seismometers and the central data receiving and processing facilities. The Fiji network has six remote VSAT stations, Yasawa, Taveuni, Kadavu, Lakeba, Dogotuki, and Tailevu, and a station at the central hub site in Suva. Tonga network has four remote VSAT stations, Vava'u, Ha'apai, Niuatoputapu, Niuafo'ou, and a radio-link station on Tongatapu near the central hub site in Nuku'alofa. Each station has a broadband seismometer Trillium 120 installed in a seismic vault filled with sand, Nanometrics Trident/Cygnus or Lynx digitizer-modem, and 2.4 m VSAT antennas. The stations are powered by 8 x 80watt solar panels. The 100sps 3-channel seismic signals from all the 10 VSAT stations are transmitted to the two central hubs in Suva and Nuku'alofa via the Intelsat 701 satellite within a 100 kHz bandwidth of C-band. The two networks are physically integrated into a single network by which the two networks can share the data in real-time and work as a back-up each other. The data are received and stored by each server and processed automatically by Nanometrics Hydra program to determine hypocenters and magnitudes automatically. Data from the global seismic network are also imported via the Internet to obtain more accurate results. Automated location is sent by e-mails to restricted subscribers. An interactive analysis system is operated independently for reviewing the auto-locations and for the back-up analysis system. The rapid earthquake information will be utilized for local tsunami warning of the countries in the future. The data will be shared with neighboring countries for monitoring earthquake and tsunami in the region.

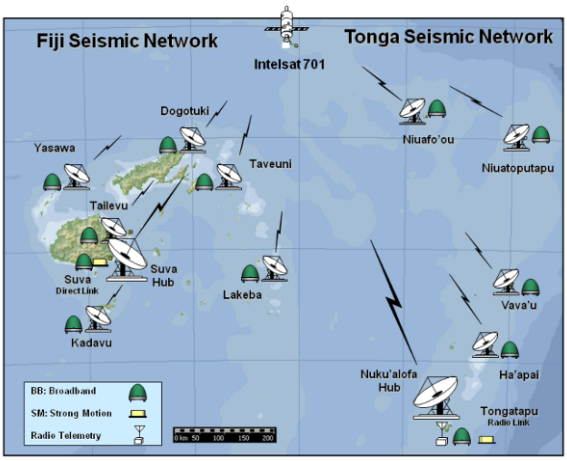


Figure 1. Fiji and Tonga seismic network

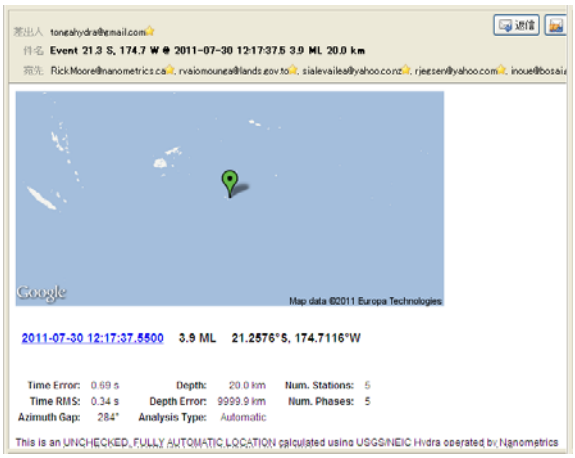


Figure 2. E-mail notification of auto-location

KRÜGER & OTHERS

Coastal inundation caused by distant storms: 20th May 2011 extreme swell event (*Loka*), Coral Coast, Viti Levu, Fiji Islands

***Jens Krüger*[1], *Zulfikar Begg*[1], *Ron Hoeke*[2], *Herve Damlamian*[1], *Salesh Kumar*[1]**
[1] SPC-SOPAC, Private bag, GPO, Suva, Fiji Islands
[2] CSIRO, Marine and Atmospheric Research, Castray Esplanade, Hobart, TAS 7000, Australia
Email: jens@sopac.org

On May 20, 2011, the ocean inundated the southern shores of Viti Levu (17.8°S, 178.0°E), Fiji, along a 50 km section commonly known as the Coral Coast. The inundations caused minor damage to infrastructure such as roads, buildings and seawalls, as well as erosion of beaches (and accretion at one survey location). The inundation coincided with spring high tides and no local weather disturbance was experienced. Instead, the inundation occurred as a result of exceptionally energetic surface gravity waves generated by a high pressure system 3-4 thousand kilometres to the southwest over the Tasman Sea. Dissipation of these waves on the fringing reefs along the Coral Coast appears to have led to high wave setup and runup, which, when coupled with high astronomical tides, resulted in the coastal inundation.

A two-day field survey was undertaken 13 days after the event. Although evidence of coastal inundation is generally ephemeral, residual accumulations of debris and saltburn of vegetation were identified with the help of eye witnesses. The flotsam levels were used to estimate wave runup. Shore-perpendicular profiles were surveyed at 9 separate locations along the Coral Coast using an auto-level and standard land survey techniques. Horizontal distances were measured landward from the base of the beach. Vertical control was established by referring local water levels to observations at the Suva tide gauge and reducing elevations to mean sea level. The average inundation was 40.5 m (ranging from 23.3 to 81.0 m), with runup averaging 3.7 m (2.0 to 5.0 m range). Current regulation for coastal development in Fiji stipulates a setback of 30 m from the high water line.

No *in situ* ocean surface wave observations are available for Fiji. A 20-year time series of modelled (hindcast) offshore wave data was obtained from the global ERA-interim fields provided by the European Centre of Medium Term Weather Forecasting for a point 150 km south-south west of Viti Levu. The wave data show incident waves with significant wave heights of 4.2 m, mean wave periods of 12.9 s, and a wave energy flux of 0.22 MW/m at the time of inundation. Extreme value analysis on declustered wave energy flux exceeding 0.20 MW/m shows that waves with characteristics similar to those that occurred on 20th May have a return interval of 1.12 years.

While analysis suggests that such waves (called *Loka* in Fijian) are relatively common, having a 89% chance of occurring in any one year, it is primarily the stage of the tide that modulates the severity of coastal inundation. However, extreme swell wave events and coastal inundation are not restricted to Fiji. An event in early December 2008 caused widespread damage and overtopping, and displaced an estimated 50,000 people across the western equatorial Pacific. These events show that coastal hazards are not limited to tropical cyclones or localised weather phenomena, but may occur as a result of storms thousands of kilometres away. This study helps to understand these extreme swell events and provides baseline information that can underpin coastal planning and guide adaptation responses.

LIAVA'A

Current developments and the vision for the future of GIS for Utilities in the Pacific Island Countries

Edwin Liava'a
SPC/SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: edwin@sopac.org

In the Pacific region, Geographical Information System (GIS) is increasingly being recognised as an essential tool for planning and development that can allow Utilities to better manage their assets in order for technical and executive managers to make well-informed planning and strategic action decisions.

The first GIS for Utilities in the region was first established with the Tonga Electric Power Board (TEPB) in 1997. The system was transferable and was adopted by Fiji Electricity Authority, Solomon Islands Electricity Authority, PNG Power Ltd, Tuvalu Electric Corporation, Tuvalu Telecommunication, Electricity Power Corporation of Samoa, Kiribati Telecommunication and most recently Water Authority of Fiji, Tonga Communication Corporation and Airport Fiji Limited. The current trend is extending the capability of the GIS from an Asset Management tool towards modelling and simulation. For instance, Load/Pressure Flow Analysis for Water and Power Utilities.

It is clear that throughout the region, Water, Power, Telecommunications and Airspace authorities are more active in their approach in adopting GIS as tool for planning mitigation, development and management decisions. Moreover, SPC Geoscience and technology division SOPAC Technical Support for GIS and Remote Sensing is an avenue for Utilities to take advantage of for assistance in developing their GIS systems.

This paper will provide updates from previous, current and a vision for future developments in GIS for utilities in the region.

LILY

Mining the Deep Seabed: Rights and Responsibilities

Hannah Lily
SPC/SOPAC, Private Mail Bag, GPO, Suva, Fiji Islands
Email: hannah@sopac.org

Sustained high prices of key metallic minerals, and recent findings suggesting high grade base and precious metals in the seabed, have re-awakened interest in deep seabed mining.

