

**ABSTRACTS OF  
PAPERS PRESENTED AT THE  
STAR\* SESSION 2003**

**John Collen**  
Editor

SOPAC Miscellaneous Report 549

**\* Science, Technology and Resources Network**

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## Foreword

STAR (SOPAC's Science, Technology and Resources network) was founded in 1984 in collaboration with IOC. STAR was formed to assist the international geoscience community to provide advice to SOPAC, particularly during the intervals between SOPAC International Workshops. The first Chairman of STAR, Dr Charles Helsley, then Director of the Hawaii Institute of Geophysics, guided STAR until 1992. He was succeeded by Keith Crook from the Hawaii Undersea Research Laboratory. Keith served until the end of 1999 when John Collen from the School of Earth Sciences at Victoria University of Wellington, New Zealand became Chair.

STAR meetings are not simply technical conferences at which individuals present scientific papers and discuss their results and implications. Participants have the additional responsibility to formulate advice to SOPAC about its Work Programme and to highlight technical and scientific issues of particular importance or urgency to the region. This advice, in the form of reports and recommendations from STAR Working Groups and reports on highlights of STAR technical presentations, is tendered to Council by way of an address in Plenary by the Chair of STAR and also during the Governing Council/Technical Advisory Group (GC/TAG) segment of the Annual Session. All STAR participants are invited and urged to participate in this phase of the meeting.

One of the great strengths of SOPAC is its ability to mobilize excellent and multidisciplinary science and bring it to bear so as to address the national needs of SOPAC's island member countries. The long-established working relationship between SOPAC and the international research community is a vital element in this endeavor, which STAR is charged to nurture. This relationship stimulated an order-of-magnitude change in the geoscience database in the SOPAC region during the 1980's. During the 1990's it supported the changes in SOPAC's scope and focus that led to the development of the three major work programmes that are still continuing.

In earlier years STAR was primarily concerned with "blue-water" marine geoscience, tectonics and resources. However, as national needs and priorities have changed, the scope of STAR has similarly altered, partly reflecting changes in focus of international science but also to ensure that SOPAC's Work Programme and its forward planning are influenced by international science that is both excellent and relevant. The wide scope of the work outlined by the abstracts in this volume is a clear indication that this evolution is continuing.

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September 2003

## Programme for 20<sup>th</sup> STAR Conference, Niue, 2003

Time	Theme	Authors & Speaker	Title
<b>Friday September 19<sup>th</sup></b>			
19:30-20:00	<b>STAR Opening</b> J. Collen, Chair, STAR & A. Simpson, Director, SOPAC		
20:00 -	<b>Social gathering</b>		
<b>Saturday September 20<sup>th</sup></b>			
09:00-10:00	<b>STAR Business Meeting</b> Agenda to be distributed		
10:00-10:20	Water & Other Non-Living Resources	<u>Greene, H.G.</u>	Atoll lagoon circulation: potential infrastructure impacts and mediations on fresh water storage, erosion, and ecology - progress of the TAP Project.
10:20-10:50	<b>Refreshment break</b>		
10:50-11:10	Water & Other Non-Living Resources	<u>Bower, R.</u>	Community participation and gender in the Water and Sanitation component of the SOPAC Community Lifelines Programme.
11:10-11:30		Mosley, L.M., Sharp, D., Singh, S. & <u>Carpenter, C.</u>	Impacts of cyclone Ami on drinking water quality: How can we best protect public health when similar disasters occur?
11:30-11:50		Hill, M., Edsall, D. & <u>Collen, J.D.</u>	Self-contained apparatus for harvesting water from humid atmosphere.
11:50-12:10		Okamoto, N. & <u>Pratt, C.</u>	Summary Report on the Results of Phase 1 (2000-2002) of Stage II of the Japan/SOPAC Cooperative Deep-sea Mineral Resources Study Programme with Future Initiatives of the Programme from 2003 to 2005.
12:10-12:30		<u>Verlaan, P.A.</u> , Cronan, D.S., & Morgan, C.L.	Regional environmental controls on nodule and crust compositional variation in the SOPAC area.
12:30-13:30	<b>Lunch break</b>		
13:30-13:50	Tectonics & Geology	<u>Fisher, C.</u>	Plans for a Multi-Leg Ridge 2000 expedition to the East Lau Spreading Center in 2004.
13:50-14:10		Wessel, P., <u>Kroenke, L.W.</u> , Harada, Y. & Sterling, A.	The Hawaii-Emperor Bend: an unequivocal record of Pacific plate motion change.
14:10-14:30		Keating, B. & <u>Helsley, C.E.</u>	Ancient strandlines on Lanai and evidence for island uplift.
14:30-14:50		<u>Bonte, M.</u> , <u>Kaloumaira, A.</u> & Mearns, A.	Exploring opportunities for greater contribution to CHARM.
14:50-15:20	<b>Refreshment break</b>		
15:20-15:40	Hazards	<u>Ramsay, D.</u> & Bell, R.	Planning for coastal hazards and climate change – examples from New Zealand and Kosrae.
15:40-16:00		<u>Matthews, A.</u>	Seasonal climate forecasts and their relevance to water resource managers.
16:00-16:20		Martin, F. & <u>Allinson, L.</u>	Reducing vulnerabilities via a web map server.
16:20-16:40	IT & remote Sensing	Leney, A., Koneteti, U. & <u>Forstreiter, W.</u>	The rubbish GIS.
16:40-17:00		Tuivanuavou, S. & <u>Forstreiter, W.</u>	NLTB - GIS Pilot Project.
Evening	Meetings of Working Groups		

<b>Monday September 22<sup>nd</sup></b>			
09:00-09:20	IT & remote Sensing	Lomani, E. & <u>Forstreiter, W.</u>	Settlement in Nasinu Town, Suva.
09:20-09:40	Habitats, Oceans & Coastal	<u>O'Connell, V.</u> , Brylinsky, C. & Greene, H.G.	Identification of yelloweye rockfish habitats: geophysical survey data in comparison with fishery logbook data.
09:40-10:00		<u>Garton, D.</u> , Montoya, J., Payne, C., Collen, J.D., Smith, R., Bertram, I. & Epati, N.	Analysis of a lagoon-based food web using stable isotopes of carbon and nitrogen.
10:00-10:20		<u>Kaluwin, C.</u>	Challenge of measuring absolute sea level changes in the Pacific.
10:20-10:50	<b>Refreshment break</b>		
10:50-11:10	Habitats, Oceans & Coastal	<u>Kennedy, D.</u> , Woodroffe, C. & Jones, B.	The southernmost atolls: sediment characteristics of Elizabeth & Middleton reefs, southwest Pacific.
11:10-11:30		<u>Collen, J.D.</u> , McCulloch, M. & Eagar, S.H.	Chronology of the Funafuti core by uranium-series dating.
11:30-11:50		<u>Smith, R.</u>	Setting the scene for sustainable development in aggregate resources, Majuro Atoll, Republic of the Marshall Islands.
11:50-12:30	STAR Working Groups		
12:30-13:30	<b>Lunch break</b>		
13:30-13:50	<b>Science &amp; Policy</b>	<u>Ramsay, D.</u> & Green, M.	The practicalities of developing sustainable sources of aggregates.
13:50-14:10		<u>Buleka, J.</u>	Where is PNG heading beyond 2003?
14:10-14:30		<u>Carpenter, C.</u>	Putting the Science back into Policy: The Pacific Regional Action Plan on Sustainable Water Management.
14:30-14:50		<u>Erb, W.</u>	Pacific Islands GOOS.
14:50-15:10		<u>Pratt, C</u>	Pacific Islands Regional Ocean Policy implementation.
15:10-15:40		<b>Refreshment break</b>	
15:40-16:00	<b>Science &amp; Policy</b>	<u>Collen, J.D.</u>	Coastal sediments of the tropical Pacific: what we know and what we need to know for their management through the 21 <sup>st</sup> Century.
16:00-16:20		<u>Howorth, R.</u>	The past, present and future status of geoscience-related work supporting development in the Pacific islands.
16:20-17:20	Special Lecture	Professor Chuck Helsley	Resources in the 21 <sup>st</sup> Century and their potential impact on island economies.
17:20 -	Discussion and Closing Session		
Evening	Meetings of Working Groups		

<b>Posters</b>	
Anton, L.	Earthquake hazard for Lae City, Papua New Guinea.
Bower, R.	Pacific Type II Partnership Initiative on sustainable water management.
Clayton, T., Wright, C.W., Brock, J. & Nayegandhi, A.	High-resolution, small-footprint, waveform-resolving Lidar: EAARL Research in South Florida.
Chandra, Y.	Regional Workshop "Gender, Energy and Sustainable Development" 4-8 August, 2003, Nadi, Fiji Islands.
Chandra, Y.	Outcomes of Regional Earth Day 2003 – "Energy for Life".
Greene, H.G., O'Connell, V., Erdey, M., Bizzarro, J., Brylinsky, C. & Lockhart, D.	Marine benthic habitat characterization of a commercial fisheries area, Fairweather Ground, Alaska: a possible technique beneficial to SOPAC.
Heydon, D.	The Nautilus Pacific Copper Project – steps towards commercial mining at 2,000 m.
Hill, M. & Edsall, D.	Self-contained apparatus for harvesting water from humid atmosphere.
Kaluwin, C. & Lal, A.	South Pacific Sea Level & Climate Monitoring Project Phase III.
Khan, I., Gani T., Enet, F., Hopfe, H., Smith, R., Young, S. & Mario, R.	Wave energy potential in the Pacific region.
Lafoy, Y., Maurizot, P. & Genna, A.	Nickel mining and environmental concerns in New Caledonia.
Lawedrau, A. & Carpenter, C.	The Global International Waters Assessment (GIWA) in the Pacific Islands.
Lawedrau, A., Carpenter, C., Mosley, L. & Scott, D.	Rainwater Harvesting Pilot Project implementation in Tonga.
McMurtry, G. M., Tappin, D.R., Fryer G.J. & Watts, P.	Megatsunami generation from giant submarine landslides on oceanic islands: new insights gained from the Hawaii evidence and modelling.
Maurizot, P. & Lafoy, Y.	Specificity of geological hazards in New Caledonia.
Mosley, L.M. & Aalbersberg, G.L.	Algae, algae everywhere and not a fish to eat: effects of sewage discharges and overfishing on the coral reefs of Fiji.
Mosusu, N.	Geophysics in groundwater exploration on small coral atolls in Papua New Guinea.
Nunn, P.	Geology of Niue.
O'Connell, V., Wakefield, W., Greene, G. & Brylinsky, C.	Using in-situ technology to identify and characterize essential fish habitat for classification of a marine reserve in the Eastern Gulf of Alaska.
Roelfsema, C.	Low cost assessment of ecosystem health indicators in the South Pacific region by combining remote sensing and (community) field monitoring methodologies.
Woods, J., Hemstock, S., Rosillo-Calle & Matakiviti, A.	Regional Biomass Resource Assessment Project.

## Earthquake hazard for Lae city, Papua New Guinea

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Situated on the earthquake-prone northern coast of Papua New Guinea (PNG), Lae is PNG's second largest city and a major manufacturing and industrial centre. Lae is the main gateway to the PNG Highlands, the major shipping port and hub of air services and telecommunications for PNG. A large damaging earthquake in Lae would be disastrous not only for Lae but also for PNG generally. The seismotectonic environment of the Lae region is most conducive to large damaging earthquakes. Although no magnitude 7 earthquakes have occurred within 50km of Lae since 1900, several magnitude 7 earthquakes have occurred around Lae on seismic zones, which pass through Lae. Lae is situated close to the triple-junction of three tectonic lithospheric plates, the India-Australia Plate, Solomon Plate and South Bismarck Plate.

Earthquake activity is from three main seismic zones that are associated with these tectonic plates. The seismic zones converge in the Lae region. The first is caused by collision of Solomon and India-Australia Plates along the Papuan Peninsula, southeast from Lae; the second is from the subduction of the Solomon Plate beneath the New Britain front of the South Bismarck Plate, to the northeast of Lae; the third zone is the northwest extension (northern coast of PNG mainland) of the northeast seismic zone, starting at about Lae. However, the interaction is between the South Bismarck and India-Australia Plates, along the line of the Ramu-Markham Valleys northwest of Lae. A fourth zone of earthquake activity results from the westward or northwestward continuing subduction of the Solomon Plate beneath the Lae region, beneath the shallow thrusting South Bismarck and India-Australia Plates (Fig. 1).

Since 1900, no magnitude 7 earthquakes have occurred within 50km of Lae. This could infer either (a) that no large earthquakes are expected to occur near Lae, or (b) that as Lae is on the earthquake zone of the northern coast PNG mainland and New Britain and as large earthquakes have occurred both east and west of Lae, then Lae is a "seismic gap" and is more likely to experience a large earthquake (Ripper and Anton, 1995). The Lae region has no record of major damage at intensity 8, but on many occasions, minor cracking has occurred, intensities 6 and 7, and people in the city have been badly scared by the shaking, intensities 5 and 6, and difficult or unable to stand, intensity 7.

Utilising the method of Epstein and Lomnitz (1966) and Lomnitz (1974), the hazard determined for Lae was found to be significant. Concentric 50km zones to a distance of 150km from Lae were combined in a seismic hazard analysis of Lae (Fig. 2). Beyond 150km, the maximum acceleration at Lae produced by the earthquake of maximum credible magnitude of 7.8 is less than 0.1g. The most appropriate method of predicting maximum ground accelerations in Lae (Ripper, 1992) is the attenuation relationship of Esteve and Villaverde (1973). Using this, for the maximum credible earthquake of magnitude 7.8, the maximum ground acceleration in the 0-50km zone is 0.52g. However, a large earthquake occurring closer than the average distance 35km (within 0-50km zone) to Lae may well produce much greater accelerations. The concentric zones were combined to give final earthquake maximum ground acceleration probabilities at Lae. Cumulative ground acceleration return periods were determined. Hazard parameters for the inner 0-50km zone were compared with the cumulative probabilities, and it was shown that the major contribution to the hazard comes from the inner 50km.

Despite the absence of magnitude 7 earthquakes within 50km, the analysis of the 0-50km zone gives a return period of 51 years for magnitude 7.0, with a corresponding Lae ground acceleration of 0.27g. Lae earthquake ground acceleration return periods for 0.1g (about intensity 7), 0.2g (about intensity 8), 0.3g, 0.4g and 0.5g (about intensity 9) are approximately 3.3, 20, 64, 132 and 232 years respectively. In a 20-year project period, the probabilities that earthquake ground accelerations of 0.1g, 0.2g, 0.3g, 0.4g and 0.5g will occur in Lae are 99%, 63%, 27%, 14% and 8%.

Earthquake hazard of the PNG city of Lae is significant. It was noted that the closest earthquakes contribute most to the hazard. Maximum acceleration 0.1g or greater can occur in Lae from earthquakes only within 150 km. The influence of earthquakes beyond 50km is minor, reducing the return period of acceleration 0.1g from 4 years in the 50km zone to 3.3 years for all earthquakes. The return period of 0.2g is reduced from 23 to 20 years. Return periods of 0.3g, 0.4g and 0.5g remain unchanged at 64, 132 and 232 years respectively. The deviation between the inner 0-50km and cumulative probability curves is greatest in the range 0.1g-0.2g.

**References:**

- Epstein, B., and Lomnitz, C., 1966. A model for the occurrence of large earthquakes. *Nature 211*: 954-956.
- Esteve, L., and Villaverde, R., 1973. Seismic risk, design spectra and structural reliability. Proceedings of the Fifth World Conference Earthquake Engineering, Ministry of Public Works, Rome, 2586-2597.
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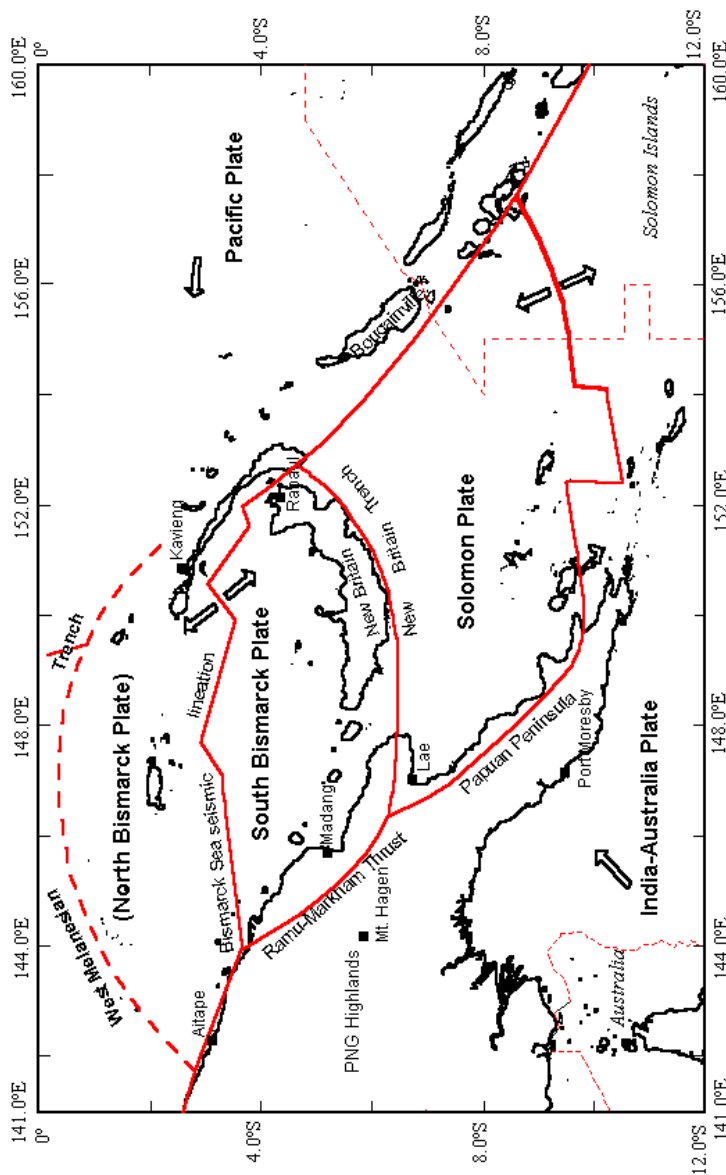


Figure 1. Lithospheric plate boundaries of the PNG region.

