

ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION 2010

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Compiled and edited by:

John Collen¹ & Lala Bukarau²

¹Victoria University of Wellington & ²SOPAC Secretariat

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SOPAC Secretariat
Private Mail Bag
GPO, Suva
Fiji Islands
Phone: (679) 338 1377
Fax: (679) 337 0040
<http://www.sopac.org>

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Note from compilers

This volume contains all abstracts received for presentation in Nadi, inclusive of those not presented due to no-show of programmed participants.

FOREWORD

STAR (the Science, Technology and Resources Network associated with SOPAC) was founded in 1985 in collaboration with the International Oceanographic Commission, to assist the international geoscience community to continue to provide advice to SOPAC. The first Chair of STAR was Charles Helsley, then Director of the Hawaii Institute of Geophysics, who was succeeded in 1992 by Keith Crook from the Hawaii Undersea Research Laboratory. In turn, John Collen from Victoria University of Wellington became Chair in 1999.

STAR meetings have not simply been technical conferences at which individuals present and discuss scientific papers, as participants had the additional responsibility to formulate advice to SOPAC about its work program and to highlight 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, has been tendered 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 Session. The participation of all STAR delegates as technical advisers during this phase of the meeting has been welcomed.

A strength of SOPAC has been 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 has been a vital element in this endeavour and stimulated a major change in the geoscience database in the SOPAC region during the 1980's. 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 have 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 has allowed wider and more detailed participation of international scientists in assisting SOPAC's work.

The future of both SOPAC and STAR has been uncertain during the past few years as the Regional Institutional Framework (RIF) process has progressed. While the details of how STAR will function and meet in the future still remain to be clarified, that future now looks bright. SOPAC will become a Suva-based division of the Secretariat of the Pacific Community (SPC) and that organisation has pledged its full support to STAR. Similar expressions of support have been received from other regional organisations. Further, the meeting this year features sessions held jointly with the Circum-Pacific Council for Energy and Mineral Resources, a relationship that I hope will continue. Thus, we can look forward to the opportunity to not only continue but to expand our endeavours in Pacific science in collaboration with and for the benefit of the SOPAC nations.

The theme of this the 27th STAR Conference is "Pacific Geoscience – Towards 2020 in the Face of Dwindling Global Natural Resources", with related joint STAR-Circum Pacific Council sessions on the theme "Map once – use many ways". The abstracts in this volume illustrate both the important issues that the region faces through pressure on resources and from natural hazards, and also information on new research and technologies aimed at dealing with those issues.

John Collen

*Chair, Science Technology and Resources Network
Centre for Marine Environmental & Economic Research
Victoria University of Wellington, Wellington, New Zealand*

October 2010

ABSTRACTS OF PAPERS

AALBERSBERG (NO SHOW)

Applying community-based adaptive management to watersheds

Bill Aalbersberg

Institute of Applied Sciences, University of the South Pacific, Suva, Fiji Islands

Email: aalbersberg@usp.ac.fj

Two emergent trends in natural resource management are participation and adaptive management. It is increasingly being recognized that the complexity of Nature precludes sure-fire interventions. The use of rapid assessments, traditional knowledge, and established best practice can suggest sensible actions whose impact can be monitored to judge the need to adapt measure undertaken. These should be undertaken by communities which have undertaken a strategic planning process to assess how their needs can best be met and threats to their resources best addressed.

These approaches have been well utilized in the marine sector in Fiji and the rest of the Pacific Islands via the Locally Managed Marine Area Network since 2000 and many benefits have arisen. More recently work has begun to apply these principles to watershed management in Fiji, Vanuatu and Samoa. Actions include tree replanting, low-impact agriculture, bans on burning and water source protection.

The presentation will describe the community-based adaptive management approach and its application to resource management (including climate change adaptation) in the Pacific islands.

ANDERSON

Benthic communities: case studies in Fiji and Canada

Edward Anderson

Division of Marine Studies, The University of the South Pacific, Suva, Fiji Islands

Email: anderson_ed@usp.ac.fj

Benthic habitat classification based on sonic mapping of the seafloor does not complete an investigation of pollution. Coupled with this should be mapping of benthic communities. The apparatus for this is simple: a sediment grab, a way to separate the animals from the sediment, and a microscope. The problem is that benthic animals which are useful for determining pollution status are small, and their identification is difficult.

The case study from Canada is an investigation of benthic recovery from pollution under net-pen culture of salmon. A community analysis showed that recovery time varied from 0 months at a high current site to 50 months at a low current site. Measurements of community diversity were confirmed by sediment H₂S, particle size and current measurements. The effects were confined within a few hundred meters of the net pens. High H₂S accompanies pollution from oxygen consuming wastes, which are the major sources of marine pollution worldwide.

The case study from Suva, Fiji is student work. We measured pollution at Walu Bay and at Kinoya sewage outfall. This study was repeated in every year from 2001 to 2010, with similar results. Diversity was depressed near each site. Benthos was completely absent in the inner reaches of Walu Bay, H₂S was high, bottom current very low. In the overlying water oxygen was near normal at the surface and also at 1m above bottom at all stations. At the entrance to Walu Bay, diversity and H₂S content were near normal, and at 450m offshore they were normal.

ANTON AND TARANU

The recent magnitude 7 earthquake doublets of the Papua New Guinea region

Lawrence Anton & Felix Taranu

Port Moresby Geophysical Observatory, P.O. Box 323, Port Moresby, National Capital District, Papua New Guinea

Email: lawrence_anton@mineral.gov.pg

The magnitude 7.3 (Mw) "Gasmata – Fullerborn Earthquake" of 18 July 2010 was one of Papua New Guinea's large earthquakes recorded from the New Britain region since the earthquakes of southern New Ireland, northern Solomon Sea and New Britain of 16 and 17 November 2000. The earthquake occurred at intermediate depth and its epicenter was located at 5.93°S, 150.59°E, at 13:34 UTC, on-shore central/southern New Britain and about 65 km southeast of Kimbe the Provincial Capital. The strong shaking caused serious and wide-spread damage to numerous village houses, water tanks, triggered numerous landslides and created ground cracks, including damage to the Gasmata airstrip. This earthquake was preceded by a magnitude 6.9 foreshock at 13:04 UTC on 18 July 2010. A strong aftershock sequence followed and populated the region of the Gasmata Local Level Government.

The tectonic significance of the July 2010 "Gasmata – Fullerborn Earthquake" is that it represents a major overthrust movement of the leading edge of the South Bismarck Plate, contributing to the long history of uplift of the coastal region of southern New Britain. Significant uplift of reefs along coastal Gasmata were observed and reported.

A magnitude 7.0 earthquake, possibly the second of the latest earthquake doublet occurred on 4th August 2010 at 22:01 UTC in the general area of the 18 July magnitude 7.3. This is typical of the region known for its' many previous earthquake doublets. Figure 1 shows the locations of the large earthquakes and aftershock sequence.

Two doublet sequences in the recent past are the July 14, 1971 ($M = 7.9$) and July 26, 1971 ($M = 7.9$) and the 14:37 UTC July 20, 1975 ($M = 7.9$) and 19:54 UTC, July 20, 1975 ($M = 7.7$). The mechanism of these seismic doublets has important bearing on the triggering mechanism of earthquakes in subduction zones. Detailed analysis of the seismic body waves and surface waves were performed on the 1971, 1974, and 1975 doublets, providing a better understanding of (Lay and Kanamori, 1980): (1) the mechanics of seismic triggering, (2) the state of stress on the fault plane, and (3) the nature of subduction between the Pacific and Solomon Plates, or Solomon and South Bismarck Plates.

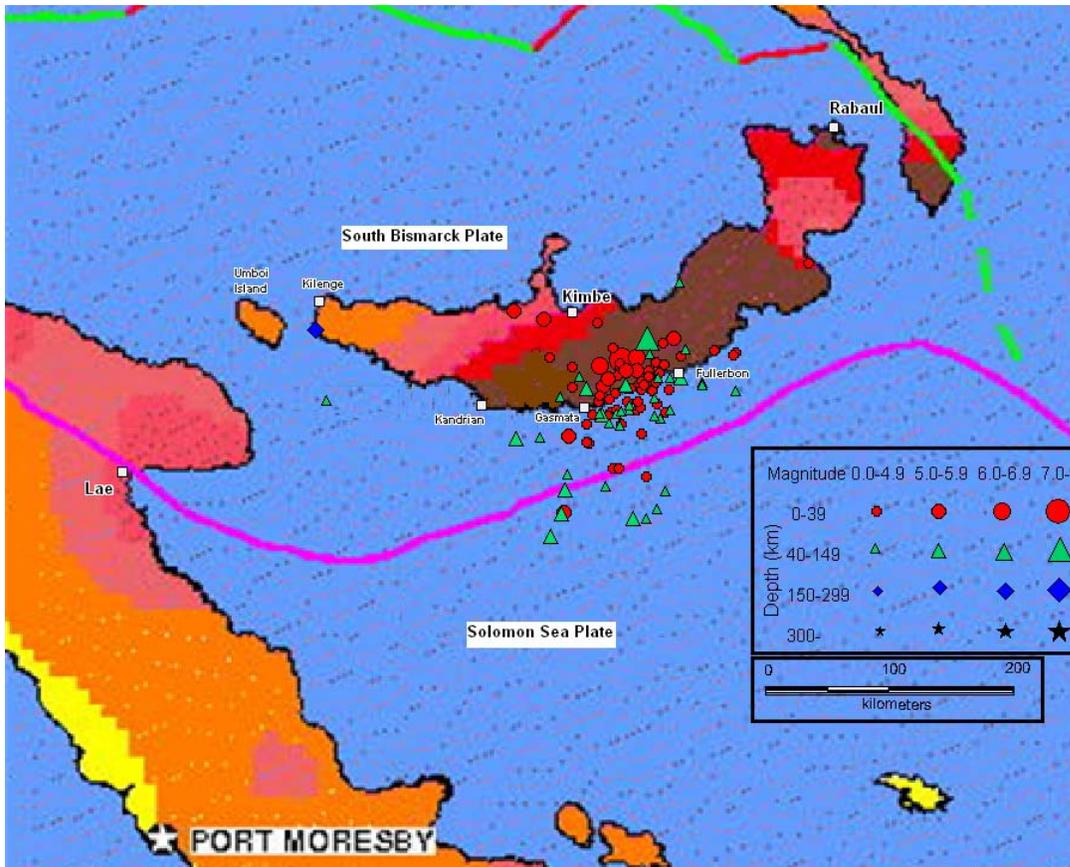


Figure 1. Map showing aftershocks in green (intermediate depth range) and red (shallow depths), including the earthquake doublet also in red. The map shows regions of Peak Ground Acceleration (m/s^2) with 10% probability of Exceedance in 50 years (USGS, 2010). Green dotted line (transform faulting) and purple (subduction) are plate boundaries. The Pacific Plate is located to the east.

Prior to the 1971 sequence, similar sequences have occurred in the same area in 1919 -1920 and 1945 - 1946 (Schwartz *et al.*, 1989). The doublets include the largest events in the region, and by constraining their mechanisms it was possible to have enhanced better understanding of the regional tectonic framework. The sets of doublets may have preceded the PNG catalogue which commences from 1900. From the beginning of historical records though, it is possible that there has been more than 20 doublets of magnitude 7 earthquakes. Table 1 lists those from 1971 to the present.

Lay and Kanamori (1980) determined a slip of 1.3 m for the 1971 sequence and the apparent recurrence interval of 25 years, and subsequently determined a seismic slip rate of 5 cm/yr. This value is a significant portion of the convergence rate between the Australia/Solomon and Pacific plates indicating that the plate motion here is taken up largely by seismic slip. Detailed analysis of the earthquake doublets in the region has led to an improved understanding of the stress distribution and nature of convergence in this portion of the Australian/Solomon - Pacific and/or Solomon - South Bismarck Plates boundary.

Other recent doublets have been the 1995 northern Solomon Sea earthquakes of 16 August at 10:27 and 23:10 UTC, and magnitudes of 7.8 and 7.1 respectively.

Also, there had been the 16 November 2000 magnitude 8.0 (M_w) earthquake of eastern Bismarck Sea (at 04:54 UTC) which ruptured south-eastward through southern New Ireland and beyond, and which was followed in a matter of hours by magnitude 7 earthquakes in the northern Solomon Sea (at 07:42 UTC) and eastern New Britain respectively (at 07:45 UTC on 17 November). The rupture associated with the first main earthquake of 16 November confirms that one component of the plate triple junction involves a dominantly strike-slip fault, consistent with the characteristics of the left-lateral fault system of south New Ireland. However, regarding the occurrences of the November 2000 events and sequences didn't resemble any of the doublets and their sequences described by Kagan and Jackson (1999). In particular, the tight

clustering in time and space of the great and the two large earthquakes which represent one of the most energetic episodes of seismic stress release recorded in PNG (Anton and McKee, 2005). But even if both the large events had occurred at great distances from the great Mw 8.0 earthquake and both having generated their own aftershock sequences with many aftershocks occurring in coincidence with each and those of the great earthquake, Geist and Parsons (2004) determined that both earthquakes could not possibly qualify as another doublet of the region. They are worth a mention though. Overall, some of these great earthquake sequences possessed features rendering them highly significant, not only locally, but regionally and globally.

Table 1. The latest of possible earthquake doublets of the PNG region.

Year	Mon	Day	Hour	Min	Sec	Lat (°)	Long (°)	Depth	Mw
1971	7	14	6	11	29.1	-5.5	153.9	47	7.8
1971	7	26	1	23	21.2	-4.94	153.17	48	7.6
1974	1	31	23	30	5.8	-7.4	155.6	34	7
1974	2	1	3	12	33	-7.38	155.57	40	7
1985	5	10	15	35	0	-5.59	151.04	26	7.3
1985	11	17	9	40	0	-1.8	134.8	10	7.3
1987	2	8	18	33	0	-6.08	147.68	54	7.5
1987	2	8	18	34	0	-5.9	147.9	34	7.4
1993	10	13	2	6	0.3	-5.89	146.02	25	7.1
1993	10	25	10	27	4.5	-5.91	145.99	30	7
1995	8	16	10	27	28.6	-5.8	154.18	30	7.8
1995	8	16	23	10	24	-5.77	154.35	33	7.1
2000	11	16	4	54	56	-3.96	152.27	33	8.1
2000	11	16	7	42	17	-5.18	153.05	...33	7.8
2000	11	16	7	45	32.2	-4.9	153.2	33	7.1
2010	7	18	13	34	59.33	-5.93	150.59	35	7.3
2010	8	4	22	01	43.62	-5.75	150.76	44	7.0

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BAKER

The University of the Sea: an Asia Pacific marine science initiative

Elaine Baker

UNEP/GRID Arendal, School of Geosciences, University of Sydney, Bld FO9, Sydney NSW, 2006 Australia
Email: ebaker@usyd.edu.au

The University of the Sea (UOS) was established in 2005 to provide practical ship-board training for tertiary marine science students from Australia and the Asia Pacific region. Since its inception, the UOS has supported the participation of more than 100 students in hands on research. The multidisciplinary programme has run in conjunction with surveys investigating a broad range of marine science topics including the history of the northern Australian monsoon, marine habitat mapping for ecosystem based management, petroleum prospectivity, basin evolution and gas hydrates. Technical training has included seabed mapping and sediment sampling, sampling and identification of benthic and pelagic organisms, measurement of water column variables including current speed and direction, salinity, temperature, dissolved O₂, report writing and results presentation and data management and handling.

The UOS Secretariat is located at the University of Sydney. There are currently 27 universities and research institutes involved in the program. Students from these institutions are invited to apply for the fully funded places. The program is independently funded and in the past has received support from the Intergovernmental Oceanographic Commission of UNESCO, the Toyota Foundation, the Asia Pacific Network for Global Change Research, ARC Network for Earth Systems Science, Geosciences Australia and MARGO (the Australian Marine Geoscience Office).

UNEP/GRID-Arendal's mission is to provide environmental information, communications and capacity building services for information management and assessment. Established to strengthen the United Nations through its Environment Programme (UNEP), our focus is to make credible, science-based knowledge understandable to the public and to decision-makers to promote sustainable development. We are dedicated to making a difference by exploring how environmental information impacts on decision-making and the environment. We seek to bridge the gap between science and politics.

BAZZURRO, BIUKOTO, BONTE-GRAPENTIN AND OTHERS

Pacific Risk exposure databases and models

Paolo Bazzuro¹, Litea Biukoto², Michael Bonte-Grapentin², Todd Bosse³, Phil Bright⁴, Edy Brotoiswor⁵, Chris Chiesa³, Steven Clegg², Phil Glassey⁶, David Heron⁶, Olivier Mahu⁷, Bishwa Pandey¹, Joy Papao², Scott Pontifex⁴, Susan Vocea²

¹AIR Worldwide, ²SOPAC Secretariat, ³Pacific Disaster Center, ⁴Secretariat of the Pacific Community, ⁵Asian Development Bank, ⁶(NZ) Institute of Geological and Nuclear Sciences Limited, ⁷World Bank
Email: michael@sopac.org

Pacific nations are exposed to a range of natural hazards such as cyclones, earthquakes, floods, tsunami and severe storms. There is a need to compare the risks posed by each hazard in a standardized manner using potential impacts such as cost and casualties. Such comparison of risk can then support decision making by determining which hazard represents the greatest risk to various communities; enabling mitigation investments to be prioritized; avoiding inappropriate land development through planning; contributing to effective emergency management plans; and thus assist in minimizing the negative social and environmental impacts of catastrophic events.

