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Note from the compilers:
Receipt of abstracts was closed Thursday, 8 November 2007. Abstracts received after that date; as well as abstracts left out of pre-Session version are included in this version. The Final Programme is at the end of this document.

FOREWORD

STAR (SOPAC's Science, Technology and Resources Network) was founded in 1985 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 Hawai'i Institute of Geophysics, guided STAR until 1992. He was succeeded by Keith Crook from the Hawai'i Undersea Research Laboratory. Keith served until the end of 1999 when John Collen from Victoria University 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 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 mobilise excellent and multi-disciplinary 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 endeavour, 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. Since 2005, Programme Monitoring and Evaluation Groups (PMEGs) composed of TAG scientists have met with SOPAC Programme Managers prior to the STAR Meeting and then reported to Council as independent advisers during the joint TAG/Council part of the Annual Session.

In earlier years STAR was primarily concerned with "blue-water" marine geoscience, tectonics and resource exploration and evaluation. However, as national needs and priorities have changed, the scope of STAR has similarly altered, partly reflecting changes in the focus of global science but also to ensure that SOPAC's Work Programme and its forward planning are assisted by international and inter-disciplinary 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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ABSTRACTS OF PAPERS

ALCOCK

Australia case study – Extended Continental Shelf Submission

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In November 2004 Australia lodged its submission for continental shelf under article 76 of UNCLOS to the Commission on the Limits of the Continental Shelf, one day short of the original 10-year deadline. This was the culmination of more than 10 years of work, and was the result of inter-agency collaboration between Geoscience Australia, the Department of Foreign Affairs and Trade, and the Attorney General's Department. Australia's submission will be one of the largest and most complex submissions that is likely to be made to the CLCS. Being only the third submission to be made, it also had to address many issues not previously considered by the CLCS.

Since 2004 the Australian delegation has attended 6 sessions of the CLCS, the latest in September this year. In this time, Australia has completed its interactions with the Subcommission considering its submission and is now at the stage of having the final recommendations considered by the full Commission. Australia fully expects these considerations to be finalised at the next session of the CLCS in April of 2008.

In this presentation I will discuss the latter part of Australia's submission process and some lessons that we have taken from it that may be of value to states as they prepare to make their own submissions.

BELL & Others

Coastal Zone Management in the Wakatobi Marine National Park, Indonesia: monitoring Marine Protected Areas (MPAs) and Habitat Connectivity

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The Wakatobi Marine National Park (WMNP) is located in the extreme south-east of Sulawesi, Indonesia and was declared in 1996. The park comprises an area of approximately 1,390,000 ha and supports highly biodiverse ecosystems including mangroves, seagrass beds and coral reefs; these ecosystems are under considerable threat from human activities. Despite more than 10 years since the park was declared the ecosystems have continued to decline, with only localised conservation efforts proving partly effective. This presentation will provide an overview of the WMNP including the specific threats and patterns of resource utilisation in the region. I will discuss the declines in reef recourses, which have been documented since large-scale monitoring was implemented in 2002, and the patterns of change in the dominant reef organisms; the

decline in coral and fish abundance has resulted in the increased abundance of other reef organisms, particularly sponges and soft corals. Furthermore, I will describe the effectiveness of small-scale Marine Protected Area use in the park and the importance of habitat connectivity in the development of sustainable coastal zone management plans. Finally, I will discuss the lessons learned from research within the WMNP and how these might provide insight into Pacific Island reef resource management.

BIRIBO & Others

The Role of Socio-Economic Information in Integrated Coastal Area Management in Kiribati

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The urban atoll of South Tarawa has an approximate land area of 16 km^2 and is now home to some 45,000 inhabitants. It is capital of Kiribati, the centre of commerce and hosts the country's main communications links and ports. Characterized by extremely rapid development and urbanization and an unavoidable departure from traditional modes of living, demand for resources is placing unsustainable pressure on the Tarawa Atoll environment.

Aggregates have traditionally been sought from the shoreline beach environment however the vastly increased demands in South Tarawa have greatly contributed to shoreline erosion and instability. This combined with dense overcrowding which forces people to live in marginal unstable shoreline zones and the overarching concerns that climate change stress brings to atoll communities, has resulted in an overwhelming need to reduce pressure on shoreline systems and take action to bolster natural resilience and reduce vulnerability of coastal communities.

The SOPAC EU-funded 'Reducing Vulnerability' Project confirmed that beach mining was a significant contributor to shoreline erosion issues in South Tarawa and in cooperation with the Government of Kiribati and the European Union, a sustainable aggregate alternative is being developed. However, it is broadly recognized that the technical solution alone is only a component of addressing the issue of beach mining and important socio-economic questions remained; e.g. who was mining aggregate and why, which areas are mined and how intensively, what types and volumes of aggregate were being removed, how important was aggregate mining as a source of income, etc.

A socio-economic study was undertaken as a component of the SOPAC/EU Project's integrated approach to shoreline instability on South Tarawa, Kiribati; and provided key analysis contributing to the design and approach of the sustainable aggregate resource solution. Much of this understanding was in turn underpinned by the results of a community household survey undertaken collaboratively by SOPAC and the Government of Kiribati. This paper will present how and why this survey was conducted and discussion of the implications of the results gained. Further, these empirical indicators continue to support efforts to address beach mining and to ongoing shoreline management in South Tarawa. Ultimately, this study highlighted the pivotal role that pertinent socio-economic data plays when integrated with sound technical approaches to vulnerability issues.

BONTE-GRAPENTIN & Others

The Navua Flood Warning System

***Michael Bonte-Grapentin*[1], *John Fenwick*[2], *Faga Finiasi*[3], *Rajendra Prasad*[4], *Joeli Rokovada*[5], *Paula Holland*[1], *Stephanie Zoll*[1], & *Anthony Blake*[1]**
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The costs to Fiji of flooding are high, with Fiji estimated to lose an average of 10 lives and F$22 million nationally every year. In Navua, a flood warning system is critical since flooding here can be particularly severe and damaging floods occur on average every 7 years according to a 200 year documented flood record. The costs of the last major flood at Navua in 2004 alone had been estimated around a minimum of F$10 million. By comparison, establishing and running the Navua Flood Warning System is estimated to cost around half a million over the next 20 years. Investing early in such disaster risk reduction initiatives is therefore a wise investment for Fiji. According to an economic benefit-cost analysis conducted by SOPAC, the Navua Flood Warning System could save the Fiji economy millions of dollars.

The implementation of the Navua Flood Warning System has been made possible with funding from the European Union through the regional SOPAC/EU Project *Reducing Vulnerability of Pacific ACP States* and the contribution of various Government agencies, namely the Hydrology Section, the Fiji Meteorological Office, the National Disaster Management Office, the Provincial Administration and local response agencies and authorities. Bringing together and strengthening the linkages and cooperation between these agencies in managing flood risks in the Greater Navua area has been the cornerstone of the system.

Timely and accurate flood warnings can save lives and property. The Navua Flood Warning System will alert and inform local response agencies and authorities as well as the population in the Greater Navua area of an approaching flood wave up to a few hours in advance. Knowing that a flood is imminent means that action can be taken in the flood-prone areas to reduce flood impacts. Such actions include safeguarding possessions, securing livestock and moving to higher ground or to an evacuation centre.

The Navua Flood Warning System is a combination of river-level gauges and rain gauges which are placed at strategic points within the Navua catchment. The river-level recordings monitor and detect rising river levels to predict when a flood is expected to impact downstream communities and the approximate severity of the flood. The available warning time depends on how far upstream the river-level gauge detecting the rising water level is located. The two newly established sites will provide approximately ¾ to 2½ hours warning, respectively. Additionally 6 rain gauges complement the system to improve the forecast and enable even longer lead times once sufficient flood data is collected to calibrate a 'rainfall – runoff' model.. The information gathered by the river-level and rain gauges is broadcasted instantly by VHF radio to a base station at the Hydrology Office in Suva.

The Hydrology Office will be responsible for archiving the data and operating and maintaining the system during 'normal times'. The ongoing field data collection programme undertaken by the Hydrology Section forms the basis of the Navua flood model. Without such ongoing field work, flood assessment, modelling and warning would not be possible.

A second base station at the Meteorological Office in Nadi, will receive data through the Internet from the Hydrology Office. The Fiji Meteorological Service, in consultation with the Hydrology Office, will provide flood forecast and warning services to national and local response agencies, authorities, media and the general public through a combination of auto faxes, text messages, e-mail and phone calls.

Once a flood warning is issued the Provincial Administration and local response agencies and authorities will manage the flood response in accordance with the Greater Navua Flood Response Plan developed as part of the system. The Provincial Administration needs to ensure communities within the Greater Navua area are aware and prepared to respond to flood warnings as well as to regularly test the Flood Response Plan.

BULEKA

Development and Partnership trends in the Pacific through the Delimitation Project beyond 2007

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Papua New Guinea (PNG) is sandwiched between the northeast migrating Australian and the southwesterly advancing Pacific plates. These two major plates have considerable influence on the regional geology and the bottom topography of the seas surrounding the Papua New Guinea mainland. A number of smaller plates have developed as a result of lengthy compressional stresses between the above two major plates.

Papua New Guinea has ratified the Law of the Sea Convention on the 14th January 1997 and as a result formed a Delimitation Committee to look at key issues for the implementation such as consent regime for conduct of marine scientific research in Papua New Guinea waters and boundary delimitation. One such issue identified was maritime boundary base-point updates under the Offshore Seas Proclamation under the National Seas Act.

There are other Law of the Sea requirements for consideration. Under the Law of the Sea Convention Papua New Guinea must submit to the UN by April 2009 charts of its extended continental shelf and this also applies to other Pacific countries. Under international law all coastal states have the legal continental shelf of the sea bed and the subsoil.

Scientific and technical criteria in the Convention are a very technical process and Papua New Guinea has obtained assistance from the Commonwealth Secretariat in London as part of the process to determine whether it can make a claim on the continental shelf. This was undertaken pursuant to a process of the desktop study through the engagement of a consultant.

There are already offshore explorations being undertaken by Nautilus Mining in the Bismarck Sea, within the archipelagic waters of Papua New Guinea. The company has increased its activities in the area with additional exploration licences.

Fisheries is the fourth important resource sector in Papua New Guinea and in other Pacific countries this is the most important and only resource for their state. The rules of origin and the Cotonou Agreement for the Pacific Island Countries is critical as most island countries, unlike Papua New Guinea, are very dependent on fish products as their main economic resource.

Papua New Guinea has proposed to a high-level meeting in Brisbane in January 2007 to explore ways for a fair and equal proportioning of the Ontong Java Plateau. Papua New Guinea has advanced this by having bilateral talks with Solomon Islands and Federated States of Micronesia and also Indonesia on the issue of maritime border treaty. This may speed up the ratification of the maritime boundary treaty with Federated States of Micronesia.

The SOPAC/EU/EDF8 Project with funding assistance carried out coastal bathymetric surveying in Papua New Guinea in 2006. Additional resources are required to map the high seas common to a number of countries to lodge a claim before the deadline.

CHAND & Others

A study of Marine Pollution in Walu Bay and Kinoya Sewage Treatment Plant outfall using foraminifera community structure analyses (Suva, Fiji Islands)

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This study was aimed at evaluating the pollution status of Walu Bay and Kinoya Sewage Treatment Plant (STP) outfall by means of foraminifera community structure analysis. Two short (40 cm long) sediment cores were taken from each of the above mentioned sites (Kinoya at 6 m depth and Walu Bay at 11 m depth). The cores were split into 8 cm segments and each segment was wet sieved to separate the foraminifera into size classes for easier picking. The foraminifera species were identified after they were picked out with the aid of a dissecting microscope. A total of 17 species were found, most of which could be identified using text books and research papers. The most abundant species were *Ammonia beccarii* (Linne, 1758), *Operculina ammonoides* (Gronovius, 1781), *Elphidium craticulatum* (Fichtel and Moll, 1798) and *Spiroloculina attenuata* (Cushman and Todd, 1944). The study of foraminifera species from core samples at Kinoya Sewage Treatment Plant outfall and Walu Bay shows an inversely proportional relationship between the foraminifera species diversity and abundance, and pollution over the length of the core. The major species in the top sediments at Kinoya is *A. beccarii* which is considered an indicator for high nutrient levels (Varshney and Govindan, 1981). At Walu Bay *O. ammonoides* is the most prominent species at the top and throughout the core probably as a function of the coarser grain size (Willem, 2003). Analyses of the fauna using the Shannon-Weiner index indicate a higher foraminifera species diversity at Walu Bay (Shannon-Weiner index range: 1.7 – 2.5) compared to Kinoya (Shannon-Weiner index range: 0.8 – 2). The bottom layer of the core has a higher foraminifera species diversity and abundance than the top. A diversity peak occurs in the middle of both cores. Smith (2005) found an average sedimentation rate of 0.5 cm/yr in Laucala Bay, and based on this the 40 cm core covers an age range of approximately 80 years (1927 – 2007). Cluster analysis of the samples and the species showed the findings of the core studies are significant. There is a higher abundance of ostracods at the Kinoya site than at the Walu Bay site, possibly due to lower salinity at the Kinoya site which is influenced by the Vatuwaqa and Vunidawa rivers. The sediment sieve analysis revealed the presence of finer-grained sediments at Kinoya compared to Walu Bay. The findings of the study identified foraminifera as an important biological indicator to assess pollution and at both sites a sharp decline in species diversity can be observed towards the top of the sediment column (most recent) suggesting that water quality has declined to more unfavourable conditions for most foraminifera species over the last 30 years.

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COLLEN & Others

Historical Shoreline Changes and Sediment Redistribution, Palmyra Atoll, Equatorial Pacific Ocean

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Reef islands of Palmyra Atoll in the northern Line Islands, equatorial Pacific Ocean underwent mainly minor natural changes in shape and size between 1878 and 1940. Naval airbase construction between 1940 and 1945 caused major changes, with a channel dredged into the lagoon, several islands greatly enlarged, most islands ringing the lagoons joined into a continuous roadway, a causeway built between two lagoons and several new islands created. Overall, the land area approximately doubled and the land volume probably trebled during this period, and water circulation between reef flats and lagoons was blocked. After 1945, new construction and most maintenance ceased and, following purchase by The Nature Conservancy in 2000, the atoll was designated a national wildlife refuge in 2001. This protection means that, unlike similar places where population pressures and infrastructural development require coastal protection, effects of natural processes on the modified islands can here be observed and monitored. Coastlines of larger islands have simplified since 1945 by infilling of bays and erosion of promontories, at net rates of up to 1.8 m/yr. Narrower land masses have broken into smaller islands with intervening channels and arcuate shapes. Sediment now moves mainly westward along ocean coasts, into lagoons on lagoon coasts, and with tidal currents where causeways have been breached.

CUMMINS & BABA

Modelling of Seismic and Tsunami wave forms for the 3 May 2006 Tonga (Mw = 8.0) and the 1 April, 2007 Solomon Islands (Mw = 8.1) earthquakes

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In order to assess the potential size of a tsunami generated by a large earthquake, not only the magnitude but also the detailed seafloor deformation caused by the earthquake is needed. When a fault ruptures in an earthquake, the fault slip is not evenly distributed over the fault but is

typically concentrated in one or more 'patches' of high slip called asperities. The effectiveness of tsunami generation is strongly dependent on where these asperities occur on the fault, and particularly on whether they occur at a deep or shallow part of the fault.

We have used seismic waveform data recorded at distant stations to estimate the slip distribution of the 3 May 2006 Tonga (Mw = 8.0) and the 1 April 2007 Solomon Islands (Mw = 8.1) earthquakes. Both of these earthquakes caused tsunamis, and we test whether the slip distribution estimated from the seismic data is sufficiently accurate to predict the tsunami waveforms recorded at deep-ocean pressure sensors and coastal tide gauges. We conclude that the slip models derived for these earthquakes are sufficient to predict tsunami waveforms recorded at deep-sea pressure gauges, but this is true for coastal tide only if high-resolution bathymetry data is available for the shallow water around the tide gauge.

This work is important for two reasons. First, the use of seismic waveforms to reliably estimate slip distributions for large subduction zone earthquakes suggests that such a procedure can be utilized in a tsunami warning system to estimate the characteristics of a tsunami that may impact coasts distant from the tsunami source. Second, understanding how far earthquake rupture extends along a subduction zone megathrust is an important constraint on the maximum magnitude of an earthquake (and hence tsunami) that can be expected to occur there.