**Figure 1: Lae in relation to the plate boundaries of the PNG region.**



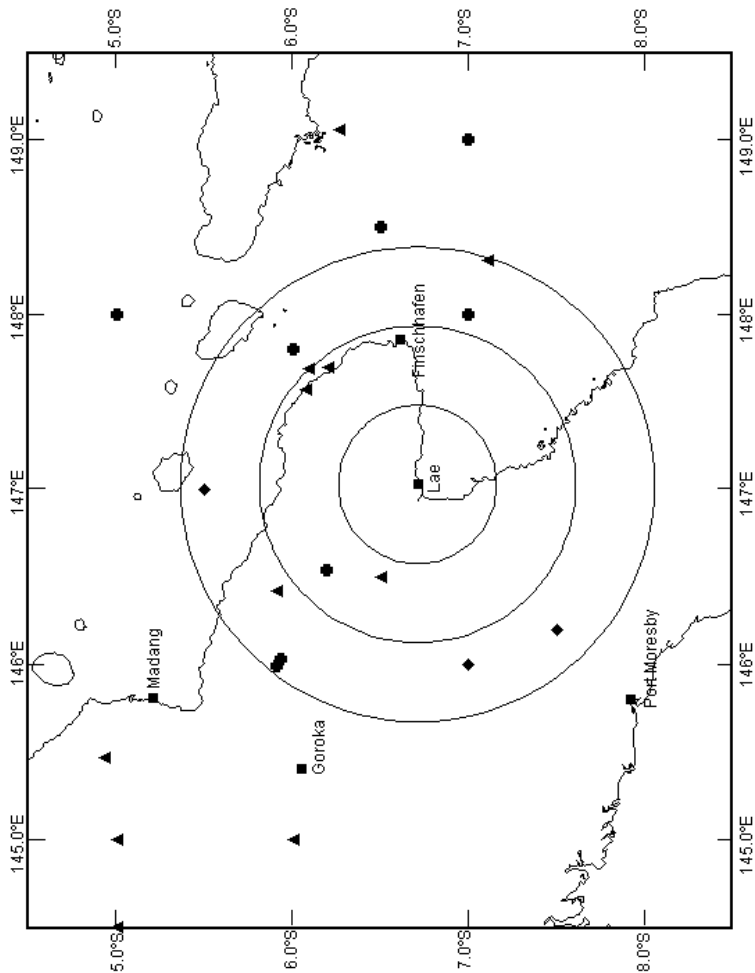


Figure 2. Magnitude 7 earthquakes in the Lae region, 1900-1993. Solid circles denote 0-39km depth, triangles 40-149km, and diamonds 150km or deeper. Concentric circles indicate 50km wide zones centred on Lae.

**Figure 2: Magnitude 7 earthquakes in the Lae region since 1900. In the Lae region, 5-8°S and 145-149°E, 21 magnitude 7 earthquakes have occurred.**

## Exploring opportunities for greater contribution to CHARM

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The Pacific island region is extremely vulnerable to many natural hazards as well as an increasing number of technological, biological, man-made (including social, economic, legislative) and environmental hazards. It is acknowledged too that development itself is a major driver influencing the increasing exposure to risk of a large population of our region. The range of significant disasters over the last decade clearly shows the emergence of new hazards and risk exposures as well as the limitations of our inherited resilience (eg floods in Fiji, Samoa, Solomon Islands; volcanoes in PNG - Rabaul, Manam and Mt Pago; tsunamis in PNG and Vanuatu; landslides in PNG, FSM and Fiji; ethnic tensions in PNG, Solomon Islands, Fiji; aircraft crashes in Fiji, Samoa; HIV, white fly infestation and money laundering). Their "impacts on our Small Island economies and societies have been more aggressive and the effects longer lasting and yet the mitigative initiatives that are available to reduce risks to such events are seldom integrated within national development strategies and are usually contained within the efforts of single departments"<sup>1</sup>. The Forum leaders first expressed similar concerns at the 1995 Madang Forum leaders' meeting in the regional vision statement "Vulnerability to the effects of natural hazards, environmental damage and other threats will be overcome".

On direction from the Forum, the regional disaster management fraternity tasked SOPAC to develop a risk management capacity within the region. The cross-cutting, multi-disciplinary and multi-functional nature of disaster risk reduction necessitates developing a risk management framework linked to national development planning. This means government and civil society stakeholders are guided to interact most effectively, which is of particular importance to our poor island states with their limited resources. Despite the fact that many activities exist which promote disaster risk reduction in the Pacific, the cost of disasters at regional, national, island and village level is still very prohibitive, signaling the existence of a major gap in our mitigation efforts and approach. A smarter approach must be found. SOPAC, with the assistance of the regional disaster managers, the Queensland Department of Emergency Services and a small group of professionals from Australia and New Zealand developed a Regional Comprehensive Hazard and Risk Management (CHARM) guideline modeled on the Australia/New Zealand Risk Management Standard AS/NZS 4360:1999.

The Guideline is a risk management tool essentially to minimize risks and enhance socio-economic benefits and sustainable development. It is linked to existing decision-making processes, particularly for socio-economic development, from community level into the national development processes. The process of risk identification and analysis at the national level brings in the geographical context, analysis of which contributes to the auditing of development opportunities. SOPAC has adopted a strategy to drive CHARM implementation centrally through governments, getting entire government commitment to a comprehensive national approach to risk management. CHARM has been designed to capture the fundamental elements of comprehensive risk reduction in a series of steps that systematically imbues a culture of building an audit trail of decision-making steps from risk identification, analysis and evaluation to risk reduction strategies enticing wide stakeholder consultation, communication and monitoring. These features of CHARM are fundamental to the development of other frameworks that will address international concerns on poverty and sustainable development.

Notwithstanding the above, CHARM is a risk management tool useable and relevant at all levels. It is flexible and has been designed to accommodate country-specific requirements for adaptation as national guidelines. It fully recognizes that it is at the community level where the island states are most exposed, largely because of the drive from emerging vulnerability forces that overshadow the inherited resilience built up through many levels of family generations. One of these drivers is the emergence of a cash-driven economy that has prompted movement of people from the outer islands into urban areas as well as the opposite redirection of development into rural areas. In the risk management context, both approaches involve development of new risk exposures with the result of making today's society "risk strangers" within their own resource systems. CHARM contributes to empowering people in risk management, enabling grassroots decisions to be systematically integrated into mainstream development planning processes.

To implement CHARM successfully needs political, scientific, and technical support. The people will always influence high-level political commitment, which in turn empowers scientific and technical researches and

<sup>1</sup> Kiribati CHARM Country Support Programme; SOPAC –DMU Report 2001

support. SOPAC has embarked on an advocacy strategy to build momentum for developing national risk management policy and implementation strategies. This presentation challenges the scientific community to identify where it can support the current paradigm shift of Pacific island countries from a narrow disaster response approach to a broader proactive risk management approach. CHARM encourages development of national risk reduction priorities, so a corresponding alignment of research priorities from the scientific community would integrate well. Further, development of monitoring programs and activities is essential in risk management. Can people themselves be empowered to monitor changing risk context?

Consultation and monitoring require that effective communication systems reach deep into the community. What are the users’ needs for information and how do we determine effective, robust and affordable community communication systems? How else can the scientific community contribute to CHARM? Are the countries ready and can we accelerate capacity building in information technology and communication tools?

The scientific community is a key stakeholder in the application of CHARM and this STAR session offers a golden opportunity to strengthen its partnership and active participation in the development of the regional and national implementation strategies of CHARM.

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**Community participation and gender in the Water and Sanitation component of the SOPAC Community Lifelines Programme**

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Studies have shown over the years the increasing importance of integrating community participation and gender issues as part of sustainable development within communities. This paper discusses the work SOPAC is carrying out within the Water and Sanitation component of the Community Lifelines Programme in addressing community participation and gender issues for which SOPAC is currently carrying out two projects.

Through the support provided to the Water and Sanitation Specialist project funded through the Department for International Development (DFID), a Community Participation and Gender survey is currently being carried out in the region. The overall objective is to collect, analyse and disseminate findings on the extent of community participation, with particular attention to gender and poverty issues, in water and sanitation in Pacific Island countries, in order to offer recommendations and guidelines for improving practice.

The main objective of the Sanitation Park project, which has recently secured funding from NZAID, is to achieve improved health in communities through the introduction and sustainable use of affordable and appropriate excreta disposal technologies. A genuinely grassroots undertaking with full community involvement, the Sanitation Park project will assist communities to identify and solve their sanitation problems by examining and selecting from a range of appropriate and affordable technical options. In addition to this, environmental health officers of local government agencies will be trained on community participation itself. As the Fiji School of Medicine is the regional training agency for Environmental Health officers throughout the South Pacific, the proposed facility will also contribute to the training of the future and existing local government staff in community participation approaches, by inclusion in their curriculum of environmental health.

These two projects are examples of the work SOPAC is carrying out in these sectors in the region.

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**Pacific Type II partnership initiative on sustainable water management**

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Efforts are underway to strengthen partnerships with various organisations within and outside the region to push forward the outcomes from the World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa from 26 August to 5 September 2002.

The Type II Initiatives were one of the key outcomes from the WSSD and calls for the strengthening and

building of Partnerships resulting in more effective future collaboration among stakeholders in the Pacific both at the regional and the national level.

The Type II Initiatives have been prepared in the Pacific by regional agencies and they comprise partnerships that aim to help with coordination and input into project concepts or projects in a given area. The partnerships that have been proposed/established include the following areas: Oceans; Energy; Adaptation to climate change; Capacity Building; Governance; Plant genetic resources; Sustainable Agriculture; Forestry; Information and Communication Technology; Conservation; and Water and Wastewater.

The submission on Water and Wastewater by SOPAC and reviewed by the CROP WSSD Working Group is entitled "Pacific Type II Partnership Initiative on Sustainable Water Management" and incorporates the outcomes of the Pacific Regional Consultation Meeting on Water in Small Island Countries held from the 29th July to 3rd August 2002 in Sigatoka, Fiji, jointly undertaken with ADB. The major outcome from this meeting titled the **Pacific Regional Action Plan on Sustainable Water Management (PRAP)** which details priority actions of the water sector in the region, has been endorsed by 18 countries, 14 of which are at ministerial level. The PRAP is structured around 6 thematic areas namely: Water Resources Management; Island Vulnerability; Awareness; Technology; Institutional Arrangements and Finance. All participants in the regional consultation are deemed active partners in this Initiative, as the regional consultation process itself is the main mechanism for input into the detailed content of the document.

The establishment of Type II partnerships is one of the mechanisms to further enhance partnerships in the water sector and is also in line with the global efforts of both the Secretariats of the World Summit and the World Water Forum to streamline events and look for synergies that help address sustainable development. Results of these partnerships can already be seen through the support provided by NZAID in hydrological training and integration of climate information and the continued support of ADB to utilities in the Pacific region. We look forward to further activities being carried out through this initiative.

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### **Geoscience Australia's Coastal CRC Project: from online estuary database development to swath mapping shallow water habitats**

*Brendan Brooke*

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The Australian Cooperative Research Centre (CRC) for Coastal Zone, Estuary and Waterway Management (Coastal CRC) has recently completed its Phase 1 research projects and is embarking on a range of new projects as part of its Phase 2 work programme (2003-2006). The Coastal CRC comprises a range of partner organisations including state, federal and local government environmental agencies, universities and small and medium business enterprises. Coastal CRC projects employ an adaptive management framework and are both multi-institutional and trans-disciplinary in character.

An adaptive management framework helps to ensure the outcomes of the research undertaken by the Coastal CRC can better inform the management of estuaries and coasts and help in the move towards sustainability of coastal ecosystems and communities. An adaptive management approach is characterised by engaging researchers, managers, stakeholders and the community in the process of sustainable management.

Major Phase 1 outputs for Geoscience Australian (GA) have been the further enhancement of OzEstuaries ([www.OzEstuaries.org](http://www.OzEstuaries.org)), Australia's national estuary online database, both in terms of functionality (e.g. online GIS) and content (e.g. conceptual models of estuaries; environmental indicators fact sheets). Phase 2 of the project at GA will see the continued development of OzEstuaries, including the further mapping and assessment of near-pristine estuaries and a switch from solely desktop studies to participation in field-based research. We will be involved in two major field projects, one focused on measuring the export of contaminants from the Fitzroy River Estuary (central Qld) into the lagoon of the Great Barrier Reef; the other project involves mapping and monitoring coastal benthic habitats at a range of sites around Australia using the Coastal CRC's new Reson 8125 swath mapping system. These projects involve research in two emerging fields of coastal science, namely measuring and modelling contaminant export to coastal waters from catchments and the remote mapping of benthic habitats using acoustic techniques.

## **Where is PNG heading beyond 2003?**

*Joe Buleka*

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Papua New Guinea is sandwiched between the northeast-advancing Australian and the southwesterly-advancing Pacific Plates. A number of small plates have developed as a result of lengthy compressional stresses between these two major plates and together these plates have contributed to the present landform of PNG.

The 1993 Finisterre Earthquake contributed more long-term damage than just killing 109 people, as its effects were complemented by the 1989 Kaiapit Landslide. The debris from the individual landslides have blocked the fast flowing rivers and formed dams. These dams have broken their saddles because of the rapid deposition and have choked the valley floor diverting the river into the valley floor.

Boana Dam was initially formed by the 1993 Finisterre Earthquake and existed for 6 years. The saddle was artificially breached only after the local people reported it and debris from the saddle destroyed two bridges and reshaped the offshore bathymetry of the Busu River. Tsunami from a submarine landslide killed more than 2000 people on the north coast of PNG. Human stupidity wasted valuable Kina and caused the loss of a bridge and more than USD50 million from coffee sales within 5 weeks.

Exploration and exploitation of minerals is at its lowest level and we believe it will rebound following recent international exposures and further incentives to developers. There is hydrothermal gold being produced from depths of more than 2.0 km beneath the sea. PNG is recognised as an archipelagical state and what is within the boundary is regarded as within her territory. The terrestrial laws do not cover the seabed nor the sea-column and this may affect both disseminated gold formed in the seabed as the result of prolonged weathering of the hydrothermal vents and migrating tuna in the sea column.

Onshore there is much talk of corporatisation and transparency and the saving of limited resources for the benefit of the majority of our people. The Mining Department is in the process of becoming an Authority but at this point a number of semi-private organisations in PNG are not profitable and we are unsure of the future as the international market may dictate the direction and profitability of the Authority.

The PNG Government invests about 7 million per year into the Department of Mining (DoM) and in return receives more than 2 billions as a result of mining activities (about 52 % of the national revenue). Accountants think this is a good investment and are willing to uphold and run with the scheme for a long time to come. This thinking is not assisting the mining industry and we hope to increase our working capital under the Authority and increase the revenue to our country.

The Geological Survey is currently remapping the Wau 1:250000 Geological Sheet with assistance from the World Bank institutional strengthening Project Loan. Remote sensing components of the loan will advance this mapping by extrapolation and groundtruthing. Defect analysis from Wau field mapping shows that mineralization resulted from intrusion of the Morobe Plutons. More recently, defect analysis was carried out for the Tolokuma mine in the above map sheet. We believe the defects control the sites of mineralisation, and mining techniques ought to target the defect systems in order to increase the recovery. The capital for the mine is controlled by the shareholders and very limited exploration is being carried out. The Geological Survey has initiated a database-sharing protocol with the Petroleum Division of the Petroleum and Energy Department. This follows the recent database development by the World Bank under the Institutional Strengthening Project and the need to integrate and upgrade the old 1990 Geological Survey database into a coherent information system with the development of an indexing system.

A number of large projects such as Sysmin (aeromagnetic survey) and the Trans Island Highway are in the pipeline and we are excited as this may bring in the exploration dollars we are currently lacking. This project may also tie in the isolated small mines such as Tolokuma and provide the infrastructure we require to sustain exploration into the future. SOPAC has helped PNG in the past and the EU EDF8-SOPAC Project and the selection of the Project site is seen as very important, as it incorporates other stakeholders' interests.

**Putting the Science back into Policy: The Pacific Regional Action Plan on Sustainable Water Management**

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The Pacific Regional Action Plan on Sustainable Water Management was one of the major outcomes of a year long consultation facilitated by SOPAC amongst its Member Countries, in preparation for the 3<sup>rd</sup> World Water Forum in 2003.

The Pacific Regional Action Plan on Sustainable Water Management (PRAP) uses a holistic framework to water management based upon six thematic areas, which together address the 18-20 priority issues and needs of small island developing states in the water sector. The thematic areas are: i) Water Resources Management; ii) Island Vulnerability; iii) Awareness; iv) Technologies; v) Institutional Arrangements and vi) Financing. The PRAP is both a regional policy level blueprint and a regional strategy articulating the agreed actions of 18 countries, (14 with ministerial level endorsement), necessary to achieve sustainable water management.