The UN Convention on the Law of the Sea ('UNCLOS') gives to coastal states sovereign rights over the minerals within its marine boundaries - which at a 200 nautical miles from the archipelagic baseline (the Exclusive Economic Zone) is a sizeable area for small island states. Mineral resource potential has been identified within the jurisdictional waters of several Pacific Island Countries.

UNCLOS also sets a regime for access for mineral exploration and exploitation within the areas outside of national jurisdiction ('the Area'), which gives certain preferential rights to developing states. Tonga and Nauru have each sponsored an exploration company that have recently obtained authorisation to explore the international seabed area (the Area).

Pacific Island Countries are therefore well-positioned to lead the way in deep seabed mining in relation to their EEZs and will be competing with developed countries in the Area. The potential to address economic vulnerability and to expand a narrow resource base, is clearly attractive. But this must be balanced against other imperatives.

As well as bestowing legal rights over deep sea minerals, UNCLOS and other international and regional instruments also impose duties on State parties. These legal standards apply regardless of a State's individual wealth or capacity, and include obligations: to protect and preserve marine resources and marine scientific research, to conserve living marine resources, habitats and rare or fragile ecosystems, to monitor risks or effects of pollution, and to minimize pollution and accidents to the fullest possible extent.

If States do not fulfill their obligations under international law they will be liable for any damage occurring as a result. States must also take measures to secure compliance with international law standards by any third-party private entities within their control. A robust regulatory regime for deep sea mining, which requires of mining contractors the same (or higher) standards as those set by international law, can therefore provide essential protection for States, marine biodiversity, other sea users, and affected communities; while providing security and clarity to mining contractors.

This paper explains how SPC-SOPAC's Deep Sea Minerals Project aims to strengthen Pacific Island Countries' position in managing their potential deep sea mineral resources, with particular focus on the development of regional and national legislative and regulatory frameworks. Additionally, the characteristics of effective regulation, and recommendations for the content of deep sea minerals legislation will be highlighted.

LOMANI

Climate Change Adaptation Options for the Rewa River Catchment in the Fiji Islands

Elizabeth Lomani
SPC-SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: elizabeth@sopac.org

This paper looks at the study undertaken to assess the impact of climate change during an extreme event within the Rewa catchment. The approach taken was identifying the most vulnerable sector and developing various adaptation options.

The climate change impacts on the different sectors is being assessed at the catchment level using results from the downscaled climate projections of the Rewa catchment provided by the Fiji Meteorological Services and sea-level rise models from other studies by USP, IPCC and CISRO.

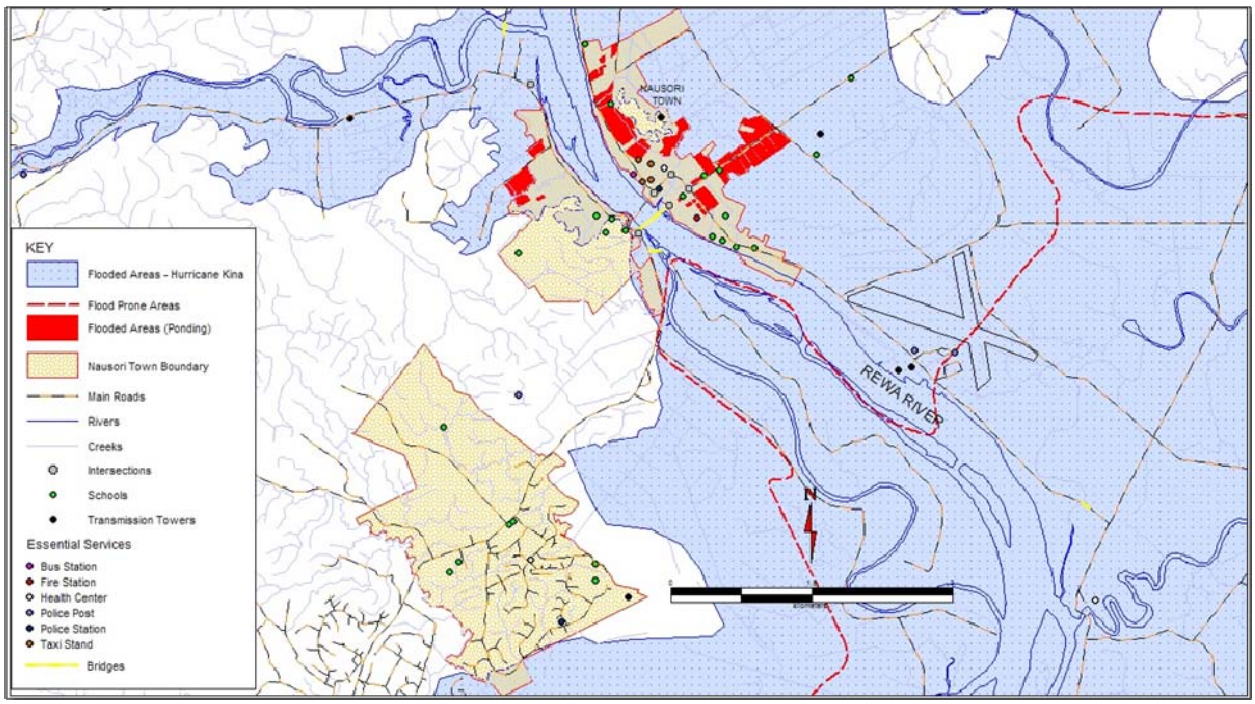


Figure 1: Map showing areas in Nausori Urban Center that were under water during Cyclone Kina which is known to be one of the extreme climatic events that occurred in Fiji.

The analysis was done through trend and spatial analysis measured against similar or worse case scenarios like the devastating Cyclone Kina and other registered storms of higher intensity which is expected in the future for the project area and its surroundings. Utilising GIS, the future climate change projections are overlaid on future developments and the baseline data.

With the assistance of the V&A Assessment matrices and the baseline data of the water sector and geographic area. The adaptation planning options for the Rewa River Catchment project area were developed.

This cutting edge methodology is being utilised for the first time in the region as a demonstration project in the absence of quality data for modelling which is a common hindrance to planners who have limited time to execute climate proofing projects. If needed any future modelling interpretation in the area may be used later to revise these assessments and adaptation plans.

MARTINEZ (POSTER)

Effects of Subduction Water on Tectonics in Back-arc Basins

Fernando Martinez
Hawaii Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, Honolulu, HI 96822,USA
Email: Fernando@hawaii.edu

The role of water in the rheology and deformation of the lithosphere is increasingly being considered an important factor in geodynamical models (*1-4*). It has been proposed that at mid-ocean ridges mantle melting and melt extraction leads to a dehydrated and therefore strong "compositional" lithosphere. This strengthening effect is further proposed to help form the narrow plate boundary zones of deformation and melt delivery observed at oceanic spreading centers (*5*). Despite important implications of these models, clear observational tests have not been made, as most oceanic lithosphere is uniformly dehydrated so that effects of variable water content cannot be examined. Subduction zone environments are key exceptions as they undergo continual water flux from underthrusting slabs. These areas provide alternate tectonic

settings in which to examine effects of high lithospheric water content on tectonics, deformation, and volcanism. We present observations from geophysical mapping in the southern Mariana margin and southern Lau Basin showing strong departures from "mid-ocean" settings in the style and mode of tectonic deformation, which are likely due to high slab water fluxes in subduction settings.

The southern Mariana margin is currently rifting parallel to the trench as a result of eastward displacement of the Mariana forearc relative to the trailing Philippine Sea plate (*6-8*). This area has predicted high water fluxes as it immediately overlies the subducting Pacific slab (*9, 10*) and lies trenchward of the arc volcanic front (*11*). The entire southern Mariana margin is broadly deforming across a ~150 km wide region (*8*) as shown by scattered earthquake epicenters, broadly distributed complex tectonic fabric, high sonar acoustic backscatter throughout the area (*12*), recovery of young lavas (*13*). We infer that water flux from the subducting slab is preventing mantle dehydration. This both weakens the lithosphere and inhibits the formation of a narrow plate boundary zone, leading to the broad volcano-tectonic zone observed. In contrast, other forearc rifts that occur behind the arc volcanic front (*14*), and are therefore subject to lower water fluxes, form narrow plate boundary zones similar to mid-ocean spreading centers. These observations suggest that water has a prominent effect on lithospheric strength and in forming organized seafloor spreading centers.