D'ADAMO & Others

Ocean Observations (*Integrated Marine Observing System*) and modelling (*Bluelink*) in Pacific Waters off Australia

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Two major oceanographic initiatives recently launched in Australia have relevance to the observation and prediction of oceanographic processes in Southwest Pacific waters off Australia. The Australian *Integrated Marine Observing System* (IMOS) (www.imos.org.au) will result in enhanced long-term monitoring of key bio-physical oceanographic variables off Australia, based around intensive monitoring in regional nodes (including the Great Barrier Reef and southeast Australia off Sydney). Additionally, the 'Blue Water and Climate' node of IMOS will provide important enhancements of the Argo float network and XBT transects from Ships of Opportunity (Sydney-Wellington, Brisbane-Fiji), and glider deployments and moorings will provide important contributions to future science plans for SPICE (Southwest Pacific Ocean Circulation and Climate Experiment). *Bluelink* (www.bom.gov.au/bluelink) is an ocean forecasting system developed under collaboration through the Australian Bureau of Meteorology, Royal Australian Navy and CSIRO. The major forecasting component of *Bluelink* is a global ocean modelling and assimilation system, OceanMAPS, with a resolution telescoping from 2º in the North Atlantic to 0.1º (about 10 km) in the Asian-Australian region (90º E to 180º E, 16º N to 75º S). This model forms the backbone of the operational ocean forecasting system operated by CSIRO and the Bureau of Meteorology and produces twice weekly forecasts of up to seven days. An interrogative tool on

the Internet allows the user to obtain forecasts on coastal and ocean currents and eddies, surface and subsurface ocean properties, that impact and are linked to maritime and commercial operations, defence applications, safety-at-sea, ecological sustainability, regional and global climate. The next *Bluelink* generation will expand the high-resolution domain of the forecasting system and will include the whole of the Indian and Pacific oceans.

DOMINEY-HOWES

Australian Tsunami

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The Indian Ocean Tsunami of 2004 (IOT 2004) has resulted in significant interest in Australia about the record of tsunami for the continent because an understanding of tsunami hazard begins with a catalogue of past events. Here a preliminary catalogue of tsunami affecting Australia is presented. The catalogue contains entries for 58 events. The oldest event is dated 3.47 Ga, the most recent is the 1st April 2007. Forty-five tsunami were recorded on the New South Wales coast although the northwest coast of Western Australia records a significant number of events. Forty-eight events have affected Australia since AD1858. Maximum run up for a historic event is +6 m asl whilst the maximum reported run up for a palaeotsunami event is at least +100 m asl. Twenty-three percent of Australian tsunami were generated by unknown causes and from the historic record, Papua New Guinea, the Solomon Islands and Indonesia collectively represent the most significant source regions. The geological record of tsunami represents a potentially important source of information about Australian tsunami; however, at the present time, the geological record is both limited and controversial and future research should seek to re-examine proposed geological evidence of Australian tsunami.

EAGAR

Pacific Island Freshwater Ostracods

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There are about 60 species of freshwater and non-marine ostracods in the Pacific islands. This is a review of work in this field. There are only a few papers on Pacific island freshwater ostracods. Eagar (2000), Meisch (2007), Victor (1983), Victor & Fernando (1978), Wolff (1969). The records are usually peripheral to other studies. The problems are: most species are probably introduced, but there may be endemic ones on the older islands. We simply do not know. When were they introduced? How? Some genera have eggs that will not withstand desiccation. There is a lack of information. Most of the species have been described from other places outside the area, but we are not sure if they are the same or just look the same. The species found are not well-known species to taxonomists. We need a survey to start the project off.

One might expect greater speciation on older islands e.g. Solomon Islands and Papua New Guinea versus new (younger) islands or atolls. The oldest recorded freshwater ostracods are

5900 ± 60 years BP years from a swamp on Efate, Vanuatu. This fauna is similar to ones from New Zealand of similar age.

Ostracods are good indicators of different environments, but there are varying parameters. We need to find out what they are. For example: the magnesium content can be an indicator of paleosalinometry and paleotemperature. Ostracods are good indicators of pollution. Parthenogenic (asexual) reproduction over sexuals are the best ostracods to establish a new habitat as they only require one egg for the new colony. Sexuals are better for competition as they can adapt to changing ecological circumstances.

High clonal diversity goes together with the existence of bisexual populations and therefore with the potential of the generation of genetic diversity. The only species without bisexual parental populations (*Darwinula stevensoni*) has also the lowest clonal diversity. The genetic variability can be used for estimating the time scale of divergence among a different lineage of a species.

FORSTREUTER

New Space Borne Image Data for Pacific Island Countries

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Introduction

Pacific Island Countries are outside the footprint of any ground antenna to receiving image data recorded by different satellites. Images have to be stored on onboard tape devices where the space has to be booked well in advance. Often the target area is cloudy and the image data is not usable. In addition, the Pacific is sparsely populated in comparison to the area it covers and companies do not record images in advance hoping that there will be a customer later.

In 2007 and 2008 new satellites are and will be in space, which could change the situation for 1:10,000 scale mapping. The data quality increased regarding the spatial resolution to 40 cm instead of 60 cm as the best option and more satellites record high-resolution image data. In addition, the onboard storage capacity increased due to improved equipment. At last the first high-resolution radar satellite which records and provides image data at night and through clouds.

CARTOSAT-2

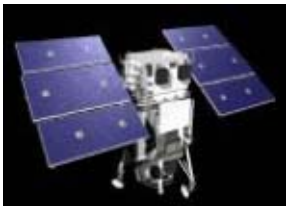
CARTOSAT-2 was launched in January 2007 and provides panchromatic (black and white) images of 80 cm spatial resolution. The sensor can look 45 degrees in all directions, which allows stereo image production and ensures a high repetition rate of image recording. It is expected that this satellite provides low-cost image data. The satellite is managed from India's National Remote Sensing Agency and the cost is not known yet.

EROS-B

EROS-B is an Israeli satellite, which was launched in April 2007. This satellite provides panchromatic images of 70 cm resolution, just 10 cm less than the best currently operating satellite QuickBird with 60 cm resolution. A

global network distributes the image data, where the point of contact for Pacific Island Countries is either the Center for Space and Remote Sensing Research in Taiwan or MDA in Canada as re-seller. It is expected that this image data will be distributed as low cost images as EROS-A data from the same company only cost USD 5 per square km while QuickBird data cost about USD 20.

WorldView-1

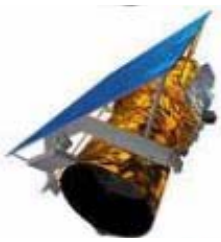


WorldView-1 will be launched in October 2007 and will provide 40 cm resolution data in panchromatic mode. Although the data will be resampled to 50 cm for customers outside USA it will be a further increase of spatial resolution, which could increase its potential use in the stratification of coconut palm stands. Also key is the increased onboard storage capacity of 750,000 km^2/day compared with 12,100 km^2 of IKONOS. DigitalGlobe handles the satellite and distributes the data.

WorldView-2

WorldView-2 will be launched in late 2008 and is also operated by DigitalGlobe. This satellite will record images of the same spatial resolution in panchromatic mode, but will have 8 spectral bands in multi-spectral mode. The coloured images will have a spatial resolution of 1.8 m and will cover new spectral bands not covered in this form by current satellites IKONOS, QuickBird or OrbView-3. The onboard storage capacity will increase to 975,000 km^2/day.

GeoEye-1



GeoEye-1 will be launched end of 2007 or beginning of 2008. The satellite will be equipped with a sensor capable of recording imagery with up to 41 cm resolution in panchromatic (which has to be resampled to 50 cm due to licensing issues) and 1.65 m in multi-spectral mode. GeoEye-1 will be able to revisit any point on Earth once every three days or sooner. The satellite will be able to collect up to 700,000 km^2/day of panchromatic (and up to 350,000 km^2/day of pan-sharpened multi-spectral) imagery per day. The image data will be distributed through Satellite Imaging Corporation in Texas for GeoEye Satellite Imaging. GeoEye also manages the satellites IKONOS and OrbView-3, which are still fully operational.

TerraSAR-X

TerraSAR-X was launched in June 2007 and is the first radar satellite recording high-resolution image data of about 1 m. The sensor also can record while orbiting the earth on the shadowed side. Infoterra GmbH, a German company, distributes the data. Available radar satellites so far such as ERS2, ENVISAT, RadarSat, etc. record with about 30 m spatial resolution, where shipping vessel were difficult to detect. This dataset allows the shape of the vessel to be recognised and the speed can be measured. The satellite will be also used for change detection of topography and high-resolution DTM production.

TanDEM-X

TanDEM-X consists of two high-resolution imaging radar satellites, which will be launched in late 2008. The systems are nearly identical to TerraSAR-X. The two satellites flying in tandem forming a huge radar interferometer capable of measuring terrain topography with 2 m height accuracy generate digital maps from any part of the world. Infoterra GmbH will also distribute the TanDEM-X data.

RTK GPS for Establishing Beach Profiles at 1 :10,000 Scale

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Introduction

Sand or beach movements on atoll islands have the potential to cause significant problems for housing and infrastructure. It is important to monitor where the sand drifts away (erosion) and where beach is building up (accretion). The reasons for these shoreline movements are still not fully understood. More understanding would allow a forecast to reduce negative impact. Contour lines of sub-metre accuracy are required to map the shape of the beach. The technique could also be used to create detailed DTM's for wind farms allowing the optimisation of windmill locations. Another application would be the ortho-correction of high-resolution image data, which so far does not work in Pacific Island Countries due to the missing DTMs. In May 2007 the sandbank in the Suva reef was surveyed representing a part of a beach on an atoll island.

Figure 1: *Base station in the centre of the sandbank of the Suva reef. From there it can transmit the position data for more than 1 km. (The transmission antenna pointing downwards on the left side of the instrument). The tripod position is marked with a peg for follow-up surveys.*

Figure 2: This base station unit contains the GPS antenna, the GPS receiving unit, the VHS transmitter and the battery.

Equipment and Setup

The survey used a Trimble R8 Global Navigation Satellite System (GNSS), which has a multi-channel, multi-frequency receiver capturing

American and Russian navigation satellite signals. The unit combines the GPS antenna, the receiver, the battery and the radio transmitter to send the base station signal to the rover unit. The rover unit is also a multi-channel, multi frequency unit, which combines antenna, GPS receiver, battery and radio receiver (see Figure 2).

The base station was set up on a tripod in the middle of the sandbank (see Figure 1) and position was temporally marked. It will be permanently marked with a stainless steel pin to be available for re-surveys.

The base station immediately averaged its position and transmitted the position data to the rover visible by a control light. Both base station and rover initialised within seconds after being switched on. This is a big improvement compared to the Trimble 4600 LS units of SOPAC, which took about 20 minutes.

Figure 3: Some lines were surveyed in the water, where the operator tried to walk in the same water depth to best capture a contour line.

Survey

The survey team first followed the visible contour lines, which are the high water mark, the water line and the vegetation line (see Figure 3). Then position data were captured along lines within the water and within the vegetation. Every 1 to 1½ metres the operator stopped, held the survey pole in the vertical position, which was verified by a little bubble and pressed the button and waited one or two seconds for the confirmation signal of correct data receiving before walking another 1½ metres. The confirmation signal ensures the receiving of correct satellite signals with the defined precision and base station signal. Re-survey due to weak signals or due to problems of differential correction can be avoided through this set up. The survey of the 4.4 hectares took about two hours including the set up of the base station.

Producing the DTM

The data download from the GPS rover unit does not require special software, as it can be exported as CSV files containing position data X, Y, Z, point ID and annotation. The CSV files (ASCII) can be imported into MapInfo, Access or ERDAS. MapInfo and Vertical Mapper were used as first display for checking the data integrity (see Figure 4).

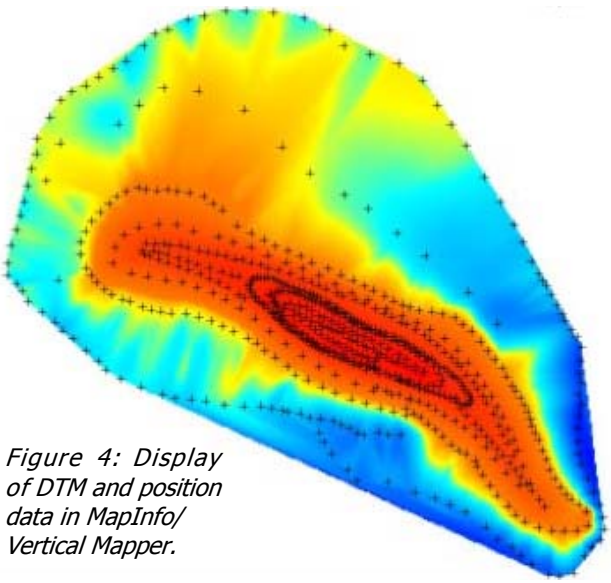

Figure 4: Display of DTM and position data in MapInfo/ Vertical Mapper.

The main data analysis was performed within ERDAS Imagine as this software environment provides more potential for data analysis and is distributed in most Pacific Island Countries. The import to ERDAS is most easy, if the ASCII file just contains X, Y and Z value

separated by a comma (,). Therefore the CSV file was first imported to Access, reformatted and exported as ASCII TXT file. The ERDAS module Create Surface produces a DTM from this ASCII file, where the user can define the cell size, the background value and the data type. The cell size of 1 x 1 m was chosen to correspond to high-resolution satellite image data purchased nowadays for Pacific Island Countries.

Calculating the Volume

For Pacific Island Countries it is important to know, how much sand is drifting away or built on the beach. Therefore the best way to quantify this is by calculating the volume using the DTM.

So far, the elevation values represented height above ellipsoid (HAE), something the user is not interested in. In the case of the sandbank survey 55 metres HAE was the lowest point measured when surveying in the water. This height value was used as a reference plane from which the DTM was re-calculated. This was performed with the ERDAS module Spatial Modeler, which reduced all height values to elevation above 55 metres HAE.

Knowing that the pixel size is 1 x 1 m (1 x 1 = 1) the volume represented by each pixel can be determined by the height value (volume = height). Therefore the total volume of the DTM is the sum of the height values of all pixels representing the survey area. There is no module in ERDAS, which sums pixel values; however, the pixel values can be exported from ERDAS to Access where a table can be created to enable the full use of analysis in the Access environment.

Simulation of Erosion Monitoring

The target of the survey and mapping exercise is to estimate the potential of quantitative change detection as mentioned above. Therefore a change of surface had to be simulated before the volume change can be calculated.

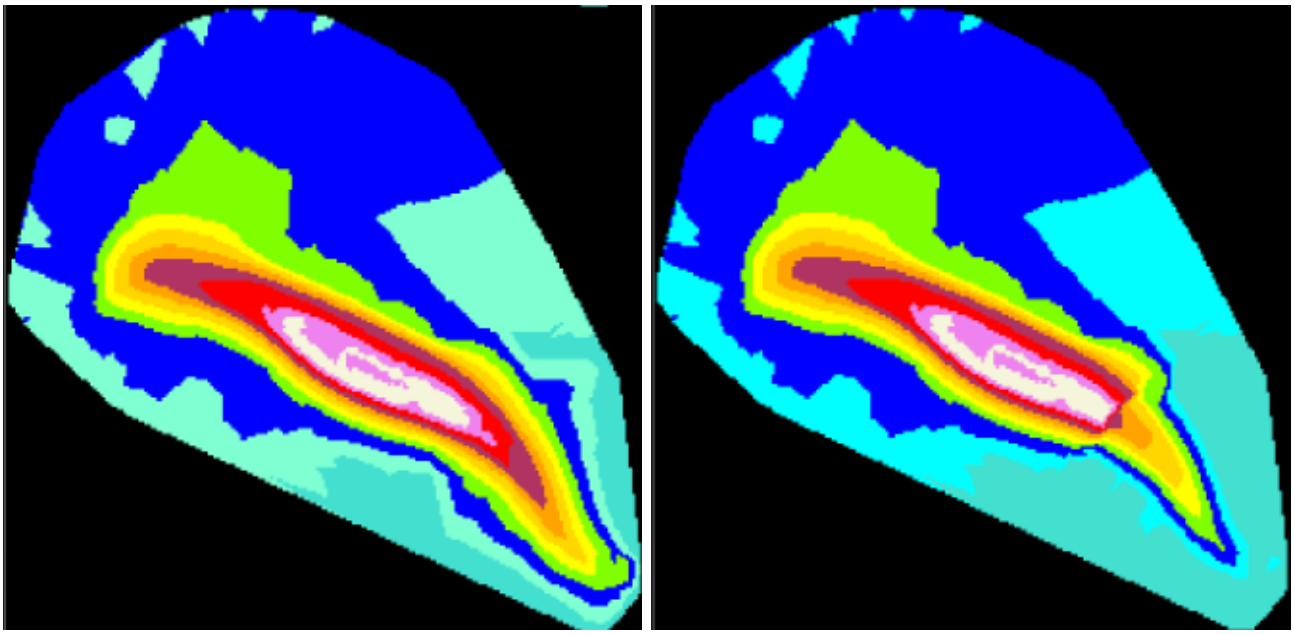

Figure 5: Display of DTM in ERDAS Imagine software as density slice of 20 cm height difference. Left the original DTM and right the simulated erosion by manipulating the GPS input data.