Integral to this regional action plan is the use of science to provide national, regional and community level stakeholders with the knowledge and information required to make informed and enhanced decisions. In a region where background data sets are often absent due to unavailable human and financial resources, the Pacific RAP identifies the need to address critical data gaps whilst building national and regional technical and scientific capacity to collect, store and use these data sets.

Application of science to national, regional and community water policy and strategy can be found in almost all of the six thematic areas, but particular attention is given to the need to link water and climate-related disciplines including meteorology, climatology, hydrology and hydrogeology to water resources management, especially during the climatic extremes of cyclone-related flooding and El Niño-related drought, and associated disaster preparedness. This is highlighted in the agreed priority action of the Pacific HYCOS proposal (Hydrological Cycle Observation System).

Other examples of the integration of science into the Pacific RAP include satellite imagery, remote sensing and GIS for water resources development and protection; vulnerability and hazard assessments for disaster preparedness of water & wastewater utilities assets; social sciences in community participation and engagement in rural water & sanitation; hydraulic modelling for water distribution system management and leakage reduction programmes; hydrochemistry and microbiology for water quality programmes and to advocate the link between good water and wastewater management and improved public health and environmental protection.

The Pacific RAP illustrates to politicians and other decision makers the need to understand the importance of science in enabling informed decisions to be made and therefore to recognise that such science has both a real and tangible value as well as a considerable cost to undertake. It also challenges scientists not to indulge in self-interest but rather concentrate their energies on applying their expertise to such science as has actual benefits to the peoples of the Pacific Islands.

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**Outcomes of Regional Earth Day 2003 – “Energy For Life”**

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The activity proposed for this years Regional Earth Day 2003 was a “Poster and Essay Competition for Schools” throughout the region with the theme of “Energy for Life”. The focus for the poster and essay competition was “Energy Efficient Homes”.

The objective for this competition was to build awareness on energy efficiency and conservation at home among school students in the Pacific region by providing the opportunity for students to express their views in

art and essays on the topic of "Energy Efficient Homes".

Entries for the competition were received from 5 countries – Fiji, Kiribati, Samoa, Tuvalu and Vanuatu. A total of 253 entries were received. Top five national winners from each of the countries were selected for the regional award in each of the age categories.

The poster presents the regional winning entries and reflects the concerns of Pacific island children expressed in drawings and essays.

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**Regional Workshop "Gender, Energy and Sustainable Development" 4-8 August, 2003, Nadi, Fiji Islands**

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The regional workshop "Gender, Energy and Sustainable Development" was a follow-up to an earlier ESCAP workshop, held in Perth, Western Australia during June/July 2001, where men and women from around the world met to explore the issues relating to women and energy.

Interest in gender can be traced back to the Pacific Platform for Action – for the Advancement of Women, adopted in 1994 by all SOPAC member countries as part of the Noumea Declaration, and formally recognises the importance of women's participation in national and regional development activities.<sup>1</sup>

In the global context these activities are consistent with Principle 20 of the Rio Declaration and Chapter 24 of UN Resolution, Agenda 21, which stressed the vital role women play in the management of the environment and natural resources and called for the full participation of women in sustainable development programmes. In addition, the recent outcomes of the WSSD process reinforce the importance of the role of women and gender mainstreaming as a mechanism for poverty eradication.

The UN Millennium Declaration and the Millennium Development Goals define the overarching aspirations of contemporary sustainable development thinking, and make unequivocal reference to the need for a gender perspective in all development activities as a key element in promoting sustainability of the environment, societies and economies. Millennium Development Goal 3 targets specifically the promotion of gender equality and the empowerment of women.

In the regional context the Regional Energy Meeting 2002 held in Rarotonga recommended SOPAC take the lead role in coordinating gender initiatives in the energy sector and a first initiative was the regional workshop "Gender, Energy and Sustainable Development".

The poster presents the outcomes of the regional workshop and reflects concerns and issues raised by member countries. Of particular note was the recommendation to form a Pacific Energy and Gender Network.

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**High-resolution, small-footprint, waveform-resolving Lidar: EAARL research in South Florida**

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The NASA Experimental Advanced Airborne Research Lidar (EAARL) is a new airborne sensor designed for light aircraft, cross-environment (subaerial and subaqueous) surveys of elevation and vertically resolved backscatter intensity. To date, approximately 160 GB of laser soundings data and 200,000 accompanying digital aerial photographs have been collected over the Florida reef tract; additional data have recently been collected in the

<sup>1</sup> The Pacific Platform for Action was the Pacific contribution to the Global Platform for Action that was endorsed in Beijing in 1995.

Lake Okeechobee and Fort Meyers areas. These experimental data are the focus of ongoing research into sensor characterization and validation, and development and evaluation of new methods of vegetation, benthic, and water-column characterization. This research lays the groundwork for the future merger of the EAARL lidar sensor with a hyperspectral imaging system.

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### **Chronology of the Funafuti core by uranium-series dating**

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In 1838, Charles Darwin proposed that atolls formed when coral reefs grew upwards in the shallow waters above subsiding volcanoes and later (1881) begged that an atoll be bored to check this. In response, expeditions under the auspices of the Royal Society drilled several holes on Fongafale Island and in the lagoon, Funafuti Atoll, Tuvalu between 1896 and 1898. The deepest reached 340 m and recovered core entirely of limestone, without reaching basalt. Despite the suggestion that some of the core may have been reef front talus deposits and thus from deep water, some coral was thought to be in growth position and thus to support Darwin's ideas. However, isotopic dating of rocks had not been developed in 1898 and there were no means of determining the age of the limestones in the core.

Recent uranium-series dating of the uppermost 50 m of the core shows three limestone sequences separated by unconformities. From 5 m to 30 m the limestone increases regularly in age from 3.2 to 8.5 ka, representing Marine Isotope Stage 1. A narrow interval at around 30-33 m is dated at 130 ka to 140 ka, representing latest MIS 6 or possibly earliest MIS 5. Strata between about 33 m and 50 m have ages from 237 ka to 290 ka, representing the early part of MIS 8. The core between 50 m and terminal depth at 340 m cannot be dated at present because of increasing amounts of calcite leading eventually to almost complete dolomitisation below about 270 m. However, given the ages in the uppermost 50 m, the lower section of the core is likely to be Pliocene or older.

Strata from MIS 1 represent the current cycle of reef growth above the last glacial unconformity. Clasts from exposed beach rock on Fongafale Island give radiocarbon ages ranging between 1160 and 1990 years BP and the net coral growth indicated by the top 30 m of the core is thus about 3.2 mm per year. Strata from MIS 6 indicate the earliest coral growth on the penultimate glacial unconformity, with younger coral from this cycle removed by erosion during the last glacial lowering of sea level. The strata from MIS 8 are more problematical, as they were deposited during falling or static sea level and also suggest much slower coral accretion rates than later strata.

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### **Coastal sediments of the tropical Pacific: what we know and what we need to know for their management through the 21<sup>st</sup> Century.**

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Coastal sediments are an important resource for habitation, tourism and construction in all tropical Pacific nations. As sediments are immediately affected by environmental change and human activities, understanding their dynamics and budgets is vital to predicting the responses of the systems to changes and to managing the coastal and nearshore environment.

Our knowledge of many processes varies; some are well understood but others need much study. The starting point is sediment composition, with relative proportions of the important components known from some areas; determining these is not always straightforward and may require sedimentological and geochemical techniques. Most sediments are biogenic carbonates so knowledge of the biology of a range of organisms, and especially rate of carbonate precipitation, is crucial. Growth rates and carbonate production are well known for some



groups for some areas (e.g. coral average  $1200 \text{ g/m}^2/\text{y}^{-1}$ ) but less so for others (*Halimeda*  $13\text{-}2000 \text{ g/m}^2/\text{y}^{-1}$ , foraminifera  $40\text{-}5000 \text{ g/m}^2/\text{y}^{-1}$ ). Most studies are of productivity of species per unit area (often areas favourable for growth or amenable to study) but total productivity across the entire system is more important. Species distribution is also important, and total productivity probably varies regionally.

Mechanical and bio-erosion processes and rates determine how much of the carbonate produced reaches the nearshore system. There are few reliable studies of this and the relative importance of normal and catastrophic events needs to be assessed. Depositional processes, including transport directions and mechanisms, beach abrasion and burial diagenesis, also need further study. It is important to determine the "normal" residence time of each type of clast in each part of the system. For example, if the residence time of a foraminiferan test on a beach is 50 years and if these contribute 60 % of the sediment (as is common), then loss of the living foraminifera will cause loss of 12 % of the beach per decade through attrition alone, without climatic change.

Parameters vary significantly across the Pacific region and understanding the sediment budget at one location will not meet all needs. Until the "normal" processes are understood, reactions of the systems to global climate and other change cannot be quantified.

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### **The Ups and Downs of Hawaiian Islands: an Update**

*Keith A. W. Crook & E. Anne Felton*

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Last year (Crook & Felton, 2002) we proposed a scenario to explain vertical movements - submergence and emergence - of the island of Lanai in the Main Hawaiian Islands. This scenario is generally applicable to active hotspot volcanic island chains such as the Samoan and Austral Island chains. It may also apply, scaled down by one or more orders of magnitude, to old island chains on the Pacific plate.

Since last year, two studies have been published that imply a scenario more complex than the one we described. Zhong & Watts (2002) have modeled the motions of Lanai, and other Hawaiian islands, using "3-D models of mantle convection to investigate the effects of plume-plate interactions on surface vertical motions and swell topography." The swell topography consists of the ridge on which the chain of islands is perched and the linear moats on each side of the chain. They show that flexural loading of the lithosphere by the island of Hawai'i is insufficient to explain the uplift of Lanai. They propose that the mantle plume beneath Hawai'i Island being sheared by the moving Pacific plate, so that uplift at Lanai is partly due to the heat added to the lithosphere by the mantle plume. However the Lanai uplift rate of  $\sim 0.15\text{m/ka}$  used in their modeling is far too small to explain the observed elevations of rocky shoreline-related facies on Lanai (Felton et al. 2000; Felton et al. 2003).

In a poster paper presented at the AGU Fall Meeting, McMurtry et al. (2002) have reported "megatsunami deposits" from the west flank of Kohala volcano on Hawai'i island, at elevations up to +80m a.s.l. The sedimentary lithofacies and petrofacies in these deposits appear to be the same as those reported from Lanai by Felton et al. (2000, 2003). This implies an alternative, non-catastrophic origin in which these deposits are the result of normal tropical rocky shoreline sedimentary processes. Furthermore, Felton and Crook (2003) have discussed various inadequacies in the evidence adduced elsewhere for tsunami transport and deposition of coarse-grained sediments.

These rocky shoreline related deposits on Kohala's western flank also carry a tectonic implication. Underwater photography from HURL's *Pisces V* submersible demonstrates conclusively that the submerged topographic bench at -950m off North Kohala, dated at 0.26 Ma by Jones (1995), is a drowned coral reef, virtually unmodified by later erosional or depositional processes. The Kohala volcano has subsided after completion of its shield-building phase, due to thermal relaxation. A subsidence rate of  $3.65\text{m/ka}$  is implied.

However, uniform subsidence is inconsistent with the presence of subaerial rocky shoreline sedimentary deposits on the western flank of the Kohala volcano, which imply uplift of up to 80m. Presumably, this uplift is a flexural response to the loading of the lithosphere by the growth of volcanic edifices further south on Hawai'i island. These deposits have not yet been dated, but as they are only 40 km SE of the drowned 0.26 Ma coral reef, they may be Holocene in age.

Evidently, the physical basis for geophysical modeling of vertical motions along hotspot island chains is more complicated and the effects are more localised than has previously been recognised.

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## Pacific Island GOOS update

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Pacific Island GOOS is coordinated by the SOPAC Secretariat and it receives advice from the IOC Perth Regional Programme Office. Over the past few years it has organized and participated in a number of workshops and meetings associated with development of ocean and coastal observing systems. The process has raised the profile of the Pacific islands worldwide and has resulted in various benefits to the people of the Pacific islands. One such project is SEREAD, which is intended to connect primary and secondary school teaching materials to operational observing systems such as the Argo profiling float project. Bill Erb, Head of the Perth Office will present a summary of the PI-GOOS work activities and identify some new initiatives.

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## Plans for a multi-leg Ridge 2000 Expedition to the East Lau Spreading Center in 2004

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Last year during the STAR sessions I presented a paper about Ridge 2000 (R2K), the new US National Science Foundation sponsored research initiative, and our hopes to develop a component of the program devoted to studies on the East Lau Spreading Center. The general goal of the Ridge 2000 Program is to understand Earth's spreading ridge system as an integrated whole, from its inception in the mantle to its manifestations in the biosphere and the water column. The scientific motivation for the R2K Program is encapsulated in the phrase "from mantle to microbes," which expresses the inextricable linkages between processes of planetary renewal below the deep ocean and the origin, evolution and sustenance of life in the absence of sunlight. Specific geographic areas will be the focus of detailed studies designed to yield new insights into the linkages among the biological, chemical, and geological processes that are involved in crustal accretion and subsequent ridge crest processes. One component of the R2K program, the Integrated Studies component, consists of multidisciplinary research that is focused on a small number of pre-selected "type" areas that are representative of important types of oceanic spreading centers. The East Lau spreading center was chosen by the scientific community of the US Ridge 2000 program as the most desirable site for integrated studies designed to increase our understanding of Back-Arc Basin Spreading Centers.

I am pleased to report that since this time last year, a multidisciplinary group of US scientists has successfully obtained a commitment of support from the US National Science Foundation for a series of research expeditions to the Lau Basin. It is our hope to schedule a total of five research expeditions to this area in 2004. These expeditions will begin with two cruises that will be mapping the deep sea floor, sampling the water column and dredging rocks from the deep sea to better characterize the spreading center and locate active hydrothermal systems on the sea floor. During these cruises another research group will be deploying oceanographic monitoring instruments to characterize the currents in the area of the active ridge system. Three more cruises will follow that will use deep-sea remotely operated vehicles (ROVs) for detailed imaging and sampling of hydrothermal systems identified during the first two cruises. These cruises will identify the central hydrothermal vent site that will be the focus of additional future integrated and interdisciplinary studies. The cruises will also provide detailed maps and inventories of the chemistry and biology of the hydrothermal systems.

The Ridge 2000 Program would like to work with SOPAC and the Kingdom of Tonga to plan these research expeditions, associated education and outreach efforts, and to determine the best way to share all findings with the Kingdom of Tonga and SOPAC. The US Ridge 2000 Program has a data policy that dictates open sharing of data. All data collected will be provided to the Kingdom of Tonga along with the software necessary for accessing and visualizing the data. We are planning to include local scientists and educators in the research expeditions and to conduct a significant outreach effort to communicate our findings to the general public and educators (both locally and in the US). We anticipate coordinating additional educational/collaborative research opportunities for a group of scientists from the region. This will include supporting the participation of local scientists in a Theoretical Institute on Back Arc Basins that Ridge 2000 is co-sponsoring with the international InterRidge program. This Institute is scheduled for May 2004, on Jeju Island, Korea.

More information on the plans and dreams for Ridge 2000 research in the Lau Basin is available on our Web site (<http://ridge2000.bio.psu.edu>), including the Lau Basin Implementation Plan, a variety of background information, and Letters of Intent for funded projects and proposals under consideration. To join the R2K mailing list, for timetables, data, upcoming meetings and workshops, contacts and other information about the R2K program, email us at [ridge2000@psu.edu](mailto:ridge2000@psu.edu), see the R2K website at <http://R2K.bio.psu.edu> or call 814-865-7434.

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### **Analysis of a lagoon-based food web using stable isotopes of carbon and nitrogen**

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Perturbation of natural ecosystems is an unavoidable consequence of activities necessary for supporting human populations, and typically more likely in situations where resources can be readily depleted such as coastal habitats associated with small islands. The goal of agencies charged with environmental protection and management is to create an economically sustainable resource whether based on cultivation or natural harvest for commercial interests, and/or protecting existing biotic communities to preserve biodiversity and prevent loss of species. Assessing and evaluating environmental impacts can often be difficult, especially if the effects on the impacted community are (1) subtle or inconspicuous, (2) occur in complex/diverse communities or (3) in locations where long-term data-sets do not exist or are too sparse for meaningful analysis. These three conditions often exist for tropical lagoon systems in the South Pacific.

Stable isotope ratios of carbon (<sup>13</sup>C) and nitrogen (<sup>15</sup>N) have proven useful in studying the flow of energy and mass through food webs, and for quantifying community responses to environmental disturbance. The ratios of stable isotopes of carbon reflect the diet of organisms, and the tissues of predators thus have carbon stable isotope ratios reflecting those of their prey. Metabolic enzymes associated with nitrogen metabolism favor slightly the excretion of the native form (<sup>14</sup>N) over the stable isotope (<sup>15</sup>N). Therefore, as nitrogen turnover increases, the ratio of <sup>15</sup>N:<sup>14</sup>N also increases. Hence, <sup>15</sup>N in the tissues of predators increases approximately 3-4 parts per mil above that of their prey. The stable isotope content of <sup>13</sup>C in tissues therefore quantifies the contribution of various prey species to the diet, whereas <sup>15</sup>N content reflects the trophic position of that species

within the food web.