In the Lau Basin the Eastern Lau Spreading Center and Valu Fa Ridge form well-defined back-arc ridges, which progressively approach the arc volcanic front from north to south (*15*). With the approach of the spreading center to the volcanic front water content in the back-arc lavas increases (*16*). At the southern end of the Valu Fa Ridge the well-organized back-arc spreading center abruptly transitions to a broad zone of volcanic emplacement and deformation (*17*). Water content in sampled small volcanic cones from this area (*18*) have high water contents, estimated to be as high as that in the volcanic arc itself. We infer that the breakdown of the narrow plate boundary zone south of the Valu Fa Ridge is due to the increasing water content in the lithospheric mantle toward the volcanic front. Geodynamical models suggest that mantle dehydration due to melt extraction helps form a strong "compositional" lithosphere and may help focus melt to the narrow neovolcanic zones observed at mid-ocean ridges (*1, 2*). In the back-arc setting increasing water flux from the slab toward the volcanic front may eventually prevent mantle dehydration, even with melting and melt extraction. The broad volcano-tectonic zone that initiates south of the Valu Fa Ridge (*17*) appears to continue into the Havre Trough (*19*) for 1500 km to New Zealand and may constitute a new form of "broad" and hydrous plate boundary zone maintained by high slab water flux.

References

1. G. Hirth, D. L. Kohlstedt, Water in the oceanic upper mantle: implications for rheology, melt extraction and the evolution of the lithosphere. *Earth Planet. Sci. Lett.* **144**, 93 (1996).
2. J. Phipps Morgan, The generation of a compositional lithosphere by mid-ocean ridge melting and its effect on subsequent off-axis hotspot upwelling and melting. *Earth Planet. Sci. Lett.* **146**, 213 (1997).
3. G. Ito, Y. Shen, G. Hirth, C. J. Wolfe, Mantle flow, melting, and dehydration of the Iceland mantle plume. *Earth Planet. Sci. Lett.* **165**, 81 (1999).
4. G. Ito, Reykjanes 'V'-shaped ridges originating from a pulsing and dehydrating mantle plume. *Nature* **411**, 681 (Jun, 2001).
5. M. Spiegelman, D. McKenzie, Simple 2-D models for melt extraction at mid-ocean ridges and island arcs. *Earth Planet. Sci. Lett.* **83**, 137 (1987).
6. T. Kato *et al.*, Geodetic evidence of back-arc spreading in the Mariana Trough. *Geophys. Res. Lett.* **30**, doi:10.1029/2002GL016757 (2003).
7. D. E. Karig, R. N. Anderson, L. D. Bibee, Characteristics of back arc spreading in the Mariana trough. *J. Geophys. Res* **83**, 1213 (1978).
8. F. Martinez, P. Fryer, N. Becker, Geophysical Characteristics of the Southern Mariana Trough, 11°50'N-13°40'N. *J. Geophys. Res* **105**, 16591 (2000).
9. K. A. Kelley *et al.*, Mantle melting as a function of water content beneath back-arc basins. *J. Geophys. Res* **111**, B09208 (2006).
10. K. A. Kelley *et al.*, Mantle Melting as a Function of Water Content beneath the Mariana Arc. *J. Petrology* **51**, 1711 (August 1, 2010, 2010).
11. N. C. Becker, P. Fryer, G. F. Moore, Malaguana-Gadao Ridge: Identification and implications of a magma chamber reflector in the southern Mariana Trough. *Geochem. Geophys. Geosyst.* **11**, Q04X13 (04/29, 2010).
12. P. Fryer *et al.*, Why is the Challenger Deep so deep? *Earth Planet. Sci. Lett.* **211**, 259 (2003/6/30, 2003).
13. J. M. Ribeiro *et al.*, paper presented at the American Geophysical Union Fall Meeting, San Francisco, CA, 2011.
14. R. Govers, M. J. R. Wortel, Lithosphere tearing at STEP faults: Response to edges of subduction zones. *Earth Planet. Sci. Lett.* **236**, 505 (2005).

15. F. Martinez, B. Taylor, E. T. Baker, J. A. Resing, S. L. Walker, Opposing trends in crustal thickness and spreading rate along the back-arc Eastern Lau Spreading Center: Implications for controls on ridge morphology, faulting, and hydrothermal activity. *Earth Planet. Sci. Lett.* **245**, 655 (30 May 2006, 2006).
16. R. A. Dunn, F. Martinez, Contrasting crustal production and rapid mantle transitions beneath back-arc ridges. *Nature* **469**, 198 (2011).
17. M. Watanabe, K. Okino, T. Kodera, Rifting to spreading in the southern Lau Basin: Variations within the transition zone. *Tectonophysics* **494**, 226 (2010).
18. K. M. Haase, S. Fretzdorff, R. Mühe, D. Garbe-Schönberg, P. Stoffers, A geochemical study of off-axis seamount lavas at the Valu Fa Ridge: Constraints on magma genesis and slab contributions in the southern Tonga subduction zone. *Lithos* **112**, 137 (2009).
19. R. J. Wysoczanski *et al.*, Backarc rifting, constructional volcanism and nascent disorganised spreading in the southern Havre Trough backarc rifts (SW Pacific). *J. Volcanol. Geotherm. Res.* **190**, 39 (2010).

MOSUSU

Progress Report on Geothermal Developments in Papua New Guinea

Nathan T. Mosusu
Geological Survey Division, Mineral Resources Authority, P.O. Box 1906, Port Moresby
Email: nmosusu@mra.gov.pg

During the year 2010 – 2011 significant advances were achieved in the Papua New Guinea geothermal sector. Most important was the tabling of the geothermal bill by the former Somare-Abal government. Although controversial due to its secrecy, with no input from key government agencies, the tabling of the geothermal bill is a sign that the Government is keen to develop this resource.

In other developments Reykjavik Geothermal Company (RGC), backed by Ambata Finance Company, established its office in Port Moresby. The company conducted initial exploration programs in the Rabaul area for possible power generation. Results of the resistivity survey chemical analysis indicate a good geothermal reservoir, with the potential to supply power to the two existing towns. But due to financial requirements, a bigger reservoir is required. Hence RGC with assistance from the Geological Survey Division of the Mineral Resources Authority (MRA), and the Rabaul Volcanological Observatory (RVO) of the Department of Mineral Policy and Geohazard Management (DMPGM) have begun investigating the Madang area for possible geothermal potential. This is due to the potential to feed into the current power grid to supply the highlands and the Madang, Morobe and Sepik areas. This project commenced with a reconnaissance survey of Karkar Island area for its geothermal potential. RGC also holds exploration permits over other areas of the country including Kairiru Island (East Sepik Province), Kimbe and Talasea areas (West New Britain Province) and the D'Entrecasteaux Islands (Milne Bay Province).

Geological Survey Division also initiated sampling programs in the Wau-Bulolo geothermal areas in the Morobe Province. The sampling program uncovered more thermal areas previously unreported, which warranted a second field visit. Newcrest Mining, owners of the Lihir gold mine on New Ireland Province, currently plans to investigate the areas for possible power development for their Hidden Valley and the Wafi Golpu mining projects. The idea is being driven by the success of its operation on Lihir Island, where geothermal power subsidises approximately 70% of the mine's power requirements. The MRA, through its Geological Survey Division, together with the Geological and Nuclear Sciences (GNS) Institute of New Zealand, will carry out further exploratory work on the area. Training of MRA staff for this project was carried out by GNS staff at Wairakei in New Zealand.

The regional geothermal heat flow program to be conducted by MRA and Melbourne University failed to get off the ground in 2011. This was mainly due to other commitments by Melbourne University staff and the heavy work programs of mining companies. However, it is still hoped that the program will eventually get off the ground before the end of the year.