In MapInfo polygons were drawn representing areas where the sand would be eroded of 25, 50 and 75 cm. The GPS points within these areas were reduced accordingly. This was performed in

Access to which the points were exported from MapInfo. In ERDAS a new DTM was established with the manipulated GPS input data

Afterwards the volume was calculated again within the Access environment allowing a comparison of both figures. Both displays beside each other (see Figure 5) allow a comparison of both shapes. In addition, ERDAS provides a routine to subtract one DTM from the other one, which visualises the area of change in more detail.

Results

The DTM covered an area of 212 x 209 metres (= 4.4 hectares) with the UTM position of 7989900, 655714 of the upper left corner. The instrument was set to record with 2 cm precision in the Z axis and recorded 55.71 m above ellipsoid as lowest and 58.02 as highest height value. The volume above 55.0 m was calculated with 38,672 m^3 before the simulated erosion and 36,934 m^3 after the simulated change. The 55.0 metre is a layer lower than all positions and most parts of the 4.4 hectares are one metre above this layer; therefore the calculated volume is big. A volume change above a layer at 56.0 m above ellipsoid shows 4020 m^3 and 3462 m^3.

Conclusion and Recommendation

The traditionally SOPAC recommended beach profiling can be replaced by RTK GPS survey and explained analysis in employing MapInfo, ERDAS and Access software. Creating a DTM there is no need to get compass bearing and the DTM represents the complete target area and not a linear representation, which might not be statistically sound. The analysis can be provided directly after the survey in quantitative change of volume. The change can be visualised with software available in all EDF8/EDF9 linked countries.

SOPAC will purchase one RTK GPS unit and should train staff in Pacific Island Countries to utilise instruments and software for carrying out beach profiling.

FORSTREUTER & LOMANI

Checking Geometric Accuracy of Pan-Sharpened QuickBird Images

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Figure 1: The GPS base station must have a 360 degree free view and has to average itself for 24 hours.

High-resolution image data arrives at SOPAC as geo-corrected products. However, due to inaccurate map reference data in Pacific Island Countries, the image position can be quite off from it's true position. For this reason accuracy has to be verified for all geo-referenced image data and often the data has to be geometrically corrected again.

Multi-spectral IKONOS Image data with 4 m spatial resolution allows thematic mapping at 1:10,000 scale. For this scale differential GPS is suitable and vegetation features of outer islands can be used as reference points.

Figure 2: This base of a flagpole was 90 cm in diameter and was clearly visible on the image, through the high contrast to the environment.

Pan-sharpened QuickBird image data can be used for up to 1:5,000 scale thematic mapping where differential correction GPS alone is not sufficient to check the geographic accuracy. The next range of equipment (see GPS base station in Figure 1) also analysing the carrier phase of the GPS signal is necessary to capture position with the required accuracy of sub-meter. Ground control points (GCPs) must be identifiable on the ground and in the image. Tests in Rotuma, Nadi and Port Moresby demonstrate that this is possible.

Some image features of 60 cm diameter are visible on the image due to high contrast to the surrounding (see Figure 2). Linear elements are often visible in image data far below the resolution. Corners of the fence proved to be ideal, as they can be easily identified on the image data. Fences of 20 cm width were visible in the image (see Figure 3).

Image data tested in Port Moresby were extremely precise. Image data checked with the same equipment in western Viti Levu had a linear shift of several metres, which is not related to the Fiji coordinate system as image data and GPS survey were based on WGS84.

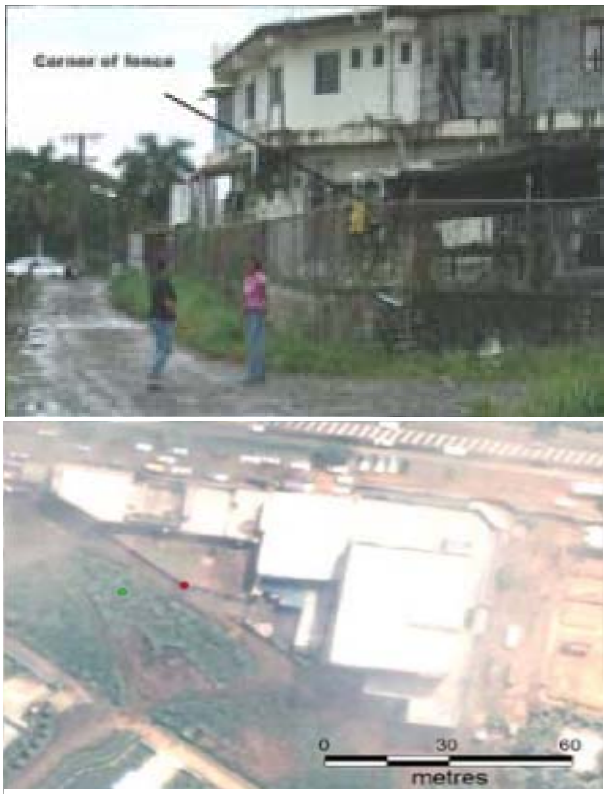

Figure 3: The fence was clearly visible on the image although the concrete base was only 20 cm in width, as linear elements can be visible far below the image resolution of 60 cm. The red dot indicates the point where the position was captured and the green point the location of the position display within the image coordinates system.

Before countries utilise QuickBird images as GIS backdrops at 1:5,000 scale level, the accuracy of the georeference has to be checked with high precision GPS as described. Training on the technique has to be transferred so that the appropriate departments in Pacific Island Countries may carry out this activity.

FORSTREUTER & ZIEROTH

Pan-Sharpened QuickBird Image Data for Coconut Resources Estimation in Rotuma

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Rotuma is a Polynesian island attached to the Republic of Fiji Islands, which is located 700 km north of Viti Levu. The main source of income was copra when copra still had a reasonable price. Copra is still harvested today, however, the prices dropped and the quality is low when it arrives at Fiji's main port due to the duration of transport time. At the same time fuel has to be transported a long way to Rotuma and the delivery faces problems, which affects electricity and subsequently the water supply, transport of school children, etc. PIEPSAP therefore wanted to investigate the option to run the generators on biodiesel produced from coconuts. The project purchased pan-sharpened QuickBird image data to estimate the available coconut resource.

Figure 1: Unmanaged coconut plantations have palms of different age. Palms in the understory are not visible in the satellite image, however, they can produce more coconuts than old and taller ones.

Stratification of Coconut Cover

Coconut palms seem to be the dominant vegetation and the first impression of Rotuma is that it has an unlimited coconut resource; however, this impression had to be revised when analysing the coconut area more precisely. Out of the pan-sharpened QuickBird image a GIS backdrop was produced allowing a stratification and subsequent estimation of palms per hectare in MapInfo GIS environment as on-screen delineation.

Two strata were defined to have nearly no coconut palms a) "**hill vegetation**" and b) "**scrub and agricultural vegetation**". Hill vegetation was the name used for the vegetation on the volcanic cones, which contained only very few palms, but this vegetation type covers 4% of the area. Scrub and agricultural vegetation cover 13% of the area. A third land-use type was called "**human infrastructure**" which is the summary of housing area, the runway of the airport, larger roads, etc. This stratum contained some coconuts around the houses but the amount was not significant from a commercial point of view. This land-use type covers 3% of the area.

The main land-use type is the stratum called "**natural forest**", which covers 53% of Rotuma's area. Coconut palms also grow here, however, only very few, less than one palm per hectare. The image data allow a clear separation of "natural forest" from areas stocked with coconuts. Whenever palms were visible exceeding 1-2 palms per hectare the area was delineated as "**scattered coconut**". The stratum named as "scattered coconut" covers 8% of Rotuma's area.

Scattered coconuts mainly have agricultural or grassland as land use. The stratum "scattered coconut" was partly delineated within "natural forest". The number of coconut palms per hectare will not allow a commercial utilisation of the coconut resource. The stratum "**natural coconut**" was used for remnant or unmanaged plantations (Figure 1).

Coconut palms have regenerated naturally and palms of different age grow together, see Figure 2. The under-growth vegetation is thick making a harvest of coconut possible but difficult. The satellite image separates these areas from others by the typical coconut texture, see also Figure 2. These areas have to be cleaned to allow a commercial utilisation of the coconut. The stratum "natural coconut" covers 12% of Rotuma's land mass. The term "coconut plantation" was used for areas where the planting lines were clearly visible in the satellite image. This type of coconut plantation covers 8% of Rotuma's area. The under-growth vegetation is grass or agricultural crops hence the coconut harvest is easy. The two strata "coconut plantation" and "natural coconut" are considered to produce harvestable coconuts, which could be used for biodiesel production. Together they cover 860 hectares, 20% of Rotuma's land area. However, this is much less than originally expected.

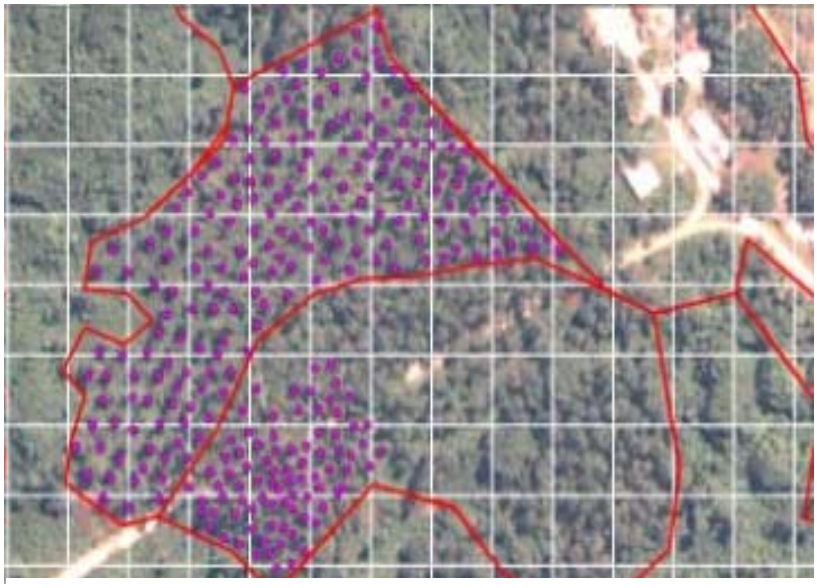

Figure 2: Counting of palms per hectare can be performed with nearly 100% accuracy for managed coconut plantations as the palm leaves do not touch or overlap with each other. For large areas (not limited to coconut plantations) MapInfo allows a grid overlay, where the counted number of palms per grid cell can be stored directly into the grid cell related record of the MapInfo table.

Figure 3: Managed coconut plantations show a clear contrast of palm leaf texture and vegetation growing underneath. They also allow an easy harvest of coconuts, where the coconut collector does not have to walk through thick undergrowth.

Coconut Palm Density

MapInfo allows easy counting of stems per hectare through an overlay of a grid a quarter hectare and storing the results directly in the corresponding records of the grid table, which is then exported to Access for statistical analysis. The number of palms per hectare can be clearly counted for "coconut plantations" where numbers of 250 to 100 palms per hectare are the normal figure, and this was verified during field checks. The contrast between coconut leaves and grass underneath makes it easy to see single palms and count them correctly. The field verification showed nearly 100% validation of the figure counted on the satellite

images. This is caused by a) single palms where the leaves do not interact with leaves of other palms, b) no small palms in the underground, which a creates a clear contrast of palm leave texture and vegetation growing underneath, see figures 2 and 3.

Figure 4: The arrow indicates an area where sand was washed onto the island creating a re-growth coconut environment. The coconut leaves are fully overlapping, which makes a counting impossible.

The stratum "natural coconut" leads to an under-estimation of palms per hectare. The leaves of several palms mostly overlap and make recognition of individual palms difficult. Old palms are visible with QuickBird data in the canopy, however, the younger palms slightly shorter are more important as they produce more coconuts. The under-estimation when counting palms in the satellite image data varied between 30 and 100%, it has not been possible yet to establish a clear correlation. The counting of coconuts for "scattered coconut" palms is exact for open areas; scattered palms within natural forest will be under-estimated, as young palms are not visible. This has to be further investigated. In pure but young coconut cover a counting was impossible as the leaves of different palms overlap each other, see Figure 4.

Transport Distance

Coconuts when harvested are manually carried in baskets from the area where they are collected to the next road. Here a truck picks up the basket and brings the baskets to the dryer. The distance from the pick-up place to the dryer is irrelevant on a small island like Rotuma, however, the distance to the next road is an economic factor with the current practice of hand carrying harvested nuts in baskets.

To further stratify the coconut productive areas an overlay analysis was carried out, which combined the layer of coconut strata with a new created layer, road distance. The resulting layer shows which part of each stratum is between 50 and 100 m away from the road, 100 and 150 m, etc. The overlay was performed in ERDAS, as raster data are more suitable for such an analysis (see Figure 5).

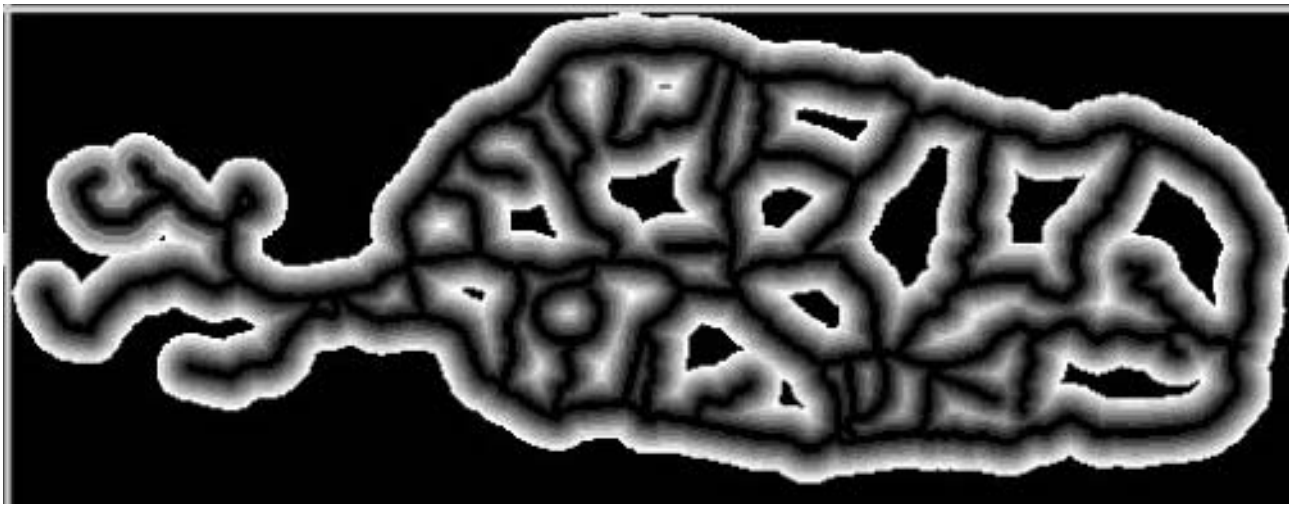

Figure 5: This ERDAS raster data layer shows areas in 50 m interval distance of the roads. It was created from files created through buffer analysis in MapInfo, exported to and overlaid within ERDAS.

Summary and Recommendation

The available coconut resource value added products in Rotuma is less than it appears at the first impression.

Pan-sharpened QuickBird data is suitable to stratify the land cover of a Pacific island into strata containing different coconut densities. The data is also suitable to count the number of palms per hectare for managed coconut plantations and scattered coconut stands. For unmanaged coconut plantations the counting of palms per hectare with QuickBird data is unreliable hence a correlation has to be worked out between counted figure and field reality.

Potential coconut production area alone is not sufficient to estimate the possible utilisation. Parameters describing the harvest have to be added and a further stratification of the available coconut area into sub strata of transport distance is essential. This can be performed with simple methods utilising MapInfo and ERDAS Imagine available in all EDF8/9 Pacific Island Countries through the SOPAC-EU Project. The estimated coconut resource in Rotuma is less than expected, however, this is also an important result before investing in facilities to utilise the resource which later turn out to be oversized. The available coconut cover is not known in Fiji main land and many Pacific Island Countries. The method described should be used to estimate the available coconut resource.