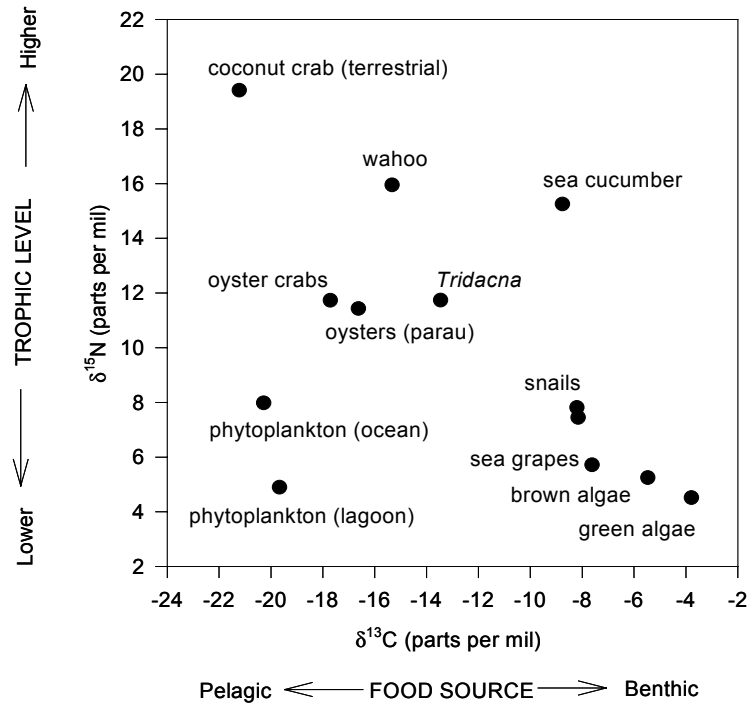
Rope culture of the black pearl oyster (*Pinctada margaritifera*) has become established in Penrhyn Lagoon in the northern Cook Islands, similar to the farms at Manihiki (Cook Islands) but at much lower intensity. As the number of oysters cultivated within Penrhyn Lagoon increases, a natural question is "what impact will this have on the lagoon ecosystem?" Oysters are efficient filter-feeders, removing phytoplankton from the water column, and depositing feces and pseudo-feces on the sediment beneath the ropes. As the number of oysters in culture increases, a greater proportion of primary production in the water column will be diverted directly to the benthos, by-passing the pelagic food chain (e.g. phytoplankton-zooplankton-fish).

Components of the food web in Penrhyn Lagoon were collected during a week-long visit in March, 2003. This included putative members of a pelagic-based food chain: phytoplankton, oysters and fish; and a benthic-based food chain: several species of attached algae, snails, giant clams, and sea cucumbers. Filters and tissues were dried, sealed and shipped to Georgia Tech for analysis. Stable isotopes of carbon and nitrogen were analyzed by continuous-flow isotope ratio mass spectrometry (CF-IRMS) using a Micromass Optima interfaced to a Carlo Erba NC elemental analyzer for combustion and purification of sample carbon and nitrogen. Isotope abundances were expressed relative to PDB and atmospheric N<sub>2</sub>.

Stable isotope ratios of carbon within Penrhyn Lagoon distinguish between pelagic (phytoplankton) and benthic (attached algae) sources of primary production. These preliminary data indicate that pearl oysters derive 78% of their diet from phytoplankton and the balance is likely suspended detritus. Carbon stable isotope ratios for the giant clam, *Tridacna*, are intermediate between phytoplankton and benthic algae, and the nitrogen stable isotope ratio is high and similar to oysters. This indicates that, although these clams have endosymbiotic algae within their tissues, consumption of plankton is an important source of energy. Sea cucumber and snail tissue stable isotope ratios reveal the importance of benthic primary production in the diets of these species.

This study demonstrates the feasibility of using stable isotopes of carbon and nitrogen to describe energy flow in the Penrhyn Lagoon ecosystem, as well as providing a preliminary baseline for detecting any significant changes as the number of farmed pearl oysters increases. For example, if the availability of phytoplankton decreases as a consequence of filter-feeding by oysters, then other species such as *Tridacna* and fish may show a corresponding shift in carbon stable isotope ratios within their tissues towards benthic-derived production (increased flow of energy through oysters to the benthos should stimulate benthic production), as well as a different trophic level. This approach to assessing environmental changes within a lagoon ecosystem does not require continuous monitoring, nor are these types of samples difficult to collect or preserve for analysis.

**Penrhyn Lagoon, April 2003**



**Marine benthic habitat characterization of a commercial fisheries area, Fairweather Ground, Alaska: a possible technique beneficial to SOPAC**

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Recent multibeam bathymetric mapping of the eastern Fairweather Ground of Alaska using proto-snippet processing of backscatter data has provided the Alaska Department of Fish and Game a high-resolution marine benthic habitat map that may refine the way rockfish is managed in SE Alaska. A new technique of overlying habitat polygons on artificial sun-shaded relief bathymetry presents a new and enlightening perspective on how to characterize habitats. In addition, new processing techniques developed in cooperation with Thales Geosolutions (Pacific), Inc. of San Diego have resulted in moving beyond multibeam pseudo-side-scan sonar to improving the textural characteristics of the seafloor and hopefully will resolve unique bottom structures such as columnar basalts and sedimentary bedrock that have been found to be important bottom fish habitats.

We present high-resolution bathymetric, backscatter and habitat maps and other images to illustrate the fine details that now can be imaged remotely. We have found that hard, high relief, rugose, features with boulder aprons attract more bottom fish than less distinct and low relief features. Such features as volcanic cones, eroded volcanic cones and lava fronts generally present desirable habitats for bottom fish and identification of these features remotely can lead to the formation of predictive maps useful in managing and conserving marine benthic biological resources. Although the techniques we present are being applied to marine benthic habitat characterization at high latitudes, the techniques are also applicable at all latitudes and should be beneficial to the characterization of benthic habitats in the SOPAC region.

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**The Atoll Project**

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The Atoll Project (TAP) is designed to assist island nations in infrastructure development that can result with little or no impact to the ecology and physical balance of lagoons. Specific concerns are related to the connection of periphery islands by causeway construction that have the potential of interrupting or restricting lagoonal circulation and curtailing the free flow of water between the lagoon and open ocean. In many cases, once the lagoon circulation is interrupted a multitude of problems occurs. Natural sedimentation processes are altered with erosion in some areas, possibly leading to reduction of terrestrial land, and in other areas accumulation occurs, possibly burying critical benthic habitat and severely altering the ecology. Equally disruptive, turbidity is increased and escapes the lagoon affecting the growth of coral reefs that surround the atoll. Lagoons of atolls are possible incubators for many marine organisms including shallow water species that live in the lagoons as well as deep ocean species. Alteration of lagoonal habitats has the potential of disturbing the natural balance of the ecology and beneficial recruitment of the oceans biological resources. In addition, the precarious balance of salt water/fresh water lenses beneath the atoll islands can be upset from improper excavation and other work needed to install causeways. We present a scheme designed to study and fund research needed to prevent ecological impacts from atoll infrastructure development while allowing the needed development to occur.

## **The Nautilus Pacific Copper Project - steps towards commercial mining at 2,000 m**

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Nautilus Minerals holds Exploration Licences and Applications in PNG, Fiji and Tonga covering over 50,000 km<sup>2</sup> of seafloor. The tenements cover numerous outcrops of copper – zinc rich Seafloor Massive Sulphide (SMS) mineralisation. Nautilus holds the largest exploration tenements and applications for Seafloor Massive Sulphide of any company in the world and has positioned itself as the leader in this field. It should be noted at this point that Nautilus is not interested in the 'active smoker vents' that are the focus of marine scientific research, but the older areas where these vents are now inactive, cold and 'dead' and a mature mineral deposit has formed.

Whilst mining of SMS has been touted for years and many papers written with attendant comic strip pictures of bulldozers on the sea floor, to our knowledge no one to date has published the results of a commercially-focused engineering study of SMS mining. So I am not going to break that tradition and publish here, as obviously much of the data and conclusions constitute commercial IP and provide Nautilus with a unique commercial advantage of what is or isn't economic. However, I will provide an overview of the issues and some of the broader conclusions.

Marine scientific groups from many nations have contributed significantly to the discovery and understanding of these occurrences. They have sampled and drilled for mineralisation on the sea floor gathering valuable scientific data but it has not been their focus to define what ORE is at these depths. "Ore" is defined as material that can be mined at a profit.

To our knowledge, no one had done an economic study of what constitutes 'ore' at depths around 2,000 m below sea level. Accordingly Nautilus undertook the world's first detailed feasibility study of mining massive copper-zinc sulphides from the Pacific at 2,000 mbsl. This was a commercial engineering study rather than those we have seen presented in the past, which are basically scientific studies. Nautilus engaged leading specialist engineering companies to determine full operating and capital costs. This study was an essential precursor to any drilling as it provided the economic parameters on which to explore. There is no point drilling a mound that has an areal extent of 50 m x 50 m if the study shows an economic minimum lens to mine is 100 m x 100 m, and likewise no point drilling an area with surface grab samples of 4% copper if the study shows the minimum economic grade at 2,000m depth is 5% copper.

Nautilus has now answered the questions: What is profitable, 4% copper, 6% copper? Is it profitable to mine 1 million tonnes per annum or do you need to mine 2 million tonnes? What is an economic size of orebody? Do you stop and mine a 0.5 million tonne ore body or is this too small?

A major part of the study was devoted to considering the optimal economic scale of operation and mining rate for each of the breaking and lifting options considered. The mining rate obviously affects the economic balance of capital versus operating costs for each option, and in addition the balance of fixed and variable costs influences the decision of the most economic method and mining rate. Accordingly we considered several mining rates during the study before an optimum level was settled on.

The final study was based on mining 2 million tonnes of ore per annum requiring a mining rate of 400 tph and a treatment plant rate of 270 tph. Indicative capital costs were US\$310 m comprising \$140 m for offshore vessel and mining plant and \$100 m for onshore treatment plant to produce 155,000 t copper in concentrates.

Remote-operated continuous miners would each mine approximately 1 cubic metre per minute, with ore hoisted in 100 t skips at 1.8 m/sec to a mining platform based on a moored semi-submersible that can winch over a 500 m x 500 m area. A deposit of 200 m x 200 m x 16 m thick provides 2 million tonnes of ore.

The study shows that, at metal prices of copper US\$1,595/t and zinc US\$795/t, the project has an internal rate of return of 22% and a C1 cash cost of 39c/lb copper (copper ore) and 23.5c/lb zinc (zinc ore).

Based on the results of this study, Nautilus has since formed an alliance with major international companies to ensure the Pacific Copper Project has the full technical capability to develop these resources (see <http://www.nautilusminerals.com/alliance.html>).

Sun Metals, a subsidiary of Korea Zinc, one of the world's largest zinc smelting companies, has lodged an expression of interest with Nautilus regarding the possible acquisition of metal concentrates from its seafloor massive sulphide deposits. In addition Nautilus and Korea Resources Corporation (KORES) are discussing options for a potential future involvement by KORES in the project.

Nautilus is currently negotiating contracts and funding for a major geophysical and drilling program next year. This would represent the most sophisticated exploration program in the Pacific for massive sulphides and the most extensive drilling program for such resources in the world. This program will generate significant geophysical data and drill core that may be of interest to MSR groups. Nautilus invites participation and collaboration from MSR's who may have an interest in the data and samples generated from this exploration program.

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**Self-contained apparatus for harvesting water from humid atmosphere**

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Atmospheric water harvesters condense water from the air using optimized refrigeration techniques and a combined photovoltaic power source. No additional fuel or power supply is required for base-line operation, especially in areas having very humid, warm airmasses. The water produced is high quality and potable with simple and rapid on the spot treatment. Water harvesters are designed to be used immediately following a natural disaster or other interruption of normal water supplies and also to supplement conventional water supplies in areas where there is a dispersed population.

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**The past, present and future status of geoscience-related work supporting sustainable development in the Pacific islands.**

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The paper takes an historical look at the application of geoscience in the region from the earliest inhabitants of the islands, through to the twentieth century, and reflects on developments over the past thirty or so years since many island countries gained independence.

The real, and very necessary, change in use of geoscience over time from being resource-based driven to supporting sustainable development is determined. The role geoscientists must play in the future at the global, regional and national levels is explored.

The importance of strengthening existing and developing new partnerships and communications strategies to ensure efficient and effective use of geoscience data, information and knowledge at all levels in the sustainable development decision-making hierarchy is discussed.

Finally, the paper concludes that for the future, a major geoscientific advance in improved understanding of Pacific coral reef systems must play a significant part in sustainable development planning and implementation at the national level.



### South Pacific Sea Level & Climate Monitoring Project Phase III

*Chalapan Kaluwin<sup>1</sup> & Andrick Laʻ*

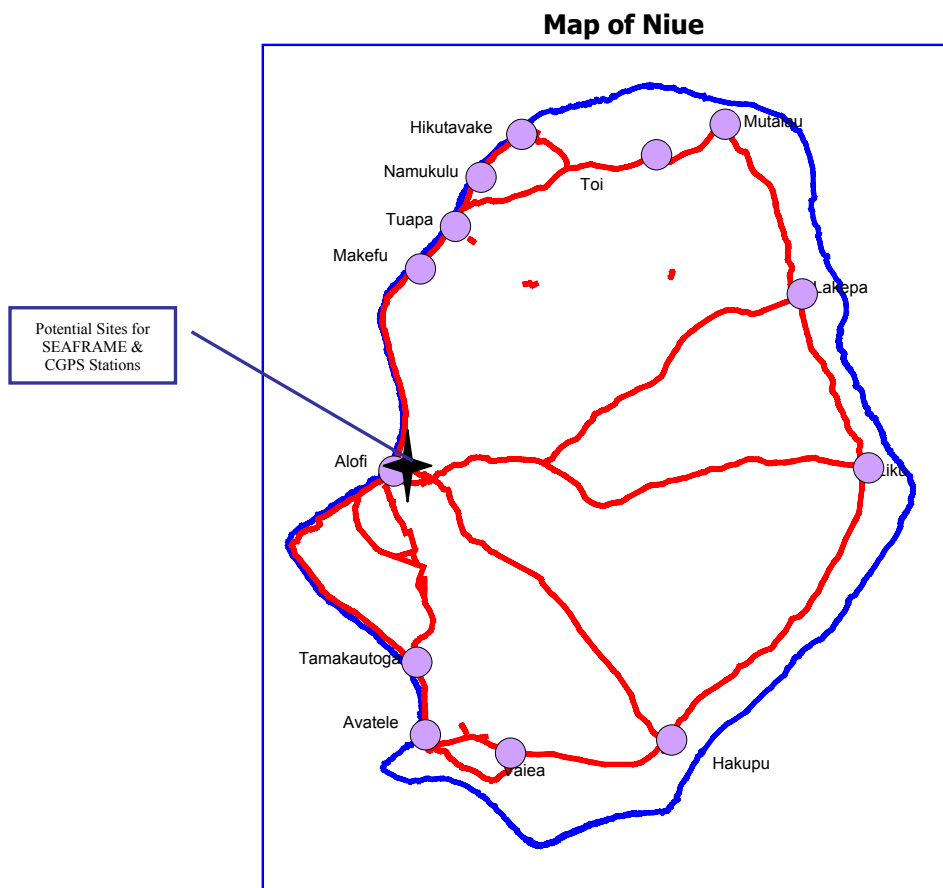
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Climate change and variability and sea-level change have been challenging issues for the Forum countries since the late 1980's. The design and implementation of the AusAID South Pacific Sea Level and Climate Monitoring Project since 1991 was to address the 14 Pacific island countries' concerns over this issue of global warming and greenhouse effect and its impact in the region.

Niue joined the Pacific Islands Forum later, after the design of the project, and approached the management of the Project and the Australian government (bi-lateral) after 1991 to have the fundamental technologies, Sea Level Fine Resolution Acoustic Measuring Equipment (SEAFRAME) and Continuous Global Positioning Systems (CGPS), installed to support the monitoring and research into climate change and sea-level variability and to facilitate policy development to mitigate their impacts on the island.

A feasibility study conducted this year by the management of the project recommended sites in Alofi in Niue that would be suitable for installing the equipment.



This project aims to provide quality meteorological and sea-level data through an array of the latest climate monitoring stations, backed by the precise geodetic survey to produce data, research and results upon which South Pacific Countries can make future development plans. A series of high-resolution sea level recording stations has already been established in twelve countries of the South Pacific Forum with data transmission via satellites.

The data collected by the project are in various forms and they are used by the meteorological departments, lands and survey departments and by research scientists. The Sea Level Fine Resolution Acoustic Measuring Equipment (SEAFRAME) measures water levels, wind, atmospheric pressure, air and sea temperatures in twelve countries. The method of data collection is through Precise Differential Levelling surveys; vertical control stations are established with the survey data also being used by the surveyors for their land and geodetic surveys. The surveyors and navigators are benefiting from the Continuous Global Positioning Systems (CGPS) survey network established by this project. The raw CGPS data is distributed and made available to the participating South Pacific Forum countries and the global scientific community in the international standard Receiver Independent Exchange Format (RINEX).

The project and its data will be presented and discussed along with its benefits to the participating countries, with opportunities to:

- Upgrade their geodetic survey network;
- Unify height datums, nationally and regionally;
- Determine transformation parameters;
- Undertake cadastral and engineering Surveys;
- Produce Digital Elevation Models (using kinematic GPS and geoids);
- Undertake coastal zone management; and
- Examine mitigation procedures.

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### **Challenges of measuring absolute sea level changes in the Pacific**

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The South Pacific Sea Level and Climate Monitoring Project has been in operation since 1991 and continues to the end of 2005. Funded by the Australian Government, it is designed to address the Pacific islands governments' concerns on global warming (greenhouse effect) in the region. It is the first group of countries in the world monitoring the absolute sea level changes linked to greenhouse signals in the Pacific region.

The project faces some new challenges that include determining absolute and relative sea level changes, collecting and archiving long-term sea level data, transferring technology and facilitating the adaptation of policy developments.