In a joint initiative by the World Bank (WB), the Asian Development Bank (ADB) and the Pacific Applied Geosciences Commission (SOPAC) disaster risk assessment tools and knowledge products are developed in close collaboration with the Institute of Geological and Nuclear Sciences Limited (GNS Science), the Pacific Disaster Center (PDC), AIR Worldwide, Geoscience Australia and the Secretariat of the Pacific Community (SPC).

As part of this initiative a Pacific GIS risk exposure database is being developed outlining built infrastructure in the Pacific as well as the risk posed to infrastructure by various natural hazards. This database will hold more than 400,000 buildings and infrastructure digitized from very-high resolution satellite imagery and detailed description of building structure and construction types for approximately 90,000 buildings. The database will also include information on major cash crops and population.

The database will be useful for disaster risk mitigation and urban planning, and will form the basis for the development of country-specific catastrophe risk models. The models will simulate the economic and fiscal impacts of natural disasters in the Pacific island countries and provide loss maps and other risk metrics that will allow the governments and their partners to better assess their economic and fiscal exposure to natural disasters and help them prioritize risk mitigation programs.

The countries covered under this project are Cook Islands, East Timor, Federated States of Micronesia, Fiji, Kiribati, Papua New Guinea, Republic of Marshall Islands, Nauru, Niue, Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

CHAPMAN

Reducing water losses & operating costs in Niue: a WDM case study

Clinton Chapman

¹Water Supply Division, Public Work Department, Niue Island

Emails: watersupplyadviser@mail.gov.nu

Globally, many utilities have problems meeting continuously increasing demand for water partly because large amounts of water are lost through leakage. Pacific island utilities are no different and generally have high system water losses, sometimes exceeding 40 percent. Reducing water losses was identified in the Pacific Regional Action Plan on Sustainable Water Management as the highest priority issue for Pacific water utilities.

The key towards sustainability is the sound management of water which is already available. This is a demand management approach - optimising use of existing water resources and infrastructure. Demand management offers significant benefits to both customers and utilities, including energy and financial savings, higher customer service levels, improved water quantity and quality (and therefore community health) and a deferred need for substantial infrastructure investment.

As part of their regional mandate, SOPAC has assisted Niue, among other Pacific countries, implement best water demand management (WDM) practices. The aim of WDM activities of SOPAC's Water and Sanitation Programme is to build the capacity of the region's water suppliers (urban and rural) to implement improved and sustained water demand management practices.

This paper uses implementation of water demand management techniques in Niue as a case study to demonstrate and advocate for the tangible benefits available to Pacific water suppliers. A System Loss Management Plan (SLMP) was developed in 2007, and recommended installation of bulk flow meters on production bores and reservoir outlets, installation of flow and pressure logging devices, active leak detection and repair, and a community water awareness campaign. Following assistance provided as part of WDM activities to fulfil these recommendations, the SLMP was revised in 2010 and demonstrated significant savings in water loss and operating costs.

In 2007, Niue's water system losses were estimated to be 92 megalitres, or approximately 34% of total water supplied. In 2010, losses were estimated to have reduced to 62 megalitres, or 24% of total water supplied. Further, the Water Divisions monthly electricity expenditure from January to April 2010 ranged from 13% to 23% less than compared to the same months in 2009.

DAMLAMIAN & KRUGER

The application of a three dimensional coupled wave-current hydrodynamic model for the management of Saipan Lagoon, CNMI

Herve Damlamian & Jens Krüger

SOPAC Secretariat, Private bag, GPO, Suva, Fiji Islands

Email: herve@sopac.org; jens@sopac.org

Wave driven circulation through tropical lagoons can have significant effects on the transport, dispersal, retention and fate of pollutants. This study considers the physical mechanisms in Saipan Lagoon, Commonwealth of Northern Mariana Islands. Month-long time series data were collected with an array of pressure sensors and acoustic current profilers. Incident wave statistics were derived from pressure sensors on the slopes of the barrier reef. Fluxes through the lagoon and out of the pass were obtained from current profilers. The field data showed a strong coupling between incident wave forcing and lagoon circulation. This prominent feature of the time series data was well reproduced using a three dimensional coupled wave-current numerical model. The model was used to derive the distribution patterns of particles discharged from a sewage outfall as well as determine the dominant sediment transport directions for different seasonal forcing mechanisms. This information provides the scientific baselines needed to update the Saipan Lagoon Management Plan.

Possible impacts from proposed channel alterations, Aitutaki, Cook Islands.

Herve Damlamian & Jens Krüger

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands

Emails: herve@sopac.org; jens@sopac.org

The almost-atoll of Aitutaki, one of Cook Island's tourism hot spots, features an enclosed lagoon that is only open to the ocean through the Arutanga Passage, a narrow and shallow navigational channel. The channel and harbour are to be developed to open up Aitutaki as a destination for yacht tourism. The shipping channel will be deepened and extended while the wharf will be re-designed to enable bigger ship to moor on Aitutaki's shore.

SOPAC is using numerical modelling tools to evaluate possible impacts from two proposed channel alterations in regards to water circulation, surface elevation, current speed and lagoon vulnerability to pollution scenario.

DIAZ-NAVEAS

Mapping efforts at the Chilean Convergent Margin

Juan Díaz-Naveas

Escuela de Ciencias del Mar, P. Universidad Católica de Valparaíso, Av.altamirano 1480, Valparaíso, Chile

Email: jdiaz@ucv.cl

The Chilean convergent margin comprises mostly the subduction of the Nazca and the Antarctic Plate beneath the Southamerican plate along more than 4 thousand kilometers. Historically the Chilean Navy has been in charge of mapping Chilean waters, what is now understood as the Exclusive Economic Zone (EEZ). The Chilean Navy put its efforts mainly in producing nautical charts, and with emphasis in turn in shallow water bodies such as bays, gulfs, straits, estuaries, rivers, lakes, etc.. Also, for historical reasons, the Chilean Navy was one of the leader institutions in Chile in oceanographic research. And within this framework deep bathymetric surveys started to be carried from the early 1950's and during the 1960's. At the same time, several US research vessels started to produce bathymetric profiles across the Peru-Chile trench. A renewed impulse was carried out during the 1970's, during which the Nazca Plate Project took place; this project being under the umbrella of the International Decade of Ocean Exploration was driven

mainly by Oregon State University and the University of Hawai'i. One of the main results was a set of 9 charts from about 3°S to 40°S along the Peru-Chile trench at a scale of 1:1.000.000. After that 15 years passed without systematic efforts for improving the coverage and resolution of the bathymetry of the Chilean margin with some notable exceptions carried out mainly by US universities: the use for the first time of multibeam echosounders and side scan sonars for mapping submarine canyons, the Chile triple junction and the O'Higgins guyot. Finally starting in 1995 German institutions (mainly IfM-GEOMAR, BGR and the University of Bremen) started systematic research of the Chilean margin which is still running today. One of the key products is the increased full coverage of the margin with multibeam bathymetry. This dataset enables to produce grids with 3" in the region from 32°S to 40°S plus other large patches as well. Parallel to this, the first very Chilean program on marine geophysics started in 2001 for exploring gas hydrates off Central Chile. This initiative complemented the coverage done by Germany. Also around 2001 the Chilean Navy hydrographic vessel Cabrales started to map the southernmost region of Chile, which comprises mainly inner waters such as straits and fjords. Thanks to all these efforts it has been possible to know with great detail the morphology of the Chilean convergent margin prior to the Mw=8.8 earthquake of February 27, 2010. And thanks to R/V Melville that was operating precisely at that very time at the Chile Triple Junction it was possible to remap the seabed of the rupture zone for the purpose of comparing possible changes. Due to this earthquake all the nautical charts inside the rupture zone must be rebuilt, an effort that will take about 7 to 8 years. Today a state-of-the-art research vessel (AGS 61 Cabo de Hornos) is being built in Chile for general oceanographic and fisheries research. It will be equipped with several multibeam sonars including a multibeam subbottom profiler.

DUNCAN

Measure once and report universally – developing an IWRM regional monitoring programme that meets water resource reporting requirements from the local to the global level

David Duncan

SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji

Email: d.duncan@sopac.org

Currently water resource monitoring in the Pacific is undertaken on an as needs basis within countries, and capacity to report water resource management at national and regional levels is often restricted by the paucity of relevant, consistent available data. Currently, strategic regional outlook reporting for ADB and UNEP is being challenged by the paucity of consistent, available water resource data. The GEF IWRM project is currently developing a sustainable regional indicator framework that is driven by in-country reporting needs, but is consistent with regional and global reporting requirements.

This presentation looks at technical, logistical and reporting challenges in developing a regional framework, with a particular focus on the challenges resourcing such a monitoring programme in the region and the ability to collect water resource data that is meaningful from the local to the global level.

GARAEBITI, TODMAN AND OTHERS

Developing monitoring capability of a volcano observatory: the example of the Vanuatu Geohazards Observatory

Esline Garaebiti¹, Sylvain Todman¹, Gill Jolly², Art Jolly², Steve Sherburn², Craig Miller², Nicolas Fournier² & Brad Scott²

¹ Geohazards Section, Department of Geology, Mines & Water Resources, Port-Vila, Vanuatu

² Institute of Geological and Nuclear Sciences, Taupo, New Zealand

Email: gesline@vanuatu.gov.vu

Vanuatu lies on the Pacific 'Ring of Fire'. With 6 active subaerial and 3 submarine (identified so far) volcanoes, monitoring and following up their activities is a considerable work for a national observatory. The Vanuatu Geohazards Observatory is a good example of what can be done from 'scratch' to develop a volcanic monitoring capability in a short space of time. A fire in June 2007 completely destroyed the old observatory building and many valuable records leaving Vanuatu with no volcano monitoring capacity. This situation forced the Government of Vanuatu to reconsider the structure of the hazards monitoring group and think about the best way to rebuild a complete volcano monitoring system.

Taking the opportunity of the re-awakening of Gaua volcano (North of Vanuatu), the Vanuatu Geohazards section in partnership with GNS Science, New Zealand developed a new program including a strategic plan for Geohazards from 2010-2020, the installation of a portable seismic network with real-time data transmission in Gaua, the support of the first permanent monitoring station installation in Ambrym and the design and implementation of volcano monitoring infrastructure and protocol.

Moreover the technology improvements of the last decade and the quick extension of enhanced communication systems across the islands of Vanuatu played a very important role for the development of this program.

In less than one year, the implementation of this program was beyond expectations and showed considerable improvement of the Vanuatu Geohazards Observatory volcano monitoring capability. In response to increased volcanic activity (or unrest) in Ambae, the Geohazards section was fully capable of the installation of a portable seismic station in April 2010 and to follow the development of the activity. Ultimately, this increased capability results in better and timelier delivery of information and advice on the threat from volcanic activity to the National Disaster Management Office and to the population of the volcanic islands.

GLEDHILL

Improving tsunami warning times

Ken Gledhill

GNS Science, Avalon, PO Box 30 368, Lower Hutt, New Zealand

Email: k.gledhill@gns.cri.nz

Most of the known deaths and damage from tsunami in the South-West Pacific (SWP) region have been caused by local or sub-regional events, rather than trans-ocean tsunami such as the 1960 Chilean or 2004 Indian Ocean tsunami. Recent examples in the region are the 2007 Solomon Islands and 2009 Samoa – Tonga events. This presents problems for tsunami warning because of the short early-warning times and the emphasis of current warning centres on trans-ocean tsunami.

Based on potential warning times, the tsunami threat can be categorised as local (less than an hour travel time), regional (up to three hours travel time) or distant (more than three hours travel time). Very few countries currently attempt to provide warning of local tsunami to their citizens (current examples include Japan, Hawaii and more recently Indonesia). Local warning for most countries (including New Zealand and other SWP countries) relies on natural signs (felt earthquakes and sea behaviour) and informal warnings from people closer to the tsunami source. The role of warning centres for the local event is often in providing confirmation of the likely severity of the tsunami when communications from the affected areas may be disrupted. Education that teaches people in the community to recognise the natural warning signs is very important for the local tsunami threat.

For regional and sub-regional tsunami threats warning centres can have an effective early-warning role if enough seismic and sea level data are available for decision making, and communities have effective response and evacuation plans in place. Possible warning times can be measured in minutes whereas the tsunami travel times will be several tens of minutes. In the SWP work needs to continue on an end-to-end approach. The warning centres do not receive enough data from the region to provide timely regional and sub-regional early warnings. To improve this situation, data from existing and planned monitoring stations must be made available to all warning centres. Further, efforts need to continue so that when warnings are

given, these are disseminated to communities, and these communities have evacuation plans in place that can quickly be executed.

GLEDHILL AND GEONET TEAM

The Darfield (Canterbury, New Zealand) Earthquake of September 2010: a preliminary report

Ken Gledhill & The GeoNet Team

GNS Science, Avalon, PO Box 30 368, Lower Hutt, New Zealand

Email: k.gledhill@gns.cri.nz

At 4:36 am on Saturday 4 September (local time) a M_w 7.1 earthquake struck near New Zealand's second largest city, Christchurch, causing extensive damage in the city and surrounding region. There was no loss of life, but about 100 people were injured (at least three of them seriously) and many more have been made homeless (at least in the short term) by housing damage. Modern buildings in Christchurch performed very well in the earthquake, but many older brick and masonry buildings were badly damaged. However, retro-fitted buildings (even to only 33% of the current building code) sustained very little damage. Liquefaction and the associated slumping caused extensive damage even to new buildings in areas near the coast with sandy soils. Current estimates put the total cost of repairs at NZ\$ 4 billion (about US\$ 3 billion).

Measured accelerations near source topped 1.25 g on the regional strong-motion network, and the event was very well recorded by the GeoNet hazards monitoring system (www.geonet.org.nz). A surface trace approximately 22 km long striking almost east-west has been identified with offsets of up to 4 m horizontally and 1.5 m vertically. Work to fully characterize the surface rupture is continuing. The closest continuous GPS station recorded 135 mm of horizontal offset at 300 degrees. Resurveying of campaign GPS marks and satellite remote sensing techniques will be used to characterize the resulting deformation. The mechanism of the earthquake was predominately strike-slip in the east-west direction, although the source-time-function is complex with at least two components to the rupture.

GREENE, JOHNSON AND OTHERS

The West Coast Governors' Agreement – a three state team effort to map the seafloor of California, Oregon and Washington, USA

H. Gary Greene¹, Sam Johnson², Chris Goldfinger³, Vaughn Barrie⁴, Sheila Semans⁵, Jennifer Hennessey⁶ & Rikk Kvitek⁷

¹*Center for Habitat Studies/Tombolo, Moss Landing Marine Labs, Moss Landing, CA USA*

²*U.S. Geological Survey, Santa Cruz, CA USA*

³*Oregon State University, Corvallis, OR USA*

⁴*Canadian Geological Survey, Sidney, BC, Canada;*

⁵*State Coastal Conservancy, Ocean Protection Council, Mendocino, CA USA*

⁶*Washington Department of Ecology, Olympia, WA USA*

⁷*Seafloor Mapping Lab, California State University, Monterey Bay, Seaside, CA USA*

Emails: greene@mlml.calstate.edu; sjohnson@usgs.gov; gold@coas.oregonstate.edu; Vaughn.Barrie@NRCan-RNCan.gc.ca; ssemans@scc.ca.gov; jenh461@ecy.wa.gov; rkviktek@csumb.edu

A major effort to map the entire seafloor within state waters of the conterminous west coast USA offshore California, Oregon, and Washington is underway. In California this offshore mapping program was initiated through California's residences' and taxpayers' initiative known as the California Ocean Protection Act (COPA), and consequently established as a common regional priority with the states of Oregon and Washington through the West Coast Governors' Agreement on Ocean Health. This effort is resulting in the construction of marine geologic, potential benthic habitats, and other derivative maps to be used in the

management and conservation of marine resources. The overall objective of the mapping group is to map once and use the resulting data to construct many different thematic maps.

An extensive set of maps is being developed for California, which will be published as a map folio by the USGS. These maps are being used to do the following:

(1) Delineation of California's marine protected areas; (2) Evaluation of ecosystem structure and connectivity; (3) Development of improved nautical charts; (4) Baselines for monitoring change; (5) Baselines for ecosystem restoration; (6) Offshore fault characterization for earthquake hazard assessment; (7) Modeling of sea-level rise impacts; (8) Modeling of inundation from large storms and tsunamis; (9) Regional sediment management activities, including planning for beach nourishment; (10) Siting of offshore energy, including renewable energy installations; (11) Coastal and Marine Spatial Planning; and (12) Public education and awareness. In Washington an international map series initially consisting of potential marine benthic habitats and geologic maps is to be published by the Canadian Geological Survey for northern Puget Sound, while other entities are leading data collection and map production in other areas of the state. Similar types of maps are in production in Oregon. Examples of the various map projects supported by the COPA will be presented.