FRITZ & KALLIGERIS

1 April 2007 Solomon Islands Tsunami Reconnaissance

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On 1 April 2007 at 20:39:56 UTC (local time: UTC+11), a magnitude M_s 8.1 earthquake occurred 50 km off the New Georgia Islands in the Solomon Sea generating a locally-focused tsunami striking more than 300 coastal communities in the Solomon Islands resulting in a confirmed death toll of 52. The 10-24 April 2007 reconnaissance covered more than 65 villages on the 13 islands of Choiseul, Vella Lavella, Ranongga, Simbo, Ghizo, Nusatupe, Kasolo (Kennedy Island), Kolombangara, Vonavona, Lola, New Georgia, Rendova and Guadalcanal. The team measured 175 tsunami and run-up heights together with 37 recorded island-level changes due to tectonic uplift and subsidence. The tsunami impact peaked at Tapurai on Simbo's north tip with run-up heights of 12 m and local flow depths of 5 m. Inundation distances and damage more than 200 m inland were recorded at Titiana on Ghizo Island and Sasamunga on Choiseul Island. Rendova Harbor to the east represents an unfortunate example of a village perfectly protected from ordinary storm waves by reefs a few kilometers offshore but extremely vulnerable to tsunami due to funnelling effects. The tsunamigenic seafloor displacements were characterized based on measured coral uplift as well as engulfed boat docks and trees. The southern part of Ranongga Island was uplifted by up to 3.6 m decreasing towards the north with only 1.5 m uplift. The islands were uplifted during the earthquake prior to tsunami arrival significantly reducing the tsunami impact. Subsidence of up to 1.5 m along the north end of Simbo Island suggests the location of the fault line between Simbo and Ranongga. Subsidence increased the vulnerability of coastal settlements requiring reconstruction further inland on higher ground. Similarly, coastal landslides along a 10-km stretch on northwestern Ranongga require resettlements of some villages. The team also recorded structural damage, interviewed eye witnesses and educated

residents about the tsunami hazard in a prime-time Solomon Islands National Broadcasting interview as well as countless ad hoc presentations and discussions. The ancestral heritage "run to high ground after an earthquake" passed on to younger generations by survivors of smaller historic tsunami triggered an immediate spontaneous self evacuation containing the death toll in the small evacuation window of a few minutes between the end of the ground shaking and the onslaught of the tsunami. The survivors remained traumatized by the tsunami, afraid of the sea and living in evacuation camps on the hills. Community-based education and awareness programmes are particularly essential to help save lives in locales at risk from near-source tsunami.

GARDNER & Others (Poster)

Centre for Marine Environmental & Economic Research – Victoria University of Wellington, New Zealand"

Jonathan Gardner[1], John Collen[1], Dave Garton[2], James Bell[1], Simon Davy[1] & Ken Ryan[1]
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Victoria University's Centre for Marine Environmental & Economic Research (CMEER) is a multi-disciplinary research centre which integrates expertise and experience in all areas of marine research. CMEER's functions are to promote and enhance collaborative marine research, to develop new working relationships with indigenous peoples in the Pacific region, and to provide independent and expert advice on all matters of marine research, including science, economics, public policy and law. In this poster presentation, CMEER's work is illustrated using examples of our research.

Pronounced dissolved oxygen stratification in a compartmentalized lagoon complex: Palmyra Atoll, northern Line Islands

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Palmyra Atoll has four partially isolated lagoons that vary in depth from 1 m to > 50 m. All lagoons have complex, variable bottom topographies resulting from natural and anthropogenic processes. We observed profound stratification of dissolved oxygen (DO) in the presence of minor reverse stratification of turbidity and the absence of stratification of temperature or salinity in the three largest lagoon compartments. Deep-bottom water anoxia causes high organic content and H_2S in bottom sediments, and may explain the relative paucity of taxa in the lagoon system.

GLASSEY & Others

GeoSource Tonga: Using GIS for Hazard Modelling and Risk Assessment

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GeoSource Tonga is a GIS-based topographical mapping system housed with the Ministry of Lands, Survey, Natural Resources and Environment (MLSNRE), built as part of the Cyclone Emergency Recovery and Management Project, B2 component; Land Hazards and Information Management. GeoSource Tonga provides a mechanism for combining topographic, hazards, buildings, infrastructure and population data to develop hazard and risk assessments thereby enabling effective risk reduction, preparedness and response measures. The system can be utilised in initial damage assessments following disasters and also to provide information to create and grow a 'community of practice' in the area of Disaster Risk Reduction.

Tonga, located in the tropics and over a tectonic subduction zone, is subject to a number of natural hazards. Hazard data and maps are stored in the system, along with new data and models that have been developed. The hazard data stored in the geodatabase and displayed in a number of map documents includes:

- coastal erosion, sand mining and coastal inundation layers for Tongatapu.
- earthquake epicentre data, and return period estimates for a set of earthquake ground shaking intensities for all Tonga Islands.
- tsunami source data, preliminary inundation models for Tonagatapu and a draft tsunami evacuation map for Tongatapu.
- historic volcanic eruption data.

An earthquake hazard model, which generates MM Intensity isoseismals based on earthquake event parameters, has been developed. The isoseismal intensities give emergency managers an understanding of which island group or groups have been subject to the greatest earthquake shaking and where immediate assistance may be required, and can be overlaid on building data for estimation of likely damage to buildings and casualties once fragility curves for buildings and population are applied. Earthquake shaking building classes and fragility curves for Tonga have been proposed.

Tsunami inundation for Tongatapu has been modelled, for wave heights at the coast of 2, 4, and 6 m, based on similar inundation modelling in NZ. The model takes the fixed wave height at the outer reef, attenuates it over "shallow water" and land and estimates the depth of water inundation. The model does not take into account directivity or the effects of local bathymetry and surrounding reef both of which will vary the inundation considerably. As with the earthquake model, buildings and population data can be overlain and according to relationships between building class and inundation depth, damage and casualties can be estimated.

To effectively strengthen infrastructure and planning, such that the impacts of natural hazards are minimised, requires that the hazard models be improved. In particular detailed topographic elevation data are required as the existing 5 m contour interval is too coarse to be effectively utilised at a development scale or for meaningful hazard modeling. Infrastructure and population data also need to be updated and incorporated into the models.

During the Project, extensive consultations with stakeholders identified strong interest and demand for application of the GeoSource Tonga facility in four over-arching areas:

- Consolidating and developing the capabilities of GeoSource Tonga

- Disaster risk reduction and disaster management
- Understanding and managing the environment
- Accelerating economic and social development

More than 30 applications were identified and documented and form part of the Ministry's operational plan for the next few years and into the future. These include utilising the data for applications as varied as land use management, biodiversity conservation, rural and urban planning and tourism.

GREENE

Seafloor Substrate and Habitat Maps as a Management Tools: examples from the Pacific northwest

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With global warming, sea-level rise, over demand for living and non-living marine resources, and increasing population along the world's coastal regions it is more critical than ever that the oceans processes be understood as comprehensively as possible. Modern geophysical technologies and processing software allow for fairly continuous coverage of the seafloor and the production of images that can show both morphology and texture in great detail. Although expensive to obtain data from such technologies, the results have proven invaluable in assessing and managing coastal and seafloor resources. An extensive international seafloor mapping project undertaken along the Pacific transboundary region of Canada and the United States has resulted in the production of multiple thematic seafloor maps that are in demand by managers and policy makers. Lessons learned from this work are applicable to the environmental concerns of SOPAC countries. Results from the Canadian-US mapping effort will be presented and its application to the SOPAC region will be discussed.

HALL

Implementation of a Water Quality Monitoring Programme in the Cook Islands

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High water quality in the Cook Islands is essential to the socio-economic development and underpins the local communities. In particular, the tourist industry, pearl oyster aquaculture production, recreational shellfish gathering and general health and well been depend on water quality. Knowledge of water quality and whether it is changing is vital if marine resources are to be effectively managed. Historically, a small amount of water quality data has being collected by the Ministry of Marine Resources (MMR), Department of the Environment and Department of Health; however, the data were not comprehensive with some areas being well covered and others not sampled at all. There exists a real need to have baseline data to assess the potential impacts of new developments; for example, a new hotel, new pearl oysters farms or introduction of other aquaculture species.

Another important need was building technical capacity within MMR for both laboratory analysis and data interpretation. In the longer term this will reduce the need to use overseas experts or to have to send samples off shore for analysis. With local capacity established, it is much more effective to activate a fast response to an issue rather than having to wait several weeks before an issue is recognised and action is taken. The project has included a review of the previous marine and stream water quality monitoring in the Cook Islands. This review has led to recommendations for a comprehensive integrated network that is relevant to the needs of the Cook Islands community. The newly-designed monitoring network has been implemented in conjunction with the staff of MMR.

HERON & Others

RiskScape: A multi-hazard modelling and risk assessment tool

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Improved community resilience and public safety from a range of natural physical hazards is the aim of every emergency manager and many government agencies. Yet despite attempts to reduce risk from natural hazards, New Zealand remains highly vulnerable to many weather-related and geological hazards (e.g., floods, storms, landslides, tsunami, earthquakes, and volcanoes). Further, in a changing climate, weather-related hazards are likely to increase in occurrence and magnitude. Against this backdrop, continued development sees communities expanding onto hazard-prone land such as river floodplains, earthquake-fault zones and expensive coastal land. Many critical engineering lifelines (e.g., roads, railways, pipelines, power networks and telecommunication cables) are exposed and susceptible to natural hazards.

RiskScape is a joint venture research programme funded by the New Zealand government which is developing a generic model that can estimate probable losses from multiple hazards. The RiskScape model is expected to be used by emergency, asset, and environmental managers, and the insurance and engineering sectors. It will benefit these agencies by supporting planning and investment decision-making prior to a natural disaster, and by providing emergency managers and government agencies with timely estimates of damage and disruption following a natural disaster.

Currently RiskScape can model scenario earthquakes and ashfall from volcanic eruptions given user-defined parameters. It is also able to read in the results of flood, tsunami and wind models developed with other software. Asset databases are loaded into RiskScape by the user and can contain point features representing buildings and people and line features representing infrastructure. RiskScape displays the selected hazard model and assets and then overlays these to determine the exposure. Losses are then estimated using in-built or user-defined fragility functions.

The RiskScape tool will assist in increasing community resilience and effective community response to natural physical hazards in New Zealand and could be adapted for use elsewhere in the Pacific where similar hazards exist.

INOUE & Others

Upgrading Seismic Networks of Fiji and Tonga

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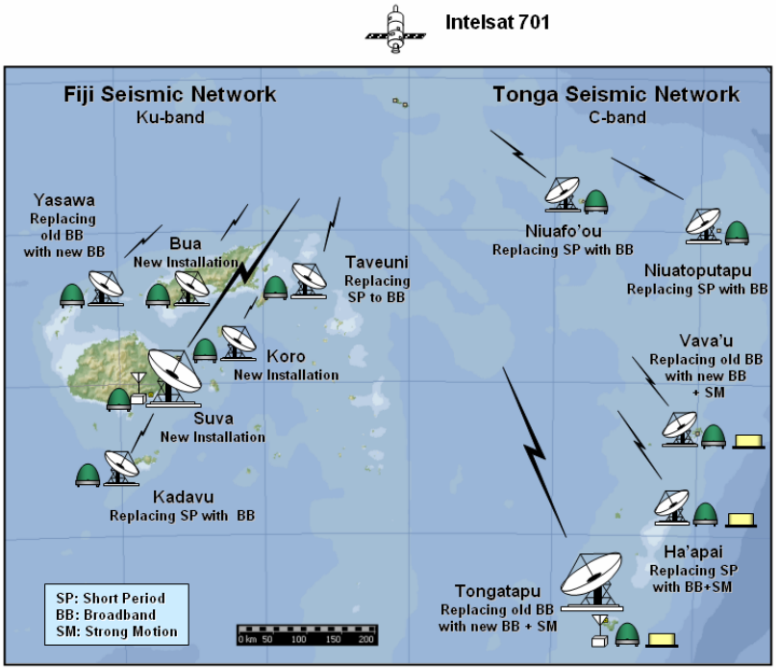
NIED of Japan, MRD of Fiji, and MLSNR of Tonga have been cooperating in the operation of the VSAT seismic network systems donated by Japan International Cooperation Agency (JICA) in 2003. The new system in Fiji was an upgrade of the old short-period analog network, and the network of Tonga was the first installation of a seismic monitoring system in the country. Each network has been producing earthquake information for the public since the installation, and waveform data are used for seismological researches. The systems, however, occasionally stopped due to power failures and other problems. Stations equipped with short-period sensors are incapable of determining magnitude of large earthquakes correctly. In Fiji, the number of VSAT stations provided was less than that of the analog network in the past. We needed more training of equipment maintenance and data analyses to make the most of the system and the high quality real-time digital data.

To further improve the earthquake monitoring capability of each country, and as a step towards establishing local tsunami warning systems, JICA launched another three-year project of technical cooperation to upgrade the seismic net-works of Fiji and Tonga in 2007. Stable power supply will be provided for all the remote stations and the data centers in Suva and Nuku'alofa. Three new stations will be installed in Fiji to fill the gap in the central part of the country. All stations will be equipped with broadband seismometers. Strong motion sensors will be installed in three stations in Tonga to record large local earthquakes without saturation.



Automated hypocenter and magnitude determination systems will be installed in the data centers. Training for seismology and data analyses will be given in Japan in cooperation with IISEE, BRI. We also plan to exchange data in real time over the Internet to improve the performance of each network and to contribute to tsunami early warning systems in the Southwest Pacific and PTWS.

JOHNSTON

Deep Sea Mineral Extraction – Potential Benefits for Southwest Pacific Nations from a non-utilized Resource

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Nautilus Minerals is currently completing exploration activities and related feasibility studies on its high grade copper-gold Solwara 1 deposit within the Bismarck Sea of the territorial waters of Papua New Guinea (PNG).

The project employs state-of-the-art high-tech robotic technologies currently in use in the offshore oil and gas and dredging industries, and marries these up with elements of the land-based hardrock mining industry. Ore extraction is forecast to be competitively priced relative to land-based operations, but with significantly smaller "footprints" and social dislocation.

Benefits have already been flowing to the State of Papua New Guinea during the exploration phase. In 2007 the company completed a +$US23 million dollar exploration and environmental programme. During the course of this work the company has increased it's manning and training, with 25% of the company's worldwide workforce now comprising Papua New Guinea nationals. The company has also paid K5 million in withholding taxes, as well as annual rents, permits, travel and accommodation for staff and contractors within Papua New Guinea, port fees, and other charges.

Long-term benefits that will accrue to Papua New Guinea from the successful start up of the project include:

- taxes, royalties and other payments associated with the extraction of an as yet "un-utilized" resource base.
- the creation of additional permanent jobs and skills transfer to Papua New Guinea nationals.
- minimal disturbance to land and social structures, as most mining activities are based offshore.
- significant new capital investment including power, water, port and road facilities.

The company is pleased with the support it receives from the various PNG Government departments with which it interacts regularly, and through regular stakeholder engagement recognises the need to provide tangible benefits to the host nation in a staged manner as it approaches production in 2010.

In keeping with these desires, the board and management approved significant financial support to the Port Moresby City Mission to help provide shelter, education and a career path for local "street kids". The company has also undertaken to invest in the education of Papua New Guinea nationals outside of its immediate work force through the establishment of bursaries to provide international training to high-calibre local candidates. Finally, the company is establishing a voluntary community development fund which will provide financial aid to local development and education, and is above the company's legislated tax and royalty requirements.

KHATRI

Water Safety Plans – Tonga

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The Water Safety Plans (WSP) Programme was initiated in 2005 after the endorsement from Pacific Health Ministers on the 'Pacific Framework on Drinking Water Quality and Health". The Water Safety Plans is a new risk assessment and risk management approach to ensure safe drinking water. Tonga is among the four countries (Vanuatu, Cook Islands and Palau) which were selected to pilot this programme. Following the initial scoping mission to Tonga, the Water Safety Plans project began with the formation of a National Steering Committee (NSC) which moves away from vesting the responsibility to one particular agency. The NSC consisted of members from Tonga Water Board, Ministry of Health, Ministry of Lands, Survey and Natural Resources, Village Water Communities, Tonga Community Development Trust, Tonga Association of NGOs, Ministry of Finance, National Planning Office, National Water Resource Committee and Department of Environment. This allowed better national coordination of agency responsibilities in terms of technical expertise, sharing of information, finding possible problems and ensuring a more integrated water resource management approach. To support Tonga a national training and planning workshop was conducted in July 2006 with the aim to train people on the WSP for urban and rural water supply systems; how to implement WSP, carry out risk assessment and to ensure all key stakeholders work together. Tonga has diligently worked on the WSP and Improvement schedules for Nuku'alofa Urban Supply, Cement Rainwater Tanks and Lomaiviti Rural Supply. The next steps for WSP in Tonga and outputs thus far will be elaborated on in the presentation.