Continuous Global Positioning System (CGPS) networks linked to tide gauge stations (known as Sea Level Fine Acoustic Measuring Equipment-SEAFRAME) have now being established. CGPS receivers are now being installed near the SEFRAME stations in the 12 Pacific Countries.

This paper will discuss the results from the project on the relative sea level changes over the last 11 years (changes of 1-2 mm per year) from individual and regional perspectives and compare these with the absolute sea level measurements currently underway in the region.

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### **Ancient strandlines on Lanai and evidence for island uplift**

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Elevated carbonate deposits have long been known along the southern coast of Lanai. The highest of these was reported at Stearns Swale, a swale formed by a fault parallel with the volcanic rift zone that down drops the western exterior margin of Kalaukapo Crater. At this site Harold Stearns reported collecting fragments of marine shells in fractures in volcanic rock. The site was revisited using a copy of Stearns field map, but no in-situ fossils have ever been found despite numerous days of searching. Instead, we find caliche filling fractures within the basalt along the fault zone. This site is situated along an ancient Hawaiian Trail. Since corals were transported to the high mountains for ceremonies and caches of several hundred pounds of coral remain at ancient sites, individual shells on the surface may be explained by human transport. Also, a road was bulldozed to the Swale during WWII for access to an observation post. The Stearns site (dating from observations made in the 1930's)

may have been destroyed during road building or the fossils collected by Stearns may not have been *in-situ*.

Two terraces at the 190 m elevation are present in the interior of the Kalaukapo Crater, SE of Stearns Swale and these units are dissected by the modern drainage course leading seaward out the southern margin of the crater, referred to as the "Narrows". A fossil basalt boulder beach, containing coral clasts, is present on the SW terrace with sea stacks preserved on its SW margin. The basalt boulders on this platform are brown-black, well-rounded, and lack weathering rinds. Just southeast of the boulder-beach platform is an isolated eroded high-ground upon which Oxisols are developed while the boulder beach area is underlain by Vertisols. This deeply weathered high-ground with red weathering rinds is interpreted as an ancient island. On the SE margin of this high-ground, numerous corals have been collected. Stearns (1978) referred to this terrace as the Kalaukapo Shoreline.

A coral-bearing conglomerate is present at an elevation of 170 m, in the bottom of the three gullies on the southern side of the crater and is well-exposed in the "Narrows" drainage channel. Stearns referred to these outcrops as the "highest fossiliferous limestone in place" at 171 m. He gave these deposits the name Manele Bay Shoreline.

Stratigraphic studies of the gully-filling outcrops within the Manele Bay Resort (up to roughly 97 m elevation) have been reported by Felton et al. (2000). At these sites a consistent stratigraphy of units from gully to gully was found with soil horizons preserved between coral-bearing units.

West of the resort golf course, geologic studies were undertaken at elevations between 100-200 m elevation. A topographic plain, at roughly 100 m elevations along the Annapuka drainage, was found with fossil corals growing, one on top of another (as opposed to individual corals on individual boulders). The plain is interpreted as an ancient embayment with coral deposits. Cliffs bound the coral-covered plain on the northern side, interpreted as fossil sea cliffs. And a black-brown well-rounded, well-sorted, boulder beach deposit (like that at 190 m in Kalaukapo Crater) is present on the eastern side. Along the south side of the embayment several horizons of fossils were found as well as some beach rock.

Between 100-200 m elevation in the Poopoo gullies a number of horizontal layers of coral-bearing conglomerates were found, often in pairs. For the most part the deposits are restricted to the eastern sides of the gullies, and have the appearance of fossil "bathtub" rings. Fossils are absent on interfluvies between the identified horizons.

In the Naha area (SE Lanai) well-sorted, uniformly-bedded deposits were found at 150 m. These deposits were described as water-lain sediments collected behind an earth dam by Stearns (field notes). Stearns found no fossils in these sediments, nor did we. A bench is present in the topography in this area at 150-180 m and is thought to be an erosional bench formed below sea level even though no marine fossils have been found. Fossil marine sea-stacks are observed in the Naha area at a similar elevation.

We interpret the outcrops of horizontal coral-bearing deposits, distributed in bathtub ring fashion as traces of ancient strandlines. Ages reported in the literature for coral include 350 ka at an elevation of 171 m, 250 ka at roughly 58 m, 211-230 ka at 28-35 m, and an age of roughly 120 ka at 23 m elevation. These horizons correspond to high-stands in the sea-level record derived from the Marine Isotope Stage record (specifically, 9.3, 7.5, 7.1, and 5.5). These correlations are consistent with an island uplift of 0.5 mm/y between 150-50 ka and 0.2 mm/y between 0-150 ka. Furthermore, the uplift model, based on the Marine Isotope Stages, explains why the horizontal layers are often observed as pairs. Still-stands in the sea-level record, when adjusted for the uplift rate, result in multiple strand lines at nearly the same elevation, for several parts of the record. The island uplift is likely to be associated with the plate motion carrying the island of Lanai across the lithospheric arch associated with the Hawaiian hot spot.

## The southernmost atolls: sediment characteristics of Elizabeth and Middleton Reefs, southwest Pacific

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Elizabeth and Middleton Reefs lie within the Lord Howe linear chain of seamounts and volcanic islands in the southwestern Pacific Ocean. Drilling, vibrocoreing and shallow seismic profiling have indicated that these reefs have been quite productive during the Holocene. Keep-up growth appears to have characterized the windward sides, while the leeward (northern) side of the atolls is characterized by catch-up growth. The reef framework is very porous being dominated by branching corals. Massive corals appear to be absent from both the modern reef communities and within the cores.

The present surface of the reef is dominated by coralline algae and, apart from in the lagoons, scleractinian coral cover is low. There are suggestions that contemporary accretion rates are low and that the windward parts of the atolls may be eroding. Surface sediment assemblages of these atolls have been investigated to assess the character of these high-latitude atolls and to assess their correspondence with the observed reef productivity. Coral, coralline algae, *Halimeda*, molluscs and foraminifers are the main sediment constituents, with atolls having a characteristic tropical sediment composition. The surface sediments are well mixed and little zonation occurs within the lagoons. There are some noticeable variations, however, between the lagoon surface and subsurface and the reef front/slope. For example *Halimeda* concentrations were much greater in the lagoon sediment cores and atoll flanks than on the contemporary lagoon surface on Middleton Reef. In the lagoon on Elizabeth Reef the *Halimeda* concentrations were generally lower than Middleton Reef. The foram *Baculogypsina* is particularly abundant on Elizabeth Reef, which also has a higher proportion of coralline algae. These results suggest that there are regional gradients in the composition of carbonate sediment production even though the growth histories of both atolls are similar. In general these sediments provide a unique insight into the composition of carbonate production at these unmodified high-latitude reefs. These data provide an inventory of sediment characteristics that can be compared with other reefs at the environmental limits of coral growth.

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## Wave energy potential in the Pacific region

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From 1986 to 1995 the Norwegian Government, through the Norwegian Agency for International Development (NORAD), funded a pre-feasibility study for wave power in the South Pacific including a comprehensive ocean wave measurement programme for the South Pacific Applied Geoscience Commission (SOPAC). This culminated in the publication of a booklet "Ocean Wave Energy in the South Pacific, the Resource and its Utilisation" (SOPAC Miscellaneous Report 234).

In 2002, SOPAC and U.S. Wave Energy signed a Memorandum of Understanding with the primary objective of reviewing and expanding the earlier work carried out by the NORAD-funded programme.

To date, U.S. Wave Energy have reviewed the raw data from the earlier NORAD study and have produced results for wave energy potential that are consistent with the earlier NORAD predictions.

U.S. Wave Energy has also calculated the likely energy output using their Wave Energy Module (WEM) that is based on the design outputs of laboratory tests of the WEM. The results are as follows:

Country	Site / Island	Potential – Average WEM output (kW)
Cook Islands	Ngatangia Harbour, Rarotonga	324
Fiji Islands	Muani, Kadavu	296
Samoa	Lotofaga / Salani, Upolu	253
Tonga	Tongatapu	276

Based on the above analysis it has been proposed to deploy a 50 kW pilot demonstration in the Fiji Islands and a full-scale 1 MW device in the Cook Islands; this, however, is subject to the availability of funding and site-specific surveys to further substantiate the wave energy potential and viability. Full feasibility studies have also been proposed for Samoa and Tonga.

In June 2003 the Fiji Department of Energy, SOPAC Community Lifelines and Ocean and Islands Programmes (of SOPAC), and U.S Wave Energy collaborated and deployed a wave gauge at 18m depth and 1000m from shore near Muani Village in Kadavu, Fiji Islands.

The poster presentation will make reference to the earlier study carried out under the NORAD-funded programme identifying the surveyed sites. It will also highlight the work carried out at Muani Village on Kadavu and will feature the basic operation of the Wave Energy Module.

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### **Nickel mining and environmental concerns in New Caledonia**

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The geology of New Caledonia was dominated at Late Eocene by the thrusting of the Ophiolite nappe over the autochthonous volcano-sedimentary substratum. These allochthonous Ultrabasic formations, which represents more than 8 000 sq. km, underwent uplift movements, with associated faulting and intense tropical weathering, altogether responsible for supergene nickel deposits. Nickel mining is a major contributor to New Caledonia's Gross Domestic Product (11 %), and the country is the world's 5<sup>th</sup> largest metallurgical producer of nickel. Garnierite nickel ore was discovered in New Caledonia by Jules Garnier in 1864. Since then, 4,500 exploitation titles have been delivered. Nickel mining is by open quarrying and involves the removal of large surface areas of laterites as well as the creation of access road and infrastructure.

There are 3 periods in the history of nickel mining in New Caledonia:

- pre 1950, small-scale mining methods had a reduced impact on the environment;
- 1950 to 1975, mining reached an industrial stage. Due to insufficient mining regulation, wastes were dumped indiscriminately; and
- post 1975, introduction of new mining techniques integrating environmental protection on most of New Caledonian nickel mines.

Nowadays, although new mining techniques are environmentally friendly, there is a need to assess the derelict sites of New Caledonia (in terms of number, surfaces, materials and other field characteristics) before launching rehabilitation programmes. Consequently, the Service of Mines and Energy of New Caledonia, jointly with the French Geological Survey (Bureau de Recherches Géologiques et Minières), started a program in 1998, based on field mapping, remote sensing data analysis and DTM processing. The joint programme aims at:

1) Improving geological knowledge to better understand the geology of nickel. Geological detailed studies are necessary to map fracturation of peridotites, distribution of lateritic units, and precise the morphogenesis of the mainland. Mapping of laterites is performed both in the field and with the help of DTM. The study of standard lateritic profile shows that karstic evolution, gravitational processes and fluid pressure play a major role in the control and thus in the concentration of nickel.

2) Mapping superficial formations and assessing geohazards. Geohazards in New Caledonia are mainly located above the serpentinite sole, within the weathered, fractured, and perched ultrabasic massif. Geohazards play an important role in erosion processes and dismantling of the lateritic cover. It is important to identify their origin (i.e.

anthropic activity and/or natural processes) and to characterize their typology for geohazards mitigation.

3) Assessing derelict mines and identifying sensitive areas with regards to the environment. Mapping of derelict sites has been undertaken mainly by aerial photographs, with complementary fieldwork. Presently, there are about 450 distinct mining sites either active or derelict. Among distinct features mapped are: wastes, platforms, open quarry, gullies resulting from retrogressive erosion, block flow valleys and clogged creeks. A multi-temporal analysis of ortho aerial photographs was made on "sensitive areas". Resulting interpreted data was converted into a GIS format and classified into a database to generate thematic and decision-making maps.

Since 1998, the multi-disciplinary approach of the joint programme has aimed at:

- understanding the cycle of nickel from its deposition to its dismantling,
- identifying both karstic evolution and gravitational processes and their major role in nickel genesis and concentration,
- mapping superficial formations and assessing geohazards,
- identifying aggravating factors both in terms of geohazard mitigation and of degraded sites (either by anthropic activity or natural processes), and
- prioritising the derelict mines' rehabilitation, including both remodelling and revegetation.

Over the last five years of the joint programme, only 1/4 of the ultrabasic massif has been mapped. Although the first results of the programme are promising, new data still need to be acquired to better improve our knowledge of the nickel deposits, geohazard mitigation and derelict mine assessment within the mainland's ultrabasic massif.  
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**The Global International Waters Assessment (GIWA) in the Pacific Islands**

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The Global International Waters Assessment (GIWA) was a project implemented by the United Nations Environmental Programme. In the Pacific, the study was coordinated by the International Ocean Institute's operational centre for the Pacific Islands (IOI – Pacific) based in Australia and the Marine Studies Programme of the University of the South Pacific (USP).

In a detailed assessment of international water concerns and issues for the Pacific Islands region (Sub-region 62), five major concerns were identified and ranked according to priority. Freshwater shortage was considered the top priority concern for the Pacific region and SOPAC was delegated to work on specific case studies within the Pacific region where freshwater shortage was a major concern.

Fiji, Tonga and Kiribati were chosen as case studies to illustrate freshwater shortage and driving forces leading to freshwater shortage were identified to include the lack of adequate policies on land and water use and their enforcement, natural phenomena and lack of access to technology.

A common theme that was seen throughout the Pacific was the need for capacity building, and for awareness-raising at all levels of society, on matters relating to proper wastewater treatment and sewage disposal practices. It was seen that Pacific Island Countries needed to be aware that they were polluting their own water resources and were putting their own citizens at risk of getting water-borne diseases such as cholera and diarrhoea.

The Pacific Wastewater Policy Statement and the Pacific Wastewater Framework for Action are two regional policy and action documents agreed to by 15 countries in the Pacific. These provide a structure to regional and national interventions on wastewater management. Also, in July 2002, 18 Pacific Island Countries formally endorsed the Pacific Regional Action Plan on Sustainable Water Management, 14 countries at ministerial level. This action plan also identified specific actions to address priority issues and constraints to achieving sustainable water management.

At present, there are no policies in place to reduce water use, or to re-cycle water, and with increasing awareness of global changes occurring, this has led to more funding being made available for training and preparedness initiatives. As is the case in most rural communities in the Pacific, raw water quality is the most important, because, in most cases, water treatment is not affordable.

## **Rainwater Harvesting Pilot Project implementation in Tonga**

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In late 2001, SOPAC signed a Project Document Agreement with the United Nations Environmental Programme (UNEP) to implement a demonstration project on Rainwater Harvesting in the Pacific. The project was titled "Empowering Women in Rainwater Harvesting in Pacific Atoll Islands" and its main purpose was to increase women's participation in implementation of rainwater harvesting systems and to increase the quantity and quality of water for project communities.

Tonga was chosen as the study area after meeting the selection criteria set out in a decision matrix that had been developed to evaluate the suitability of each of the six prospective countries that were short listed. The Tonga Development Community Trust (TCDT) was contracted as the local partner to implement the project at the proposed field sites, using the resources of its existing Village Women's Development network (VWD). Following stakeholder consultations, the project has got underway and initial surveys were carried out when SOPAC personnel visited Vava'u in May, 2003. A number of tanks from a previous rainwater harvesting project (1987) were found to be leaking or totally empty. It was observed that there was severe erosion around the base of the tanks, most likely as a result of pigs burrowing in the dirt or water leakage or the two effects combined.

During the field visit, information on roof sizes and household numbers were collected to assist SOPAC personnel in the assessment of tank design criteria. An average house size of 10.8 m<sup>2</sup> was found and the average number of people in each house was 3 adults and 6 children. An important part of the pilot project is to look carefully at rainfall records, in particular the length of dry periods, which is critical in regard to the whether tanks will run dry. We analysed rainfall data provided by the Tonga Met. Service and found an average of 2200 mm per year in Vava'u. We have developed a computer-based EXCEL spreadsheet model that uses actual rainfall data to calculate the level in a tank of a particular size over time. The model calculates the tank level by taking into account various parameters affecting rain supply (i.e. rainfall amount and frequency, roof size, level of guttering) and demand (number of people, average amount of water used per day per person). It is of concern that the models suggest tanks will periodically run dry due to the large average number of people in each house and the small size of their house/roof area to catch rainfall.

Over 50% of samples of water taken from the current rain tanks tested positive for faecal coliforms and most had coliform bacteria present. Both community water tanks were contaminated with bacteria. Levels of bacteria were of concern as rainwater does not have these bacteria in it. More care needs to be taken by people to try and look after their rainwater tanks, by keeping pigs away, and by making sure tanks are covered and gutters kept clean. A focus of the project, once new tanks are installed, would be to use VWD staff to educate people on how to care for and maintain their tanks.

In the next month, full social and technical surveys will be carried out at Utungake to establish a baseline to assess the impact of the rain tank project on the village. While implementation is being carried out at this site, a second outer-island site will be selected. Knowledge gained from the project will be used to compile a report on rainwater harvesting methods for use in the Pacific.

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## **Reducing vulnerabilities via a web map server**

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### **Short CV:**

Franck Martin is an ICT specialist working for SOPAC and the Pacific Island Countries. He is vice-chair of the Pacific Islands Chapter of the Internet Society and has worked on the development of Internet in many countries by setting up ISPs or advising ISPs. He has worked on Geographic Information Systems (GIS), doing training or putting in place such systems. He is now ICT specialist for an EU-funded project to install Internet map servers to help decision making for reducing vulnerability in Pacific states.



**Abstract:**

SOPAC is implementing a project funded by the European Union called "Reducing Vulnerability in Pacific ACP states". The project will use Island Systems Management as a tool. This tool will be composed mainly of a map server, presenting maps via the web, inside a collaborative environment developed with OpenSource software. Internet is the enabling tool to bring all the stakeholders around the same data and information for better decision making and therefore reduce vulnerability leading towards sustainable development.