O'BRIEN

Vegetation Change Detection at 1:10,000 Scale Level for Vaitupu and Nanumea in Tuvalu

Kilifi T. O'Brien
Environment Department, Office of the Prime Minister, Private mail Bag, Vaiaku, Funafuti, Tuvalu
Email: obrienkilifi@gmail.com

Vegetation change detection is an application that is uniquely important for making well informed decisions on vulnerable atoll island countries such as Tuvalu. The issues that influence vegetation change are not only restricted to environmental factors but also economic and social factors. In this study very high resolution (VHR) pan-sharpened QuickBird image data was used for 2006 and multi-spectral IKONOS image data recorded in 2003. The IKONOS image data were atmospherically corrected and contrast enhanced before any interpretation work was undertaken. The 2003 dataset was rectified with DGPS image reference points by Litea Buikoto and was used as reference for image rectification of the 2006 image data.

The image data for 2006 was interpreted and 6 land cover classes were delineated: 1) Coconut; 2) Forest; 3) Shrubs; 4) Waterbody; 5) Settlement and 6) Bareland. The corresponding polygons were overlayed over the IKONOS image from 2003 and adjustments were made for any changes identified.

Bothe vegetation layers from 2003 and 2006 were exported to ERDAS for a subsequent overlay analysis in raster data environment.

The analysis demonstrates that change can be recorded already after a period of three years if VHR image data is geometrically corrected and interpreted accurately. The results show the location of change between the classes and the analysis quantifies the change in square meters. This data is required by others who will analyse the reasons for vegetation change and finally by decision makers which will manage and protect the natural resources.

OKAMOTO & OTHERS

Approach to Environmental Impact Assessment and Conservation Measures of Biodiversity for Mining Seafloor Massive Sulphides

***Nobuyuki Okamoto*, Tetsuhiko Toyohara, Teruyoshi Narita, Satoshi Ueda**
Deep-sea Mineral Exploration & Technology Division, Japan Oil, Gas and Metals National Corporation (JOGMEC), 2-10-1 Toranomon, Minato-ku, Tokyo, 105-0001, Japan
Emails: okamoto-nobuyuki@jogmec.go.jp, ueda-satoshi@jogmec.go.jp

In Japan, the Ministry of Economy, Trade and Industry (METI) commenced a research and development (R&D) project on seafloor massive sulphides (SMS) in Japan's exclusive economic zone (EEZ) in the 2008 fiscal year. The project defines the plan for the commercialization of SMS. Japan Oil, Gas and Metals National Corporation (JOGMEC) conducted the research under contract to METI. SMS are widely distributed in the sea area surrounding Japan and are expected to become domestic metal resources. Since the SMS fields include hydrothermal ecosystems, which often host dense endemic animal communities, an adequate environmental impact assessment (EIA) and a conservation strategy to protect biodiversity are required for sustainable development. We outline an environmental framework that is intended to contribute to a global standard for assessing the environmental impacts of SMS exploration and mining.

PARKER

The Sea Level Monitoring Project in the Pacific under the new COSPPac initiative

Phil Parker
South Pacific Sea Level & Climate Monitoring Project, Bureau of Meteorology Australia, Melbourne, Victoria 3001, Australia
Email: P.Parker@bom.gov.au

The South Pacific Sea Level & Climate Monitoring Project (SPSLCMP) has been operating in the SW Pacific region, and including Micronesia, since 1991. It has been funded by the Australian international aid and development agency (now AusAID). The sea level data that have been collected, managed and provided to the regional and international user communities for over 20 years, form the basis of the main sea level climate reference data set in the region.

Over the recent year or so AusAID has undertaken a strategic review of its interests in the region regarding its priorities for assisting Pacific Island countries in their abilities to respond to emerging climate change challenges. In particular it has sought to bring together existing programs projects such as SPSLCMP and the Pacific Island Climate Prediction Project (PICPP) under a new project umbrella for the future. Further, an enhanced component dealing with capacity development and communications will be added to provide for improved connectivity with national needs, enhanced delivery and outreach activities. Alignment with related scientific development priorities and activities such as the PacificAustralia Climate Change Science and Adaptation Program (PACCSAP) were also a major design factor.

The new initiative, to be called the Climate and Oceans Support Program for the Pacific (COSPPac)[1] is expected to commence operations January 2012, for a 5-year period. As part of the initiative the sea level network and services provided by the ongoing Sea Level Monitoring Project component are to be enhanced.

This presentation will outline the COSPPac initiative focusing on sea level aspects.

RATTENBURY

Oceania's contribution to the OneGeology digital geological map data for the world project

Mark Rattenbury
GNS Science, PO Box 30368, Lower Hutt, New Zealand
Email: m.rattenbury@gns.cri.nz

The OneGeology project started in 2007 (www.onegeology.com) and aims to have digital geological maps from every country in the world served through its web portal (http://portal.onegeology.org). OneGeology wants to make existing geological map data accessible in whatever digital format is available in each country, to transfer know-how to those who need it by adopting an approach that recognises that different nations have differing abilities to participate, and to stimulate a rapid increase in data interoperability.

To date 117 countries are participating in the project and of those 50 are currently serving geological maps to the portal. The Oceania region has only Australia and New Zealand participating and serving maps so far. There are two main requirements to contribute. Firstly a national geological map needs to be made available in digital form. Ideally this map will be in GIS format but it is possible to serve a scanned and georeferenced geological map image as another option. Secondly the map data need to be served with appropriate information technology systems across the internet. The key difference with the OneGeology

[1] Subject to final approval by AusAID

approach is that the national geological map data remains with the participating nation and the data are accessed live on demand from their server. The OneGeology project recognises that some countries may lack the hardware or expertise to maintain a web map service and therefore have developed a "buddy system" where countries with established systems serve other countries' data on their behalf. The buddy system is presently being used for 15 nations.

There are several reasons for South Pacific countries to become involved; to make accessible the best geological map data they have, to work towards consistent standards for data access, and to enhance and increase the use and usability of their data, particularly for resource and hazard assessment. OneGeology is a demonstration of national capability, of international cooperation, and of global science connectivity.

ROSSER

Public preparedness and capacity building for tsunami evacuation in Samoa: the development, installation and testing of fit-for-purpose tsunami evacuation information

Brenda Rosser
On behalf of: Michele Daly, Nora Gale, Graham Leonard, Filomena Nelson, William Power, Martin Reyners, Laura Wallace, Xiaoming Wang, Kim Wright
GNS Science, PO Box 30-368, Lower Hutt 6315, New Zealand
Email: B.Rosser@gns.cri.nz

GNS Science is currently partnering with the Samoa Disaster Management Office on a NZ Aid Programme funded project to map tsunami evacuation zones for all of Samoa, and pilot detailed evacuation planning in four locations. The project combines GNS expertise in tsunami source modelling, inundation mapping, understanding and delivery of tsunami warnings, best-practice in signage and preparedness with disaster management planning and community consultation expertise in Samoa.

The process adopted was one which had been used successfully by GNS Science in New Zealand communities; integrating the physical science of tsunami (sources, wave behaviour, inundation) with social science including best-practice disaster management, understanding of warnings, emergency planning and fostering appropriate responses. The process used by GNS Science recognises the important of community input into planning, as the best results can be expected when communities understand the issues and work together with support agencies to create solutions that will work locally, underpinned by robust science. The community consultation process is perhaps the most critical phase, if those at-risk do not understand the natural and official warnings for tsunami, where the hazard zones are, their best evacuation routes and how to know when they have reached a safe location, the project will not succeed.

The project commenced in February, 2011. We will provide an outline of the goals of the project, the steps involved and an update on where we are at so far. Key successes of the project so far include high levels of interest and engagement in our pilot villages and a team of confident and competent Samoan facilitators in place to carry on the project when GNS Science involvement ends in November. The ability for locals to put their own stamp on resources has proved popular and still allows for national and international consistency of terminology and design. This project demonstrates the importance of the 'science to practice' process, where practical solutions to mitigate natural hazard risks are developed alongside communities, with support from authorities.