HARRIS

Map once – use many ways: global and Australian examples

Peter T. Harris

Marine and Coastal Environment Group, Geoscience Australia, GPO Box 378, Canberra ACT 2601, Australia

Email: peter.harris@ga.gov.au

In this paper, examples will be described where seafloor habitat mapping has been carried out at different scales which have multiple applications. We shall start with the ETOPO1 global bathymetry model and explore how different interpretations of this information have been applied to different purposes, including derivation of maps of seamounts, submarine canyons and geomorphic features around the Antarctic which have fisheries and conservation applications. The second part of the presentation will deal with mapping work carried out in Torres Strait by Geoscience Australia, that has applications for mapping benthic habitats, the management of fisheries, spatial marine environmental management, design of marine reserves, supporting offshore oil and gas infrastructure development, safe navigation, and defence. These examples demonstrate how the theme "Map once - use many ways" underpins and justifies government-funded seafloor mapping programs as well as the creation of national and regional databases and environmental information systems.

HART AND BROOK

Fiji – a new petroleum province?

Alan W. Hart¹ & Bill Brook²

¹*Golden Downs Consulting, Wakefield, New Zealand*

²*Akura Limited, Nadi, Fiji Islands*

Email: sulubill@connect.com.fj

Akura Limited, a Fijian-based petroleum exploration company, was awarded three petroleum prospecting permits by the Mineral Resources Department in August, 2009. The three licences, totaling 17,600 km², are located in Nadi Bay, Bligh Waters Basin and Bau Waters Basin around the island of Viti Levu.

During Year 1 of the permits, Akura Ltd. collated the existing seismic and well data and conducted several geological reviews to initiate its exploration programme in the most effective manner. Seismic data acquired by Amoco, Chevron, Mobil, Mapco and PEM from 1973-1982 serve as the primary source of

subsurface information in Akura's permits. Akura has reprocessed over 700 line km of the digital seismic data from the Fiji Petroleum Data Package. The deep water Amoco and Mobil data exhibit the most improvement from the reprocessing effort, displaying structural elements of the Oligocene-Miocene section not discernable in the original processed data.

Seismic data indicates the current southerly trace of the Wainimala River system in the Rewa area may be a modern phenomenon, due to capture by the Rewa River, as thick prograding Pliocene sediment packages are evident in the marine Bau Water Basin off eastern Viti Levu. Seismic data shows the thickest wedge of Pliocene sediments is positioned between Ovalau Island and the Nasilai River, not off the southern coast near Suva.

Several play concepts have been identified in the seismic database, including Mio-Pliocene carbonate buildups, Pliocene turbidites, Mio-Pliocene half-graben sediment wedges and possible Pliocene fault block traps. Many of these leads will require new seismic data coverage to elevate them to a prospect category.

An amplitude anomaly near Nasilai in the Bau Waters Basin approximately 20 kilometres east of Suva may serve as a possible indication of trapped gas at a depth of 600 metres. Akura plans to explore this prospect in 2011 and if commercially successful, a gas discovery at Nasilai could replace 25-50% of imported diesel used for electricity generation in Viti Levu for a decade.

HASAN AND GERBER

The economics of drinking water safety planning: an advocacy tool

Tasleem Hasan & Federica Gerber

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands

Email: tasleem@sopac.org; federica@sopac.org

Good water quality is essential for the well-being of all people. In response to a growing realization that safe water is limited, the United Nations has declared access to clean water a basic human right. Unfortunately in many countries around the world, including the Pacific islands, some drinking water supplies are becoming increasingly contaminated, impacting the health and economic development of the country. To protect drinking water safety, conventional practice in many Pacific island countries has been to monitor the quality of the treated drinking water at the end of the supply chain through water quality testing and assessing compliance against standards. However, this approach does not, among other things, provide timely information to prevent the consumption of contaminated water already distributed. Consequently, the World Health Organization (WHO) now promotes the use of drinking water safety planning to assess and manage the risks associated with drinking water from catchment to consumer.

Selected Pacific island countries have endorsed the drinking water safety planning approach and are working with SOPAC and WHO to establish their own supply-specific water safety plans. Nevertheless, as the concept of drinking water safety planning is still new, evidence is required to demonstrate the value of the approach to ensure that government agencies and water suppliers not only adopt the approach but maintain sustainability through ongoing financial and technical support.

This paper uses an economic case study from Palau to demonstrate the benefit and cost effectiveness of drinking water safety planning in the long term. The cost-benefit analysis for implementing the drinking water safety plan for the Koror-Airai water supply in Palau shows that a return of US\$ 5.90 is expected on every US\$ 1.00 invested towards implementing the plan. The case study provides an effective advocacy tool for the promotion of drinking water safety planning both in the Pacific region and globally.

HEMER, KATZFEY AND KELAREVA

Surface wind-wave climate of the Pacific region: variability, trends and future projections

Mark Hemer¹, Jack Katzfey² & Galina Kelareva¹

The Centre for Australian Weather and Climate Research: A Partnership between CSIRO and the Bureau of Meteorology and the CSIRO Wealth from Oceans flagship.

¹Hobart, Tasmania, Australia; ²Aspendale, VIC, Australia.

Email: Mark.Hemer@csiro.au

Climate driven variations in key climatic parameters such as wind and mean sea level lead to significant physical impacts in the Pacific region. The IPCC fourth assessment report (AR4) recognised the strong focus on sea-level rise regarding the coastal impacts of climate change, and recommended that this interest be broadened to include all climate drivers in the coastal zone. Surface wind-waves are a dominant contributor to two major coastal hazards which are expected to worsen with climate change and rising sea levels (coastal inundation during extreme sea level events and ephemeral and chronic coastal erosion). Consequently, knowledge of the Pacific wave climate, both present conditions and how conditions might alter in the face of a changing climate, is critical for understanding the potential coastal impacts of climate change in the region.

This project, funded by the Australian Government Pacific Adaptation Strategy Program, has two objectives: Firstly, available wave data for the region obtained from in-situ and remotely sensed observations, models and reanalyses are analysed to provide underpinning information on the present-day wave climate, and what processes drive variability of wave climate, in the Pacific region. Secondly, provide an assessment of projected change in wave climate of the Pacific region under a range of future emission scenarios. CSIRO's cubic-conformal atmospheric model (CCAM) has been used to produce an ensemble of 140-year simulations at 60km resolution which dynamically downscale the outputs of 6 WCRP CMIP-3 coupled global climate models for the SRES A2 scenario. A 1.0 degree resolution global implementation of the NOAA WaveWatch III spectral wave model will be forced using surface winds obtained from the CCAM climate model simulations for two 30-yr time-slices (present day, 1979-2009; and future scenario, 2070-2099), enabling an ensemble distribution of present and projected wave conditions from which model skill (comparisons to observed present climate), and projected change in wave conditions may be determined. These wave simulations will contribute to a WCRP/JCOMM supported international collaborative program, COWCLIP, which aims to assess potential climate change driven variation in global wave climate and investigate uncertainty of wave climate projections associated with forcing scenarios, multi-model ensembles, and downscaling or wave modelling approaches. Results of this study are preliminary, and reference to an eastern Australian regional study will be made to demonstrate methodology and outputs.

The underpinning broad scale results from this study will identify regions sensitive to wave climate variability. Once identified, it is anticipated that future projects will further downscale project results to focussed localised studies.

IGC

International Geological Congress in Brisbane, August 2012

On behalf of the Oceania region, Australia is hosting the 34th International Geological Congress (IGC), in Brisbane from 5 to 10 August 2012. The International Geological Congress (IGC) is held every four years. It is the main meeting under the scientific sponsorship of the International Union of Geological Sciences (IUGS). Many thousands of delegates will attend the event from over 110 countries. The IGC presents a once in a generation opportunity for Oceania to showcase its geoscience strengths and fascinating geology to the world.

Under the theme *Unearthing our Past and Future – Resourcing Tomorrow*, the IGC program will cover all facets of the geosciences and highlight the crucial contributions of the geosciences in meeting societal needs and sustaining planet Earth. Topics of specific interest to delegates from developing countries include; geological hazards, submarine mining, United Nations Convention on Law of the Sea (UNCLOS) and marine zone management.

The organisers of the 34th IGC are committed to maximising participation in the event by delegates from the Pacific nations and there will be some support programs available. Training workshops aimed at attracting funding to support attendance by delegates from developing countries are being planned with topics such as sustainable mining, carbon sequestration, geohazards and groundwater under consideration.

Further ideas for supporting delegates in attending are welcome. Anyone who would like to make any suggestions, volunteer their services, organise business meetings during the event, or simply register interest in attending should do so through the 34th IGC website, www.34igc.org, using the "Register your interest" tab.

INOUE, ANDO AND OTHERS

2009 Niuatoputapu Tsunami video interview for sharing lessons of the disaster

Hiroshi Inoue¹, Masaharu Ando², Anau Fonokalafi² & Rennie Vaiomo'unga³

¹National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan

²Tonga Broadcasting Commission, Nuku'alofa, Tonga

³Ministry of Land, Survey, Natural Resources and Environment, Nuku'alofa, Tonga

Email: inoue@bosai.go.jp

Niuatoputapu Island of Tonga was attacked by a large tsunami on September 30, 2009 caused by the earthquake of M8.1 occurred at about 200km away towards American Samoa. Nine people died and more than half of the houses were heavily damaged on the island. Most of the people were not aware of tsunami when they felt the earthquake. People rushed to high grounds after they realized the big wave was approaching to the shore. If they had the knowledge and been trained for evacuation, most of the victims would have been saved.

In order to reduce future tsunami disasters in Tonga, it is primarily important to share the experiences and the lessons learnt by the people of Niuatoputapu. For providing such opportunities to other people of Tonga, we are attempting to make video interviews with the suffered people and make them an archive.

Ando and Fonokalafi visited the island three months after the tsunami with TV equipments to stay one month and shot video interviews with 53 people. A Tongan artist accompanied the team and drew 31 paintings of the scenes of the tsunami disaster based on stories told by the people. The interviews were compiled with the pictures into a 60 minutes program and broadcasted in Tonga. The combination of video interviews taken at affected site and pictures describing the scene works efficiently to transmit the experiences and lessons to others. DVD with English captions and book will be published as tsunami educational tools supported by UNESCO.

Inoue and Vaiomo'unga revisited the island to continue the interviews. Our ultimate goal is to make interviews with all the people of Niuatoputapu, and to publicize the archive on the web with considerations to the portrait rights, so that people of Tonga and other countries as well can easily access in the near future. Unlike the TV team, we used inexpensive digital cameras with movie function which enable us to collect many interview videos efficiently in cooperation with the community. It was difficult to make such a video archive ten years ago when digital cameras and storage were expensive, but now it is a useful way of sharing the people's lessons of any types of disasters.



Figure 1. Niuatoputapu Island.



Figure 2. Video interview.



Figure 3. Artist's drawing.

KUMAR, A

Flood forecasting and warning in Fiji

Ashok Kumar

*Water Authority of Fiji, Kings Road, Nasinu, GPO Box 1272, Suva, Fiji Islands
 Email: ashok.kumar@waf.com.fj*

The high rainfall, steep topography and relatively large catchments combined with intensive agricultural use of lowlands by village communities have made Fiji susceptible to flood disasters over the years. Inland flooding is currently the most frequent and damaging hazard to communities in Fiji with almost one event each year on average (SOPAC 2005). With an estimated annual mean of 10 casualties and around F\$ 20 million total damage, floods are a serious draw back to Fiji's socio-economic development. Apart from damage to infrastructure and agriculture and homes, there is considerable disruption to transport and inland communications. Floods in 2003 and 2004 caused extensive damage to crops, livestock, houses, roads and bridges and thousands of people lost their homes and belongings. For several weeks after both events over 10,000 people were still requiring food rations as much of the subsistence agricultural crops were severely damaged or destroyed. Though these events weren't associated with unusual meteorological extreme events they still caused significant damage with 29 deaths and over 67 Mio F\$ damage. Again, regional flooding in 2006 and 2007 has caused serious damages and deaths in several parts of Fiji. For example in 2004 about 90% of the 0.5 Million F\$ damage to medical supplies and equipment at Navua hospital could have been saved, if material could have been moved upstairs in a timely manner. According to estimates by Yeo (SOPAC 2000a) 65% of the estimated F\$ 15 million direct losses during the 1999 flooding in Ba could have been avoided with an operational flood warning system and a community prepared to take advantage of it.

More recently flooding in the Nadi Basin January 2009 during a non cyclonic event resulted in a 'largest in living memory' flood event resulting in an estimates losses of F\$100 million and of several lives including serious damages water related and land based infrastructure. The Hydrology Section of the Water Authority of Fiji now operates flood monitoring, forecasting and warning systems on two of Fiji's major river systems, the Navua (2007) and Rewa (2008) in order to deliver advanced warning of significant flooding. This is include the Nadi Basin in late 2010 and the Ba is forecast for installation in the near future. It is also very important to note that hydrological stations are installed to monitor and assess the complete catchment flow regime and that the data is equally suitable for drought or flood analysis or any other water resource analysis or assessment.

This presentation will demonstrate aspects of these flood warning systems, what is required to install, calibrate and sustain, lessons learnt and illustrate measured data and forecasts given from some of the more recent flooding events. Above all, it will demonstrate why measured flood data is essential for any water related risk project.



Photograph 1. Nadi floods January 2009.



Photograph 2. Navua at Nakavu flood warning station.

KUMAR, S

Pacific Petroleum Project – Phase One

Shakil Kumar

*Secretariat of the Pacific Community, Suva regional Office, Suva, Fiji Islands
Email: Shakil@spc.int*

Energy cost and security is one of the Pacific region's key priorities. Energy is an essential requirement for the Island States and a substantial proportion of energy required is imported as petroleum fuel. The cost of petroleum imports, particularly when prices increase rapidly on international markets, places particular pressure on national budgets. In an effort to improve both security and the cost of petroleum supply to the region, Pacific Island Leaders have committed their governments to the implementation of a bulk procurement of petroleum initiative. This Pacific Petroleum Project initiative is being run through the Pacific Islands Forum Secretariat (PIFS) with technical assistance from, Secretariat of Pacific Community (SPC). Hale & Twomey Limited has been appointed as the consultant to carry out Phase 1 of the Project.

The current signatories to the Project (signatories) are Cook Islands, Nauru, Niue, Republic of the Marshall Islands and Tuvalu although it is recognised that more countries may sign up to the initiative during the course of the project. A bulk procurement process does not necessarily mean a single supply method to each country at the same cost. The most efficient method of supply to each country may vary so any procurement process needs to allow all options to ensure the most competitive overall supply. As demand in the current Signatories is small, typically this means that the supply will need to come in more than one supply step using transport options that are more expensive on a per litre basis. Bulk procurement cannot change the cost resulting from geography – as a result of the smaller volumes and longer supply chain, the cost of fuel in the small island states will always be more expensive than those in larger countries (excluding any tax impact).

The presentation will highlight the current progress of the project and the challenges of the signatories to enter into bulk procurement. It will conclude with a forward plan and a tendering toolkit to achieve the best outcome for the whole of a country's demand rather than only part of it, along with the opportunity to obtain synergies between countries.

KUMAR AND KRUGER

At the crossroads: seamless coastal terrain models in the Pacific Region

Salesh Kumar & Jens Krüger

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands

Emails: salesh@sopac.org; jens@sopac.org

Pacific Island Countries have some of the world's largest ratios of coastline length to land area, with low-lying atoll nations such as Tuvalu, Kiribati, and Federated States of Micronesia (FSM) being inherently coastal entities. Healthy economies and ecosystems are therefore inextricably linked to the activities and processes that occur within this dynamic coastal zone. The lack of easily accessible geospatial baseline data is seen as one of the main impediments to effective coastal zone management and evidence-based adaptation. Accurate coastal terrain models (CTM) that seamlessly cross the land-sea interface are the most requested baseline information by managers and decision makers. If bathymetric and topographic data of sufficient resolution exist, it is often difficult to judge the quality of the data and to understand the limitations that apply to their use. With differences in scales, datums, projections, formats, or resolution, the data are often difficult to handle and even more difficult to integrate.

Coordinated efforts to collect complementary LiDAR topography and bathymetry as well as multibeam echosounder bathymetry data have resulted in nearly 100% high-resolution coverage from ridge to reef for some islands. This is in contrast to the majority of locations, which, although they are the subject of numerous data acquisition projects, suffer from ad-hoc and often redundant efforts using conventional survey methods. In this study we look at the practicalities and constraints in creating CTMs for data-rich Saipan, CNMI, and relatively data-poor Funafuti, Tuvalu. In addition, we look at the trade-off involving the cost, spatial resolution and temporal control for each of the different methods, and how this trade-off ultimately determines the absolute accuracy and suitability of the CTM for the purposes required.