**Full Text:**

SOPAC is implementing a project funded by the European Union called "Reducing Vulnerability in Pacific ACP states". The project has 3 components, aggregates, water and sanitation, and risk management. There will be data collected based on these 3 components and on the needs of the stakeholders of the 8 Pacific ACP (African, Carribean, Pacific) states. How can this data contribute to reducing vulnerabilities as data is not information, information is not knowledge, knowledge is not wisdom and all of that is not action? The goal of this project seems presumptuous, only there to please donors with catchy sentences instead of work benefiting the community? What are we, world savers? The link is not obvious but it will appear, thanks to Internet technology.

Many reviews are carried out in developing countries that leads to the production of simple recommendations or at best action reports. Most of the time these reports are not read by interested parties and little is actioned because there are in fact no incentives to change what is already established. Sustainable development comes from the understanding of our environment and how it interacts with us or rather how we interact with it. Development made sustainable requires long-term sacrifices against fast gain. There must be a buy-in from the community for the actions recommended in many projects and this is hard to achieve. Reaching the community is essential and therefore the dissemination of the information is critical, however in many developing countries information is still considered as power. The withholding of information, like telecom monopolies, stops the path of progress. The information needs to be distributed freely to the widest audience.

Internet is the perfect tool for this task. The information can be both distributed via the official channels as well as to the whole public. There is always a stakeholder in any project that gets forgotten, by distributing the information via the Internet, it ensures that all potential stakeholders will access it. Our project "reducing the vulnerability of Pacific ACP states", is using as a tool to reach its goal of "Island Systems Management". This is another catch term, but it depicts an holistic approach. This holistic approach includes all data that can be collected about an area to facilitate decision making, so that the data can be converted into action.

For this system to be fully efficient, it requires that all decision makers have access to the information in a simple form. As the data that we collect is mainly geographically-based, it is best to present it inside a Geographic Information System (GIS) or simply spatial system. Unfortunately, most systems require specialised software that requires skilled operators. This is where the counterpart of the Internet philosophy comes in place: OpenSource.

OpenSource is based on the same principles of the Internet, a widely published standard with no royalties or licensing terms that would stop any group to use the system for reasons of costs or other criteria. By using OpenSource software, the project ensures that all stakeholders will have access to the information at the lowest cost. GIS software is very specialised, fulfilling a niche market, therefore with substantial costs. OpenSource software follows Open Standards, like the Internet it gives all access to the data. This is important as in the aid business, the cost of equipment is sometime not fully relevant as a donor is ready to pay for it, but there is the maintenance and the sustainability of the equipment and the project at stake. Implementing organisation and companies often choose to lock in the recipient with "black boxes" that only skilled technicians from the implementing organisation may modify or maintain. While OpenSource may not be familiar in developing countries, anybody can gain capacity to maintain and modify such systems.



As seen the main data for this project is geographically-based and must be presented to a wide audience. As seen the data must be presented as information. The thinking process is to present the information as a dynamic map to allow any possible analysis. The map should be available over the Internet. One software answers such requirement, the Mapserver from the University of Minnesota. This software presents interactive maps based on raw data from various commercial GIS packages. It also follows the OpenGIS standards which will allow it to interact with other products. The maps are presented as images via a web server. An interface allows the user to query the maps and display the relevant information. While the geographical data can be presented it does not fully ensure user buy-in. There must be an interface to facilitate the collaboration and interaction of all stakeholders holding information. The Mapserver is therefore included inside a web-based forum tool: Tiki. This tool offers easy to edit pages as well as file and image galleries and areas to publish logs and articles using no software but a web browser.

Tiki offers this extra functionality to the map serving process: a dynamic knowledge base. Editing web pages is simple and based on the wiki concept. A little parenthesis here, wiki means fast in Hawaiian (a Polynesian language) and tiki means idol in Maori (another Polynesian language). Wiki was developed to create quickly web sites without the user having to learn a specialised software or the principles of good design. The edition of a page is done inside a text box with some very simple tags. Links to other web pages are auto-magically created by using CapitalisedWords. The main formatting and organisation of the pages is left to the application. Some web sites have given anyone permission to modify the wiki pages, creating a fully interactive web site where the whole Internet community is a potential writer. Defacement is avoided by using an historic system where page versions are kept allowing to roll back easily... Tiki adds areas for FAQ (Frequently Asked Questions), file galleries, image galleries and forums. Each page can have comments allowing further interaction between the authors and the readers. This facilitates the creation of a knowledge base where each map layer can be described but even better explained by an expert to the masses, pointing to interesting features in the datasets, supplementing it with images, animation, movies, documents...

How this application, a collaborative map server, can provide wisdom and action? One has to go back to the ISM paradigm.

Historically the monitoring and management of social and environmental factors has been conducted at the issue level, leading to, at times, fragmented and disparate policies and actions. Recent awareness of the need to view systems in an integrated manner, and manage them taking into account the causal chains and inherent linkages across sectors (agriculture, fisheries, urban development and so on) represents a paradigm shift in thinking. At present however, much of this new thinking remains at the conceptual phase. Project intervention at the individual country level is, therefore, a vital next step in implementing these ideas

It is from this background that the concept of ISM has come about, based on the utmost need, especially for small islands, to view all activities and sectors as interconnected, and to tackle issues of development and vulnerability with the same breadth of focus. Such an approach has implications for the way that research is done and the formulation of resultant policies and long-term strategies that seek to ensure economic, social and environmental sustainability.

Due to the nature of the SOPAC EU-Project, and its multi-disciplinary approach to reducing vulnerability of small island states, it is SOPAC's intention to develop a practical ISM methodology. This framework is intended to be a systems-oriented integrated management model of resource management for islands.

Resources are unlikely to be found in urban centres, but the policy makers are. Resources are located in rural areas. Similarly the development of an island is global and not limited to special areas, however the communities in these areas are the primary people affected by decisions taken globally and elsewhere. The local and customary wisdom is lost due to a lack of understanding of the local issues. The benefit for the country is not perceived by the local community because they are excluded from the decision thinking process and the work of experts that write reports that will never be distributed to the local community. In short these two disparate communities must enter in relation to facilitate the decision process. What better tool than the Internet? Internet is not everywhere, but the development of Internet kiosks in rural villages such as in the Solomon Islands via the PeopleFirstNetwork has shown that remote communities can access the information where even commercial communication companies do not dare to do business.

On the example of PeopleFirstNetwork, many Pacific Island nations are considering the idea of using radios to be on the Internet. The beauty of the Internet is that it has been developed when 300bauds was considered broadband. There are still many applications out there especially on the Unix/Linux platforms that perform

efficiently in very poor network conditions. Global access is also now possible via satellite over the Pacific at reasonable costs. Using DVBIP technology, sharing a satellite channel with other Internet stations, it is possible to get 64kb/s speed both ways for about USD200 a month using a less than a meter dish. The connection is not suitable for running businesses but enough for the use of an Internet Community station. If it was not due to licensing and monopolistic practises these systems would be everywhere in the Pacific. However it shows that the Internet can reach all communities and any application based on Internet Technology can reach all stakeholders at affordable costs. It makes sense now to develop applications based on Internet Technology.

Now the wisdom of the local community can be shared amongst all, this ensures that development is pursued in accordance with the aspiration of the local people, preservation of the environment, improvement of living conditions, community sharing principles, respect of traditional values... Using tiki and the Internet they can know about the perception of their environment decision makers have (through geographically analysed data), they can understand the decisions made and more they can query the decisions taken, participating actively in a democratic process. The democratic process is not necessary as even in traditional society with chiefly systems the elders play the role of advisers and participate actively in the decision-making process.

The action is finally achievable. The action can to the best of the knowledge and wisdom of all stakeholders, be performed towards reducing vulnerability. At each level, each individual in its area of influence can see the local but also big picture and make appropriate decisions. Internet offers this power of easily sharing data, information, knowledge and wisdom amongst a wide variety of the population.

From data to decision, a web-based map server using Internet technology and OpenSource in facilitating data sharing. There is a free flow of information between all stakeholders which implies that datasets are no longer costly to share, they just need to be published on the Internet. Organisations and businesses benefit as they can work on base data, avoid duplication of resources for re-entering this base data and enhance the base data with more interesting layers...

This is how this project wants to tackle its goal of "reducing vulnerability in Pacific ACP states" through the implementation of an Island Systems Management. Internet is an essential pillar of such development bringing a controlled anarchy suitable for the participation of all stakeholders regardless of their gender, skills, or title.

Resources:

[map.sopac.org](http://map.sopac.org)

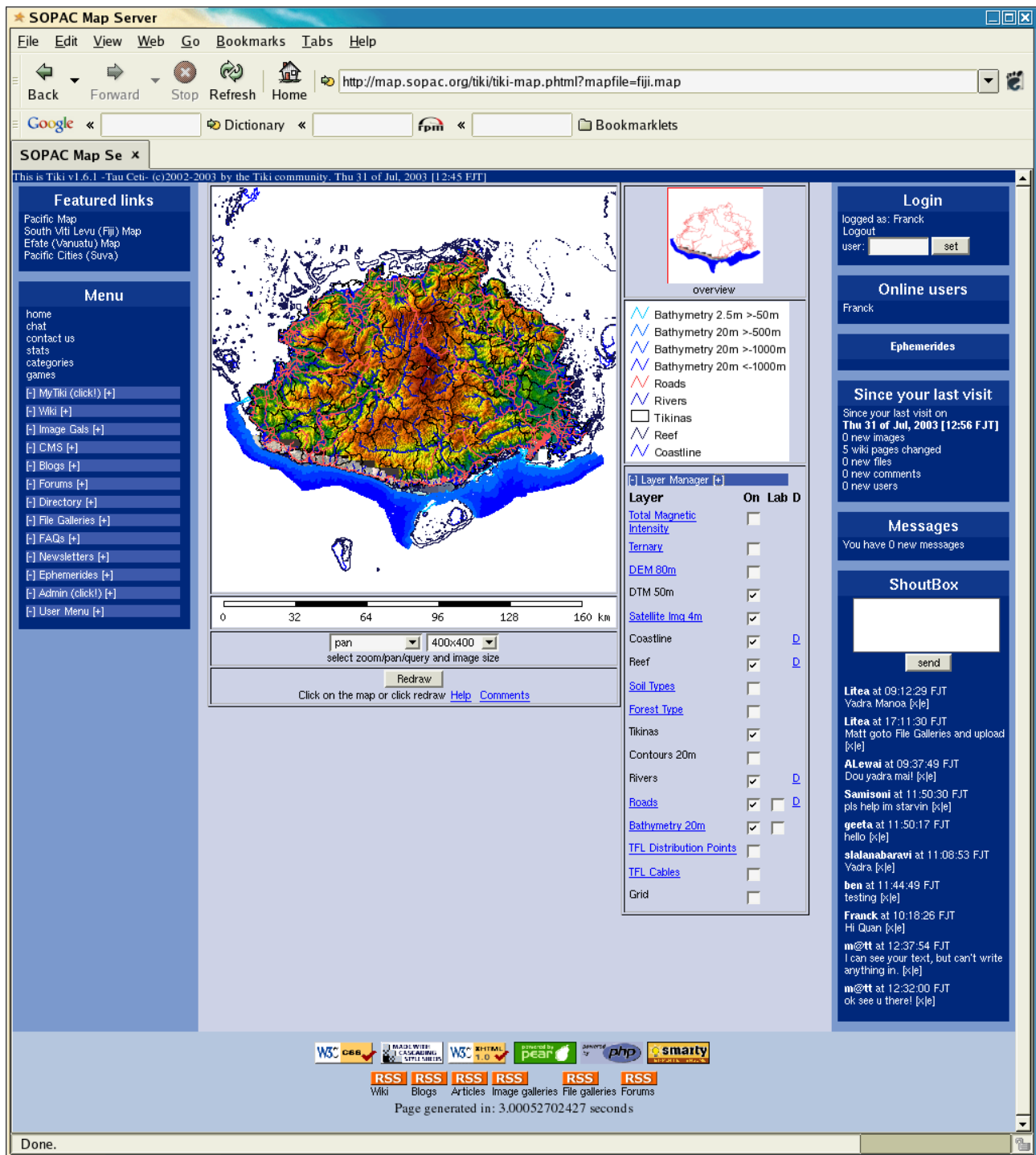
[www.sopac.org](http://www.sopac.org)

[www.tikiwiki.org](http://www.tikiwiki.org)

[mapserver.gis.umn.edu](http://mapserver.gis.umn.edu)

[www.opensource.org](http://www.opensource.org)

Illustrations:



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## Specificity of geological hazards in New Caledonia

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Of the natural hazards that affect the Southwest Pacific region, and thus New Caledonia, geological hazards play a major role. Tropical cyclones and excessive rainfall often trigger slope failures and landslides.

The geology of New Caledonia is dominated by the peridotite nappe thrust during the late Eocene over the autochthonous volcano-sedimentary substratum. This allochthonous Ultrabasic formation which represents more than 8 000 sq. km, underwent tropical weathering responsible for supergene nickel deposits. The country is the world's 5<sup>th</sup> largest metallurgical producer of nickel, with nickel ore being exploited in open pits and quarries.

The specificity of the geology, land use and economy of New Caledonia is responsible for specific geohazards and requires a specific approach. The tectonic contact between the perched peridotites and the substratum occurs through an impermeable serpentinite sole where a great variety of instabilities occur. The weathered, perched mountainous peridotitic massives that overlie inhabited villages and valleys represent potential vulnerability areas. Therefore, for geohazards mitigation, it is important to identify their origin (i.e. anthropic activity and/or natural processes) and characterize their typology.

Consequently, New Caledonia has started, jointly with the B.R.G.M. (Bureau de Recherches Géologiques et Minières), a pluriannual programme that aims at assessing the slope instability hazards within sensitive areas selected by decision makers. Moreover, the mining industry is not without influence regarding this sensitive environment. Therefore, accurate geohazard assessment, integrating past and present ground conditions, must be achieved.

We present here the main results of our joint programme. A typology of the different slope instabilities and mass movements is proposed. Within the volcano-sedimentary substratum, instabilities are limited in terms of both volume and intensity. Localized rock falls, superficial landslides and erosion have been recorded. Within the peridotitic massive, the following hazards, ranked by increasing disorder degree have been observed and mapped: lavaka (hydric erosion), rock falls, retrogressive gullies, landslides (translational and rotational), debris flows. Within the peridotitic perched mountainous units where most of geohazards have been mapped, the weathered, unstable material and the high altitude gradients often initiate a strong downfall potential energy.

Although the joint programme results are promising, there is a need to keep acquiring new data for geohazards mitigation, and to raise awareness of ground stability issues in the context of increasing development, both industrial (mining sector) and urban, in New Caledonia.

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### **Megatsunami generation from giant submarine landslides on oceanic islands: new insights gained from the Hawaii evidence and modeling**

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High-elevation marine gravels on the Hawaiian islands of Lanai and Molokai either mark uplifted shorelines or are deposits from massive tsunamis. The subsidence history of those islands has been too ambiguous to differentiate these causes, leading to controversy over the deposit's origins and to confusion over the impacts, or even the existence of megatsunamis generated from giant submarine landslides (GSL) mapped offshore. U-series ages of these deposits that correlate with sea-level high stands have added to the confusion. Our initial approach to solving this controversy has been to directly date the GSL using sediment stratigraphy, such as for the Alika phase 2 event from Mauna Loa volcano on the island of Hawaii (McMurtry et al., 1999). Recently, we directed our attention to deposits on Kohala volcano on Hawaii, where continuous subsidence is well established from its stairway of submerged reefs (McMurtry et al., in review). On Kohala, we have found a fossiliferous marine conglomerate 1.5–8 m above present sea level. The deposit is the same age, 120±10 ka, as the giant Alika landslide from nearby Mauna Loa volcano. The present depth of the 120-ka shoreline implies that the deposit was left by a tsunami whose runup exceeded 400 m.

Landslide tsunami simulations have advanced to the point where the tsunamigenic potential of GSLs can be affirmed. We show that megatsunamis are a sufficient explanation for the observed pattern of debris height of calcareous marine deposits on some of the Hawaiian Islands. Further, our tsunami simulations, using the Alika

GSL as example, can be used to reduce the considerable uncertainty in subsidence history of the different Hawaiian Islands, a current obstacle to interpreting the deposits from large waves. Modeled runups of 800 m occurred directly landward of the Alika 2 slide on west Hawaii and were up to 300 m on west Lanai, in agreement with previous deposit estimates there (Moore & Moore, 1984, 1988). We also show in McMurtry et al. (in press) that the onset of interglacials provides a probable explanation for the timing of these giant landslides over at least the last five million years. The climate change mechanism both explains the confusion with eustatic sea-level rise and provides a reasonable triggering mechanism for giant landslides from oceanic island volcanoes. For the late Pleistocene, large volcanic failures and exposed marine deposits both correlate foremost with sea level high stands, and in particular with the onset of interglacial conditions that are reflected in Hawaii by the apex ages of the low-stand fringing reefs. We have shown that such large volcanic failures inevitably generate megatsunamis, and we conclude that persistent climate effects during sea level high stands eventually unleash large volcanic failures and megatsunamis amongst the Hawaiian Islands and perhaps all volcanically active oceanic islands, with invariable propagation toward the continental coasts.