KLEPPEN & Others

Water Demand Management for Pacific Island Water Utilities. Case study: Niue

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From mid 2006 SOPAC have been managing the implementation of the New Zealand's International Aid & Development Agency funded project *"Water Demand Management (WDM) for Pacific Island Countries 2006 – 2009".* A partnership with world leading experts in this field, Wide Bay Water Corporation, was established to ensure that state-of-the-art WDM techniques and technologies are being introduced to participating countries. The programme is initially focusing on five countries: Cook Islands, Federated States of Micronesia, Niue, Republic of the Marshall Islands and Solomon Islands.

Niue has one of the most proactive water utilities in the Pacific and therefore enjoys the full potential of assistance through the WDM and other related water programmes implemented by SOPAC and its partners. Based upon needs detailed by the Manager of the Water Division in Niue (Mr Andre Siohane), a comprehensive WDM project has been developed in Niue.

A fundamental part of any water loss intervention is to understand where action is needed and where resources are best implemented to achieve the best return for the utility. The key to this understanding is achieved through quality data collection and analysis. Collection of good quality baseline data has been accomplished through installing of bulk flow meters at all supply points throughout the islands water supply network. In conjunction with each bulk flow meter a data logger has been installed to capture and monitor flows through the meters. The loggers are programmed and the data downloaded using a laptop computer that has been provided as part of the project and contains the appropriate software needed to install, download and analyse the data. In addition to the flow loggers, provided pressure loggers can be installed. These are equipped to measure the pressure in the reticulation system, which can be simply programmed using the same software, and then connected to a tap or directly to the water main using pressure hoses and correct fittings. Using pressure loggers around the reticulation network will enable problems in the water supply system to be identified. The data collected can be used in conjunction with the flow data, facilitating prioritisation of actions deemed necessary to maintain a steady water supply to all areas of Niue.

Equipment for leak detection and pipe location has been supplied and customised training was provided in sectorisation, minimum night flow determination and analysis of pressure and flow data. Continued support is being provided in order to ensure the sustainability of this effort in Niue.

The Water Division now enjoys close to 100% knowledge about where the reticulated water is going and by comparing the performance of each sector or district metered area, priorities can be set on where and what kind of intervention needs to take place in order to minimise water losses and save pumping cost.

LAFOY & Others

The complementary ZoNéCo, FAUST and EXTRAPLAC programmes: An Integrated approach for the Southwest Pacific

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France, which holds the power in terms of Continental Shelf extension, must deposit its claim to the United Nations Commission for the Limit of the Continental Shelf (CLCS) before May, 2009.

As France ratified the UNCLOS in 1996, a decision to undertake a national programme on that issue was taken. Therefore, the French Extended Continental Shelf programme (EXTRAPLAC), sponsored by the French Department of Industry, was launched in 2002.

As New Caledonia was identified as one of the programme's priorities, two cruises were scheduled and conducted in 2004 aboard R/V L'Atalante offshore New Caledonia, along the Lord Howe Rise and the Loyalty Ridge and within international waters. The cruises were conducted under the responsibility of IFREMER with New Caledonia participating. The cruise results have enabled us to determine key parameters such as foot slopes and sedimentary thicknesses. After discussions between New Zealand, Australia, France and New Caledonian authorities in 2006, possible extension could be claimed by France beyond the 200 nautical miles border that delimits New Caledonia's EEZ.

France's claim pertaining to the New Caledonian Continental Shelf was lodged with the Commission for the Limit of the Continental Shelf on 22nd May this year. New Caledonia was part of the French delegation that formally presented the New Caledonian Claim to the CLCS in New York on 31 August 2007.

The complementary ZoNéCo (1993-ongoing), FAUST (French-Australian Seismic Transect, 1998-2001) and EXTRAPLAC (2002-ongoing) programmes carried out within and off New Caledonia's EEZ was aimed at:

- dealing with UNCLOS issues: New Caledonia – part of the French delegation – is involved in discussions with CLCS in New York.
- improving our knowledge of the geodynamic evolution of the Southwest Pacific (> petroleum and natural gas potential).
- increasing cooperation between France, Australia and New Zealand in establishing complementary research programmes based on both technological facilities (research vessels) and scientific knowledge (> ZoNéCo- IFREMER PhD student (2006-2008)).
- increasing New Caledonia's involvement through its Geological Survey in geoscience programmes and data exchanges.

LAL & ARTACK

The Pacific Islands Regional Maritime Boundaries Project (PIRMBP)

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The accurate delineation of maritime boundaries is critical to successful marine governance and proper stewardship of marine resources, both living and non-living. The challenges faced by Pacific Islands countries (PICs) in defining their maritime boundaries can be particularly complex as the sea regions encompassed by their Exclusive Economic Zones (EEZs) are in many cases vast. Many PICs lack the necessary technical resources and information to prepare accurate submissions under UNCLOS (United Nations Convention on the Law of the Sea) to obtain formal recognition of EEZ boundary positions under international law.

Assistance to PICs in defining and delineating their maritime boundaries is currently provided by SOPAC, the Pacific Islands Applied Geoscience Commission. Within the framework of the Pacific Islands Regional Maritime Boundaries Project (PIRMBP), SOPAC provides assistance to its Pacific Island member countries in accurately determining national baselines. This information can subsequently be used to define boundaries for Territorial and Archipelagic Seas, Contiguous Zones and EEZs, and to establish whether there are grounds for potential claims for extended Continental Shelf limits (eCS).

Specific objectives of the project are as follows:

- Developing comprehensive datasets to facilitate definition of the legal and administrative offshore limits for SOPAC member countries in accordance with the provisions of UNCLOS, and making this data and information available to countries.
- Building national capacity within member countries to undertake these assessments.
- Providing advice and assistance to member countries on relevant provisions of UNCLOS.
- Acting as an information and data repository.

An important component of the project is the capture and validation of existing baseline data into the Pacific Islands Regional Maritime Boundaries Information System (PIRMBIS). Based on Geographic Information Systems technology, PIRMBIS will serve as a regional database for UNCLOS compliant baseline and maritime boundaries. In addition to baseline data, PIRMBIS also contains information on existing, recently signed, and negotiated treaties, and the provisional median lines between adjacent and opposite states. To date, of the 47 shared boundaries, there have been 18 signed treaties, 5 are currently being negotiated and 24 boundaries are still to be negotiated (Figure 1).

The continuation of the PIRMBIS will help ensure that boundary positions are settled and by doing so contribute to regional stability through clarity of management responsibility over maritime resources. Agreed maritime boundaries among Pacific Island nations will provide a firm foundation for bilateral and regional resource management arrangements and for effective surveillance and enforcement.

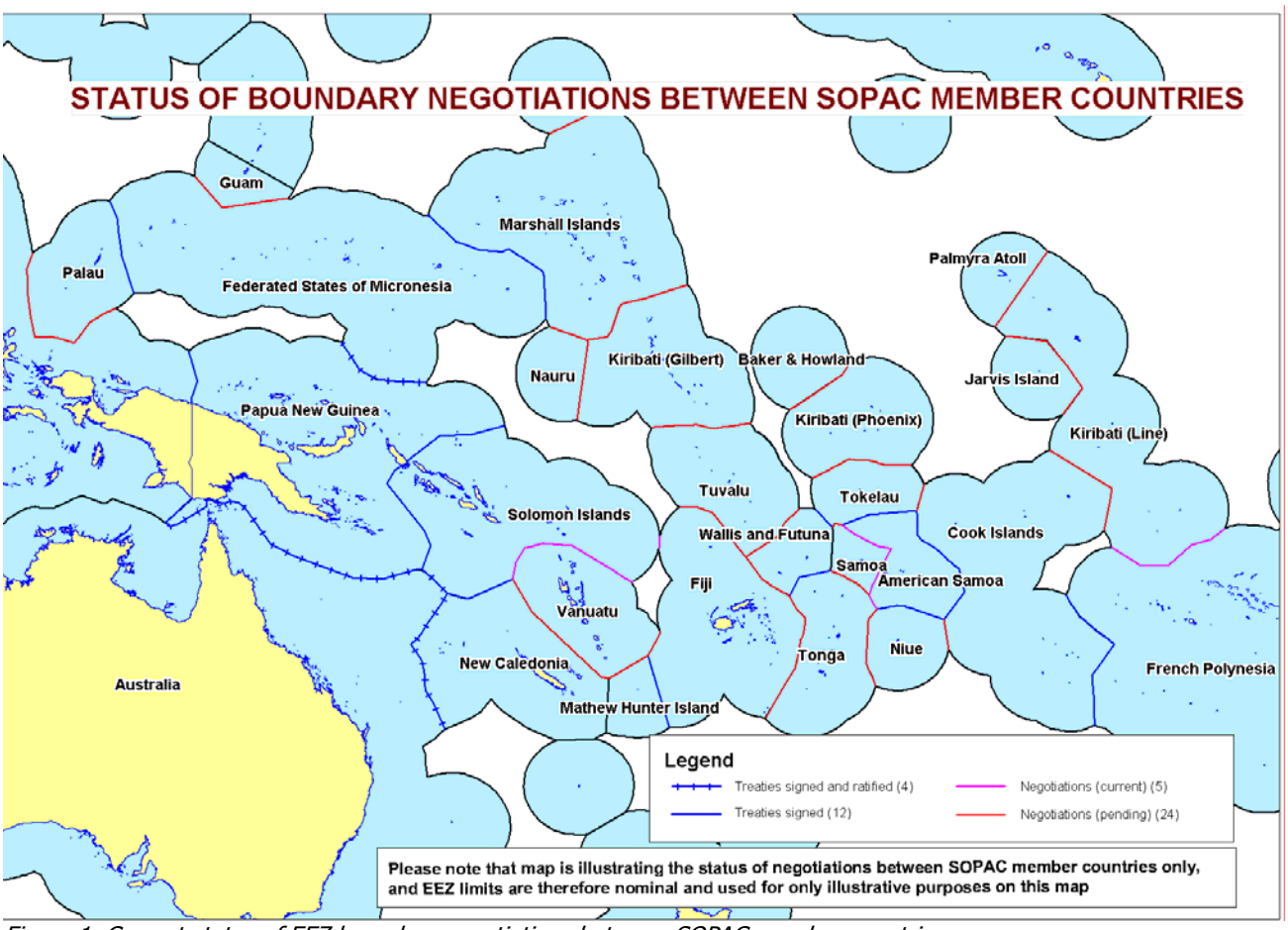

Figure 1. Current status of EEZ boundary negotiations between SOPAC member countries.

The Pacific Islands Regional Maritime Boundaries Project (PIRMBP): tackling Extended Continental Shelf (eCS) issues

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The United Nations Convention on the Law of the Sea 1982 (UNCLOS) provides countries with exclusive jurisdiction over the living and non-living resources of the water column, seabed and subsoil to a minimum of 200 nautical miles from their coasts, or to seabed boundaries agreed with neighbouring countries. All claims must be based on sound technical data and meet requirements prescribed within UNCLOS. The major objective of the Pacific Islands Regional Maritime Boundaries Project (PIRMBP) is to assist Pacific Island Countries (PICs) in developing the necessary data resources to help define their Territorial and Archipelagic Seas, Contiguous Zones, and Exclusive Economic Zones. Assistance is also being given to establish whether there are grounds for potential claims for extended Continental Shelf limits (eCS) as these would give countries exclusive rights to seabed and subsoil resources beyond their expected 200 nm EEZ boundary.

Given the potential importance of eCS, SOPAC commissioned a specific study in July 2006 to assess whether there was sufficient evidence to support eCS claims by Federated States of Micronesia (FSM), Kiribati, Tuvalu, Palau, Solomon Islands, and Vanuatu. An earlier study undertaken in 2005 by UNEP GRID had identified these states as having the potential for eCS claims. A number of other SOPAC member countries, namely Papua New Guinea (PNG), Fiji, and Tonga, undertook their own independent study in support of eCS claims. Based on available evidence, and without potential impacts on the rights of other states, the countries that appear to have good grounds for progressing with eCS claims are Fiji, Kiribati, Palau, Solomon Islands, Federated States of Micronesia, Tonga, and Papua New Guinea. In order that eCS claims obtain full recognition under UNCLOS, these countries now have the challenge of meeting a number of scientific, technical and legal requirements by the May 2009 deadline for formal submissions. Papua New Guinea, Solomon Islands, and Federated States of Micronesia are currently considering the possibility of submitting a joint claim over the Ontong Java Plateau area. This is an innovative approach as it would leave unlimited time (after the 2009 deadline) for internal or shared boundary negotiations.

To help PICs prepare claims for eCSs, a technical meeting was hosted in July 2007 by our project partner Geoscience Australia (GA) and SOPAC in Canberra. The purpose of the meeting was to facilitate the preparation of submissions through a range of capacity enhancement activities designed to help country technical staff:

- assess the quality and suitability of existing data needed to construct a credible case for an eCS claim.
- become familiar with relevant tools such as the UNCLOS module within the GeoCap software[1].
- prepare reports on the geology and morphology of the area in relation to Article 76 of UNCLOS in order to build the arguments for the delineation of the eCS.
- develop a strategy and project plan for eCS definition, submission preparation and lodgement.

The training in July was a first to be conducted for technical representatives from Papua New Guinea, Solomon Islands and Federated States of Micronesia. The proposed ongoing technical

[1] http://www.geocap.no/products/product_UNCLOS_index.shtml

support and capacity building activities will develop the required technical skills at the national level to support not only the preparation of submissions but also the ongoing process of defending them to the Commission on the Limits of the Continental Shelf (CLCS). The CLCS has indicated that it strongly favours the joint approach where there is potential for overlapping claims.

LOMANI-WHIPPY

Establishment of a Geographic Information System in the Water and Sewerage Department in Fiji

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The establishment of a GIS in the Water and Sewerage Department through the SOPAC/EU Project, was carried out in the Sigatoka area located on the western side of Viti Levu. This pilot project area was selected from within the agreed SOPAC/EU Project intervention area. This was later extended to the Deuba – Navua region.

Establishing the GIS was undertaken in the following five phases:

Phase 1: Training of Water and Sewerage Department staff. The Water and Sewerage staff were trained to:

- design an Access database and link the records to MapInfo;
- handle GPS and edit data in MapInfo; and
- customise MapInfo using the MapBasic programming language.

Phase 2: Designing and populating the database to keep records of the entire asset existing in the Sigatoka and Deuba Water Supply. The database was developed in a way to assign a unique ID to every asset. This unique ID would then allow link up to other spatial elements in the GIS, which would then allow thematic map production. Relationships were established for each table to query existing information in the database with minimal input from the end user.

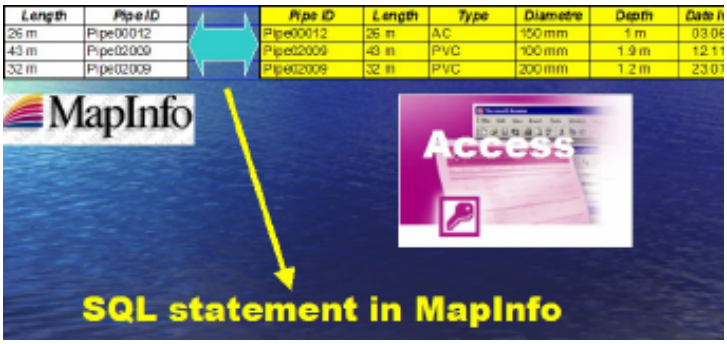

Figure 1. Linking of attribute data from Access with the spatial data from MapInfo.

Phase 3: Capturing the position of the entire range of assets within the region using remote sensing and GIS. These assets are pipelines, valves and nodes. Cadastral maps, road maps and satellite image backdrops of the Sigatoka to Navua corridor, were used as a guide to digitise the position of each asset. The positions were then exported to MapInfo and then assigned unique values corresponding to its attribute data in the database.

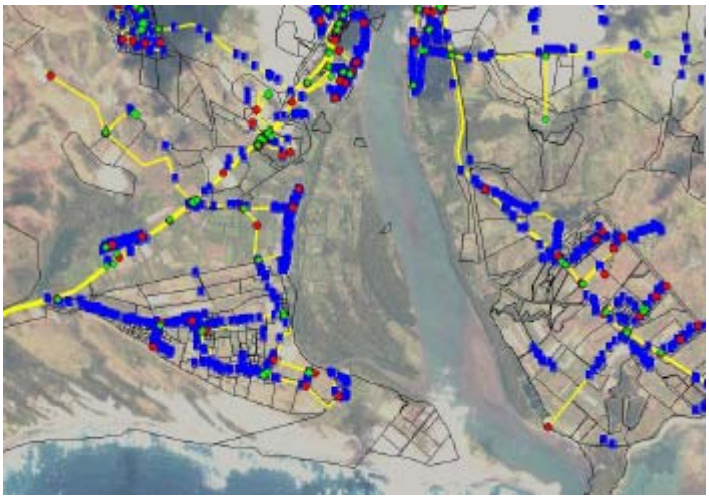

Figure 2: Satellite image used as a base map to digitise the location of the assets.