LAFOY AND ZoNéCo WORKING GROUP

The ZoNéCo programme in New Caledonia: a tentative approach to link marine habitats knowledge to policy making

Yves Lafoy & The ZoNéCo Programme Working Group

Office of Regional Cooperation and External Relations, BP M2 – 98849 Nouméa Cedex, Nouvelle-Calédonie (currently at NIWA, Wellington, New Zealand)

Email: yves.lafoy@gouv.nc

In 1993 the ZoNéCo programme (for “*Zone économique de Nouvelle-Calédonie*”) was launched in New Caledonia to open new avenues for both economic development and sound EEZ governance.

The programme’s goals (<http://www.zoneco.nc>) fit into the Pacific Islands Regional Ocean Policy (PIROP) (<http://www.spc.int>), approved by Pacific Island Forum leaders in 2002, and that represents the first policy ever in terms of a regionalized approach to ocean management.

In the last fifteen years in New Caledonia, nine surveys have focused at investigating deep sea, mega-scale habitats within the framework of the ZoNéCo programme. Six seafloor mapping, geophysics and physical oceanography cruises were conducted aboard Ifremer’s R/V *L’Atalante*, followed by three related exploratory fishing surveys in order to survey potential sites of interest for fishery resources. Those nine surveys have swath-mapped, imaged, and sampled (down to water depths of 2,500 m.) an area of about 500,000 sq. km, i.e. about 35% of New Caledonia’s EEZ.

Since the Circum Pacific Council GeoHAB Conference that was held in Noumea, New Caledonia in May 2007, the following “milestone” events have led to attempts toward a whole “bridging Science to Policy” approach, i.e.:

point as defined under UNCLOS. The baseline in PIC is usually defined as the outermost edge of a fringing reef, exposed at lowest astronomical tide. In order to define where a baseline position lays, source data such as topographical maps, hydrographic charts and satellite imageries are used. All maps, charts and images have to be correctly geographically referenced to an internationally recognised datum or reference system.

The SOPAC Pacific Islands Regional Maritime Boundaries Sector has a Geographical Information System (GIS) database called the Pacific Islands Regional Maritime Boundaries Information System (PIRMBIS) which holds PIC baseline as well as maritime boundary solutions.

Recent advances in technological, especially high resolution satellite imagery, are now being made available to the Pacific and the use of this imagery to verify the position baselines is being undertaken for the SOPAC project countries. Imagery has a number of advantages in that products with high spatial resolution can show reef edge details not captured in charts or maps. However, imagery geographical positioning has until recently required field surveys to correct the geographic position and make these acceptable for use in maritime boundaries applications. Very recently available satellite derived products may provide not only high spatial resolution to clearly define baseline position but the level inherent geographic accuracy is claimed to be within the range of 5m. Such accuracy provide a new and exciting development in maritime boundary work in the PIC since the logistics and cost of field survey in our many remote and far flung islands prohibit rapid field survey to provide controls points to geographically correct imagery. The MBS will experiment over the coming year to verify the claimed accuracy of these new satellite products and if proven consistently adequate for regional use these could bring significant advantages to the MBS work and PICs.

LAMARCHE, GOFF AND PELLETIER

Paleo-tsunami record and tsunami hazard in Wallis and Futuna

Geoffroy Lamarche¹, James Goff² & Bernard Pelletier²

¹*National Institute of Water & Atmospheric Research, Private Bag 14-901, Wellington, New Zealand*

²*Institut de Recherche pour le Développement, Nouméa, New Caledonia*

³*Australian Tsunami Research Centre, University of New South Wales, Sydney, Australia*

Email: g.lamarche@niwa.co.nz

The 29 September 2009 Tonga earthquake occurred at 5:48 am on 30 September local time in Futuna (Wallis & Futuna), ~650 km west of the epicentre. The Pacific Tsunami Warning Centre, in Hawai'i, issued a warning at 6:04 am for a tsunami arrival in Wallis at 6.35 am. No warnings were issued on Wallis and Futuna territory, however the South Pacific Tsunami (SPT) hit the archipelago of Futuna (islands of Futuna and Alofi) between 7.00 and 7.20 am on 30 September. There was no reported tsunami on Wallis, located 230 km to the NW of Futuna.

During an 8 day survey funded by the French Ministry of Foreign Affairs, we measured run-ups, in-land inundations, and flow depths associated with the SPT at 41 sites around the islands of Futuna and Alofi. Run-ups were estimated based on visual evidence of recent coastal impact, e.g., salt-burnt plants and displaced debris. We interviewed the population on multiple occasions. The maximum run-up (4.5 m) inundation (95 m) and flow depth (4.5 m) did not occur at the same place, but all demonstrate a substantial impact. The damage were more severe on Futuna's north coast. Most witnesses report two main waves and indicate that the sea withdrew first. The reef was exposed well below the lowest tides during withdrawal. There were no casualties. A significant disaster was avoided because it was early and the tide was low when the tsunami hit. Such an event at high tide would have added ~1m in height to the wave.

Two palaeo-tsunami dated 1860-2000BP and c.470BP were also identified from sediment and archaeological data collected in trenches. Preliminary analyses suggest that the first event is associated with a tsunami sourced from the Tonga-Kermadec Trench region. The second event is markedly larger than event 1 and tentatively correlated to a contemporaneous event in the South Pacific around 470BP. Oral tradition suggest a destructive wave that may correlate to the c.470 event. These events, together with a

small tsunami triggered by a local M_w 6.4 earthquake in Mars 1993, indicate that the tsunami risk is high for the >4000 Futuna's inhabitants who live almost exclusively on a 50-400 m-wide coastal strip, between a narrow reef and coastal cliffs. The hour and 10 minutes that the 2009 SPT took to reach the island provided sufficient time to issue a warning to the population who can rapidly reach safety on this mountainous landscape.

Future work will include numerical scenario modelling of tsunami impact on Wallis and Futuna and a field trip on Wallis is planned in August 2011 to study palaeo-tsunami having impacted the island.

LAMARCHE, LUCIEER AND ROWDEN

Submarine substrate and biodiversity mapping using multiscale analysis of bathymetric and backscatter data: examples from Cook Strait and the Kermadec Arc, New Zealand

Geoffroy Lamarche¹, Vanessa Lucieer² & Ashley Rowden¹

¹NIWA, Private Bag 14-901, Wellington

²Marine Research Laboratories, TAFI, University of Tasmania, Private Bag 49, Hobart, Tasmania, Australia

Email: g.lamarche@niwa.co.nz

Monitoring and management of geological hazard, evaluation of resources and site investigation over large areas of the seafloor imperatively require the acquisition, processing and interpretation of multibeam echo-sounder data, consisting of bathymetry and backscatter data, and high resolution seismic data. The tendency is evolving irremediably toward a quantitative use of such data to retrieve data usable in prediction models. The combined use of backscatter data and micro-topography provides a powerful tool to characterize the seafloor and investigate issues pertinent to the management or exploitation of the seafloor: e.g., slope stability, habitat mapping, sediment transport and deposition centers and erosion processes. The backscatter data generated by multibeam echo-sounder relates to grain-size and small-scale topography, and provide information on substrate composition and roughness by emphasizing topographic and geological features otherwise not recognized with conventional surveying.

Here, we present examples from the Cook Strait and the Kermadec Arc, New Zealand, where multibeam echo-sounder data, geological data and seafloor photos are used to generate a biodiversity map of the seafloor. We use the backscatter data to obtain information on substrate composition and roughness. Quantitative backscatter signal analysis help emphasizing topographic and geological features otherwise not recognised with conventional surveying. Object-oriented image segmentation is used to identify homogeneous regions in the backscatter images. The results provide an improved understanding of the utility of different marine biophysical variables as surrogates for benthic habitats, and promotes the use of spatial uncertainty techniques to assess the application of these methods for biodiversity assessment.

Finally, we apply a habitat heterogeneity – biodiversity relationship to develop a map of biodiversity on the flanks of a submarine volcano along the Kermadec Arc. This example demonstrates the possibility of using a simple method to map predicted biodiversity and is applicable to other areas worldwide.

LAMARCHE AND NODDER

Ocean Survey 20/20: NIWA's involvement in New Zealand's National Ocean and Coastal Mapping Programme

Geoffroy Lamarche and Scott Nodder

National Institute of Water & Atmospheric Research, Private Bag 14-901, Wellington, New Zealand

Email: g.lamarche@niwa.co.nz

In 2004, the New Zealand Government agreed to establish the Ocean Survey 20/20 programme as a 15 year project that aimed to complete a survey of New Zealand's ocean territory by 2020. Expert panels were convened and proposed a series of individual surveys, encompassing coastal to deep ocean environments that were then evaluated and prioritised. The first of these surveys was conducted in 2006-07 with a project focussing on determining the relationships between benthic habitats (mapped spatially using multibeam) and biodiversity (sampled using cameras, corers and dredges) on the Chatham Rise and Challenger Plateau. The second survey was undertaken as part of the International Polar Year in 2008-11 and involved a voyage to sample continental shelf, slope and abyssal waters and seafloor habitats in the Ross Sea. The most recent survey in 2009-10 was undertaken in the iconic tourist destination, the Bay of Islands and the wider Northland continental shelf. Close liaison with local interest groups and stakeholders ensured that this recent survey focussed on significant coastal issues of sedimentation, water quality and biodiversity degradation. Additional Ocean Survey 20/20 voyages have been completed on Chatham Rise seamounts and in the future on mapping unique coastal habitats around New Zealand and marine hydrothermal mineral deposits in the Kermadec Arc.

LOCO

Hydrogeology of the middle Sigatoka Valley and human impacts on groundwater resources

Amini Loco

Mineral Resources Department, Suva, Fiji Islands

Email: AMINI@mrd.gov.fj

The Middle-Lower Sigatoka Valley is well-known for its massive agricultural potential. Recent groundwater investigations are being undertaken by Fiji's Mineral Resources Department's Groundwater Unit to assess the potential for additional water resources and its sustainable development. The focus of the groundwater studies is in the Middle Sigatoka Valley, at Bilalevu and Dubalevu, which are located approximately 15-20 km inland from Sigatoka. The study area is characterized by abandoned meanders, alluvial terraces, alluvial flats and fans associated with the Sigatoka River. Geological investigations have identified that the study areas, are bounded by a highly dissected and hilly landscape comprising of Late Miocene highly deformed conglomerate and sandstones making up the Tuva Sedimentary Group in the as well as Upper Oligocene to Middle Miocene Wainimala Group sediments. Geological/geomorphic mapping and aerial photo interpretation undertaken showed the extent of the transported alluvial materials and the numerous structural controls such as the ENE-WSW sinistral Nasovatava fault and the development of jointing and fracture systems in the underlying sedimentary and volcanoclastic units. Increased development coupled with more frequent extreme climatic conditions, over the past two decades, has created additional groundwater demand for potable and irrigation purposes. There is a need for sound groundwater investigation to determine its sustainability and develop appropriate groundwater allocation for a sustainable irrigation industry. Structural geology investigations suggest that they are important in the control of storage and transmission of groundwater within the investigation area. Preliminary hydro-chemistry results show the dominance of calcium-bicarbonate type groundwaters. Surface geophysical surveys using electrical resistivity and electromagnetic methods together with groundwater exploration drilling using mud-rotary method has proved the presence of an underlying fractured-bedrock aquifer, comprising of highly weathered sandstone, mudstone and conglomerate. The drilling identified sediments characterized by significant discoloration and high degree of iron coating, underlying the alluvial sediments suggesting a useful fractured bedrock aquifer.

Several assessments and/or tests remain to assist and guide future groundwater development in the Valley. These investigations, planned for later this year and early next year, include:

- evaluation of aquifer parameters through pumping tests,
- analysis of spatial variability of isotopic composition in groundwater,
- gauging of Sigatoka River to determine losses and gains from/into groundwater systems,
- and groundwater dating through CFC's.

These data will dictate the holistic evaluation of groundwater sustainability and any groundwater allocation practice within the Middle Sigatoka Valley

McMURTRY (NO SHOW)

Development of compact, field portable mass spectrometers for use in atmospheric, shallow-water and deep-ocean applications

Gary M. McMurtry

*SOEST, University of Hawaii, Honolulu, Hawaii, 96822 USA, and
Pacific Environmental Technologies, LLC, Honolulu, Hawaii, 96825 USA
Email: garym@soest.hawaii.edu*

Because of their (1) extremely high sensitivity (single ion counting is possible), (2) isotopic resolution, and (3) wide dynamic range (allowing simultaneous detection from ppb to percent level), mass spectrometers in general, and field-portable units in particular, are considered by many as the ultimate tool of analytical chemistry. Gases, liquids, and solids can be analyzed with appropriate inlet systems, providing molecular characterization, concentration and isotopic information from light noble gases to large organic molecules. Commonly found in large analytical laboratories, these versatile instruments have been shrinking both in size and power requirements while maintaining much of their analytical prowess.

Mini-DOMS is based on an earlier deep-ocean mass spectrometer (DOMS) that was developed by the University of Hawaii's School of Ocean and Earth Sciences and Technology (SOEST). The DOMS instrument employed a Stanford Research Systems (SRS) quadrupole mass spectrometer with turbomolecular high-vacuum pumping, and was 6.6 inches diameter by 60 inches total length; it required 75-100 watts power in operational mode. DOMS was pressure tested to 4000 m equivalent water depth, and successfully deployed at 1000 m water depth for four months in 2005 at a methane gas rich "cold seep" area off the Costa Rica Pacific margin.

A smaller, lower power, and analytically improved version of the DOMS system is presently being developed and tested by Pacific Environmental Technologies under the National Defense Center of Excellence for Research in Ocean Sciences (CEROS) sponsorship. A primary upgrade is a new autoresonate ion trap mass spectrometer recently developed by Brooks Automation (Fig. 1). This new component will replace the SRS quadrupole mass spectrometer and will offer a number of system enhancements, among them size reduction, power reduction, greatly increased mass scan speed (by 100-1000X), and extended mass range, from 0 to >1000 atomic mass units. The current development effort includes design changes to improve the sensitivity of the membrane introduction sample inlet (patent to be applied for), improvements to the system operating software, and a lower-power NEG-ion pumped vacuum system to achieve overall system power reduction to below 30 watts (Fig. 2).

This research effort is expected to be complete by March 2011, and to result in both shallow (≤ 2000 m unmanned; ≤ 1000 m manned) and deep-ocean (≤ 6000 m unmanned, ≤ 4000 m manned) prototype instruments. Field-testing is planned at munitions disposal sites offshore of Oahu, Hawaii, in collaboration with the Hawaii Undersea Military Munitions Assessment Project under the technical direction of Department of Defense (DoD) Office of the Deputy Assistant Secretary of the Army-Environmental Safety and Occupational Health (ODASA-ESOH).

We are also building and testing a new ion trap mass spectrometer instrument that measures the CO₂ content of volcanic plumes and enables the continuous determination of the CO₂ flux from volcanoes. The mini-Autonomous Volcano Mass Spectrometer (mini-AVGM) instrument is based on an earlier instrument design of that was developed several years ago for direct monitoring of volcanic gases at volcanic vents. This project plans for extensive testing and calibration in the lab and in the field on Kilauea volcano, Hawaii. Because CO₂ concentrations (at ppm) alone do not yield a flux (mass/time) we will also use newly developed atmospheric plume models in conjunction with the University of New Mexico that link CO₂ concentrations with local atmospheric measurements to estimate CO₂ fluxes for a given volcano. The goal is to build an instrument that is completely autonomous and able to collect and transmit CO₂ concentration data for months without any maintenance. The data feeds directly into the model that calculates CO₂ flux in

near-real time. No instrument set up is currently available that provides continuous volcanic CO₂ flux measurements.



Figure 1. Component view of Brooks Automation Autoresonant Ion Trap Mass Spectrometer. Dimensions are approximately 3 cm diameter by 14 cm total length.

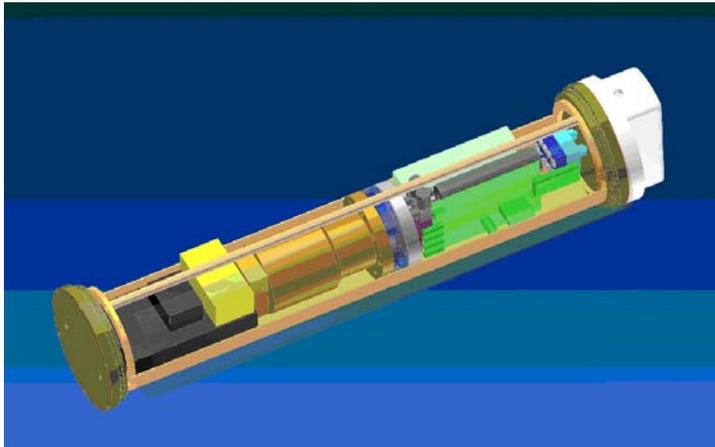
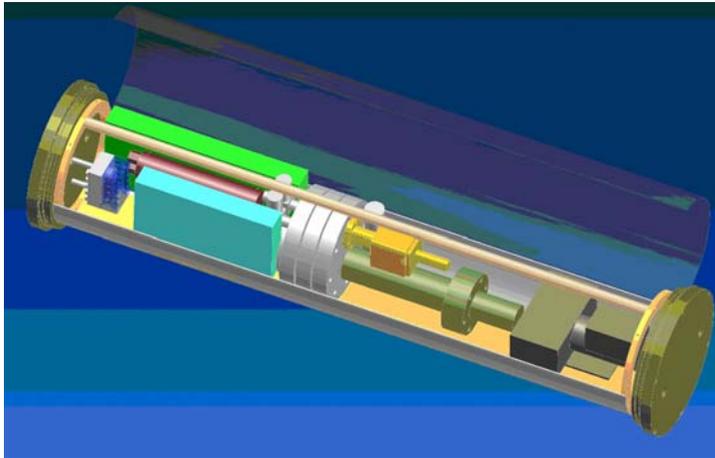


Figure 2. Drawings of the mini-deep ocean mass spectrometer (DOMS) instrument. Top diagram features a low-power non-evaporable getter (NEG)-ion pump vacuum version. Bottom diagram is a turbo-rough pumped vacuum version. Both instruments are housed in pressure vessels to 30 inches (76 cm) total length by 6.6 inches (16.8 cm) outside diameter. White plastic plenum holds fluids for recirculation while heating the high-pressure membrane interface.