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## Algae, algae everywhere and not a fish to eat: effects of sewage discharges and overfishing on the coral reefs of Fiji

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Coral reefs are an extremely important natural resource in the South Pacific. They are highly productive and biodiverse ecosystems which are important as local fisheries, tourist attractions, and for protection of the coastline from the damaging effects of waves. Over the years, increased development of the coastline and utilisation of coastal resources have caused significant degradation of reef habitats. These impacts have been observed as the result of factors such as increased erosion on land and siltation of reefs, water pollution, overfishing, and coral harvesting.

Sewage discharges at many locations in the Pacific Islands are causing severe negative effects of corals, particularly where fringing reef systems are present. Nutrients found in sewage such as ammonia ( $\text{NH}_4^+$ ) nitrate ( $\text{NO}_3^-$ ) and phosphate ( $\text{PO}_4^{3-}$ ) are naturally present in seawater but in the tropical Pacific ocean levels are generally very low. Elevated levels of nutrients from sewage discharges can cause serious negative effects on coral reefs. One major effect is that the 'fertilisation' of the water with nutrients enables large macro-algae (seaweeds) to thrive and smother the coral. The level of fishing pressure is also extremely important as herbivore species can graze the algae and prevent it becoming dominant, even if nutrients are above background levels. If herbivore species are overfished and nutrients are elevated, algae can become dominant to the detriment of live coral. Coral reef recovery, once algae become dominant, is slow as there are few settlement sites for coral larvae.

In Fiji, algal-dominated reefs have become numerous, particularly along the Coral Coast and in the Mamanuca Islands. In this paper we report elevated (above background) nutrient levels ( $>14 \mu\text{g/L}$  ( $1 \mu\text{M}$ ) dissolved N and  $>3 \mu\text{g/L}$  ( $0.1 \mu\text{M}$ ) of dissolved P) in several areas, generally as a result of sewage discharges (point and non-point), in particular outflows from hotels. Coupled with overfishing this has resulted in degraded and algae-dominated reef systems, particularly in areas that are intensively developed for tourism, and near villages and urban areas.

The solution to the problem is not easy and it requires the will power of communities, government, tourism operators and wastewater engineers and consulting companies. There is a widespread lack of application of appropriate sewage treatment technologies in the Pacific Islands. Lack of funding for advanced treatment systems is an issue in some cases but in the long term the benefits will offset this expenditure. Low-cost bio-treatment technologies exist and could be adopted in many situations. On a government level, water quality standards specific for coral reefs should be developed into legislation and effluent discharges made to conform to them. Other practical options to consider may be using phosphate-free detergents, using composting toilet systems in the villages and small resorts, and establishing more marine protected areas to protect herbivore species. If more of these options are not carried out then several more of the coral reefs in the Pacific Islands may be destroyed which will have serious negative social and economic consequences.

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### **Impacts of Cyclone Ami on drinking water quality: How can we best protect public health when similar disasters occur?**

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Cyclones are a common occurrence throughout the summer months in the islands of the South Pacific. They often have devastating consequences, causing loss of life, destruction of houses and other infrastructure, ruining of crops and negative health consequences. Cyclone Ami struck Fiji in mid-January 2003 and had devastating effects on the islands of Vanua Levu, Taveuni and eastern islands in the Lau group. Sadly, many lives were lost during a large flood and homes, bridges, roads and crops destroyed. In the aftermath of the disaster, health authorities were concerned that people in the area were at a high risk in contracting dengue and typhoid fever. After the cyclone, approximately 60 water-quality tests were taken from samples on points within the major public water supply systems in Vanua Levu and also several private boreholes. The results showed that many of the drinking water supplies in areas of Vanua Levu were contaminated with faecal coliform bacteria following the cyclone and water quality had declined in many areas (higher turbidity, more coliforms). There were also water supply problems due to destroyed supply infrastructure and ironically a drought occurred in the weeks after the cyclone.

In conjunction with the regular microbiological (total and faecal coliforms) water testing, evaluation of a simple water testing (H<sub>2</sub>S) kit was also performed. The H<sub>2</sub>S test is a presence/absence test which turns black when H<sub>2</sub>S producers found in faecal matter are present in water. It correlated well with the other indicators and further research is confirming the link between positive test kit results and the presence of disease-causing organisms. The major advantages of kits is that they are very low cost, no laboratory or training is required, and communities can easily test their own water supplies. In a disaster situation such as a cyclone the kits could be widely distributed by disaster and health agencies and people could test their own water, with instructions to boil/treat it until no positive results are shown.

The potential effects of a cyclone on public health can be minimized by effective public education before and after such a disaster occurs and by appropriate and coordinated responses by disaster management, health and water authorities. Pre-cyclone activities should focus on people storing bottled water in the cyclone season, education on alternative water sources (e.g. green coconuts, *niu*) and how to protect water sources. Post-cyclone, efforts should be focused on education (e.g. on radio) on how to treat water to make it safe to drink (boiling, added disinfectant) and on community-health education. Public water authorities should concentrate on maintaining and even increasing chlorination to protect public health following cyclones. In order to better safeguard human health, relevant agencies should co-operate more to share health, water supply and water quality data.

## Geophysics in groundwater exploration on small coral atolls in Papua New Guinea

*Nathan Mosusu*

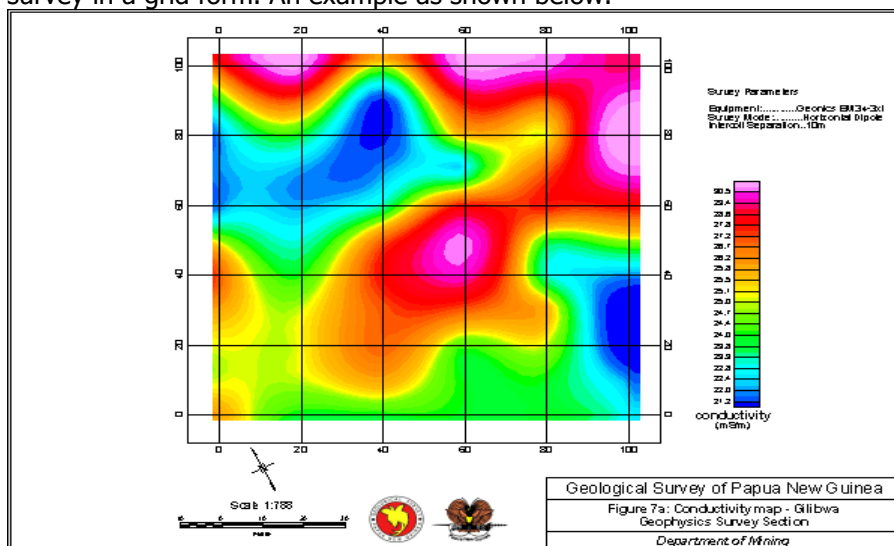
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Access to clean potable water on many small islands is a major problem in many Pacific Island nations. In Papua New Guinea, where almost half of the country's total land mass is made up of small coral islands, this problem continues to haunt all authorities concerned.

During the 1997 El Niño, many parts of Papua New Guinea were severely affected by lack of fresh water. The small coral atolls of the Milne Bay Province were among those worst affected. In attempting to improve the situation a reconnaissance survey (Lytham et al., 1998) of the atolls recommended the use of geophysical methods to help delineate fresh water aquifers on the islands. The Geological Survey of Papua New Guinea (GSPNG) was tasked to carry out the geophysical surveys. The two main applications used were the electromagnetic conductivity and direct-current resistivity (Mosusu et al., 2000). Of the two methods, direct current has been used far more successfully than conductivity, which is just beginning to enjoy some degree of success.

The equipment used for conducting ground conductivity was the Scintrex's EM34-3XL. This equipment is capable of penetrating down to a vertical depth of 60 m. EM 34 uses a self-induced electromagnetic signal for exploration, so it does not rely on the radio signals generated by external sources.

An ideal survey technique for the EM34 is to define the lateral variation in conductivity, by conducting the survey in a grid form. An example as shown below.



In direct current resistivity surveying the ABEM's SAS300 terrameter, with its accompanying SAS2000 terrameter booster were used. The SAS300 is a robust equipment ideal for tropical conditions. It has a maximum penetration depth of 1000 m in ideal conditions. It is powered by a 12-volt rechargeable nickel-cadmium battery, and has a current output of 1m Ampere.

The Schlumberger-array vertical electrical sounding was the preferred choice of surveying due to the relative ease at which the survey can be conducted.

Conducting ground geophysical surveys for groundwater on small coral islands is a daunting task for any geophysicist. Not only is the re-growth sometimes impenetrable, the terrain can also be difficult with some coral islands having altitudes exceeding 100 m. Conducting geophysical surveys on such islands may prove very challenging, given the great lengths of cables involved in the data acquisition.

Interpreting geophysical data obtained from coral atolls may also require some basic knowledge of the behavior of groundwater on coral atolls. Depending on the aim of the survey the choice of equipment and the survey method may prove to be the deciding factor between a waste and a successful survey.

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## Geology of Niue

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The island Niue in the central South Pacific is an emerged atoll riding up the outer flank of the lithospheric flexure formed as a result of Pacific Plate convergence along the Tonga-Kermadec Trench 275 km west. Calculations suggest that the island began ascending the flexure around 500,000 years ago at a rate of 0.13-0.16 mm a<sup>-1</sup>. The form of the atoll which existed around 600,000 years ago is preserved as a ring-reef (the Mutalau Reef), now reaching 70 m above the modern reef, enclosing the former lagoon. Fringing the Mutalau Reef are a series of seven terraces marking fringing reefs which began growing at times of relative land-ocean stability. Dates from these terraces and consideration of Quaternary sea-level changes allow the chronology of terrace formation to be discerned. The broadest terrace (the main Alofi Terrace) is of Last Interglacial age while those higher up are all considered to have formed during earlier Quaternary sea-level maxima. The narrow discontinuous 18-m terrace is suggested as having formed during the later and lower of two Last Interglacial sea-level maxima. Cosmogenic-isotope dating of an erosional platform emerged 7.2-7.6 m at Namukulu show that it formed 8.23-10.83 ka, most plausibly during the sea-level maxima associated with the 8200-ka Event. The Holocene maximum sea level is recorded by an emerged notch 1.9-2.7 m above the modern shoreline.

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## Identification of yelloweye rockfish habitat: geophysical survey data in comparison with fishery logbook data

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The Alaska Department of Fish and Game (AFD&G) has been conducting a habitat-based stock assessment of yelloweye rockfish (*Sebastes ruberrimus*) since 1989. Yelloweye rockfish are a large (90 cm) marine fish that occur in rugged rocky terrain on the continental shelf of the Eastern Gulf of Alaska. They are an important commercial species and are taken in a directed bottom longline fishery and as bycatch in the halibut (*Hippoglossis stenalepis*) fishery. Biomass is derived as the product of density, average weight, and area of habitat. Density is based on line transect surveys conducted from an occupied submersible and average weight is estimated from port samples of commercial catch. Area estimates of yelloweye habitat are based on the probable distribution of rocky habitat inshore of 220 m. Information used to identify these areas include National Ocean Survey data, sidescan and multibeam data, direct observation from the submersible, and commercial logbook data from the directed DSR fishery. The estimates of yelloweye habitat are highly subjective. Although a defined protocol allows for a standard interpretation there is no way to estimate variance of this data.

Our use of geophysical data for bottomfish assessment may be of use to SOPAC countries interested in evaluating fisheries using a geological database. In areas where multibeam and/or sidescan sonar data are available the area of yelloweye rockfish habitat is delineated based on defined substrate types within the mapped area. For areas without these geophysical data sets we use the position data from 1993-2000 commercial logbooks, buffered to 0.5 mi from the start position. Longline sets must have at least a 0.04 yelloweye/hook catch rate to be included in the data. Prior to this assessment the commercial logbook data was not buffered and our estimate of yelloweye habitat was based on hand drawing polygons encompassing set start locations as well as NOS habitat data.



In 2001 we conducted a multibeam survey for a portion of seafloor off of Larch Bay, Baranof Island. Of the 293.7 km<sup>2</sup> surveyed offshore of Larch Bay, 112 km<sup>2</sup> were identified as yelloweye habitat based on interpretation of the multibeam bathymetry and backscatter data. A comparison of fishing data with the habitat interpretation from multibeam is illustrative of the problem with habitat definitions. In the Larch Bay multibeam site the habitat interpretation yielded 112 km<sup>2</sup> of yelloweye habitat. However, placement of the commercial fishing data yields an estimate of 65.6 km<sup>2</sup>. This is a 41% difference in area. It appears from the fishing data that there is some difference in habitat within one of our habitat categories that is not resolvable from the multibeam data.

In the summer of 2003 we conducted submersible line transect surveys in the area that was defined as rockfish habitat by both the logbook data and multibeam data compared to the area that was defined as rockfish habitat using the multibeam data alone. Data have not yet been thoroughly analyzed but preliminary analysis shows a significant difference in yelloweye density between the two areas: 3,300 yelloweye/km<sup>2</sup> in the logbook area compared to 1,276 yelloweye/km<sup>2</sup> in the multibeam-only area.

These results underscore the utility of using geophysical techniques to delineate habitats and aid in fisheries management. Geophysical surveys reveal the extent of all rocky habitat. Not surprisingly, fishermen target areas of high abundance; in the case of rockfish this equates to prime rocky habitat. Limiting of surveys to prime habitat may result in inaccurate stock assessments as density may remain stable in prime habitat while declining in surrounding habitats. For example, indications of declining stock may be first noticeable in less desirable habitat as fish will move into prime habitat as space becomes available. By assessing fish densities in all rockfish habitat, as delineated by geophysical surveys, we may have a better indicator of stock condition.

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### **Using in-situ technology to identify and characterize essential fish habitat for classification of a marine reserve in the Eastern Gulf of Alaska**

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The Alaska Department of Fish and Game has used a submersible to obtain habitat-specific density estimates of demersal shelf rockfishes in the Eastern Gulf of Alaska since 1990. During these surveys we have made over 450 dives in depths between 40 m and 400 m between Dixon Entrance (54°30' N) and Fairweather Ground (58°30' N). Direct observation using in-situ technology has greatly increased our understanding of the linkage in the marine system between species diversity, abundance, and habitat complexity. It has also allowed us to identify areas that appear to be of critical importance to a variety of fish species. A specific habitat that is particularly important is an area off Cape Edgecumbe dominated by large volcanic cones, rising steeply from 140 m to 40 m. This pinnacle is flanked by immense boulders at the base, providing important refuge for adult fishes. Juvenile rockfishes occur in great abundance at the top of the pinnacles and use the dense assemblages of sessile invertebrates, including *Metridium* and hydrocorals for cover. Adult lingcod (*Ophiodon elongatus*) use the top of the pinnacles as a seasonal feeding platform after spawning. These fishes occur in extremely dense aggregations during the late spring and early summer. The small size of the area, large density, and feeding behavior make them extremely susceptible to fishing pressure. Lingcod eggmasses have also been seen in the pinnacles habitat, occurring in much deeper waters than previously reported in the literature (O'Connell, 1993). Using a combination of technology, including submersibles, lasers, sidescan sonars, and multibeam sonar, we were able to characterize this habitat, determine habitat-specific fish densities, and complete detailed quantification of habitat. This analysis allows us to clearly defend the definition of this area as a Habitat of Particular Concern under the Magnuson-Stevens Fishery Conservation and Management Act. Based on this research the Alaska Department of Fish and Game proposed classifying the area as a no-take marine reserve. Proposals were submitted to the Alaska Board of Fisheries and the North Pacific Fishery Management Council requesting a closure to all harvest of groundfish and to prohibit anchoring. The Board of Fish closed the area to lingcod and rockfish harvest in February 1998 and the NPFMC closed the area to all other groundfish, halibut and scallop harvest and has prohibited anchoring. This is the first no-take groundfish reserve in Alaska.

**Reference:**

O'Connell, V.M. 1993. Submersible observations on lingcod, *Ophiodon elongatus*, nesting below 30 m off Sitka, Alaska. *Mar. Fish. Rev.* 55(1): 19-24.

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**Summary Report on the Results of Phase I [2000-2002] of Stage II of the Japan/SOPAC Co-operative Deep-sea Mineral Resources Study with Future Initiatives of the Programme from 2003 to 2005**

*Nobuyuki Okamoto & Cristelle Pratt*  
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SOPAC and the Government of Japan have been jointly conducting surveys of deep ocean mineral resources in the EEZs of SOPAC member countries since 1985. The first stage of this joint project comprised three, five-year phases, with surveys conducted within the EEZ's of eleven SOPAC member countries, being the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. The primary objective of the first stage was to assess the marine mineral potential of these eleven countries.

The first three-year phase of Stage 2, completed in March 2003, involved surveys within the EEZ's of the Cook Islands, Fiji and the Marshall Islands. Its objectives, and the proposed objectives for the recently finalised second phase, was to evaluate the resource potential of marine minerals in the prospective areas found during Stage 1 in selected countries, as well as acquire environmental baseline data for use in environmental assessments in the event of future marine mining activities.

A new agreement for ongoing deep ocean mineral exploration of the seabed in selected areas within the Exclusive Economic Zones (EEZs) of the Federated States of Micronesia (FSM), Fiji, Kiribati and Niue, was signed on 27 February 2003, at the SOPAC Secretariat in Suva by representatives of those countries, the South Pacific Applied Geoscience Commission (SOPAC), the Japan International Co-operation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The new agreement covers seabed surveys to be carried out over a three-year period commencing in April of 2003. The 2003 survey cruise will be conducted in the EEZs of Kiribati and Niue in November-December, 2003. The 2004 and 2005 survey cruises will acquire data within the EEZs of Fiji and FSM, respectively. The one-month surveys will use the Japanese Research Vessel *Hakurei Maru No 2*.