Phase 4: Capturing Meter Position using Ground Positioning Systems

Every meter position was captured with a hand-held Geoxm rover at a 1:10,000 scale. The rovers were placed on top of each meter where a minimum of ten logging positions were established. The positions were then exported to MapInfo and assigned unique values corresponding to its attribute data in the database.

Figure 3: Capturing of water meters using GPS.

Phase 5: Customising MapInfo for End Users

A MapBasic programme was then used to customise MapInfo so that the end users, and more importantly, decision makers are able to locate the asset item with a click of a button.

McADOO & Others

Geologic survey of the 2 April 2007 Solomon Islands earthquake and tsunami

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On 2 April 2007 at 7:39AM local time (20:39 on 1 April UTC), a magnitude 8.1 earthquake generated a tsunami that killed 52 people in the western Solomon Islands and Choiseul Provinces. Our team surveyed the geological effects of the event with the aim of better understanding earthquake and tsunami processes, and how they might be recorded in the geologic record. In the sheltered lagoons between the barrier reef and the islands, the earthquake sheared off the delicate tabular and branching coral colonies which came to rest near their bases without having been significantly moved by a current. The tsunami rapidly lost energy as it came on shore. Inundation distances exceeded several hundred meters in places with flow depths greater than 4 m, depositing sand and gravel-sized particles with occasional boulders, yet houses floated off their foundations with little damage, floated cars landed on all four wheels, and tabular coral colonies broken by the earthquake remained near their original locations. Backflow from the tsunami moved sediment into the lagoons, and normal littoral processes re-established the sediment equilibrium by moving excess material into deeper water via channels in the reef. Scientists working in the field following an event should coordinate with government and aid agencies in planning the recovery phases, keeping in mind the long-term geologic changes to the environment that will affect the local economies.

MARTINEZ & Others

Exploring the off-axis distribution of hydrothermal activity and its geological controls at the back-arc Eastern Lau Spreading Center, Tonga

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Since its initial discovery over 30 years ago, hydrothermal activity at seafloor spreading centers has been studied primarily as a one-dimensional along-axis variable. The abundance of ridge crest hydrothermal activity and the apparent scarcity of venting known from far fewer studies away from the ridge axis have led to a prevailing view that high temperature hydrothermal venting is concentrated at the axis, beyond which the flanks are dominated by diffuse low-temperature venting and/or primarily serve as recharge zones for the axial discharge. This paradigm is challenged by recent studies of the thermal structure across the ridge axis. At intermediate to fast spreading ridges the crustal layer near the axis is characterized by a seismic low-velocity zone several (~5) km wide abruptly flanked by higher seismic velocities. These seismic velocity changes have been modelled as an abrupt transition from a hot axial region at near magmatic temperatures containing some partial melt to a completely solid and much cooler crust in the flanks. The development of large ridge-flanking faults is closely associated with this thermal transition and further implies strong rheological changes from a largely ductile to a brittle crustal layer. To achieve the abrupt changes in thermal structure that seismic data infer, numerical modelling experiments require strong advective heat extraction across the entire crustal thickness at the boundaries of the low-velocity zone. Collectively, these studies suggest that the boundaries of the axial seismic low-velocity zone, located roughly 2-4 km off axis, should be favorable locations for extensive hydrothermal activity. To date, however, no systematic exploration of these boundaries has been conducted at any ridge. Accordingly, we plan to carry out a detailed seafloor and hydrothermal plume mapping expedition at the Eastern Lau Spreading

Center (ELSC) in the Kingdom of Tonga, to examine the variation in seafloor structure and hydrothermal activity across this predicted thermal boundary.

To date, most ridge thermal modelling studies have been two-dimensional and steady-state; therefore they address only first-order spatial variations with distance from the axis. The advective extraction of heat along and across the ridge and throughout the crustal thickness is both three-dimensional as well as spatially and temporally variable. It is also likely correlated with the development of large faults that provide permeability pathways for fluid flow. There are feed-back processes among hydrothermal heat extraction, changes in crustal rheology, stress development and relaxation, and faulting. Thus, in order to encompass some of the expected spatio-temporal variability of hydrothermal processes and their possible correlation with the development of faulting, we plan a continuous near-bottom side-scan sonar seafloor mapping survey along several ridge segments and encompassing the region predicted to undergo the largest changes in ridge thermal structure. The seafloor mapping survey will be combined with an array of oceanographic sensors attached to the sonar's tow cable to simultaneously map a vertical swath of the water column for hydrothermal plumes. Because the tow lines will be closely spaced (offset laterally by 500 to 1000 m) the combined sides-scan sonar/oceanographic survey will essentially encompass the entire seafloor area and near-bottom water volume surrounding the ridge axis. The survey will provide the most complete and extensive survey of hydrothermal activity and seafloor structure yet conducted at any ridge. It will be used to examine the along- and across-axis distribution and nature of hydrothermal activity and its association with the development of seafloor structure from the axis and across the near-axis thermal boundary zones.

The ELSC was selected for this study because, as one of the Ridge 2000 Integrated Studies Sites, this survey will provide the regional seafloor structural and hydrothermal context within which to better interpret the multi-disciplinary local studies at the focus vent sites. In a broader context, because of subduction effects, the back-arc ELSC provides new variables not present at open-ocean ridges within which to study controls on hydrothermal activity. Subduction introduces water into the mantle and may recycle depleted material via mantle corner flow. These subduction effects create gradients in mantle wedge chemistry which can be parameterized as a function of distance from the arc volcanic front. The systematically-varying proximity of the ELSC to the arc and with respect to underlying mantle wedge chemical gradients controls its magmatic productivity and chemistry of erupted lavas. The planned survey spans major transitions in these ELSC characteristics. Thus, the ELSC variations in seafloor structure and hydrothermal activity can be examined within the context of these larger scale subduction-mediated variations in ridge characteristics.

The possible occurrence of significant off-axis hydrothermal activity rooted in large faults that serve to cool the entire crustal thickness has important implications for the formation of mineral deposits and hosting of biological vent communities. Such off-axis systems would be removed from the tectonically and volcanically unstable neovolcanic environment of the axis. They would therefore likely host longer lived and more stable hydrothermal systems and associated biological communities and larger mineral deposits than their neovolcanic counterparts.

MATAKIVITI & MARIO

Strategic Energy Planning and Policy – A Tool for Fostering Economic Growth

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The paper provides an overview on the importance of integrating energy policy into national development plans or strategies and the contribution it makes towards achieving the social and economic development goals of Pacific Island Countries (PICs).

PICs continue to be disadvantaged by the increasing price of imported fossil fuels, their vulnerability to security of supply and hence are becoming more and more aware of the significance in ensuring the provision of reliable, affordable and environmentally friendly renewable energy services to achieve sustainable development.

Over the past two years there have been steep increases in the cost of consumer items where the escalating costs of imported fuels has been one of the contributing factors. Since all PICs are so heavily reliant upon imported fossil fuels this then impacts significantly on small economies, which can be astounding.

Several PICs are barely keeping their power utilities operating and have been forced to put regulatory measures in place so as to at least be able to provide the very basic level of service acceptable. The challenge of trying to maintain energy security is often exacerbated by the need to keep in mind the health of the environment and reducing greenhouse gas emissions into the atmosphere.

The Pacific Islands Energy Policy and Strategic Action Planning (PIEPSAP) Project, has demonstrated tangible results amongst 14 PICs that a national energy policy framework is a critical instrument and a fundamental driver for growth and development.

The impact in countries of having a national energy policy, which along with its companion strategic work plan effectively integrated into national development plans, was recently assessed on its contribution to strengthening the energy sector.

MAY

Pacific Disaster Net

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The Pacific Disaster Net is a Web Portal and Database System – *Virtual Centre of Excellence* – for Disaster Risk Management in the Pacific Region.

It is available online (as a Test version at the moment) – *www.PacificDisaster.net* – and will be available offline as frequently updated DVD distribution.

The portal is designed to be the largest and most comprehensive information resource in relation to Disaster Risk Management for the Pacific Island Countries. It supports National Action Planning, Decision Making and provides in-country information for distribution within the region.

It is a living collection and growing resource to enable and facilitate actors and stakeholders to research and collaborate, improving Information and Knowledge Management.

The Pacific Disaster Net hosts material relating to Governance, Risk Assessment, Early Warning and Monitoring, Disaster Risk Management, Training and Tools from various sources like Countries, Bodies, Organizations and Agencies at regional, national and international level.

A focal point in the development was multiple access entries with a range of retrieval and display options. Inexperienced and expert users will find their information and documents within a range of formats.

The formats include up-to-date and alive information like Alerts with notification, Events, Calendar, Contacts, Forum & Message board and Publications, Reports, Data inventories, Maps, Links, Audio/Visual files etc.

Information from the portal can be viewed, downloaded, sent by email and even exported into other formats.

For interactive use there are different levels of access to discuss a variety of issues.

A Country page provides filtered, dynamic and fixed data and information with Events, Contacts, Links and Basic facts – available per country, organization etc.

Outlook and Future perspective

- Data collection and input – with contribution of Partners and Users, providing.
- Support and preparation of documents and material in the countries with installation, training and data input.

Document – Information and Display.

Provide/send digital material/documents – *NOW* !

- Hardware upgrades.
- Develop additional features and improve functionality (with Standards).
- Final Graphic Design.
- Maintenance and Quality Control.

Developed within the Partnership Network by SOPAC and in cooperation with IFRC, UNDP and UNOCHA.

MITCHELL & Others

South Pacific Sea Level & Climate Monitoring Project

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Estimated rates of global average sea-level rise during the 20th century were about 1.7 mm yr^{-1} and since the early 1990's, rates have been estimated to have increased to around 3 mm yr^{-1}. The two major contributors to these increasing rates are; ocean thermal expansion (expansion due to warming) and melt water from land-based ice both of which are linked to environmental shifts caused by anthropogenic climate change (IPCC, 2007). Increasing rates of sea-level rise directly threaten low-lying coastal communities across the Pacific region, through inundation, saline incursion, land loss, greater vulnerability to storm events, and in the case of atoll nations, where average land height is barely 1 m above spring high-tide level, global sea-level rise threatens their very existence.

Given the significance of this issue to the Pacific community, highly accurate sea-level monitoring accompanied by similarly accurate tectonic (land-elevation change) monitoring is of crucial importance to informing island nations of the status of sea-level rise in their region and is fundamental to the design and planning of adaptation responses. It is also stressed that even though global averages of sea-level rise are reasonably well established, these rates are in fact not expected to be uniform across the globe and there is a critical need to identify regional and sub-regional rates.

The main objective of the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) is to monitor sea level and climate change. It is funded by AusAID and managed by the ABoM (Australian Bureau of Meteorology). Technical support is provided through the National Tidal Centre Australia, Geoscience Australia and SOPAC (Pacific Islands Applied Geoscience Commission). The Project is now entering its 16th year of operation with Phase IV beginning in January 2006. The Project's regional office is based in the Ocean & Islands Programme, SOPAC, which not only provides technical support but also acts as the regional data archive centre.

This Project provides extremely accurate, high-resolution meteorological and sea-level data through an array of sophisticated climate-monitoring stations from twelve countries within the South Pacific Forum. In association with these stations is a network of precise geodetic survey stations (CGPS) which measures vertical land movement extremely accurately and is an obvious, critical component towards understanding rates of sea-level rise in any particular location.

These SEAFRAME (Sea Level Fine Resolution Acoustic Measuring Equipment) stations continuously measure seawater level, wind, atmospheric pressure, air and sea temperatures in each location and transmit this data via satellites and phone lines to Australia Bureau of Meteorology. To ensure accuracy, manual precision leveling surveys are routinely undertaken to monitor any vertical movement in any of the components of the SEAFRAME system. One of the additional benefits from this survey work is that it assists to establish consistent and accurate height datum information for these countries.

The raw CGPS data are 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 data collected by the Project are also being used at local, regional and international level by oceanographic and meteorological departments, lands and survey departments, research institutes and many others. The Project data and information is also available as fact sheets, SEAFRAME & CGPS data reports, six-monthly newsletters and tidal calendars. The data provide benefits to the national infrastructure of the participating countries with opportunities to:

- upgrade their geodetic survey network;
- unify height datum, nationally and regionally;
- determine transformation parameters;
- participate in cadastral and engineering surveys;
- generate Digital Elevation Models (using kinematic GPS and geoids);
- assist Coastal Zone Management; and
- respond and adapt to Climate Change Mitigation.

A SEAFRAME station was established in Tonga in January 1993 and the CGPS (Continuous Global Positioning System) was subsequently commissioned in February 2002. The Tongan Department of Lands & Survey is the local agency facilitating this Project and have supported Project field survey visits which are conducted on an 18-month cycle to calibrate and maintain the SEAFRAME station. Precision levelling monitoring surveys to detect movement and establish the link between the SEAFRAME and the CGPS station are also undertaken routinely.

NEWSOME & Others

GeoSource Tonga: a spatial information system for hazards, land management and development

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GeoSource Tonga is a new GIS-based topographical mapping system housed with the Ministry of Lands, Survey, Natural Resources and Environment (MLSNRE), built as part of the Cyclone Emergency Recovery and Management Project, B2 component; Land Hazards and Information Management. GeoSource Tonga has rejuvenated land resource databasing, GIS analysis and

topographic mapping for application in areas as varied as natural hazards, land management, biodiversity conservation, rural and urban planning and tourism.

The Project has:

- developed a new geodetic datum and coordinate system for the Kingdom;
- acquired new high-resolution satellite imagery;
- installed new computers and GIS software;
- captured over 50 national topographic and land resource layers; and
- produced new topographic maps of Tonga.

A new Tonga Geodetic Datum has replaced the former 13 separate and independent datums of the Kingdom and a new national map projection (Tonga Map Grid) can now be applied to both surveying and mapping. Tonga's surveying and mapping data is now based on an international reference system compatible with modern GPS and GIS systems.

National pan-sharpened, multi-spectral QuickBird imagery has been acquired covering all major land and reef areas of the Kingdom of Tonga. This has been ortho-rectified using a 5-10m Digital Elevation Model, ground control points obtained from ground survey and satellite ephemeris data. The resulting 0.5 m image mosaics are managed and accessed using the ESRI Raster Catalogue facility.

A central fileserver with over 0.5 Terrabytes of hot-swap disk storage supports six desktop GIS workstations. Four ArcView ArcGIS licences are served to any GIS-capable computer in the Ministry. An additional ArcGIS licence is located on a hardware key to allow GIS use in the field or at a remote site during emergencies. A high-resolution A0 colour scanner can input images from paper maps, plans and photographs, and finished maps are output to a high-resolution A0 Inkjet plotter as well as A3 and A4 desktop printers.

Over 50 national spatial layers were captured into the GeoSource Tonga system by a combination of screen-digitising and conversion from existing data. Many of these are small layers of simple features with limited attribution (such as waterfalls and caves) while others are large with comprehensive descriptors such as roads, land cover and soil. All layers have comprehensive embedded metadata describing their origin, content, custody and ownership and access protocols.

From these data and using the advanced cartographic functions of ArcMap, a new topographic map series has been compiled and printed for the entire Kingdom of Tonga. Of key significance is that these maps are created directly from the GIS database using GIS tools and printed on-demand using a large-format high-quality plotter. This means that currency between resource information and published maps is maintained with almost no requirement for map storage.

NGAU CHUN

Expansion of Hydrometric Network for Upolu – surface water site selection

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Since the establishment of the Hydrology Section under the Meteorology Division back in the 1970s, a hydrometric network was also set up to investigate water resources in the country. A

number of recording stations are located in the Vaisigano catchment which consists of the three Alaoa branches; in the Fuluasou catchment which consists of the three Fuluasou branches; and a few rain gauges namely, Afulilo and Lanutoo, are part of the network. The old stations which were first set up are now damaged due to strong river flows and are soon to be rehabilitated. Information collected from these stations and areas will improve the volume of data needed by newly-built infrastructure and areas with the potential mainly for water supply and hydro power. Two old mechanically operated stations still exist and running which measures the water level only. A number of sites are proposed and to be rehabilitated for hydrological data collection and analysis.

NIDUNG

The Coordination of the Tripartite Submission Concerning the Ontong Java Plateau between Papua New Guinea, Solomon Islands and the Federated States of Micronesia

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A number of South Pacific Island States including Papua New Guinea, Solomon Islands and Federated States of Micronesia had Desktop Studies undertaken to determine whether the countries had potential areas for which to prepare submissions to delineate the outer limits of their continental shelf beyond their 200 nautical mile exclusive economic zones as provided for by Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS).

The findings from previous assessments undertaken by SOPAC were later confirmed by the Desktop studies. A number of technical workshops were organised to prepare officials on the implications of the UN deadline (12 of May 2009) which would have raised political, legal and technical dimensions on the issue including the financial and resource constraints currently faced by the Pacific Coastal States.