McMURTRY, CAMPBELL AND OTHERS (NO SHOW)

Tsunami deposits exposed at Marine Isotope Stage (MIS) 5e and 9 on Oahu, Hawaii: implications for sea level at interglacial stages

Gary M. McMurtry¹, J. Frisbee Campbell², Gerard J. Fryer³, David R. Tappin⁴ & Jan Fietzke⁵

¹*SOEST, University of Hawaii, Honolulu, Hawaii, USA*

²*HIG, University of Hawaii, Honolulu, Hawaii, USA (retired)*

³*Pacific Tsunami Warning Center, NOAA, Ewa Beach, Hawaii, USA*

⁴*British Geological Survey, Kingsley Dunham Centre, Nottingham, UK*

⁵*Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR, Kiel, Germany*

Email: garym@soest.hawaii.edu

Sandy, basalt-coral conglomerates associated with both beachrock and coral reefs are found at high elevations on Oahu, Hawaii. They are attributed either to brief sea level high-stands or storms. The Kahe Point conglomerates are at 12.5 m elevation, whereas the main MIS-5e reef at this location has a maximum elevation of 8.2 m. They are loosely consolidated and poorly cemented, graded, poorly sorted, and with varying amounts of basalt and coral clasts ranging from cobble to boulder size. Coral in these deposits has been U-series dated by us at between 120-125 ka (n=5). Four distinct beds, with a gently seaward tilt, are recognized in a road cut section, with each bed composed of a few cm-thick topset bed of fine-grained, shelly, calcareous sand to silt. Similar conglomerates and MIS-5e reefs at other high elevations are also described at Mokapu and Kaena Points. Their location at other sites on Oahu at similar elevations indicates an island-wide deposit. Older coral clasts, dated at 130 to 142 ka (n=6; oldest date by alpha spectrometry) found in association with the stage 5e corals suggest reworking and incorporation of older, low-stand reef material into these deposits. The coarse grain size of the conglomerates indicates deposition from a high-energy event; thus a high-stand source is ruled out. We also consider that the up to 0.5 m bed thickness and overall lithology are not the result of storms; a series of high frequency storm events is considered unlikely. The weight of the evidence in our opinion clearly indicates deposition by a series of tsunami waves, with minimum runups of only 4.3 m at this location. If correct, this has implications for "probabilistic" models of sea level peaks at least 6.6 m higher than present at MIS 5e that use such data in their models (e. g., Kopp et al., 2009), at least for Oahu.

Within about 2 km of the Kahe Point deposit, in a road cut at Ko Olina, there is another markedly similar high-energy, sandy basalt-bearing coral conglomerate sequence at 21 to 25 m elevation. There are at least two distinct beds about one meter in thickness; both gently seaward tilting and with bed layer containing a few cm-thick topset of fine, shelly, calcareous sand to silt. The sediments are loosely consolidated and poorly cemented, graded, moderately sorted, with coral clasts ranging from pebble to boulder size, predominately cobble. Compared to the deposits at Kahe Point, those at Ko Olina are more heavily dominated by rounded coral clasts that are U-series dated by us at between 302-363 ka (n=5); broadly correlative with MIS 9. Previously described as a high-stand reef deposit, we suggest it is more likely to be a tsunami deposit too; perhaps considering its' elevation, laid down from a mega-tsunami, if it was deposited prior to the MIS 9 high-stand at approximately 325 ka.

MOSUSU

Geothermal development in Papua New Guinea: current status and future aspirations

Nathan Mosusu

Mineral Resources Authority, P.O. Box 1906, Port Moresby, Papua New Guinea

Email: nmosusu@mra.gov.pg

Papua New Guinea currently produces 56 MW electrical energy, from the Lihir Gold Limited (now Newcrest Lihir) geothermal power plant on Lihir Island, New Ireland Province. This puts the country's ranking at 15th out of a total of 24 geothermal energy producing countries in the world (GEA, 2010).

With more than forty (40) reported geothermal sites scattered mostly throughout the northern islands, Papua New Guinea has a mammoth task of locating, documenting, analysing and developing these possible resources. The Mineral Resources Authority (MRA) of Papua New Guinea, as part of its mandated responsibility to enhance geo-scientific data of the country's natural resources, is continuing to carry out exploration programs over geothermal areas.

In 2009 a reconnaissance survey was carried out on Kairiru Island, East Sepik Province. Now with the backing of the World Bank, MRA has embarked on a project to collate existing information on the country's geothermal sites and create a geothermal database for the country. Field data collected by MRA scientific officers will be added into the database to enhance the understanding of the country's geothermal resources. Given that the World Bank funding is small, it is anticipated the MRA personnel will need to be adequately trained in other jurisdictions that have greater expertise in this resource so that they can be engaged in field data acquisition programs. A six-month training for two staff members in the understanding and documentation of geothermal resources at the United Nations University, Iceland, has been identified for this purpose.

In developing geothermal resources in Papua New Guinea, potential developers continue to confront two main issues.

The first and major issue is that there is very little available data on geothermal sites. The data that does exist is mainly on temperature and pH measurements and this is only present for less than half of the reported sites. Even for these areas less than half, have had analyses of the chemical components of the resident water and gas components from internationally accredited geothermal laboratories.

This lack of data does not allow any accurate or comprehensive assessment of the geothermal resources for potential developers, and consequently impacts on their capacity to secure financial backing for the development of these resources.

The second issue, which has significant legal and financial implications, is that there is no legally established authority or regulations to allow geothermal exploration and development in PNG.

Development of geothermal resources, and coal seam gas (CSG) are not adequately covered by either the Papua New Guinea Mining Act 1992 and Oil and Gas Act of 1998. In the case of coal seam gas the Mining Act allows for exploration of coal and related resources, but for geothermal energy there is no legislation that allows either exploration or development. These are the two main obstacles facing potential geothermal developers, keen to take their share in the natural resource boom that Papua New Guinea is currently experiencing.

OWEN, DUNBAR AND OTHERS

SWAN wave modelling for Palmyra Atoll, central Pacific Ocean: understanding the depositional environments of beachrock

Kim Owen, Gavin Dunbar, Dan Zwartz & John Collen

*Centre for Marine Environmental and Economic Research,
Victoria University of Wellington, PO Box 600, Wellington,
New Zealand*

Email: kim.owen@vuw.ac.nz

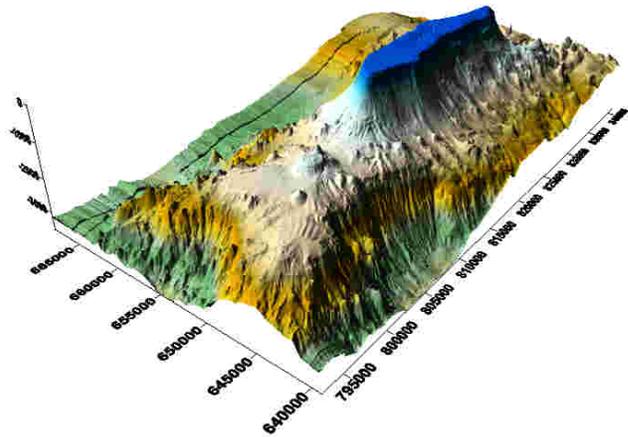


Figure 1: Bathymetry of Palmyra Atoll and surrounding slope environments.

http://www.soest.hawaii.edu/pibhmc/pibhmc_pria_pal.htm

Palmyra Atoll (5°52'N 162°04'W), in the northern Line Islands, is part of the newly-created United States "Pacific Remote Islands Marine National Monument" and is now the focus of intensive scientific study through the Palmyra Atoll Research Consortium (PARC). This research focuses on the beachrock deposits, which represent one of the few physical records of past processes and events. Beachrock forms through rapid cementation of biogenic carbonate sediments in the intertidal zone by the precipitation of authigenic calcium carbonate. Results from radiocarbon dating of *Tridacna maxima* and other biogenic carbonate material cemented by beachrock give ages ranging from 1250 ± 56 cal. yr BP to present day for the beachrock deposits at Palmyra. However, the ages only date the death of the animal and therefore the incorporation into the beachrock is assumed to be younger on the order of a few hundred years. As a result, these dates give the oldest possible age for the beachrock outcrop. Additionally, the results are considerably younger than most ages obtained for similar deposits elsewhere in the central Pacific (e.g. Tuamotus 3170 ± 60 yrs BP [Pirazzoli, 1987]). The deposition of these formations is also linked to past sea levels as they form within the limited intertidal zone. Understanding the sea level in the central Pacific Ocean, where there is little information, is crucial to understanding current climate changes.

As the beachrock on Palmyra is one of the few physical records of paleo-environments, numerical modelling using the SWAN (Simulating WAVes Nearshore) wave model (Booij et al., 1999) has allowed definition of the conditions required to deposit both the beachrock sediments and Barren Island, the easternmost island that only appeared above sea level in 1935. Modelling results suggest that the beachrock was deposited primarily from large, infrequent storm events because only during these events is the energy that is exerted on the seafloor sufficient enough to move sediment of the sizes found within the beachrock. Therefore, an entire beachrock outcrop, which have been shown to irreversible alter the characteristics of the shoreline (Vousdoukas et al., 2007), have formed from a few rare, extreme storm events.

Despite limitations caused by lack of climate and other environmental data due to the isolation of the study area, results appear valid and have important applications to the study and management of oceanic atolls and beachrock coastlines worldwide. This is a result of the ability of beachrock to hold information about past climates and sea levels, but also may protect and preserve dynamic shorelines on low-lying coasts that are vulnerable to a range of future climate change impacts.

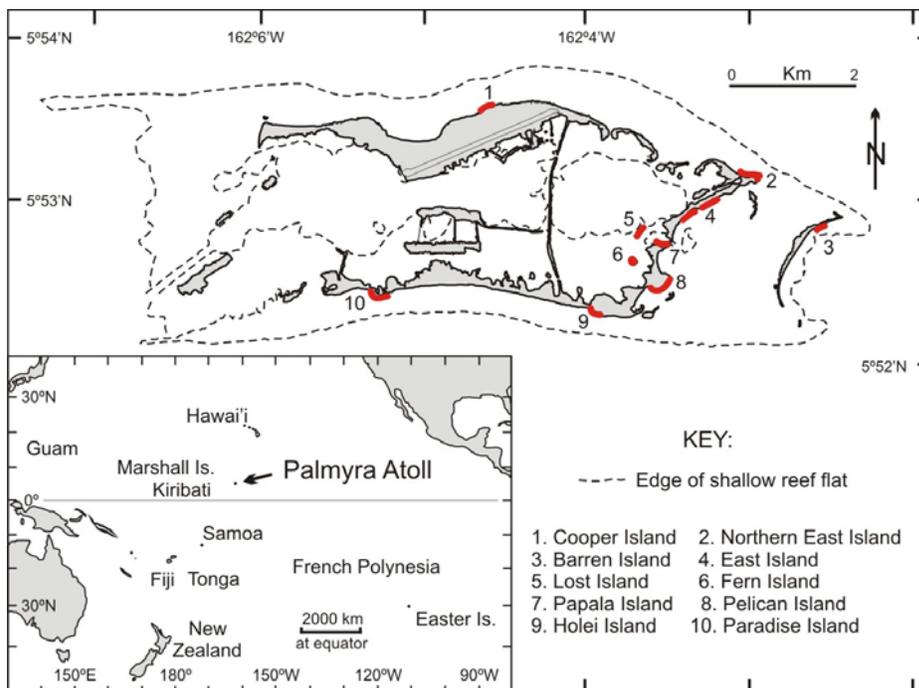
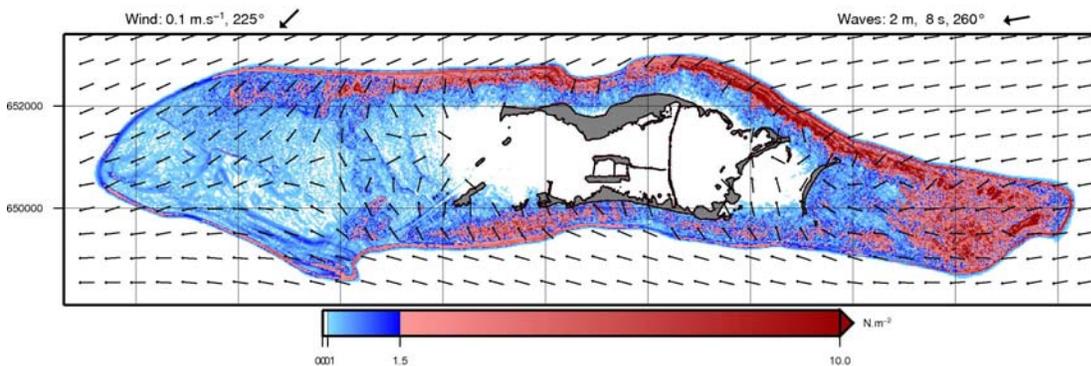


Figure 2: Palmyra Atoll with outcrops of beachrock indicated by red areas.

Palmyra Atoll: Shear Stress



Palmyra Atoll: Bottom Velocities

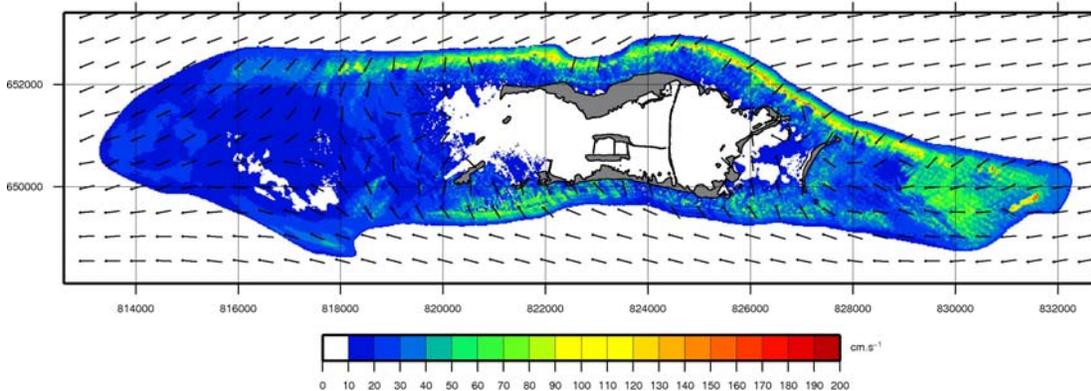


Figure 3: SWAN results for summer (JJA) tradewind conditions at high tide (minimal wind from the northeast, and 2 m waves coming from 080° with a period of 8 seconds). The top plot shows the changes in wave induced seafloor shear stress across the atoll. The bottom plot shows bottom orbital velocities of the waves under the same conditions. These parameters determine the amount and direction of sediment movement on the seafloor.

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PARKER

**The South Pacific Sea Level & Climate Monitoring Project (SPSLCMP):
developing into the future**

Phil Parker

*Bureau of Meteorology, Melbourne, Australia
Email: P.Parker@bom.gov.au*

The SPSLCMP has been providing many island countries of the west and south west Pacific (PICs) with sea level services since its inception in the early 1990s. There are 12 PICs which currently host SEAFRAME tide gauges¹ and a further 2 which are provided with tidal services and climate mentoring advice². A major project to renew the infrastructure at the 12 operational sites was approved in 2009 and is now underway. The observing network upgrade project (ONUP) will be undertaken over the coming 2-3 years. This presentation provides a current overview of the progress of this project.

The SPSLCMP has been funded and organised in 5-year Phases. The current Phase 4 is due to end, and a new Phase 5 to commence, in January 2011. Planning for Phase 5 is at an early stage. Its overall scope is being discussed in Australia and will be explored and reviewed during a regional stakeholders meeting in the Pacific before proceeding to formal negotiations with the project contractors. It is understood that meeting may be held in November. This presentation provides an outline of the expected scope of Phase 5.