SINGH & OTHERS

The SOPAC Compendium Project 2011-2012

Manish Singh, Sachindra Singh, Rave K. Tiuhe'a, Amali S. Shaw, Eferemo C. Kubunavanua, Sanivalati Tubuna, Flory Toba, Kata Duaibe, Leonard Wong, Lala Bukarau
SPC/SOPAC, Private bag, GPO, Suva, Fiji Islands
Emails: manish@sopac.org; sachindra@sopac.org; rave@sopac.org; amali@sopac.org; eferemo@sopac.org; sanivalati@sopac.org; flory@sopac.org; kata@sopac.org; leonard@sopac.org; lala@sopac.org

The SOPAC Compendium Project is a data management/rescue/security digital collation exercise being undertaken on the SOPAC holdings of data collected and information generated from 1972 to 2010. The main purpose being to create final updated country datasets for each island Member of SOPAC the Commission, that will contain a record of all the work undertaken for each Member along with electronic copies of all raw datasets, products of processed datasets including maps/charts and reports. The central set of hardcopy material will have upgraded climate-controlled storage facilities through the Compendium Project. The final digital full set of all island Members' compendia and the regional collection of SOPAC Commission work programme generated data and information will be held and managed by the SPC on behalf of the Pacific island countries.

The datasets range from the hard copy large format drawings (*cruise track plots, bathymetry maps, navigational charts, hydrography, physiography, topography maps etc.*), satellite imagery, aerial photographs, maps to the already digital living repositories containing datasets of the same categories of information as well as computer models from the more recent years. A number of older digital datasets are undergoing transcription into a format compatible with current versions of software and online platforms. The SOPAC Compendium Project involves the researching, collation, digitising, cataloguing and packaging of these datasets. In the process, the metadata of the digital datasets are being researched, written and catalogued into online repositories (Geonetwork, Electronic Data Management System) for access internally and externally according to proprietary data access protocols administered by SPC on behalf of the Member owners of the information.

Country compendia are being assembled for the Cook Islands, Federated States of Micronesia, Fiji Islands, Guam, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Samoa, Tuvalu and Tonga. Compendia for Niue and Vanuatu were assembled in the pilot phase of the Project and are being refined in terms of addition of more data and the software system design that is undergoing continuous testing and improvement as Project implementation advances. The compendia packages are being assembled using an open-source system. The compendia will also capture existing databases/portals that already hold a wealth of information and data on SOPAC's activities in its Member countries, like the Virtual Library, Training (Participants) Database, Pacific Disaster Net, Pacific Risk Database and the Maps and Spatial Data Repository.

The outcomes of this pioneering project will form the largest collection of baseline data from the Pacific that is an imperative to inform adaptation strategies on the Pacific environment to mitigate the effects of extreme events attributed to climate change. This is value adding to the end product for island Member countries of SOPAC, through the digital collections of the data and information that will accrue to Members at the end of the SOPAC Compendium Project.

SMITH

Aerial Photography in a Lunch Box

Robert Smith
SPC/SOPAC, Private Mail Bag, GPO, Suva, Fiji Islands
Email: robert@sopac.org

We are all familiar with the acquisition and value of aerial photography and satellite imagery. The widespread use of Google Earth provides an example of this.

Assessment of coastal change, monitoring deforestation, sand and gravel mining in rivers, flood and associated hazards, and disaster analysis all require the use of remotely sensed data as the primary tool to complete any interpretation of change or impact. Time is the one variable needed for any form of monitoring change. Difficulties and data limitations experienced with an existing study of the Navua coast prompted the question of whether there is a way to obtain imagery with better control on variables such as weather, low cloud and tide, on a budget that would not pay for a taxi to the airport. The aim was to obtain coastal imagery to assess erosion and the processes by which it takes place under controlled conditions; for example, at varying states of the tide and with frequent images.

For the coastal study of the Navua region, a significant aerial photographic resource dating back to 1954 was available. However, these photos were at different scales and the intervals between flights were variable. More recently, satellite imagery has been available with resolution that has improved with time but with limitations that include the difficulty of meeting cloud-free requirements. Further, satellite imagery does not deal with the necessity to cover different states of the tides.

Using off-the-shelf items and our existing hydrographic mapping technology I have put together a system to acquire aerial images using a small private plane with a remotely controlled camera mounted under the wing. The camera was mounted to be as vertical as possible during flight. With a laptop running Hypack surveying software, I am able not only to record the flight track but also to control the camera remotely and provide a real time flight track for the pilot to follow, as well as recording flight track details, speed, location and elevation.

The idea is not new but it provides an opportunity to highlight the value and benefits that TAG and Star bring to SOPAC in the application of our work studies. Here I will present the methodology and preliminary results, and conclude with some practical ideas for further research and monitoring applications.

STEPHENS & OTHERS

Long-Term Climate and Environmental Change Recorded in Cave Sediments in Pacific Islands: Preliminary Results from Volivoli Cave, SW Viti Levu Island, Fiji

Stephens, M.[1],Mattey, D.[2], Anton, E.[3], Hoffman, D., Dredge, J.[5], Fisher, R.[2], and Lowry, D.[2]
[1]School of Geography, Earth Science and Environment, Faculty of Science, Technology and Environment, University of the South Pacific, Suva, Fiji.
[2]Department of Earth Sciences, Royal Holloway, University of London, Egham, Surrey, TW20 0EX, UK.
[3]Geology Dept, Nacional Sciences Museum, Madrid, Spain.
[4]CENIEH, Burgos, Spain.
[5]GEES, University of Birmingham, Birmingham, United Kingdom.
Email: Stephens_m@usp.ac.fj

Caves are excellent archives of long-term climate and environmental change and although there are numerous caves on Pacific islands, detailed terrestrial records of climate change are scarce and here we report on the first study from speleothem in Fiji. A laminated calcite speleothem from Volivoli Cave, SW Viti

Levu, dated by U-Th methods and analysed with $\delta^{18}O$ and $\delta^{13}C$, spans a 1500 year interval. A major shift in $\delta^{13}C$ occurs dated at 1200-1300 AD and likely represents the transition between the Medieval Warm Period and the Little Ice Age. No major shifts are observed in $\delta^{18}O$ values measured at 2 mm resolution and these data show a simple trend that monotonically decreases by ≈1‰. High resolution micromilling at 100 micron resolution however reveals smooth oscillations in $\delta^{18}O$ which possess regular periods. A major question is whether these cycles are annual or multi annual, related to longer term changes controlled by climate modes such as ENSO. Cave monitoring of local processes and their relationships to seasonal weather patterns has been carried out since 2009. The Volivoli chemical record provides clear evidence of an underlying climate signal and further work will provide information on long-term trends in intradecadal ENSO periodicity and intensity in terms of $\delta^{18}O$ cycles that can be related directly to precipitation amount and sea surface temperature, and greatly improve understanding of the impact of short-lived climate changes on past and future societies.

TAUMOEPEAU & SMITH

Seafloor massive sulphide resource production – Solwara 1 Project update

Paul Taumoepeau[1] & Samantha Smith[2]
[1] Nautilus Minerals, PO Box 893, Nuku'alofa, Tonga
[2] Nautilus Minerals, PO Box 1213, Milton, Queensland 4064, Australia
Email: pmt@nautilusminerals.com; sls@nautilusminerals.com

Nautilus Minerals (Nautilus) is following the lead of the offshore oil and gas industry to tap vast offshore resources. It is the first company to commercially explore the seafloor for massive sulphide systems, a potential source of high grade copper, gold, zinc and silver.

The first deposit to be developed by the company is located at a depth of 1600 m at Solwara 1, in the benign waters of the Bismarck Sea. This location lies within the territorial waters of Papua New Guinea. After following a >2 year process, Nautilus has secured the key permits (Mining Lease and Environment Permit) required to progress the Solwara 1 Project and plans are advancing to bring this project into development.

Nautilus has relied heavily on proven deepwater technologies from the oil and gas industry in the design of its offshore production system. Pipeline trenching units, workclass remotely operated vehicles, deepwater production risers and other technologies will be adapted to enable the extraction of these high grade Seafloor Massive Sulphide (SMS) systems on a commercial scale. Key contractors used by Nautilus on this innovative project have all been selected for their deepwater experience (gained in the oil and gas industry), creativity and determination to launch this new industry responsibly and successfully.