A High-Level Colloquium was initiated by SOPAC in consultation with Pacific Coastal States on the "Establishment of the Outer Limits of the Continental Shelf" and convened from 12 to 15 of February 2007, in Brisbane (Australia) to bring the results of the Desktop studies to individual member countries so they might work out the approach for advancing the work on the outer limits of the continental shelf on a country-by-country basis.

At the Brisbane meeting a number of representatives from various technical and administrative partners namely, Forum Fisheries Agency, Geoscience Australia, governments of Australia, Ireland, Japan and France, the Commonwealth Secretariat, UNEP-SHELF, UN DOALOS and UK National Oceanographic Centre were present to discuss the implications to the Pacific Coastal States and among other things discussed possible approaches to take in preparing submissions to the Commission such as the approach UK, France, Spain, and Ireland took in their joint submission.

One of the potential areas of claiming beyond the 200 nm EEZ's is the Ontong Java Plateau which implicates Papua New Guinea, Federated States of Micronesia and Solomon Islands. During the data review of the Ontong Java Plateau in Canberra during 9-13 of July 2007 it was revealed that there were overlaps in jurisdiction and that separate submissions by each State would not be appropriate mindful of potential disputes to be raised. If one State disputed a claim by any of the other states involved, that would defeat the submission of the other states.

A joint submission approach was informally agreed to by the technical officials and it was agreed that PNG would take the lead to coordinate the meetings between the three countries since PNG already had a permanent Secretariat dealing with continental shelf issues through its Maritime Boundary Project endorsed by the Papua New Guinea Government.

The purpose of this presentation by the three countries is therefore to raise some of the challenges and difficulties faced by technical officials in undertaking a joint submission and to point out what is involved in the whole exercise. Some of the challenges, difficulties and lessons learnt include the following:

- Awareness to wider government network in country because of the various implications and linkages of different stakeholders in this work.
- Institutional arrangements must be in place such as a Permanent Secretariat or an Office to be allocated as overall coordination point.
- Funding or Budget to support this work due to high costs in technical work programme, software and travel associated.
- Membership of national committee to be wide with inter-agency type approach with regular meetings of the national committee to be abreast of the work undertaken. Heads of various departments must be regularly informed.
- Regular informal discussions between technical officials from each respective country to work together and keep each other informed through regular email contact.
- Exchange of desktops with each other to enable joint work to proceed.
- Joint work programmes to be approved and work to be treated as a stand-alone matter.
- Regular contact to be maintained with Departments of Foreign Affairs and High Commissions/Embassies, Permanent Missions in New York on the efforts.
- Border treaties to be negotiated or ratified, if any. Otherwise general mutual agreements (tripartite) should be in place to show commitment and to essentially avoid disputes.
- Keep SOPAC informed of any difficulties faced and request guidance where needed.
- Complex technical area of work for GIS personnel, lawyers, geologists, hydrographers, policy officials etc.

Difficulties

- When officials have other work responsibilities and priorities not given to eCS work.
- Changes in Heads of Departments can be a problem when new Head is not cooperating or delays experienced in getting certain funds approved by the Head for tabling submissions.
- Funds are held by other organisations and difficulties could be experienced with government accounting system when funding requisitions are signed by certain officials who are constantly travelling or not available.
- Delays in getting approvals done.
- Constant dialogues with other country officials could be a problem if they also travel frequently in their normal duties.
- Communication systems in other countries must be up and running such as email contacts most easier way to keep in contact and send documents.
- Countries need to plan ahead and budget for eCS.
- Time constraints mean keeping priorities and remaining focused which may cause problems if no separate office/arrangement dealing with eCS exists.
- When Heads of organizations/departments are not advised regularly could cause problems or set backs.

Lessons learnt

- Informal communication between officials are perhaps the way to move on eCS between countries because formal processes will delay progress.
- Personalities are important. Officials not getting on with each other could be a hindering factor in maintaining communications.
- Maintaining open, trust, and transparent approach to sharing of information.
- Initiate discussions and plan ahead, never leave things to the last minute.
- Cooperation is the most effective way of getting things done.
- Ask for help if faced with difficulties.

PEARCE

Tsunami Hazard Assessment in the Southwest Pacific:– Availability of data and options for tsunami inundation and risk modelling

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SOPAC and Geoscience Australia, funded by AusAID have established the first component of a multi-stage project to look at tsunami hazard and risk assessment in the Southwest Pacific. As part of that project Geoscience have produced a tsunami hazard assessment for the Southwest Pacific based on a deterministic deep-water tsunami propagation model (*A Preliminary Study into the Tsunami Hazard faced by Southwest Pacific Nations*, Thomas et al. 2007). In parallel with that component of the project a review of data available for inundation modelling in Southwest Pacific is being conducted by SOPAC; as inundation modelling requires significantly higher resolution bathymetry, inter-tidal and coastal topography than the deepwater propagation models.

Deepwater models alone are not sufficient to develop detailed understanding of tsunami inundation on coastlines and ultimately it is proposed that the deepwater model output will be used to define the boundary conditions and as an input for more detailed, site-specific tsunami inundation models. The combination of the deepwater propagation and inundation model output will then be used to provide tools for emergency management and infrastructure planning in the Southwest Pacific.

With use of the deepwater modelling as input into island-specific, finer resolution tsunami inundation models a greater understanding of the potential risk and possible impacts of tsunami may be realised. It will then be extremely important to communicate the comparative risks and consequences within all-hazard frameworks and action plans. It should be noted however that accurate detailed tsunami inundation modelling can only be undertaken if adequate bathymetric (seafloor mapping) and topographic (land height or elevation) information exists.

Three country assessments have been completed: Tonga, Niue and Kiribati and several more are in progress, including Solomon Islands. These reports are highlighting a number of issues and gaps common to most Pacific Island countries:

- Availability of high-resolution bathymetry/topography of low-lying areas.

- Lack of host countries real-time access to sea-level data collected in country and in the region for international purposes.
- Technical understanding of how to complement PTWC warning for national and regional needs.
- Technical advice on comparative risk and consequences.

PELLETIER & Others

The « Vanuatu Arc » Project: eruption dynamics and the seismic cycle in the Vanuatu arc

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Our best and fastest chance to understand the sources of volcanic eruptions and strong earthquakes in subduction zones, to unlock the relations between subduction dynamics and the seismic and eruptive cycles and to identify precursors for these destructive events is to study convergent margins undergoing rapid deformation, with frequent events and also conditions favorable to dating past events and quantifying dynamic processes. The young and very active Vanuatu convergent margin combines all of these characteristics. Present-day motions are large: 10 to 17 cm/yr of convergence and up to 1 cm/yr of vertical motion. Earthquakes are abundant: more than 1 magnitude 7 per year. The active volcanoes, mafic and explosive, erupt frequently and in some cases quasi-permanently, sometimes generating ash plumes and eruptive columns with exceptionally high SO_2 flux (peaks up to 20000 tonnes/day). The presence of coral formations – remarkable dating tools and excellent recorders of relative sea level and seawater chemical composition – allows the study of historical and recent eruptions and vertical motions (including inter-seismic motions).

The Vanuatu Arc Project is focused on two sections of the Vanuatu arc, each in a different geodynamic setting.

The first is the central arc and Ambrym and Lopevi volcanos. This section of the arc, sitting at the level of asperities that are entering into subduction, is characterized by a strong coupling at the trench, back-arc and intra-arc shortening, strong vertical uplift, high earthquake recurrence rate, and enormous explosive volcanos that have created cataclysmic hydro-magmatic eruptions. The presence of islands at the front and back of this arc and of shallow waters near to and on both sides of the trench offer an exceptional opportunity to study the seismicity and the geometry of the subduction interface and seismogenic zones and to measure the stress accumulation across the entire margin. The active Ambrym and Lopevi volcanos generate strong eruptive plumes and are choice sites for studying gas accumulation and the source mechanisms for strong plume eruptions, to better understand precursory phenomena and forecast eruptions.

The second is Yasur volcano in the southern section of the arc. Permanent activity, strong fluctuations in eruption intensity, and easy access make this an ideal site for a multi-disciplinary study of the eruptive cyclicity. With its resurgent dome and associated hydrothermal system, it also offers the opportunity to study the processes controlling dome resurgence in calderas.

The following approaches and methods, combining geophysics, geochemistry, petrology and geology, have been proposed:

- Near- and far-field acoustic measurements to quantify degassing dynamics (pressure, volume, flux) and to understand the mechanisms behind different types of activity, with the goal of improving remote surveillance and warning.
- Measures of the chemical composition (FTIR) and mass flux of gas emissions (FTIR, near-field acoustics, radar), amount and evolution of dissolved volatiles in magmas (glassy intrusions) and Uranium isotope series fractionation to study the amount and dynamics of magma degassing.
- Geochemical analysis of volcanic products and crystals to determine residence times in magma reservoirs and eruption cyclicity.
- Electric and electromagnetic measurements, combined with mapping and overall CO_2 emission measurements, to study the hydrothermal system of the Yenkahe dome on Yasur volcano.
- Seismological measurements to constrain the location and dimensions of reservoirs, conduits, the subduction interface, other seismogenic zones and the fate of the subducting plate.
- Continuous geodetic measurements on edifices and across the margin, to determine the deformations during volcanic and seismic events and the build up and relaxation of stress throughout the seismic cycle. Identify, if possible, transient deformations and precursor signals to cataclysmic events.
- Determination of eruption/seismic chronology through studies of corals, including better constraints on eruptive cycles, determination of inter-, co- and post-seismic vertical motions, and identification of margin segmentation and potential rupture zones.

This multi-disciplinary, 3-year (2007-2009) research project unites several institutions (DGMWR Vanuatu, DLS Vanuatu, CNRS, IRD, IPG Paris, EOPG Clermont-Ferrand, CEA, IGN, Universities of Nantes, Lyon, Grenoble, Montpellier, Chile and Canberra), and is partly funded by the French National Agency for Research (ANR).

PENAIA & Others

Reducing Flood Risk – From Science to Policy: The Samoa Process

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River flooding, especially flash floods, are a serious and frequent problem in Samoa and in particular Apia where steep catchments with rapid flood onsets are subject to frequent heavy rainfall events. The April 2001 flood event inundated large parts of Apia urban area within a negligible time lag from the beginning of the intense rainfall. The surrounding watersheds responded to the flash floods with combined overbank/overland flow. Approximately 5,000 local residents were directly affected by the flood and resulting damages were estimated in excess of WST$ 11 million. Such events are not rare for Samoa. The Vaisigano catchment was selected for the study due to its impacts on Apia during flood events. It is also the best-monitored watershed

in Samoa with discharge records available between 1973 and 1990 and precipitation records from several locations on Upolu with two records dating back some 100 years.

In addressing flood risk management, previous studies have concluded that technical mitigation measures such as channel or detention basins are only of local, and thus limited, effect. As the development described above is mainly caused by urban extension activity only considered flood plain management strategies and urban development planning strategies adapted to flood drainage are sustainable and therefore of high importance for the future protection of Apia, the principal centre of population, administration and commercial activity in Samoa.

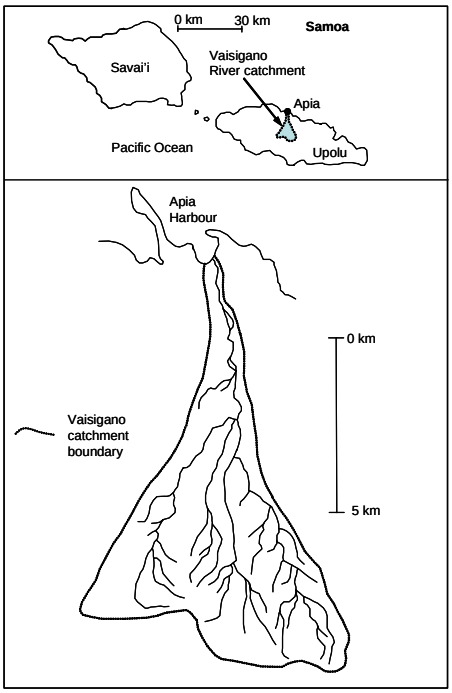

Figure 1. Location of Vaisigano River in Apia, Samoa.

The overall goal of the study is to reduce flood risks for urban Apia by enhancing flood risk management capacity within Samoa. To address the goal the Project first focussed on the capacity needs of the Meteorological Division's Water Resources Division and the Planning and Urban Management Agency (PUMA) in understanding flood hazards of Apia urban area by identifying areas prone to flooding and quantification of flood hazard, extent and intensity. The training and ensuing modelling and mapping served as guides for improved urban planning and floodplain management.

The process taken by the Project is depicted below (Figure 2).

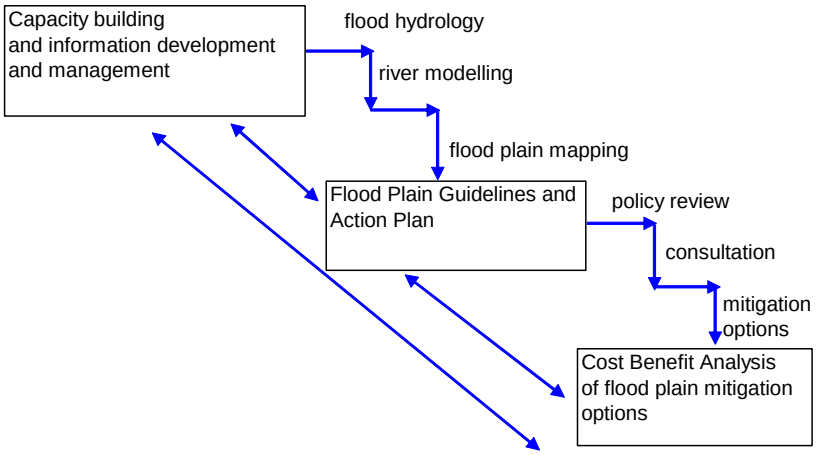

Figure 2. Steps undertaken by Project to address flood risk in Samoa.

In a combination of formal lectures and hands-on training, lead government agencies had been guided through the process of flood risk assessment, from data capture to the production of flood hazard maps for certain design events. These formed the basis of the development and evaluation of flood risk reduction options and policy documents, such as the flood management guidelines and action plan. The aspects listed below had been covered.

- Training in flood hydrology, river modelling, floodplain mapping and flood mitigation.
- Introduction into flood modelling using license free software packages from the US Corps of Engineers.
- Development of a hydrological model and a flood inundation model of the Vaisigano River catchment.
- Production of flood hazard maps.
- Estimation of flood risks.
- Technical evaluation of flood risk reduction measures.

Floodplain Management Guidelines

The Guidelines were defined in consultation with Samoan stakeholders to determine acceptable design events based on potential damage categories and severity with respect to local vulnerability (social and financial), land-use, infrastructure and available disaster relief action.

The objectives of the Guidelines are to:

- assist the (PUMA) in its planning and development assessment as prescribed by the 2004 Planning and Urban Management Act Part III, Section 8 and Part IV.
- promote awareness and provide information for developers on the requirements of the development consents process for development proposed for floodplains.
- provide useful resource and advisory to responsible authority (PUMA) as provided for under Section 46 of the 2004 PUM Act and, authorities enforcing building codes, building and maintenance of public infrastructure, utilities, drainage systems and emergency agencies to coordinate their relevant and 'connected' activities in various aspects of the floodplain to reduce flood risks and associated flood costs.

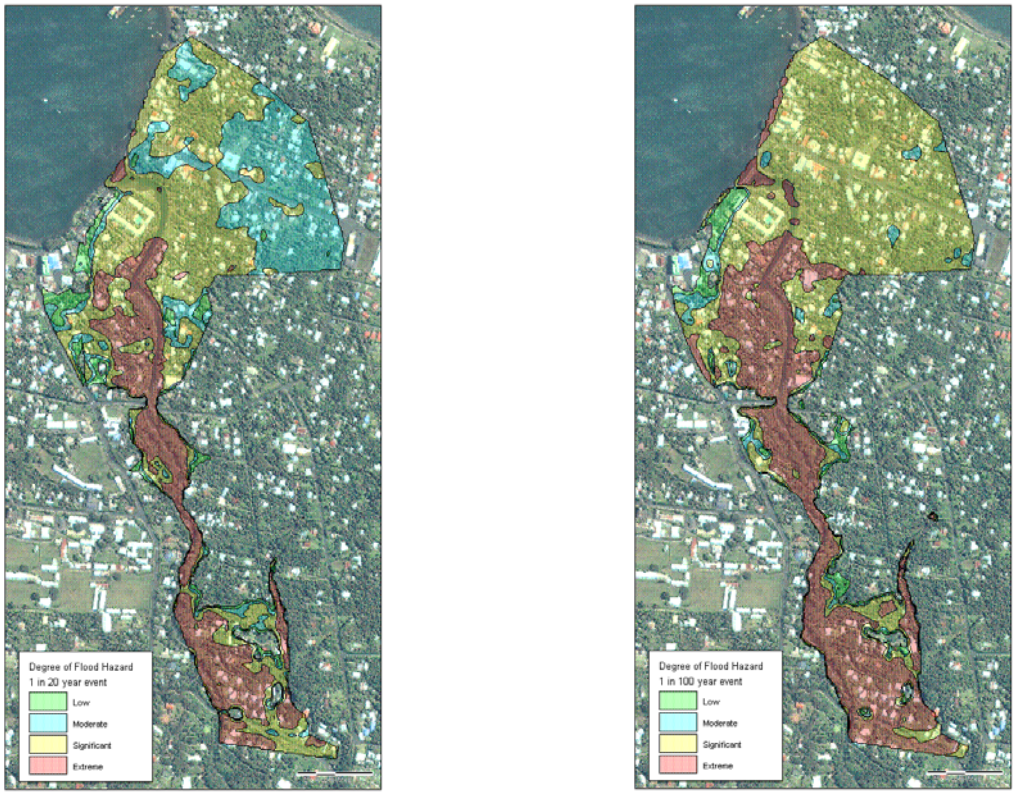

Figure 3. Flood hazard maps for a 20- and 100-year-return-period event.