POHLER, BEGG AND OTHERS

**Application of benthic habitat mapping to calculating a sediment budget for
the Namuka Reef Flat, Suva, Fiji Islands**

Susanne Pohler¹, Zulfikar Begg¹, John Collen², Chris Roelfsema³ & Johnson Seeto¹

¹Division of Marine Studies, School of Islands and Oceans, University of the South Pacific, Private Bag, Suva, Fiji Islands

²Centre for Marine Environmental and Economic Research, Victoria University of Wellington, PO Box 600, Wellington, New Zealand

³Biophysical Remote Sensing Group, School of Geography, Planning and Environmental Management, University of Queensland, Australia.

The Namuka Reef Flat (southwest of Suva Harbour, Fiji) was recently mapped at a coral reef benthic community spatial scale. The map is a result of object based image analysis (Phinn and Roelfsema in press) using benthic field data and high spatial resolution image data acquired in 2006 (Roelfsema et al 2010). The map distinguishes a number of different zones across the reef complex relating to (a) coral cover, (b) two categories of algal-cover (1. Seagrass and algae; 2. Algae, rock and rubble); (c) four categories of sea grass cover (1. Seagrass; 2. Seagrass and algae; 3. Seagrass and sand; 4. Seagrass, rubble and sand); and

¹ Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Nauru, Papua New Guinea, Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

² Niue and Palau

(d) six categories of sediment cover (1. Coral, rock and rubble; 2. Mud flat; 3. Pumice stone; 4. Rubble; 5. Rock and rubble; 6. Sand and rubble).

In addition, studies by Atkinson (1999) and Atkinson & Collen (2000) (summarized in Pohler & Collen, 2006) and Cakacaka (2007) give detailed information about sedimentary cover, sediment composition and grain sizes. Numerous studies from the Suva Barrier Reef include information about carbonate producing organisms in general (e.g., Morton & Raj, 1980; Lovell *et al.*, 1997); and specifically about echinoderms (Seeto, 1994, in prep.; Appana & Vuki, 2003, Zann, unpublished data on Crown of Thorn starfish), mollusks (Seeto, 1998, 2000, 2001 and unpublished data from USP's marine collection), calcareous red and green algae (Keats, 1995, 1997, Keats *et al.*, 1996, 1997; N'Yeurt & South, 1996, N'Yeurt, 1997; South & Skelton, 2003), corals (Vave, 2005; Lovell, unpublished field trip notes) and bioeroding fishes (Cakacaka, 2007; Seeto & Baldwin, 2010). This information can be utilized to estimate carbonate production potential as well as highlight dearth of data in certain areas.

The net sea level trend in Fiji is computed as 3.1 mm/ year (Pacific Country report on Sea level and Climate: Their present state. Fiji, 2004). If the reef complex cannot keep up with sea level then higher water above the reef flat will allow higher energy waves to reach the shoreline due to decreased wave attenuation and this, combined with sediment deficiencies of the "carbonate factory" could result in a landward shift of the beach zone. Alternatively, high sedimentation rates and reef growth could out-pace sea level rise. This research aims to review and integrate information from various sources into the benthic community map in order to assess the growth and production potential of the Namuka reef flat and its possible response to projected sea level rise.

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RAJ

Water governance in the Pacific

Subhashni Raj

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: subhashni@sopac.org

26th July, 2010 will be remembered as an historic day in human history. The UN General Assembly passed a resolution declaring access to water and sanitation a **Human Right**. Both the developed and the developing world including the Pacific Island countries (PICs) are party to the resolution. The implications of this are vast, but what it clearly indicates is the recognition of water and sanitation issues as an important area of focus in development. To further heighten the attention water and sanitation is receiving, the Pacific along with the rest of the world have also committed to achieving the United Nations Millennium Development Goals (MDG's) and Targets. MDG 7 focuses on water and sanitation, where the target is to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by the year 2015.

This is only 4 years away and as statistics would have it, Oceania as a region is off track in achieving the UN MDG'S for access to water and sanitation. So much so, that the Pacific statistics for access to water and sanitation are below par compared to global averages as demonstrated below:

- 46% of Pacific populations have access to improved drinking water compared to the global average of 87%;
- 48% of Pacific populations have access to improved sanitation compared to 62% globally.

Intuitively, one would know that this not acceptable, given that 20% of all deaths in children in the Pacific up to 14 years of age is attributable to unsafe water, inadequate sanitation and insufficient hygiene; and this is even higher in children below the age of five.

In 2006 Pacific Leaders agreed that water, sanitation and hygiene challenges facing the region should be addressed through the implementation of the Pacific Regional Action Plan on Sustainable Water Management (RAP). Improved water resource management was recognised as a key element in addressing water and sanitation issues, in conjunction with other elements concerned with the overall resource, such as hydrological monitoring, water quality monitoring, water safety and risk management and water demand and water use efficiency.

In response, the Pacific Integrated Water Resources Management (IWRM) Programme was undertaken in the region. This consisted of 2 projects being implemented simultaneously:

- GEF funded "Sustainable Integrated Water Resources and Wastewater Management Project in Pacific Island Countries" (Pacific IWRM Project for short), involving 14 demonstration projects in 13 PICs
- EU funded "Pacific IWRM Planning programme", working on water governance and planning issues across 14 PICs

The Pacific IWRM Planning programme had its inception in 2008 and has been in progress over the last three years. The Planning Programme was set up with the objective of improving the sustainability of water resources and at the same time increasing stakeholder consultation in managing water. IWRM recognises water as a cross cutting issue that can not be productively dealt with in isolation. The Planning programme focuses on achieving this objective by improving governance mechanisms and tools in countries. This means helping create better enabling environments, putting in place governance tools such as water policies, strategies and plans to help direct the institutional reform and facilitating the set up of water committees to deal with water management decisions in a coordinated and consultative manner.

The presentation will look at the importance of water governance in the Pacific, the different facets of water governance and the different approaches undertaken by countries to work towards improving their water governance capacity, directly as a result of the Pacific IWRM Planning programme. The presentation will also discuss the link between IWRM and its importance in improving access to water and sanitation.

RAM, TERRY AND OTHERS

Investigating short-term temporal relationships between rainfall parameters and fluvial sediment transport within a steep forested catchment in southern Viti Levu, Fiji Islands

A.R. Ram¹, J.P. Terry², J. Comley¹ & W.B. Aalbersberg¹

¹*Institute of Applied Sciences, The University of the South Pacific*

²*Geography Department, National University of Singapore*

Email: arishmareshmiram@yahoo.com

Suspended sediment matter in stream waters delivered to coastal marine ecosystems can have detrimental effects, particularly on coral reefs, mangroves and marine nursery areas through sedimentation and by acting as a medium of transport for pollutants including heavy metals, pesticides and other organic substances. Although suspended solids occur naturally in stream waters, human activities can greatly increase their concentrations. Sources of suspended solids in streams include waste discharge, urban runoff, eroding stream banks, excessive algal growth, and erosion from construction, forestry or

agricultural sites. For the South Pacific region, recent changes in land use plus coastal development activities have produced markedly increased sediment loads in some places. For Fiji in particular, marine productivity is threatened by the land-based activities that cause soil erosion and on the largest island of Viti Levu, grazing, commercial forestry, ginger farming, and sugar cane cultivation on steep slopes in different areas are causing accelerated catchment erosion hence greater sediment delivery to waterways.

The majority of Fiji's coastal hinterlands are occupied by smaller watersheds that are normally steep. Logging in such watersheds is likely one of the major contributors to degradation of coastal marine ecosystems and fisheries in Fiji since such watersheds have a low retention capacity for sediments relative to larger catchments. Reefs adjacent to smaller coastal watersheds, unlike those near larger rivers, are not adapted to periodic exposure to high sediment loads, and may suffer long-term degradation. This being said, however, there is very little evidence that quantifies the linkage and a lack of sufficient data for suspended sediment transport is hindering the identification of vulnerable areas and implementation of watershed restoration efforts.

In response, this study investigates temporal sediment dynamics in relation to rainfall parameters in a steep, naturally forested, coastal watershed in southern Fiji, to provide a benchmark against which comparisons can be made for adjacent areas of more intense land use. The project was undertaken within Votua Creek catchment along the Coral Coast near Sigatoka on Viti Levu island. The Coral Coast has the largest continuous fringing reef running for 100 kilometers and drains mostly small watersheds where logging activities are frequently undertaken. Stream water turbidity in the Votua Creek was monitored continuously with a sonde device over a period of 8 months from early October 2009 to early June 2010. Grab samples of the stream water were taken during baseflows and at high stream flows to compare TSS measurements with automatic turbidity readings for calibration purposes (Fig 1). Preliminary results are presented here (e.g. Fig.2) to illustrate the links between the rainfall characteristics of storm events and corresponding suspended sediment concentration patterns in the stream.

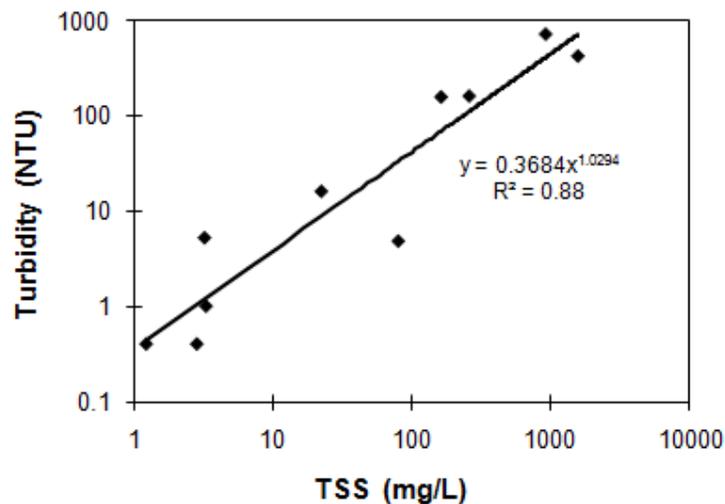


Figure 1. Correlation between total suspended solids (TSS, from grab samples) and automatic turbidity readings in Votua Creek during a single storm event.

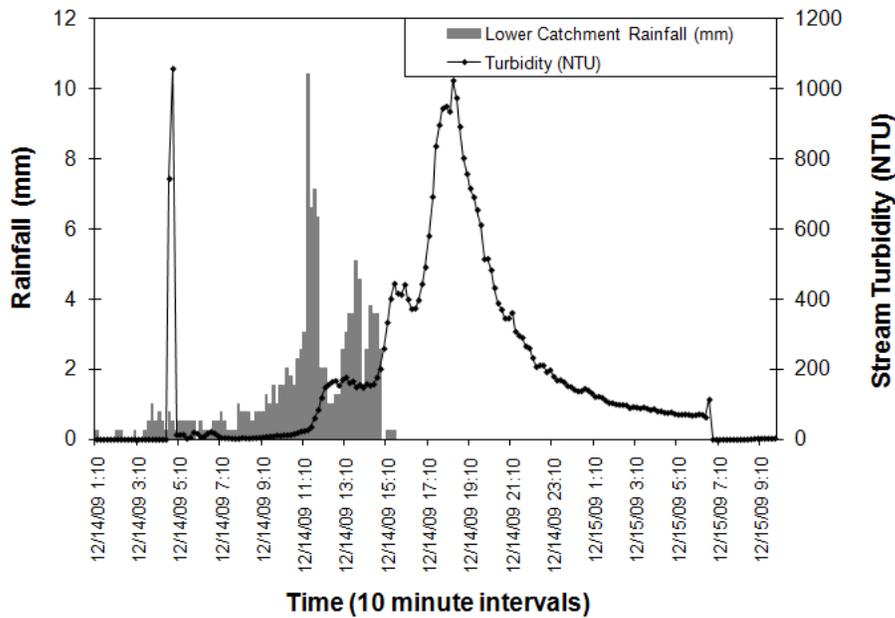


Figure 2. Stream turbidity versus rainfall during Cyclone Mick over 14-15th December 2009 in Votua Creek on the Coral Coast, Fiji.

RAMSAY, STEPHENS AND BELL

Sea-level changes and their impacts on the coastline of South Tarawa

D.L. Ramsay, S. Stephens & R. Bell
NIWA, PO Box 11115, Hamilton, New Zealand
Email: d.ramsay@niwa.co.nz

Kiribati is one of the most vulnerable countries in the world to the effects of climate change and sea level rise. Most of the land in urban Tarawa is less than 3 metres above sea level, and the island has an average width of only 450 metres. Anecdotal evidence suggests that Kiribati is experiencing much more frequent storm surge events than have occurred in the past, increased wave heights and frequency of storm events.

Analysis of sea levels since 1974 suggest that there is little indication that storm surge frequency or magnitude has increased. In the period since 1974 the upward trend in the highest annual sea-levels are similar to the trend in mean-sea level over this period, but over shorter timeframes but this can vary significantly and in different ways to the trend in mean annual sea level, e.g., the period since 1993 over which there has been a slight reduction in the trend of the highest annual sea-level. However, despite considerable variability from year to year there is a clear indication that over the last 20 or so years high tides have exceeded what would be considered a very high sea level for a longer cumulative period of time each year than over the previous 20 or so years. This is primarily due to a combination of an increased frequency of La Niña events (compared to the period prior to 2000) which has pushed sea levels up and further exacerbated by sea-level rise.

Small variations or increases in sea level, and hence increased water depths over the reef flats, will result in larger wave conditions reaching the shoreline on Tarawa. As both wave run-up and overtopping of coastal defences can be extremely sensitive to small changes in water levels and wave conditions reaching the shoreline, even very small changes in sea-level rise may have a significant impact on the frequency and volume of inundation of the immediate coastal margins of Tarawa, or overtopping of the causeways between the various islets. As an example, for a storm condition that has a 10% chance of occurring in any one year and for a low, medium and high I-Kiribati sea-level rise scenarios, wave overtopping volume of

the causeway between Bairiki and Betio could increase by 59%, 141% and 275% respectively by the period 2060 to 2084.

The paper will further quantify some of the coastal responses on different sections and types of the South Tarawa coastline and discuss some of the issues and limitations in attempting to better quantify climate change and sea-level rise impacts on the frequency and magnitude of inundation of coastal margins.

RAQISIA

Building geospatial baselines: historical air photo rescue activities

Keleni Raqisia

SOPAC Secretariat, Private bag, GPO, Suva, Fiji Islands

Email: keleni@sopac.org

Historical Aerial Photographs can be used for diverse purposes by government agencies, surveyors, planners, consulting scientists, engineers and other individuals. These purposes include determination of past land uses, marine mapping, coral reef habitat mapping, coastal change detection, restoration of natural areas, assessing historical changes, and a variety of other applications. The SOPAC Secretariats aerial photographs collection is a unique and detailed record of the physical landscapes from the different member Pacific Island countries, which has so far only been available in hard-copy. In our effort to save and preserve valuable information, the Secretariat has been involved in the digitising of aerial photographs. Activities include scanning, mosaicking and publishing on the geospatial web catalog, the SOPAC Geonetwork. (<http://geonetwork.sopac.org>). This work has been very valuable in documenting and restoration of historical environmental information of the Pacific islands. Presentation features the work flow undertaken to rescue aerial photographs and accessibility of this information. This also includes an introduction to the general use of Geonetwork and a quick reference at other resources available from the SOPAC Geonetwork website.

SHARMA AND KAYANNE

Using Foraminifera for Coastal Rehabilitation of Damaged Areas in Tuvalu

Ashishika Sharma¹ & Dr Hajime Kayanne²

¹SOPAC Secretariat, Private bag, GPO, Suva, Fiji Islands

²Department of Earth & Planetary Science, The University of Tokyo, Tokyo, Japan

Email: ashishika@sopac.org

Tuvalu is considered to be one of the most vulnerable places with regards to the impacts of global warming, as it poses a great threat to the 10,000 Tuvaluans residing on nine low-lying coral reef islands and atolls. The main atoll, Funafuti, has been the site of numerous scientific studies, including coastal erosion and inundation. Any strategies to utilise lagoon aggregates for rehabilitation or foreshore protection need to have a strong focus on sand production, movement, and deposition mechanisms. This needs to include the biological origin and physical transport of sediment.

Foraminifera (often abbreviated to "forams") are acellular organisms (protists) that form shells (tests) of calcium carbonate or cemented grains of sand or other material which, when the animals die, may form calcareous sand. In some lagoon areas foraminifera are important contributors to carbonate sand production. In the nutrient-poor marine waters of the tropics, the symbiont-bearing foraminifera can grow up to 2 mm in size, and make a significant contribution to the overall deposition of calcium carbonate on coral reefs. In some tropical lagoons the sands consist largely of dead foraminiferal tests. These organisms are capable of generating 2 kg of carbonate skeletons/m²/year. The outer reef flats of Funafuti, Tuvalu are densely populated with foraminifera species and generate approximately 2 L of sediments/m²/yr. About 50% to 90% of the islet bodies are composed of foraminifera.

The Japan International Co-operation Agency (JICA) is funding a survey in Tuvalu, for rehabilitation of damaged areas, to increase resilience of Tuvalu against future sea level rise through rehabilitation of ecosystem and artificial support for production, transportation and sedimentation processes. Part of the work is to find a way to utilise foraminifera for coastal rehabilitation. Research focuses on the larger benthic foraminifera species present on Fongafale Islet, *AMPHISTEGINA*, *BACULOGYPSINA* and *CALCARINA*, with the aim to culture them at faster rates and replenish beaches with live reproducing adults.