This paper summarises the progress to date of this development which will provide a new source of minerals to the world and which will contribute to sustainable growth for the future.

TOKALAUVERE

Visual interpretation for forest change detection in Fiji

Vilisi Tokalauvere
SPC-SOPAC, Private Bag, GPO, Suva, Fiji Islands
Email: vilisi@sopac.org

This presentation will discuss why and how the visual interpretation was used as a method for forest change detection exercise in Fiji rather than the semi-automatic image analysis.

The data available for the Forest Change detection in Fiji included the forest cover layer of 1991. The digital forest layer of 1991 was created by a company in Germany. Image data of 1991 is limited and had to be downloaded from the internet as original data at the Forestry Department were lost due to storage problems. The data which could be downloaded is apparently not the full set of data recorded at this time. Most probably scenes where only small parts are cloud free were not placed on the website. The forest layer 2001 was produced through unsupervised maximum likelihood image classification, mask building and intensive field work.

The visual interpretation was favoured due to several reasons. Firstly, the atmospheric conditions in the Pacific are very different to other parts of the world; in certain areas it is very difficult to get image data that is haze or cloud free. The Pacific also has high species diversity. The very time consuming approach of visual image interpretation was also necessary as both layers of 1991 and 2001 showed interpretation problems of possibly different origin. Both original forest layers were geometrically corrected where the digital river system of the Fiji Lands Department was utilised as reference.

The interpretation is carried out in map sections which are 10 x 10 km areas, where 12 of the sections cover one map sheet. The Forestry department staff who has a vast field knowledge and experience guided the interpretation. For each map section the interpreter starts with the 1991 dataset where he uses the forest cover layer 1991 and corrects it wherever the 1991 image data is cloud free. The interpreter toggles between the natural colour (blue, green, red) and the false colour infrared (green, red and near infrared) images. The interpreter also notes the image data his interpretation is based on in a corresponding access database and he documents if the image data is cloudy and the digitising is based on the forest cover layer 1991. Plantation areas visible in the forest cover layer 1991 are excluded from the image interpretation. A atmospheric correction was performed on the images and assisted in reducing the atmospheric differences related to relief and local haze but visual interpretation was still necessary for parts of the images affected by haze.

Figure 1: *Image interpretation by Forestry Department staff, display of image data in GIS environment*

If the interpretation of the 1991 data is finished for a 10 x 10 km section the interpreter copies the vector file containing the polygons of forest or mangrove cover for 1991 to a corresponding file labelled as 2001. Then he displays the 2001 image data and corrects the polygons wherever the forest has disappeared. The interpreter also records in the database if an area is cloudy in the 2001 dataset and the 1991 forest area cannot be corrected and the image data used. For some areas that were cloudy in the 2001 image data, the interpreter uses the "Google Earth Connection Utility" tool whereby the digitised polygon in MapInfo is exported as kml format and automatically opened on Google earth. No changes would be made to the 2001 polygons if the area is still the same according to the latest 2011 cloud free image data available on Google Earth. The latest image data covering the whole of Fiji was recorded in 2007 and GIZ financed its purchase. The data was visually interpreted with the above method and a third forest cover layer was produced. The change was calculated accordingly.

The change detection is not based on image data alone as plantation areas were not interpreted regarding the current forest cover and areas covered by clouds in the 1991 data set were digitised from the 1991 forest cover layer. Coconut was not interpreted from image data as well the areas were received from Fiji Agriculture Department and incorporated into the forest layers.

The analysis of change was performed with ERDAS raster GIS software, where the inventory output layers were combined through Goedel's method. The analysis is based on number of pixels which then is converted to area knowing that each pixel of 25 x 25 m represents 0.0625 hectare. To reduce the 'salt and pepper' effect it was agreed to filter areas smaller than 1 hectare.

A field verification is carried out after analysis in the office, and that allowed the interpreter to compare image data and what is really on the ground. The Forestry Department officers who have a vast knowledge and experience in field work are involved in the field verification.

The visual interpretation was time consuming but created a transparent result, where others can visualise and comprehend the mapping for every 10 x 10 km map section. Forestry and SOPAC staff are trained and can train other Pacific Island countries with forest cover such as Solomon Islands, Vanuatu, Samoa etc.

WILES & OTHERS

Landfill leaching and reef flat dynamics in a tropical Pacific lagoon

Philip Wiles[1,2], Anne Brasher[3], Tim Clark[4] & Rob Baskin[3].
[1]Secretariat of the Pacific Regional Environment Program, PO Box 240, Apia, Samoa
[2]American Samoa Environmental Protection Agency, PO Box PPA, Utulei Office Building, Pago Pago, American Samoa 96799
[3]United States Geological Survey, 2329 West Orton Circle, West Valley City, UT 84119-2047
[4]National Park of American Samoa. Pago Pago, American Samoa 96799
Emails: philipw@sprep.org; abrasher@usgs.gov; rbaskin@usgs.gov

The interplay of tide and wave driven currents on circulation over a reef flat are investigated using a combination of measurements in the National Park of American Samoa, on the island of Ofu. A nearby unlined landfill threatens to degrade this relatively pristine resource which provides a significant source of protein for the local population.

Fieldwork was undertaken on Ofu in September 2011. A moored ADCP, roving ADCP and GPS-tracked drifters were used to identify circulation patterns and estimate flushing times on the reef flat. Soil, water and biological samples were also taken to estimate the impact of the landfill on biota.

YASUDA & OTHERS

Wind and wave hindcast due to cyclone Tomas and climate change impact analysis on tropical cyclone in Fiji

Tomohiro Yasuda[1], Yusuke Tanaka[2], Junichi Ninomiya[2], Sota Nakajo[1], Nobuhito Mori[1] & Hajime Mase[1]
[1]Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan
[2]Graduate School of Engineering, Kyoto University, Kyotodaigaku-Katsura, Nishikyo-ku, Kyoto 615-8246, Japan
Email: tomo@oceanwave.jp

Micronesia is extremely sensitive and vulnerable area against climate change. Mean sea level rise will cause significant impacts on the small islands. Climate change also may affect tropical cyclone (TC) intensity in these regions. Cyclone Tomas which was the most intense TC since Bebe in 1972 struck Fiji on 15th March 2010 as shown in Figure 1. The minimum pressure of TC Tomas was 944 hPa and the averaged sustained wind speeds were 51 m/s. One person was killed by large swells near Namilamila Bay in Vanua Levu, north island of Fiji. Many houses along the Pacific were washed away by high tides and waves. In this study, wind and wave hindcast simulation was carried out to investigate stormy sea state around Fiji islands. Statistic analysis was employed to examine how large TC Tomas was historically and whether TC intensity will be varied by the climate change.

Mesoscale weather hindcast simulation was carried out by WRF and its output was used as a driving force of wave simulation by SWAN. Simulation period was 12/3/2010 0:00 to 17/3 0:00 (UTC). NCEP/NCAR final analysis data (FNL) was employed as initial and boundary conditions. GTOPO30 was used for topographic and land use data. Sea level pressure and sea surface wind were estimated as shown in Figures 2 and 3. As shown in Figure 2, TC Tomas transited very close to Vanua Levu and could cause a storm surge due to the barometric depression. The east coast was met significantly high wind faster than 50 m/s as shown in Figure 3 (a). Even in south coast of Viti Levu, south island of Fiji, more than 25 m/s wind blew in the north direction shown in the panel (b).

Wave hindcast simulation was conducted by SWAN v40.81. GEBCO30 was employed as bathymetry data and interpolated to coastal domain which resolution was 500 m. Maximum significant wave height H_s was shown in Figure 4. Estimated maximum H_s were 26 m in Vanua Levu and 6.5 m in Viti Levu, respectively.