The overall project, since its inception in 1985, has obtained excellent results and has identified numerous sites with potential marine mineral resources of manganese nodules, cobalt-rich manganese crusts and polymetallic massive sulphides. The deep-sea mineral resources contain valuable metals such as nickel, copper, cobalt, zinc, lead, silver, gold and other minerals. Pacific Island countries acknowledge the need to continue to collect deep-sea mineral resources data and information, in order to identify new mineral occurrences, as well as improve understanding of those resources that have already been found, as well as to understand the environmental baseline conditions that exist.

Findings indicate greater abundance of deep ocean mineral resources than similar mineral resources found on land. Anticipated manganese, nickel and cobalt resources of manganese nodules on the seabed are estimated to be over a hundred-fold greater than on-land resources. If this is indeed the case, it follows that deep-sea mineral resources within the Pacific Islands region may hold an important opportunity to the future sustainable economic development of some Pacific Island States.

To date, the Japanese Government has spent approximately FJD 120 million on this eighteen-year joint project. A further FJD 15 million is anticipated to be spent over the next three-years.

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**Pacific Islands Regional Ocean Policy Implementation**

*Cristelle Pratt for the CROP- Marine Sector Working Group [MSWG]*

The Pacific Islands Regional Ocean Policy [PIROP], which was endorsed by the Pacific Islands Forum Leaders in

August 2000, promotes stewardship in addition to ownership and articulates the following guiding principles:

- Improving our understanding of the ocean.
- Maintaining the health of the ocean.
- Creating partnerships and promoting cooperation.
- Sustainably developing and managing the use of ocean resources.
- Promoting the peaceful use of the ocean.

In response to instructions from the Pacific Islands Forum Leaders, the Council of Regional Organisations in the Pacific [CROP] will be convening the Pacific Islands Regional Ocean Forum [PIROF], as the implementation mechanism for the PIROP. The objective of the PIROF is to produce a comprehensive *Pacific Islands Regional Ocean Framework for Integrated Strategic Action [PIROF-ISA]* for:

- The sustainable development of ocean resources in the region.
- Achieving better coordination of implementation of existing international and regional obligations.
- Consistent/compatible national action on ocean issues.
- More effective coordination of regional organizations.

This regional framework for ocean initiatives based on the PIROP will ensure the sustainable development of all ocean resources and provide an enabling environment for ocean governance for the Pacific region.

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**Planning for coastal hazards and climate change – examples from New Zealand and Kosrae**

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At first glance one would not expect coastal hazard problems and issues experienced on the New Zealand coastline to be similar to those on a small Pacific Island such as Kosrae in the Federated States of Micronesia. Whilst there are indeed many differences, most of the problems and issues that arise in relation to coastal hazards, and the approaches for mitigating and adapting to them, are indeed similar.

Too often, the management of coastal hazard risks has favoured reactive, short-term solutions such as inappropriate coastal defences, with insufficient regard for the over-riding objective of sustainable management of the coast. In attempting to achieve this objective, coastal resource managers and planners face increasing pressures and difficulties. Examples are the increasing social, economic and political pressures to intensify development of coastal areas, the public perception of existing use rights, permanence of buildings and infrastructure, (local) government responsibilities for protection from coastal hazards, a lack of guidance on the range of land-use management options available, and how to apply them effectively over longer planning horizons, to name but a few.

Increasingly the use of risk-assessment techniques is being used to incorporate issues such as coastal hazards and climate change in to the overall decision-making process, whether it be at the policy, strategy or project level.

Risk is usually thought of as the combination of the *likelihood* of say a particular hazard occurring with the *consequence* that arises should that hazard happen. In attempting to manage the impacts of coastal hazard risks, bitter experience has shown us that reducing the likelihood of coastal hazards occurring can be a difficult, and in many cases, a futile, expensive and non-sustainable process. Although such approaches to mitigating risk are often the most widely applied, e.g. coastal defences, and are appropriate in certain cases, managing (or avoiding) the consequences is generally a more effective long-term strategy. Experience in New Zealand and Kosrae has shown that the key to better management of the consequences is highly dependent on:

- Increasing our current understanding of the short- and long-term variability in coastal hazard “drivers”, their interactions and causes, together with the effects climate change may have on each of these “drivers” individually and collectively;
- Raising awareness of coastal hazard and climate-change issues both within the decision-making process and with local coastal communities;
- Focussing on long-term adaptation through effective planning, guidance and decision-making;
- Effective monitoring and review programmes in place that are based on site-specific objectives;
- Ensuring that the mechanisms for extensive and ongoing communication are in place for all stakeholders.

As an example, to strengthen the links and interactions between scientists, policy makers, planners and emergency managers in New Zealand, NIWA and the Institute of Geological and Nuclear Sciences (or GNS) have established the Natural Hazards Centre that covers all natural hazards. This builds on NIWA’s (and complementary research at GNS) research programme on Mitigating Weather, Flooding and Coastal Hazards and the public-good activities associated with this research. The key role of the Centre is to communicate research results and information to assist the incorporation of an “all-hazards” consideration within relevant decision-making processes.

NIWA has also recently developed Guidance Notes, funded by the Ministry for the Environment, to strengthen the integration of coastal hazards and climate change within the land-use and development planning process using a risk-based approach. This provides a framework for incorporating risk assessment within the decision-making process and aims to be flexible enough to be applied to a wide range of situations where both coastal hazards and climate change need to be considered, e.g. policy, strategy planning, specific localised issues. The Guidance Notes are applicable to all levels of risk assessment, depending on the level of information and monitoring data available and the degree of vulnerability.

The island of Kosrae, applied the same key considerations for adapting to coastal hazards on an island-wide scale through the process of a shoreline management project. This commenced in 1998 and was coordinated by the Development Review Commission on Kosrae. A major effort in the early stages of the project was focused on identifying and understanding the coastal hazards likely to affect Kosrae, public consultation to ensure all issues were addressed, and raising awareness of these hazards both through training of local Government staff and public education activities. Whilst these activities are still ongoing, the emphasis has moved on to adapting to these hazards, and the potential effects of climate change, through long-term planning to reduce the potential consequences that these hazards pose. Examples of long-term adaptation activities occurring on Kosrae include:

- Provision of tools for improved land-use planning, which has included implementation of a Government wide GIS system (with SOPAC’s assistance), improving coordination between Government Departments, and degree training in GIS and Land Management at USP for Kosraean staff;
- Developing effective procedures to ensure that all housing funded through the Government Housing Loan Program is located on land where the long-term risk from coastal hazards is low;
- A long-term approach to Lifelines e.g., upgrading inland roads between the main villages to ensure access can be maintained if the coastal road is damaged or lost in the future, and re-direction of electric power lines along the inland roads (which in itself will encourage people to move inland);
- Investigations to develop more sustainable sources of construction aggregates.

So in essence, there are many elements of commonality in planning for and adaptation to coastal hazards and pending climate change impacts, which can be built around a flexible risk-based approach.

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**The practicalities of developing sustainable sources of aggregates**

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The removal of sand and coral rubble from the coastline has been a major cause of coastal erosion on the island of Kosrae in the FSM, as on many Pacific islands. Large-scale (mechanical) removal of sand from the beaches on Kosrae ceased in the early 1990s when a permit process was introduced to control aggregate extraction. However, small-scale, localized sand mining by hand continued, exacerbating the significant ongoing coastal erosion problems being experienced around the island. In addition, suitable land-based deposits were

becoming extremely limited with the permit process increasingly under pressure to allow sand extraction from unsuitable sites.

Attempts to control sand mining have typically focussed on regulatory mechanisms. However, there are few examples from small island states where regulating the removal of sand from beaches has been successful without other supporting activities.

An integral component of the Kosrae Shoreline Management Project, being conducted by the Development Review Commission on Kosrae, was the development of a road map to address Kosrae’s sand resource and sand mining problems. Whilst there was considerable pressure to implement full sand mining regulation, this found that such a measure alone would impact most on low-income households, did little to solve the problem of where people can get construction sand from, would lead to pressure on the Development Review Commission to permit sand mining from unsuitable locations, and be difficult to enforce on a small island such as Kosrae. To fully address the problem required:

- Complete political support to stopping sand mining practices;
- Development of a good and affordable alternative source of aggregate and appropriate scientific assessment of the resource and impacts of its utilisation;
- Continued education campaigns;
- Tackling special interests groups with sand mining interests, e.g. housing loan recipients; and
- Perseverance – the problem will not be solved overnight, month or year, it is a problem that needs to be continually addressed.

Only by adopting such an integrated approach would it be possible to begin to tackle Kosrae’s sand aggregate and beach sand mining problems, and to effectively implement regulatory measures.

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**Low-cost assessment of ecosystem health indicators in the South Pacific region by combining remote sensing and (community) field monitoring methodologies**

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Volunteer marine monitoring programmes are implemented worldwide but are not yet contributing globally to observations of coral and seagrass habitats using remote sensing. Remote sensing is an effective tool to cover substantial areas and areas which are logistically challenging to reach. These areas are often the coastlines of those countries in the world that do not have the funding, equipment and knowledge to monitor the health of these habitats. It is these coastlines that are highly important for those countries as free barriers and as natural resources, and for the world as primary producers. Worldwide knowledge about these ecosystems is needed to have a better understanding of large-scale impacts such as global warming. It is these countries that have a large network along their coastlines of tourist areas where volunteer monitoring programmes have started to be implemented. This study will determine how global field monitoring programs can be adjusted to contribute to the validation of multi-spectral imagery. The field methodology in combination with remote sensing imagery and analysis technique needs to be low cost, effective and simple to implement so that it will improve global monitoring and the management of tropical marine environments.

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**Setting the scene for sustainable development in aggregate resources, Majuro Atoll, Republic of the Marshall Islands**

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The Environmental Protection Agency (EPA) of the Republic of the Marshall Islands is concerned that continuing extraction of sand and gravel aggregate from the reef, beaches and nearshore areas of Majuro Lagoon is unsustainable and is contributing to fringing reef degradation and shoreline erosion.

Existing sand extraction sites and methodologies used in Majuro have generated a number of social, economic and physical (coastal erosion) issues which require the government, private sector and the traditional

landowners to work jointly towards a common goal that is environmentally and economically acceptable to all stakeholders.

Government in its pursuit of sustainable development goals in developing policy and environmental planning can achieve some of those goals if their decision-making is backed up by sound geoscience information. For the private sector, economic viability is the primary issue and therefore investment confidence must be realized. For traditional landowners, their understanding and consent, and their confidence in government to be a responsible custodian in development are also issues to be balanced against equally desirable economic growth.

To assist Government in adequately addressing these issues, a comprehensive survey was undertaken using high-resolution multibeam bathymetric mapping combined with IKONOS satellite imagery as the base on which existing and new data were collated into one integrated database. As a tool for whole Island Management, this geoscience database will be invaluable not only towards the control and monitoring of aggregate extraction areas but also provide an inventory of other resources within Majuro Lagoon.

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**NLTB – GIS pilot project**

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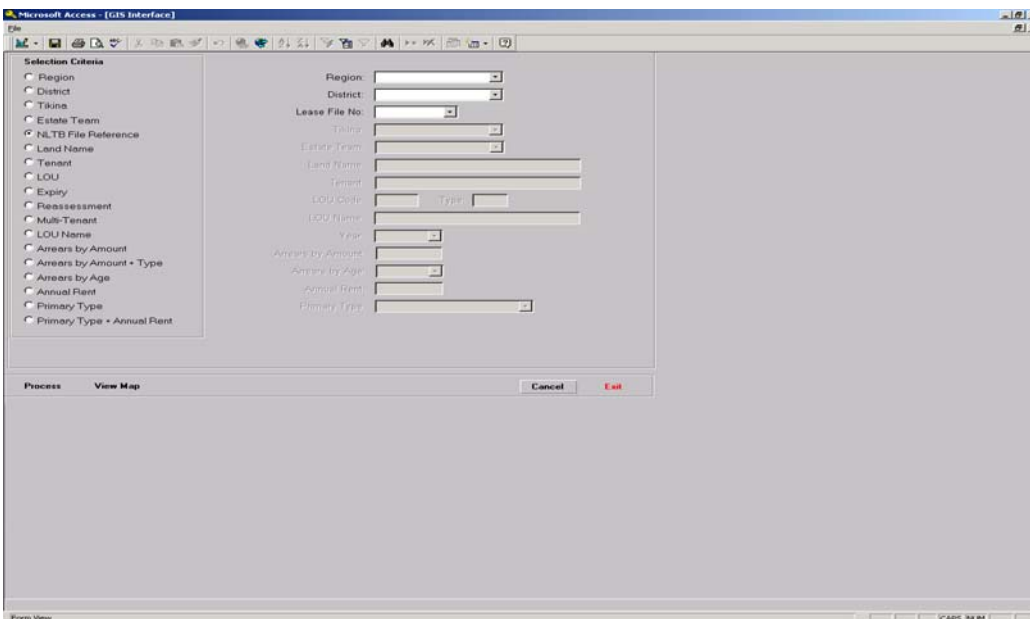
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The Native Land Trust Board administers 93.7% of the total lands in Fiji. For the organisation to be efficient and effective in its services to the stakeholders, it is vital that a system is in place to enable the organisation to achieve its goals. Therefore, a GIS system was set up to address issues like expiring leases and lease allocation to new tenants to name a few. This system has also been set up to facilitate the allocation of suitable land for agriculture, residential, industrial and commercial developments.

A pilot project was then designed to address queries that are normally made through our public counter by the Public as well as the Estate officers to help them carry out their jobs efficiently.

The software used for this project are Microsoft Access and MapInfo with MapBasic. The Interface is Microsoft Access whereby when queries are made, a temporary output table is created in Access. This table will then link with the table in MapInfo graphics. Concurrently the Map Basic program calls up the MapInfo, which then opens the table (graphics) of the queried data. The database called the Native Land Management System (NLMS) already exists in Sequel Server and selected fields only are displayed when the queries are made to create the output table. In effect there is always a live link to the NLMS whenever a query is made and this table will always be replaced by the new queries that are run.

The Interface Form in Access is shown below:



## Regional environmental controls on nodule and crust compositional variation in the SOPAC area

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Regional variation of Mn, Fe, Co, Ni and Cu in ferromanganese nodules and crusts in the central south Pacific is related to primary productivity, oxygen minimum layer, and calcium carbonate compensation depth. The largely latitudinal influence of these environmental parameters on deposit composition reflects their predominantly latitudinal variation. Primary productivity is the overarching regional environmental control, influencing diagenetic enrichment in nodules through its effect, mediated by the CCD, on supply and concentration of labile organic matter vs. carbonate remains to the sediments, and hydrogenetic enrichment in nodules and crusts through its effect, mediated by the O<sub>2</sub> minimum layer (mainly in the case of crusts), on the elements' export from surface waters. The elements' varying susceptibility to being scavenged or organically bound influences the contrasting composition of diagenetic vs. hydrogenetic ferromanganese oxides, which is further influenced by depth. Hydrogenesis is the fundamental process governing nodule and crust formation, superimposed on which is diagenesis under specific circumstances; both are subject to intermittent interruption, diminution and augmentation by changes in environmental parameters. Application of regionally-operative environmental controls locally explains local compositional variations and helps refine exploration criteria for potentially economically viable nodules and crusts.

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## The Hawaii-Emperor Bend: an unequivocal record of Pacific Plate motion change

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At the brink of being explained away as the mere consequence of a drifting plume, newly reported radiometric dates on seamounts at the Hawaii-Emperor Bend (HEB) reveal an age much older than expected. Unlike the previous younger age (~43 Ma), the older age (~48-49 Ma) allows the bend to be directly correlated with a period of pronounced, global tectonic reorganizations. This new HEB age has been incorporated in a newly revised Pacific Absolute Plate Motion (APM) model based on an iterative hybrid method using both the Polygonal Finite Rotation Method, to determine accurate positions of finite rotation poles, and the hot-spotting technique, to predict present locations of all hotspots. Considering the success of the newly-revised Pacific APM model to simultaneously fit numerous Pacific trails with contemporaneous bends, we grant the fixed hotspot hypothesis a new lease of life.

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## Regional Biomass Resource Assessment Project

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Biomass energy resources have been and remain to be the major source of energy for the people of Pacific Island Countries (PICs). On average, biomass accounts for about 90% of the rural energy use and 25% of the urban energy use.

The regional biomass resource assessment project is part of an overall programme designed to facilitate the development of SOPAC member countries' biomass resources in order to provide alternative options of meeting the countries energy needs. As a start, six PICs participated in the first phase. The limit in the number of participating countries has been due to funding constraints.

There were two parts to the project, one being the training component which entails in-country training on biomass resource assessment techniques and methodologies and the second component covering the quantification of the biomass resources available in each participating country. The training component more specifically covered areas such as:

- The biomass fuel production chains;
- Types of biomass resources e.g. energy crops, residues and wastes (including municipal, animal, human and industrial wastes);
- Methodologies for measuring biomass resources;
- Project implementation;
- Policy issues relating to biomass production and use and linking this with environmental considerations;
- Case Studies – coconut oil, forestry residues, waste treatment & management; and
- A general introduction to biomass energy – its role in the development process, its impact and other issues such as climate change and linking these with the various international agreements relating to greenhouse gas emissions and climate change.

In addition to the training material, three Reports have also been produced:

- Individual Country Biomass Resource Assessments;
- Regional Synthesis Biomass Resource Assessment; and
- Biomass Energy – Master Development Plan.

The project has already identified a number of potential biomass projects that can either be implemented on a regional basis or nationally, and is identifying a series of 'next steps' to implementing a regional biomass energy programme.



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