SINCLAIR

Challenges faced in developing water resource assessment and monitoring in Pacific Island Countries

Peter Sinclair

SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands

Email: peter@sopac.org

The variety in physical and geographic setting of Pacific Island Countries PIC's is of course great. Large landmasses with mountains, rivers, streams and lakes, contrast with flat low lying atolls of only tens of metres wide with no surface water resources at all. The often restricted resources, and in many cases great distances between habitable islands has resulted in communities developing in isolation and surviving on limited means. Large rainfalls which, during "normal" years, are often sufficient for providing their freshwater needs often typify many of the PIC's. They are very reliant on these high rainfalls as much as their regular frequency to ensure sufficient water for demands and to provide limited tank storage.

Of the 14 countries participating under the Pacific HYCOS project only 8 have any significant surface water supplies, whilst the remainder rely solely on a combination of collected rainwater and groundwater sources. The small physical extent and limited resources result in a reduced resilience to extended dry periods, where existing storages of surface water, groundwater and rainwater are often insufficient to meet demands.

The predominant demand for freshwater in small PIC's is for potable and domestic requirements for communities. Irrigation is limited to subsistence farming for domestic markets on the small islands but has great potential for food production on the larger ones. The production of hydroelectric power generation is limited to the countries of, Fiji, Papua New Guinea, Solomon's, Federated States of Micronesia, Vanuatu and Samoa with recent investigations on its potential for further development for mini and micro systems. Other industrial uses include water for mining, fishing canneries and processing, small intensive livestock farming (chickens and pigs), and bottled water sources. However at this stage development is not large, mostly unlicensed and unregulated. In addition to this is the need for water information for a range of infrastructure development but not limited to urban drainage, roads and bridges, irrigation potential, climate change, disaster risk and Integrated Water Resource Management.

To date, the focus in the Pacific has been on limited investigation for development of water resources. Management of water resources is a relatively new concept, brought about by compromised supplies where an increasing urban population is placing additional pressure on already limited freshwater resources in addition to external factors such as increased climate variability. Monitoring of the resource has been sporadic and inconsistent, often project driven and with little success in developing long-term reliable datasets which water resource management demands. Whilst significant capacity development in resource monitoring and assessment is still required, increasingly there is a need for reliable, consistent and long-term datasets to plan for future climate and resource needs scenarios and better understand the innate resilience of the hydrological systems as well as their tipping points as these systems become increasingly stressed.

It comes as no surprise that National Hydrological Services (for SW and GW) in the true sense of the word do not exist in the Pacific, the function is undertaken within perhaps a water utility, EPA or the like and operate with limited technically skilled staff. Hydrologists with the appropriate training and qualifications do

not exist leading to depleted capacity and visibility of what hydrology is about. Significant investment in water resource development over the last 50 years has been provided to PICs through aid and development loans, but has not been backed up with capacity building for monitoring and assessment which is an integral component of this development work. It often focuses on providing a local counterpart with new equipment and a few days of hands on training and not necessarily by a specialist. Afterwards, a list of identified job tasks is given to the local counterpart to undertake on behalf of the specialist. In the backdrop of an island setting, whereby isolation, limited resources, more pressing demands, and lack of ongoing support and long-term investment, it should come as no surprise that this approach to capacity building frequently fails. Other approaches include providing short term training in donor countries or elsewhere, where lack of relevance, results in these opportunities being considered by PIC participants as more about the travel than the opportunity to learn, study and migrate this knowledge to their and migrate this knowledge to their peers.

Isolation brings with it a lack of access to quality education and health services. Limited resources result in inadequate operational funding, poor wages, and a small skill base from which to draw upon for an ever increasing number of tasks and demands. The difficulties these developing countries live with are compounded by a lack of stability and vision from some governments, early retirement ages, lack of succession planning, limited mentoring and poor management and leadership. There is an additional loss of capacity caused where skilled staff move to better paid positions with little skill transferral, resulting in the need for ongoing specialist operational training. Increasingly there is evidence of a culture of apathy developing leading to ambivalence to work, and an aid-reliant mentality in some organisations and countries.

This paper will review what approaches have been observed and used in capacity building in the area of water resources assessment and management over recent years. Identifying those approaches which have met with more apparent success in the short to medium term will offer some options for further development. It will consider the need and options for longer term capacity development in the region to the benefit of donors and the Pacific Island Countries.



Examples of hands on training opportunities which have been seen of tremendous benefit to Pacific HYCOS in advancing the PIC staff development.

SMITH, L

HYCOS in Palau – small catchment streamflow analysis

Llyod Smith

SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
 Email: Llyod@sopac.org

Water Resources data in the Pacific for informed decision making over a range of water resource projects is still significantly deficient. This is despite the 4 year Pacific HYCOS initiative providing assistance across the PIC's in supplying equipment, technologies and capacity development in how to collect, archive and analyse this essential data. Palau through EQPB has been particularly successful in achieving timely implementation and advancing towards the projects aims and is now starting to assess its surface water resource including rainfall with increasing levels of confidence. This is despite coming from a low starting base with no capacity or knowledge of operational hydrology. A number of stream flow stations have now been installed, some on the closed USGS sites, to recommence monitoring activities. Given the need for data for Climate change, disaster risk management, IWRM planning and design options for future water sources, Palau sees this initiative as essential and has embarked on a robust well supported monitoring program on the main Island of Babeldaob.

One of the focus streams is the Tabercheding Stream and this is of interest for future surface water supply options for Arai and Koror. This paper will concentrate on the type of data collected, what is involved in its collection and will demonstrate some of the data analysis and how this is useful for future planning options. The dataset is limited in duration being only of 18 months but is already proving useful for assessment of short duration flows, drought analysis and water pollutant loading. When considered with the USGS data 2002 – 2004, it provides some comparative indications on catchment yield especially for dry periods. Pacific HYCOS is also assisting EQPB with installing streamflow stations within the IWRM GEF demonstration catchment on the Ngerikill and Kmekumel streams, the source of Arai and Koror's water supply.

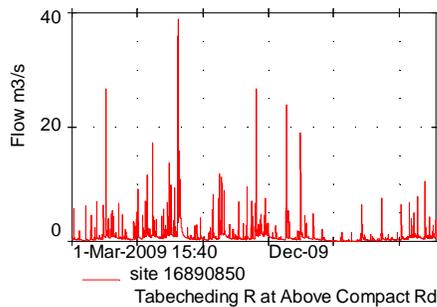


Figure 4: Streamflow hydrograph

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.546	1.337	0.104	0.016	0.246	0.282	0.688	?	?	?	?	?
2	0.486	1.016	0.094	0.030	0.200	0.264	0.566	?	?	?	?	?
3	0.491	0.531	0.085	0.034	0.148	0.329	0.533	?	?	?	?	?
4	0.429	0.453	0.091	0.202	0.300	1.937	0.489	?	?	?	?	?
5	0.455	0.415	0.090	0.076	0.180	0.706	0.479	?	?	?	?	?
6	0.393	0.382	0.075	0.067	0.153	0.531	0.529	?	?	?	?	?
7	0.501	0.385	0.060	0.054	0.449	0.512	2.515	?	?	?	?	?
8	0.377	0.368	0.051	0.443	2.599	0.440	1.128	?	?	?	?	?
9	0.343	0.325	0.046	0.289	0.722	0.450	0.865	?	?	?	?	?
10	0.615	0.338	0.036	1.752	0.454	0.406	0.670	?	?	?	?	?
11	0.386	0.285	0.057	1.052	0.363	0.352	0.723	?	?	?	?	?
12	0.594	0.261	0.280	0.537	0.336	0.573	0.589	?	?	?	?	?
13	0.408	0.761	0.510	0.346	0.454	0.426	1.428	?	?	?	?	?

14	3.614	0.444	0.474	0.659	0.373	0.596	0.819	?	?	?	?	?
15	4.830	0.306	0.184	0.372	0.355	1.570	0.658	?	?	?	?	?
16	1.256	0.399	0.114	0.280	0.380	0.912	0.650	?	?	?	?	?
17	0.878	0.279	0.111	0.261	0.618	0.778	0.878	?	?	?	?	?
18	0.741	0.242	0.081	0.212	0.354	1.321	0.776	?	?	?	?	?
19	0.639	0.223	0.069	0.218	0.286	0.856	1.003	?	?	?	?	?
20	0.666	0.212	0.090	0.185	0.337	0.975	0.710	?	?	?	?	?
21	2.310	0.209	0.090	0.198	0.299	1.468	0.636	?	?	?	?	?
22	0.858	0.185	0.054	0.395	0.385	1.532	?	?	?	?	?	?
23	1.206	0.173	0.160	0.210	0.324	1.010	?	?	?	?	?	?
24	0.732	0.156	0.063	0.198	0.273	0.828	?	?	?	?	?	?
25	0.690	0.142	0.039	0.361	0.276	0.805	?	?	?	?	?	?
26	0.666	0.133	0.297	0.327	0.291	0.676	?	?	?	?	?	?
27	0.559	0.123	0.189	0.265	0.259	2.223	?	?	?	?	?	?
28	0.529	0.113	0.083	0.194	0.232	0.907	?	?	?	?	?	?
29	0.484	?	0.051	0.153	0.469	0.753	?	?	?	?	?	?
30	0.452	?	0.037	0.134	0.639	0.701	?	?	?	?	?	?
31	0.418	?	0.021	?	0.319	?	?	?	?	?	?	?
Min	0.343	0.113	0.021	0.016	0.148	0.264	0.479	?	?	?	?	0.016
Mean	0.889	0.364	0.122	0.317	0.422	0.837	0.825	?	?	?	?	0.528
Max	4.830	1.337	0.510	1.752	2.599	2.223	2.515	?	?	?	?	4.830

End of process

Figure 5: 2010 data with firm drought indicators



Figure 6: EQPB team preparing to undertake streamflow measurement

SMITH, R

Reservoir sedimentation, Monasavu Hydro Lake, central Viti Levu, Fiji: an analysis using multibeam mapping technology

Robert Smith

SOPAC Secretariat, Private bag, GPO, Suva, Fiji Islands

Email: Robert@sopac.org

The Monasavu hydroelectric facility is an important renewable energy source providing much needed power for the good of Fiji's economic development and its most important physical characteristic is its storage capacity. As with any impounded body of water the accumulation or build up of sediment within the reservoir may impact its operation and reduce its ability to generate power.

Sedimentation in a reservoir, like Monasavu, can be monitored using geophysical mapping techniques. The methodology used involves repeating surveys over established transects from which presumed changes in profiles can be interpreted in relationship to the build up of sediment. Six profiles spaced at varying intervals along the 11 kilometer length of the reservoir, when at spillway level, were established and first surveyed in 1991. These profiles were then re-surveyed in 1993 and 1998. In the 1998 survey it was found that of the 12 original control points for the profiles, one was lost due to landslides and a number of others were under threat to landslide or slope instability. It was noted also in the 1998 survey that slope failure was the primary source for sedimentation in the reservoir and that failure was not confined to the location of the profiles only.

In 2010, DGPS multibeam and single channel seismic were used for the first time to map the reservoir after a lapse of twelve years. It was also done at a time when water level in the dam was 15 m lower than the three previous surveys. From the exposed embankments numerous landslips were evident, with many of the original benchmarks set up for the profiles lost due to landslides.

The results of the survey show that multibeam is the tool to examine and monitor in detail the real extent of sedimentation within the reservoir; and conclude that the six profiles at the time may have been sufficient to monitor sedimentation at site-specific locations but are insufficient for a reservoir with significant variation in topography and geology. The results of the multibeam survey provide a more definitive analysis of the state of the reservoir leading to the conclusion that the current sedimentation rates do not pose a future risk to the reservoir.

SMITH, S

Deep ocean seafloor mineral extraction - the dawn of a new industry

Samantha Smith

Nautilus Minerals Inc., Brisbane, QLD, Australia

Email: sls@nautilusminerals.com

Nautilus Minerals (Nautilus) is following the lead of the petroleum industry as it strives to tap vast offshore resources. Planning is well underway for the Solwara 1 Project in the Bismarck Sea, Papua New Guinea (PNG) to recover high-grade seafloor massive sulphide deposits in 1600 m water depth. The deposit contains an average copper grade >10 times higher than a typical land-based porphyry copper mine. The high grades combined with a relatively small amount of overburden ensure the Solwara 1 Project will have a significantly smaller physical footprint than its land-based counterparts. Offshore minerals production also has the advantage of minimal social disturbance.

Nautilus is dedicated to setting a high environmental and social responsibility standard. Nautilus recognises the importance of transparent and inclusive stakeholder engagement and has taken a proactive approach to involve as many key stakeholders as possible. One of the first steps in the permitting process in PNG is the preparation of the Environmental Inception Report, which describes the project, its envisaged impacts and the proposed studies for the Environmental Impact Assessment (EIA). Local (PNG-based) and international environmental scientists, anthropologists, NGOs and other experts were involved in the definition of studies conducted for the Solwara 1 EIA and a team of world-leading experts was involved with carrying out the studies, culminating in the preparation of the Environmental Impact Statement (EIS). To ensure transparency, collaborating researchers are free to publish their findings. Following its submission, the EIS was made available for public review and public hearings were held at several locations. The EIS has also undergone a rigorous independent review by PNG government-engaged consultants. Outside the permitting process, Nautilus works alongside government officials to carry out ongoing community consultations. Information dissemination and feedback acquisition has also occurred through the Nautilus website and attendance at a number of international conferences, workshops, and meetings.

This paper will outline the leading edge approach Nautilus has taken in completing the environmental impact statement for the world's first deep seafloor copper-gold mine. In addition, this paper will review the permitting process and the government and stakeholder engagement undertaken as part of Nautilus' desire to "do it right" in this exciting new industry.

TAWAKE

Deep sea mineral resource estimates of selected countries in the Pacific Islands Region

Akuila K. Tawake

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands

Email: akuila@sopac.org

Occurrences of polymetallic minerals were confirmed within the Exclusive Economic Zones (EEZs) of many Pacific Island Countries (PICs) in the early years of marine scientific researches and seabed minerals exploration in the region. SOPAC (then the CCOP/SOPAC) was actively involved with deep sea mineral exploration in many South Pacific countries between the 1970s and the mid 1980s that led to the discovery of these seabed minerals. Much of the results of these early minerals prospecting in the region had been rendered redundant by the systematic and reasonably detailed works that were carried out during the 1985-2005 Japan-SOPAC Cooperative Study programme. This deep sea mineral resources investigation programme has greatly enhanced the geological knowledge of deep sea mineral resources in the region particularly for the twelve participating countries.

The Metal Mining Agency of Japan (MMAJ) was responsible for the technical studies of the programme. With the aid of new deep sea minerals exploration technology, significant sea areas of participating countries were surveyed and target areas were investigated in reasonable detail. Based on the results of the Japan-SOPAC study, the mineral potential of a number of countries in the region was confirmed with certain degree of variability in terms of geology, types of deposit, abundance and metal concentration. Seafloor Massive Sulphide (SMS) deposits are confirmed in PNG, Tonga and Fiji while the Cook Islands and Kiribati have high manganese nodule resources potential in addition to significant occurrences of Cobalt-rich Crust (CRC) within the EEZs of the Marshall Islands and the Federated States of Micronesia.

For the Cook Islands, four research cruises (i.e. in 1985, 1986, 1990 and 2000) were carried out as part of this programme and manganese nodules distribution, abundance and metal concentration have been determined. Above the assumed cut-off nodule abundance of 5 kg/m², a nodule resource of 4,461 million tonnes was estimated in a total area of 360,000 km². In addition, a total of thirteen seamounts were surveyed for CRC within the EEZ of the Marshall Islands in 1996, 1998 and 2002 as part of the Japan-SOPAC partnership. A CRC resource estimate of the thirteen seamounts confirmed a total inferred resource of 186 million tonnes of crust. For SMS deposits, it was realised that the data gathered from previous investigations were insufficient to warrant any credible estimates of mineral resources. However, Golder Associates performed an independent resource estimate for the Nautilus Minerals' Solwara 1 Project in PNG and confirmed Indicated and Inferred mineral resources of 0.87 Mt and 1.3 Mt respectively containing elevated copper, zinc, gold and silver grades.

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TAYLOR

The Tofua Volcanic Arc, Kingdom of Tonga, southwest Pacific: a review of eruptive activity over the past decade

Paul W. Taylor

*Australian Volcanological Investigations, PO Box 291, Pymble, NSW 2073, Australia
Email: avitaylor@optusnet.com.au*

The Tofua Volcanic Arc (TVA) forms a prominent tectonic feature in the SW Pacific and is a classic example of an active oceanic island arc. The arc comprises a series of several dozen active, dormant, and extinct, subaerial and submarine volcanic centres that have formed on a N-S trending submarine ridge, between latitudes 14.5°S and 26°S. In the northern and central parts, the arc is located 40-50 km W of the Tonga Platform. Active volcanism has been occurring along almost the entire length of the TVA since its initiation after the formation of the Lau Basin between 3 Ma and 5 Ma. During the past decade eruptions have occurred at, at least five centres, several eruptions resulting in the formation of ephemeral islands. Several eruptions have attracted considerable coverage in the international media.