Statistic analysis was carried out by using the historical TC data, IBTrACS provided by NOAA. Employed archived data period was from 1955 to 2008. 63 TCs were extracted by the condition that TC transited within 400 km from Suva, the capital city of Fiji. Number of annual strongest TC which means lowest central pressure TC became 33. Time history of annual minimum TC pressure was shown in Figure 5 and Tomas's minimum pressure 944 hPa is indicated by red line. As shown in Figure 5, it is obvious that Tomas wasn't worst TC in recent years in Micronesia. Cumulative density function was fitted by Weibull distribution function as shown in Figure 6, and the return period of Tomas was estimated as about 10 years.

Global climate simulation was conducted by the Meteorological Research Institute, Japan Meteorological Agency (MRI/JMA) for the present (1979-2003) and the future (2075-2099) employing the time slice experiment. Numbers of TC passed near Fiji were estimated as 41 and 47 for 25 years for the present and the future, respectively. Although there is non negligible bias for the present climate projection results in this region, it was projected that the number of approaching TC will be nearly same or slightly increased and the intensity will be weaker as shown in Figure 6.

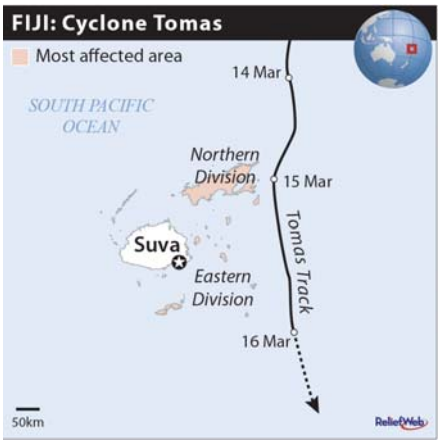


Fig.1 Track of Tropical Cyclone Tomas

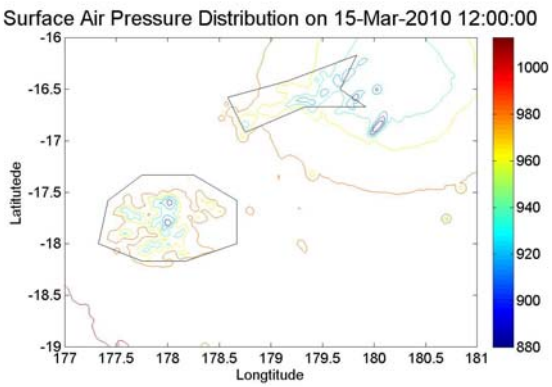
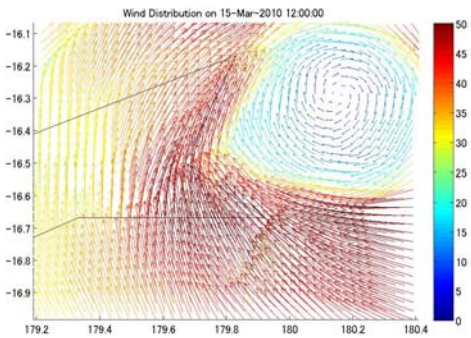
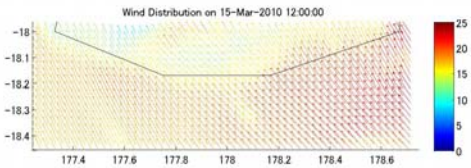


Fig.2 Sea level pressure distribution around Fiji on 12:00 15 March simulated by WRF [unit: hPa]

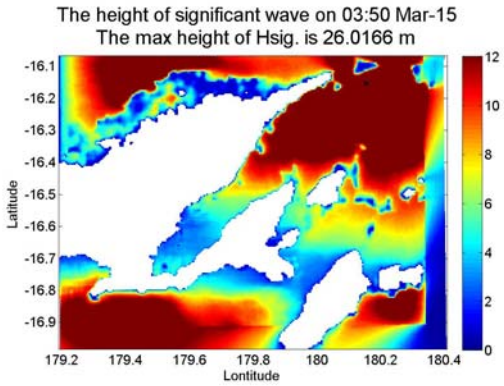


(a) East coast of Vanua Levu

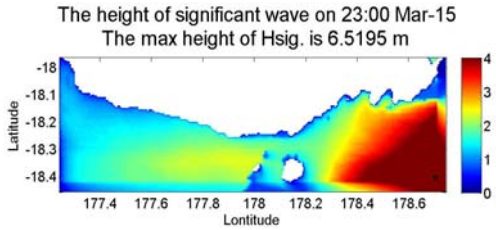


(b) South coast of Viti Levu

Fig.3 Sea surface wind distribution around Fiji on 12:00 15 March simulated by WRF [unit: m/s]



(a) East coast of Vanua Levu



(b) South coast of Viti Levu

Fig.4 Maximum significant wave height distribution around Fiji simulated by SWAN [unit: m]

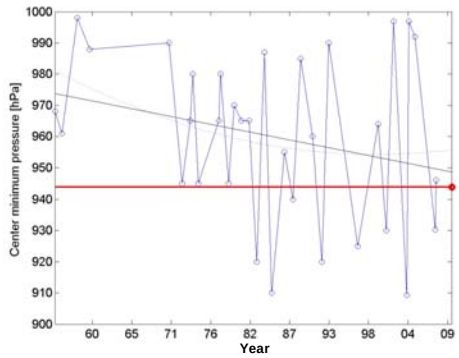


Fig.5 Time history of annual minimum TC pressure which transited within 400 km from Suva, Fiji

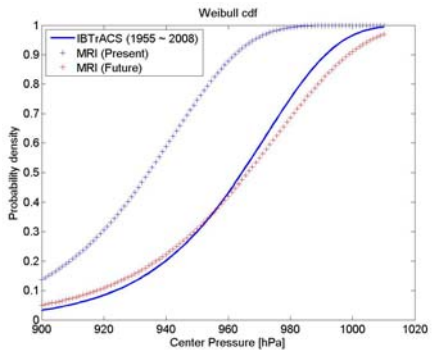


Fig.6 Cumulative density function of TC central pressure of IBTrACs, MRI-GCM present (1979-2003) and future (2075-2099) projections

---

YEO

Flood Fatalities in Fiji, 2000-2009

Stephen W. Yeo
Risk Frontiers, Dept. of Environment & Geography, Macquarie University, North Ryde NSW 2109, Australia
Email: SYeo@bewsher.com.au

A database has been constructed to record information about fatalities associated with riverine flooding in Fiji. Sources include Government records and media reports especially the *Fiji Times*. The record is believed to be virtually complete for the past decade, which provides an insight into contemporary patterns useful for planning educational strategies to reduce future loss of life.

For the period 2000-2009:

- *General:* 64 flood fatalities are recorded, an average of 6.4/year; these fatalities are associated with 22 distinct flood events; the median number of fatalities per event is one;
- *Nature of event:* 42 out of the 64 fatalities (66%) are *not* associated with tropical cyclone floods, though the severe flooding at night associated with Tropical Cyclone Ami in January 2003 accounts for the largest single loss of life (16, 25%);
- *Location:* The flood fatalities are widely distributed across Viti Levu and Vanua Levu, with a concentration around Labasa (where the impacts of TC Ami were greatest);
- *Seasonality:* Almost 90% of fatalities occurred between January and April;
- *Ethnicity:* Where reported, 56% of fatalities are of Indian and 42% of Fijian ethnicity; the death rate per 100,000 people is double that for Indians (9.2) compared to Fijians (4.6) based on the 2007 Census; however, excluding the fatalities associated with TC Ami, the death rate is at parity (4.4) – in most floods Fijians appear to be just as likely to drown as Indians;
- *Gender:* Where reported, 65% of fatalities are male and 35% female; however, excluding the fatalities associated with TC Ami, the proportion of male fatalities increases to 75%;
- *Age:* Where reported, 35% of fatalities are aged 15-24 years, an age group that comprises 19% of the total population based on the 2007 Census; conversely the 0-10 age group is under-represented in these flood fatalities; the median age of flood fatalities is 23 years;
- *Circumstances:* Where reported, 63% of fatalities are considered 'active', with the victim contributing to their death by attempting to cross floodwaters usually on foot or, less frequently, playing or swimming in the floodwater; 37% of fatalities are considered 'passive' – in January 2003 when houses near Labasa were washed away, and in April 2004 when a stationary bus was pushed into the Wainibuka River by a landslide; however, excluding the fatalities associated with TC Ami, 83% of fatalities are 'active', especially males, and especially Fijian males.

An important implication of this research is the need for a strategy to educate the public – most notably 15-24 year old males – not to attempt to cross floodwaters or to play in flooded streams, since these are the activities most associated with drowning during floods. There is also a need to target the reasons why people choose to enter floodwaters (e.g. for property protection or to get to work), though these are not well understood. At critical sites it may also be practical to improve infrastructure to reduce the likelihood of lives being lost (e.g. the new Naqali Bridge is higher than its predecessor).

Fortunately loss of life connected to the flooding of houses has been infrequent in Fiji – the loss associated with TC Ami is believed to be the highest toll since the record disaster of February 1931. Nevertheless, the recent event does provide fresh impetus for the holistic management approach required to avert such disasters, including flood hazard mapping, land use planning, building design, flash flood warning systems and community-based evacuation planning.

ATTACHMENT

PROGRAMME as at 13 October 2011 (check daily at the meeting venue for updates)

Programme for 28th STAR Conference, Nadi, Fiji
October 2011
Tanoa Hotel

Time	Theme	Authors & Speaker	Title
Sunday October 16th			
10:00-16:00	Picnic and Volleyball Tournament Venue is Nadi Airport Boat Club, transport provided from Tanoa Hotel		
Evening	Informal gathering Hotel Bar		
Monday October 17th **Conference registration from 07:00 at Tanoa Hotel, Nadi**			
08:30-09:00	Opening of STAR		
09:00-09:20	Hazards & DRM	Anton, L. & Kuduon, J	Finschhafen Earthquake Swarm, Morobe Province, Papua New Guinea
09:20-09:40		Glassey, P.	The effects of the Canterbury 2010 and Christchurch 2011 earthquakes
09:40-10:00		Garaebiti, E., Todman, S., Lebellegard, P.	Developing national seismic monitoring capability for regional earthquake and tsunami warning center: the example of New Caledonia-Vanuatu seismic regional network
10:00-10:20		Inoue, H., Suetsugu, D., Vunisa, S., Vaiomo'unga, R., Seru, S., Vailea, S.	Upgrading Seismic Networks of Fiji and Tonga (2)
10:20-10:50	Refreshment break		
10:50-11:10	Hazards & DRM	Glassey, P., Heron, D., Buikoto, L., Papao, J., Vocea, S., Bosse, T.	The Pacific Exposure database, hazard models and risk
11:10-11:30		Baca, A., Bazzurro, P., Biukoto, L. , Bonte-Grapentin, M., Glassey, P., Heron, D., Ketewai, M., Mahul, O., Papao, J., Raj, A., Roop, J., Singh, S., Vocea, S.	PCRAFI: Better Information Smarter Investments
11:30-11:50		Gledhill, K., Kong, L., Guard, J.	PacWave'11: A Pacific-wide tsunami warning and communications exercise, 9-10 November 2011
11:50-12:10		Rosser, B.	Public preparedness and capacity building for tsunami evacuation in Samoa: the development, installation and testing of fit-for-purpose tsunami evacuation information
12:10-12:30		Gledhill, K.	*The proposed changes to PTWS tsunami alerts: using forecast models, threat levels and coastal zones*
12:30-13:30	Lunch break		
13:30-13:50	Hazards & DRM	Yeo, S.	Flood fatalities in Fiji, 2000-2009
13:50-14:10		Kruger, J., Begg, Z., Hoeke, R., Damlamian, H., Kumar, S.	Coastal inundation caused by distant storms: 20th May 2011 extreme swell event (*Loka*), Coral Coast, Viti Levu, Fiji Islands
14:10-14:30		Yasuda, T., Tanaka, Y., Ninomiya, S., Mori, N., Mase, H.	Wind and wave hindcast due to cyclone Tomas and climate change impact analysis on tropical cyclone in Fiji

14:30-14:50	Technical Support	Singh, M., Singh, S., Tiuhe'a, R.., Shaw, A., Kubunavanua, E., Tubuna, S., Toba, F., Duaibe, K., Wong, L., Bukarau, L.	The SOPAC Compendium Project 2011-2012
14:50-15:20	Refreshment break		
15:20-15:40	CPC Session: Sea Bed Minerals	Taumoepeau, P. & Smith, S.	Seafloor massive sulphide resource production – Solwara 1 Project update
15:40-16:00		Okamoto, N., Tohyohara T. , Narita, T., Ueda, S.	Approach to environmental impact assessment and conservation measures of biodiversity for mining seafloor massive sulphides
16:00-16:20		Fisher, C.	Vulnerability and resilience of the hydrothermal vent communities to polymetallic sulfide deposit mining.
16:20-16:40		Harris, P.	Global reporting on the state of the marine environment
16:40-17:00		Greene, G.	The quest for substrate and habitat knowledge by the renewable energy sector
17:00-17:20		Lily, H.	Mining the deep seabed: rights and responsibilities
17:20-18:00	STAR Business Meeting		
18:00-20:00	Ice Breaker, Poolside Meetings of Working Groups		

Tuesday October 18th			
09:00-09:20	Remote Sensing & Databases	Forstreuter, W.	Forest change detection in Fiji, results and lessons learned
09:20-09:40		Tokalauvere, V.	Visual interpretation for forest change detection in Fiji
09:40-10:00		O'Brien, K.	Vegetation Change Detection at 1:10,000 Scale Level for Vaitupu and Nanumea in Tuvalu
10:00-10:20		Forstreuter, W.	Land cover mapping of low lying Pacific islands baseline for drought mapping?
10:20-10:50	Refreshment break		
10:50-11:10	Remote Sensing & Databases	Gaunavou, L.	Atmospheric correction – for rugged terrain (ATCOR3)
11:10-11:30		Liava'a, E.	Current developments and the vision for the future of GIS for Utilities in the Pacific Island Countries
11:30-11:50		Smith, R.	Aerial photography in a lunch box
11:50-12:10		Rattenbury, M.	Oceania's contribution to the OneGeology digital geological map data for the world project
12:10-12:30	Energy	Mosusu, N.	Progress report on geothermal developments in Papua New Guinea
12:30-13:30	Lunch break		
13:30-13:50	Climate Change & Climate Change Adaptation	Gerber, F.	Assessing the socio-economic value of water-related climate change adaptation projects in Funafuti, Tuvalu
13:50-14:10		Stephens, M., Mattey, D., Anton, E., Hoffman, D., Dredge, J., Fisher, R., Lowry, D.	Long-term climate and environmental change recorded in cave sediments in Pacific islands: preliminary results from Volivoli Cave, SW Viti Levu Island, Fiji
14:10-14:30		Lomani, E.	Climate change adaptation options for the Rewa River Catchment in the Fiji Islands
14:30-14:50	Coastal, Oceans & Ecosystems	Collen, J.D., Garton, D.W., Gardner, J.P.A.	*In-situ* measurements of H_2S concentrations in euxinic atoll lagoon waters
14:50-15:10		Wiles, P., Brasher, A., Clark, T., Baskin, R.	Landfill leaching and reef flat dynamics in a tropical Pacific lagoon
15:10-15:40	Refreshment break		
15:40-16:00	Coastal, Oceans & Ecosystems	Harris, P. & Baker, E.	GeoHab Atlas of seafloor geomorphic features and benthic habitats – synthesis and lessons learned
16:00-16:20		Artack, E., Webb, A., Lal, A.	Successful progress of the PICs national efforts relating to the Maritime Boundaries Sector activities in the Pacific
16:20-16:40		Baker, E., Lawrence, A., Lutz, S.	Blue Carbon – Management of coastal ecosystems to support Millennium Development Goals

16:40-17:00		Parker, P.	The Sea Level Monitoring Project in the Pacific under the new COSPPac initiative
17:00-17:20		Anderson, E.	Aquatic pollution in Suva, Fiji
17:20-17:30	Discussion and Conference Conclusion		
Evening	Meetings of Working Groups		

Wednesday – Friday, October 19th – 21st
09:00 SOPAC Division Meeting begins and all STAR participants are invited to attend as technical advisers