The most recent eruption occurred at several submarine vents that formed adjacent to the island of *Hunga Ha'apai* located about 58 km to the NNW of *Nuku'alofa*. Two vents opened to the W of island and a third vent formed to the S on 17 March 2009. Activity appears to have been preceded by a number of seismic shocks that were felt in *Nuku'alofa*. All vents produced periods of extremely explosive "Surtseyan-type" activity. The southern vent produced a low tuff cone composed of pyroclastic material. Activity persisted until the about 21 March after which fumarolic activity was observed until about mid-April. For detail on this eruption please refer to the poster paper by the author.

A period of activity was also reported at Submarine Volcano III during late-January and early February 2007. This submarine centre located 35 km NW of *Tongatapu* was previously active during January 1999. Little is known about this latest activity, however, "bright green patches of water" and a strong smell of sulfur were reported by local fishermen. Several seismic shocks were reported in late-January from the site suggesting that deep submarine activity may have been occurring, but no subaerial activity was reported.

On 08 August 2006 submarine explosive activity was again reported at *Home Reef* SW of *Vava'u*. An extensive pumice raft was observed on satellite photographs indicating submarine activity, the raft moved toward the NW. By 11 August an island had been formed by the explosive activity. When observed by a passing yacht, activity included strong jetting of ash and steam plumes. By early-October activity had subsided with mild steam plumes being produced. By early-December a NZ Air Force over flight reported that only minor activity persisted in the active vent. By February 2007 the island had disappeared with only a sandy shoal remaining.

During late-September 2001, explosive activity was reported at a previously unknown centre W of *Vava'u*. This short-lived period of activity was preceded by seismic activity that was recorded in French Polynesia. Reports of an island being formed may have been mistaken for a pumice raft reaching the surface; however, no pumice strandings were reported in Fiji and eventually along the NE coast of Australia.

On a flight between *Niufo'ou* and *Vava'u* on 25 October 2002, the author observed extensive rafts of pumice on the ocean surface which appeared to be moving in a S to SW direction. Pumice strandings were observed on the coast of *Niufo'ou* and again along the N coast of *Vava'u*. There were no reports of activity at the known centres in the region of *Niutoputapu*, so the source of the pumice is unknown. However, during several research vessel visits to the northern termination of the TVA during the past few years, observations of deep submarine explosive activity were made by ROVs at a centre named *West Mata*. Several other submarine centres in the area were also reported to be active. Was one of these centres the source of the pumice observed in October 2002?

The data presented here has been drawn for all known sources and suggests that submarine activity is occurring frequently along the TVA, if not continuously at different centres. It can be utilised during future studies that may particularly relate to the evaluation of the volcanic hazards in the region.

TAYLOR [Poster]

The March 2009 eruption of the *Hunga Tonga* and *Hunga Ha'apai* Volcano, Kingdom of Tonga

Paul W. Taylor

Australian Volcanological Investigations, PO Box 291, Pymble, NSW 2073 Australia

Email: avitaylor@optusnet.com.au

Hunga Tonga and *Hunga Ha'apai* are the subaerial remnants of a large active submarine volcano in the central part of the Tofua Volcanic Arc (TVA) located 58 km NW of *Tongatapu*. Although evidence would suggest considerable activity has occurred in the past, only five periods of activity have been reported since the early-1900s. Historic activity has been dominated by small-magnitude submarine explosive eruptions sometimes producing pyroclastic material and rocky shoals.

The most recent eruption occurred during the period 17-21 March 2009. The initial submarine phase of the eruption resulted in the formation of three vents, two on the NW edge, and the third to the SE of *Hunga Ha'apai*. The event was dominated by explosive Surtseyan-type activity producing large amounts of pyroclastic material. Toward the end of the activity, an island of unconsolidated pyroclastic material had formed around the southern vent. The island was elliptical in shape covering an area of approx 2 km². Although a small amount of pumice was produced during the early phases of activity, strandings have not been reported on surrounding islands.

A number of seismic events were recorded during the period prior to the eruption. Local Tongan scientists visited the site and observed the activity. A preliminary hazard assessment has been completed showing the hazards and the zones of potential risk around the site.

As a result of the eruption, numerous tourist visits were made to the site of activity during and following the activity, some even landing on the island that was produced by the eruption. These visits raise the issue of safety associated with "geo-tourism", what are the risks associated with the perfect photo opportunity?

Due to the proximity of this volcano to densely inhabited areas of Tonga this eruption has again emphasised the need for the establishment of a dedicated volcano-monitoring program for the Kingdom of Tonga.

WALLACE, ANTON AND OTHERS

Exploring partnerships between Papua New Guinea and New Zealand in geohazards research

Laura Wallace¹, Lawrence Antor², Chris McKee², Steve Saunders³, John Arumba², Timothy Little⁴, Ken Gledhill¹, Hannah Brackley¹ & Kelvin Berryman¹

¹GNS Science, PO Box 30368, Lower Hutt, New Zealand

²Port Moresby Geophysical Observatory, P.O. Box 323, Port Moresby, National Capital District, Papua New Guinea

³Rabaul Volcano Observatory, Rabaul, Papua New Guinea

⁴Victoria University of Wellington, Wellington, New Zealand

Email: L.Wallace@gns.cri.nz

Papua New Guinea (PNG) and New Zealand (NZ) are each subjected to a vast array of geological hazards, including earthquakes, volcanoes, tsunami and landslides. Both nations straddle the boundary zone between the Pacific and Australian Plates; in NZ, the relative motions between the Pacific and Australian plate are 3-4 cm/yr, while in PNG the plates converge much more rapidly at ~11 cm/yr. NZ is fortunate to

have strong government support for a large community of geoscientists with expertise in geohazards, while in PNG there are fewer resources available to support the much-needed geohazards work there.

Geological hazards in PNG have a profound impact on the livelihoods of people and their surroundings. Most notably, the 1998 Magnitude 7.1 earthquake and subsequent tsunami killed ~2400 people near Aitape. Earthquakes similar to the one that triggered this 1998 tsunami could happen again on numerous other fault lines in PNG, and the risk to lives and infrastructure in PNG from such events is not well-known. Seismic hazards are an issue throughout most of PNG, particularly for some of PNG's large cities, such as Lae (population 120,000), which is an industrial centre for the country and straddles one of the most active fault lines on Earth (the Ramu Markham Fault). Among other things, more detailed GPS studies are needed to constrain the current locations of build-up of tectonic strain throughout PNG. Paleoseismological studies of some of PNG's major active faults would lead to an improved understanding of their past behaviour and earthquake generating potential. The vast array of potential tsunami sources that could impact PNG's coastlines requires a probabilistic approach to tsunami hazard assessment.

Plate tectonic activity in PNG also leads to high rates (up to several mm/yr) of coastal uplift or subsidence in many locations throughout the country; accurate knowledge of local coastal uplift or subsidence is key to anticipating the impacts of relative sea level change. Relative sea level change in PNG can be determined using a variety of methods, including geological studies of raised or drowned coral reefs, and increased monitoring with tide gauges and continuous GPS.

There is an array of stakeholders that would benefit from an improved understanding of PNG's geological hazards, ranging from people at the local village level, through to government agencies and major multinational mining and petroleum companies. To this end, we are currently developing an initiative to increase collaboration between NZ and PNG geoscientists with regards to geohazards research, which will be of benefit to both countries. Particular subjects of interest are issues surrounding seismic hazard, tsunami hazard, and sea level change.

WEBB

Atoll shoreline response to sea level rise over the last 50 years – SOPAC PRISMS (Pacific Regional Island Shoreline Monitoring System)

Arthur Webb

SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands

Email: arthur@sopac.org

This talk discusses the implications and provides an explanation of the research which underpinned a topical research paper released this earlier year entitled "*The dynamic response of reef islands to sea-level rise: Evidence from multi-decadal analysis of island change in the Central Pacific*" (Global & Planetary Change, 2010). Many global media outlets misunderstood and thus misrepresented this research and as a consequence there was significant confusion regarding the important findings and implications of this research to Pacific Atoll communities.

This research used data developed by the SOPAC, Pacific Regional Island Shoreline Monitoring System (PRISMS) which was established to provide clear empirical facts to decision makers regarding shoreline response to stress such as sea level rise, engineering and resource use impacts. Currently atolls are the primary target of PRISMS since these shores are widely seen as the most fragile in the region and atoll shoreline dynamics are not complicated by terrigenous sediment processes (sediments derived from surface flow and rivers).

The preliminary results of PRISMS has provided new insights into the nature of atoll shoreline dynamics over the last half century of sea level rise and where not disturbed by development pressures the results indicate that at present Pacific Atoll shorelines, contrary to contemporary models, show a degree of resilience and stability. These results have far reaching implications for coastal management and design of adaptation responses in the immediate shoreline zone.

ATTACHMENT

FINAL PROGRAMME as at 19 October 2010 (as it happened)

STAR 2010 Programme as at 19 October 2010

Friday October 15th evening – Registration

Time	Theme	Authors & Presenter	Title	Time	Theme	Authors & Presenter	Title
Saturday October 16th							
Venue: Main Conference Centre, Tanoa Hotel, Nadi, Fiji							
09:00-09:20	STAR Opening – Gary Greene, Acting Chair of STAR & Russell Howorth, Director, SOPAC						
Session 1 (Chair – H. Gary Greene)							
09:20-09:40	Hazards	<u>Bazzurro, P., Biukoto, L., Bonte-Grapentin, M. & others</u>	Pacific exposure databases and models				
09:40-10:00		<u>Wallace, L., Gledhill, K. & others</u>	Exploring partnerships between Papua New Guinea and New Zealand in geohazards research				
10:00-10:20		<u>Lamarche, G. & others</u>	Paleo-tsunami record and tsunami hazard in Wallis and Futuna				
10:20-10:50	Refreshment break						
Session 2 (Chair – Litea Biukoto)							
10:50-11:10	Hazards	<u>Gledhill, K.</u>	Improving tsunami warning times				
11:10-11:30		<u>Inoue, H. & others</u>	2009 Niuaotupapu Tsunami video interview for sharing lessons of the disaster				
11:30-11:50		<u>Garaebiti, E. & others</u>	Developing monitoring capability of a volcano observatory: the example of the Vanuatu Geohazards Observatory				
11:50-12:10		<u>Taylor, P.</u>	The Tofua Volcanic Arc, Kingdom of Tonga, southwest Pacific: a review of eruptive activity over the past decade				
12:10-12:30		<u>Anton, L. & Taranu, F.</u>	The recent magnitude 7 earthquake doublets of the Papua New Guinea region				
12:30-14:00	Lunch						
Session 3 (Chair – Peter Harris)							
14:00-14:20	Hazards	<u>Gledhill, K. & GeoNet team.</u>	The Darfield (Canterbury, New Zealand) Earthquake of September 2010: a preliminary report				
14:20-14:40	Oceans & Climate Change	<u>Hemer, M. & others</u>	Surface wind-wave climate of the Pacific region: variability, trends and future projection				
14:40-15:00		<u>Parker, P. (Crane, G.)</u>	The South Pacific Sea Level & Climate Monitoring Project (SPSLCMP): developing into the future				
15:00-15:20		<u>Lal, A. & Artack, E.</u>	SOPAC Pacific Islands Regional Maritime Boundaries Sector				
15:20-15:50	Refreshment break						
Joint Session 4A (Chair – Doug Ramsay)				Joint Session 4B (Chair – Emily Artack)			
15:50-16:10	Mapping, Management & Training	<u>Harris, P.</u>	Map once – use many ways: global and Australian examples	15:50-16:10	Energy & minerals	<u>Smith, S.</u>	Deep ocean seafloor mineral extraction - the dawn of a new industry
16:10-16:30		<u>Baker, E.</u>	The University of the Sea: an Asia Pacific marine science initiative	16:10-16:30		<u>Hart, A.W. & Brook, B.</u>	Fiji – a new petroleum province?
16:30-16:50		<u>Harris, P.</u>	IGC STAR Brief	16:30-16:50		<u>Kumar, S.</u>	Pacific Petroleum Project: Phase One
16:50-17:10	IGC			16:50-17:10		<u>Mosusu, N.</u>	Geothermal development in Papua New Guinea: current status and future aspirations
17:10-18:00	STAR Business Meeting						

Saturday Evening – Icebreaker, venue outside Main Conference centre, Tanoa Hotel

Sunday – BBQ Lunch and Doug Rearic Volley Ball Competition, Wailoaloa Beach, Nadi (shuttle bus departs hotel 11:00 onwards, return 16:00)

Monday October 18th

Joint Session 5A (Chair – Keu Mataroa)				Joint Session 5B (Chair – Rhonda Robinson)			
09:00-09:20	CPC/STAR Map Once - Use Many Ways	<u>Greene, H. G.</u> , & others	The West Coast Governors' Agreement – a three state team effort to map the seafloor of California, Oregon and Washington, USA	09:00-09:20	Water	<u>Raj, S.</u>	Water governance in the Pacific
09:20-09:40		<u>Lamarche, G.</u> & Nodder, S.	Ocean Survey 20/20: NIWA's involvement in New Zealand's National Ocean and Coastal Mapping Programme	09:20-09:40		<u>Hasan, T.</u> & Gerber, F.	The economics of drinking water safety planning
09:40-10:00		<u>Lafoy, Y.</u> ; <u>Lamarche, G.</u> & others	The ZoNéCo programme in New Caledonia: a tentative approach to link marine habitats knowledge to policy making	09:40-10:00		<u>Sinclair, P.</u>	Challenges faced in developing water resource assessment and monitoring in Pacific Island Countries
10:00-10:20		<u>Diaz-Naveas, J.</u>	Mapping efforts at the Chilean convergent margin	10:00-10:20		<u>Smith, L.</u>	HYCOS in the Palau - small catchment streamflow analysis
10:20-10:50	Refreshment break			10:20-10:50	Refreshment break		
Joint Session 6A (Co-Chairs – Elaine Baker, Geoffroy Lamarche)				Joint Session 6B (Chair – Jan Gregor)			
10:50-11:10	CPC/STAR Map Once – Use Many Ways	<u>Lamarche, G.</u> & others	Submarine substrate and biodiversity mapping using multiscale analysis of bathymetric and backscatter data: examples from Cook Strait and the Kermadec Arc, New Zealand	10:50-11:10	Water	Chapman, C.	Reducing water losses & operating costs in Niue: A WDM case study
11:10-11:30		<u>Anderson, E.</u>	Benthic communities: case studies in Fiji and Canada	11:10-12:30		<u>Loco, A.</u>	Hydrogeology of the middle Sigatoka Valley and human impacts on groundwater resources
11:30-11:50		<u>Tawake, A.</u>	Deep sea mineral resource estimates of selected countries in the Pacific Islands region	11:30-11:50		<u>Kumar, A.</u>	Flood forecasting and warning in Fiji
11:50-12:10		<u>Smith, R.</u>	Reservoir sedimentation, Monasavu Hydro Lake, central Viti Levu, Fiji. An analysis using multibeam mapping technology	11:50-12:10		<u>Duncan, D.</u>	Measure once and report universally – developing an IWRM regional monitoring programme that meets water resource reporting requirements from the local to the global level
12:10-12:30							
12:30-14:00	Lunch						
Session 7 (Chair – Alf Simpson)							
14:00-14:20	Coastal & Sediments	<u>Damlamian, H.</u> & Kruger, J.	The application of a three dimensional coupled wave-current hydrodynamic model for the management of Saipan Lagoon, CNMI				
14:20-14:40		<u>Damlamian, H.</u> & Kruger, J.	Possible impacts from proposed channel alterations, Aitutaki, Cook Islands				
14:40-15:00		<u>Owen, K.</u> & others	SWAN wave modelling for Palmyra Atoll, central Pacific Ocean: understanding the depositional environments of beachrock				
15:00-15:20		<u>Ramsay, D.L.</u> ; Stephens, S. & Bell, R.	Sea-level changes and their impacts on the coastline of South Tarawa				
15:20-15:50	Refreshment break						
Session 8 (Chair – Doug Ramsay)							
15:50-16:10	Coastal & Sediments	<u>Kumar, S.</u> & Kruger, J.	At the crossroads: seamless coastal terrain models in the Pacific Region				
16:10-16:30		<u>Ram, A.</u> & others	Investigating short-term temporal relationships between rainfall parameters and fluvial sediment transport within a steep forested catchment in southern Viti Levu, Fiji Islands				
16:30-16:50		<u>Sharma, A.</u> & Kayanne, H.	Using foraminifera for coastal rehabilitation of damaged areas in Tuvalu				
16:50-17:10		<u>Raqisia, K.</u>	Building geospatial baselines: historical air photo rescue activities				
17:10-17:30		<u>Webb, A.</u>	Atoll shoreline response to sea level rise over the last 50 years – SOPAC PRISMS (Pacific Regional Shoreline Monitoring)				

Tuesday October 19th – Opening of SOPAC Annual Session