Flood Risk Management Plan

The Action Plan includes proposed flood mitigation strategies and measures (structural/non-structural) based on the flood hazard mapping carried out. The framework was developed in partnership with Samoan stakeholders outlining future activities, priorities and institutional requirements for effective flood risk management.

The overall goal of the Action Plan is to reduce social, economic and environmental impacts of floods on the people of Apia thereby facilitating the achievement of national development goals.

The objectives of the Plan are to:

- identify and map the flood hazard within the lower Vaisigano River catchment.
- identify flood risk management options and indicate how these may be assessed in more detail.
- strengthen nationally-coordinated flood forecasting and warning systems.
- support public outreach and education activities to improve awareness of flood risk and hazard and promote recommended preparedness actions communities can take to reduce risks to themselves and to others.
- manage activities in floodplains in a manner compatible with multiple and competing uses, including existing and proposed urban development within Apia.
- strengthen the capacity of the Ministry of Natural Resources and Environment, in particular Water Resources Division, PUMA, Meteorology Division and DMO and other relevant agencies to provide consistency in flood risk management.
- incorporate flood risk management in the national planning and budgetary processes.

- update the Action Plan regularly and employ adaptive management strategies in order to take full advantage of scientific and technological advances, and to use the best available floodplain management practices, principles and information.

Economic analysis of flood risk reduction measures for the lower Vaisigano catchment area

The economic study assessed the priority structural and non-structural measures identified by stakeholders during a consultation meeting held with SOPAC in March 2007. These include the construction of floodwalls, the construction of a by-pass channel, improvement of the current flood forecasting system and strengthened development control by requiring houses built in the floodplain to have raised floors.

The study concludes that significant future savings can be achieved by investing in flood management measures. Savings, in terms of avoided flood damages, can be realized through an improved flood forecasting system accompanied by an improved flood warning system. The most effective measure, in terms of reducing flood damages, according to the study is building new homes located in the floodplain with raised flood heights. The study also considered the costs and benefits of investing in large-scale flood management projects such as floodwalls along the banks of the lower Vaisigano and the construction of a by-pass channel. However these measures were found not to be economically feasible due to the high construction and maintenance costs involved.

RAMSAY

Are seawalls a long-term adaptation option for atoll environments? Examples from Tokelau of the role they may play

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The effects of climate change, particularly in the Pacific, are likely to be felt first (and possibly most significantly) through the impacts of episodic extreme weather events (such as cyclones). Thus the most significant effects will usually occur as 'disasters', often with little warning. Atoll states in particular believe that their very survival is threatened. Indeed, socio-economic changes and rapid development of Pacific Island infrastructure over the last 30-40 years, whilst resulting in many benefits, has generally led to an erosion of traditional coping mechanisms and community resilience to disasters exacerbating the inherent community ability, and range of options available, to effectively adapt.

Pacific Island countries have no option but to adapt to the effects of climate change. In terms of coastal erosion and cyclone-related inundation hazards, it is well recognised that adaptation options fall under three basic options: planned retreat, accommodation or protection. It is the latter, in the form of hard defences aimed at reducing the potential effect of coastal hazards, that have typically been used, and cited by atoll (and many other coastal) communities as the socially preferred option of reducing such risks.

However, seawalls and other coast protection are, in most cases, not as permanent as communities apparently 'protected' by them assume, particularly in atoll settings where the range of construction options and materials available are typically much more limited. In many situations the construction of such defences and the perception of the protection that such

structures provide have over time significantly increased the level of risk facing atoll communities. In many situations they have also essentially 'locked in' future generations to a permanent reliance on coastal defences and considerable ongoing expenditure associated with maintaining an acceptable standard of protection.

The immediate negative environmental impact of typical forms of linear hard defences on adjacent sections of coast are also well known. However, where such structures essentially become permanent features there will be longer-term impacts that will affect the natural adaptive capacity of *motu* to continue to adjust and respond to the long-term effects of climate change. Such aspects are rarely considered but are important in the context of effective adaptation within atoll communities.

The three atolls of Tokelau demonstrate at different levels both the natural adaptive processes occurring and how hard defence structures impact on such adaptive capacity. Built defence structures will undoubtedly continue to play an integral part in the range of measures used to reduce risks caused by coastal hazards on the Tokelau communities, more so on some of the atolls than others. However, their design and form has been modified in collaboration with each Tokelau community to better accommodate these natural adaptive processes. In doing so these defences also provide a more effective and sustained standard of protection to the community as well as limiting some of the common negative impacts that defences can cause in trying to "hold the line".

RAMSAY & Others

Returning the sand to the Sandy Beach Hotel on Kosrae

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The construction of linear hard defences, such as revetments or seawalls, on open-coast beach environments often lead to negative environmental impacts, such as loss of beach fronting the defence, exacerbated end effects or downdrift erosion adjacent to the ends of the structure. In many cases initial construction of such defences leads to a cycle where the resulting impacts necessitate the extension or construction of longer and larger structures, which in turn leads to further or larger impacts, which then leads to further defences and so on. Breaking out of such cycles, once commenced, is not easy.

Such a cycle occurred over a number of decades on the north-east facing coast of Kosrae which led to the near loss of the Sandy Beach Hotel, Kosrae's first resort hotel. Constructed in 1982 the hotel consisted of nine local-style units located behind a white sand beach on the wind-ward north-east corner of the island. From the early 1990s, the traditional style units were replaced by six concrete buildings containing 16 rooms and a restaurant.

The background to the erosion problems on the northeast coast of Kosrae stems back over a number of decades before the Sandy Beach Hotel was constructed, relating to the removal of large quantities of coral rubble from the intertidal fringing reef during the initial development of the circumferential road. However, it was during the widening of the circumferential road in the late 1980s that problems began to occur. Widening the road extended it on to the upper part of the beach with some rock rubble protection installed to protect the road. This rock quickly moved off west due to the prevailing wave induced longshore transport, resulting in a layer of black

volcanic rock covering the white sand beach fronting the hotel. Over the subsequent decade various gabion defences were installed to protect sections of the road, with the length of the defence ever increasing. However, the gabion baskets quickly broke down, releasing more volcanic rock that ended up covering the beach at the hotel resulting in a legal trial concerning the removal of the rocks from the hotel frontage.

A more substantial and longer rock armoured revetment was completed in 1998 which extended to the eastern boundary of the Sandy Beach Hotel. In the months following the construction, accelerated erosion occurred immediately to the western end of the rock revetment, undermining the Sandy Beach restaurant foundations and resulting in a net loss of beach along the entire frontage of the hotel. High tides and waves during December 1999 resulted in further loss of beach along the Sandy Beach frontage threatening most of the hotel property.

Whilst the hotel owner had consent to construct a rock revetment along the front of the property, extending the defence would continue to move the erosion problem further along the coast. The last remnants of the sand beach from which the hotel took its name would also have been lost. In a further legal case brought against Kosrae State by the hotel owner, the judge ruled that the State had the obligation to re-instate the sand beach and the protection it provided to the hotel.

To stabilise the downdrift effects and protect the hotel from further damage, a rock breakwater structure design was developed to control the future shape and stability of the beach. Beach nourishment was conducted along the hotel frontage to replenish the sand that had been lost due to erosion. The scheme was constructed in 2001 and has successfully maintained the sandy beach in front of the hotel. It has withstood a number of storms and has provided effective protection to the hotel, as well as alleviating the continued downdrift problems that had occurred previously.

RATIRAM & Others

Identifying sources of abundant coarse bedload sediments that form the Jourdain River braidplain on Santo Island, Vanuatu – preliminary results

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The Jourdain River is a large river system draining generally northwards on the island of Espiritu Santo, Vanuatu. The river transports enormous quantities of coarse bedload sediment, comprising many different lithologies, which have formed an extensive braidplain landscape in the Big Bay hinterland. Santo Island has a complex geology, where the eastern basement is mainly raised limestone reefs and the western division is dominated by rugged mountains of volcanic origin. Large areas are underlain by sequences of volcanic-derived breccias plus Pliocene to Recent gravels and sands of marine origin.

This paper presents the preliminary results of lithological studies of the Jourdain River sediments, carried out to identify the source areas for the coarse bedload deposits. This is important in order to understand the origin, processes and long-term evolution of the braided river network, which is an unusual feature for the humid tropics. Sampling of clast lithologies was carried out over two field seasons in 2006 and 2007 at 22 individual sampling sites on gravel bars across the braidplain. The rocks are generally classified into volcanic or sedimentary origins, then further subdivided into specific groups based on their geochemistry, grain size and texture.

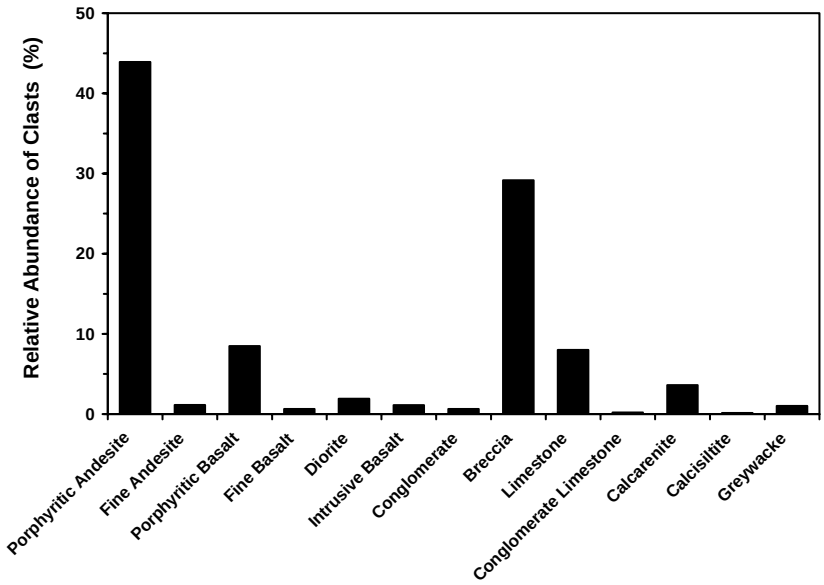

Figure 1. Relative abundance of different lithologies of the coarse deposits forming the Jourdain River braidplain.

Preliminary results suggest that volcanic origins dominate the rock types. Volcanic porphyritic andesites and breccias are the most common of the sampled clasts representing approximately 44% and 29% respectively. Carbonates, which are soluble and/or soft rocks (reef limestone, calcarenite, calcisiltite), are evenly distributed within the braidplain but are not so abundant, representing only 12% of the sampled clasts. The importance of various clast lithologies is influenced by proximity to the bedrock formations, the location of the tributaries of Jourdain River on different rock types and the relative texture and hardness of the clasts.

REO & Others

Republic of Kiribati Maritime Boundaries Project

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Kiribati consists of three groups of islands; the Phoenix Islands, the Line Islands and the Gilbert Islands. It has one of the largest Exclusive Economic Zones (EEZ) in the South Pacific region. Most of the islands in Kiribati are low-lying atolls and have extensive reefs that extend the maritime limits.

The accurate delineation of maritime boundaries is critical to successful marine governance and proper stewardship of marine resources, both living and non-living to Kiribati and the challenges faced by Kiribati in defining their maritime boundaries is the lack of technical resources and information to prepare accurate submissions under UNCLOS (United Nations Convention on the Law of the Sea) to obtain formal recognition of EEZ boundary positions under international law.

Therefore in defining the maritime limts of Kiribati, the Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC) is providing technical assistance to Kiribati to accurately determine national baselines. This information can subsequently be used to define boundaries for

Territorial and Archipelagic Seas, Contiguous Zones and EEZs, and to establish whether there are grounds for potential claims for extended Continental Shelf limits (eCS).

Specific objectives of the project are as follows:

- Developing comprehensive datasets to facilitate definition of the legal and administrative offshore limits for Kiribati in accordance with the provisions of UNCLOS; and making this data and information available to countries.

An important component of the project is the capture of new baseline data to upload into the Pacific Islands Regional Maritime Boundaries Information System (PIRMBIS) for all the Kiribati island groups. Based on Geographic Information Systems technology, PIRMBIS will serve as a national database for UNCLOS-compliant baseline and maritime boundaries. In addition to baseline data, PIRMBIS also contains information on existing, recently signed, and negotiated treaties, and the provisional median lines between adjacent and opposite states.

The continuation of the PIRMBIS will help ensure that boundary positions are settled and by doing so contribute to regional stability through clarity of management responsibility over maritime resources. Agreed maritime boundaries among Pacific Island nations will provide a firm foundation for bilateral and regional resource management arrangements and for effective surveillance and enforcement.

ROEMMICH & Others

Ocean temperature, salinity and circulation from the Argo Project

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In early November 2007, the Argo Project (http://www.argo.ucsd.edu) is expected to reach its milestone of 3,000 autonomous profiling floats measuring temperature, salinity, and ocean current in the upper 2 km of the oceans. There are presently about 2918 Argo floats spread over

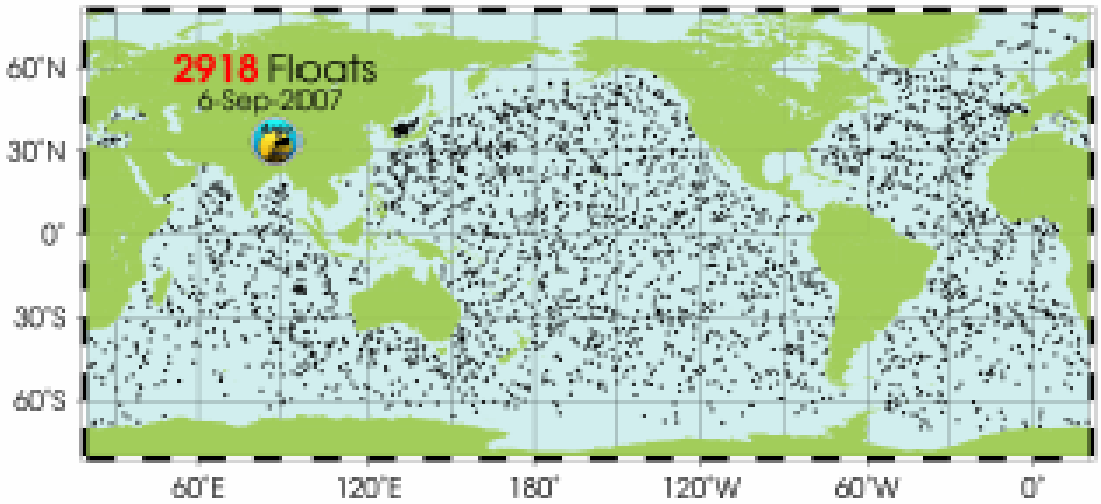

Figure 1: *Location of 2918 Argo floats as of September 6, 2007.*

all oceans (Figure 1), including 660 in the tropical Pacific, each providing a profile of temperature and salinity every 10 days. Through these measurements, Argo observes the ocean's role in storage and transport of heat and freshwater, which are fundamental elements of the climate system. Argo reveals the seasonal-to-interannual variability in the ocean due to atmosphere/ocean climate phenomena such as El Niño. Argo is a central component of the Global Ocean Observing System, with a wide variety of research and operational applications. All Argo data are freely available to anyone via the internet within about 24 hours of collection.

The Argo dataset has been used to produce global monthly gridded (1º x 1º) fields of temperature and salinity as a function of depth, for the period from January 2004 to September 2007. The gridded Argo dataset is available in NetCDF format, and will be distributed as part of a planned PI-GOOS Pacific Marine Atlas. Some basic products that are easily generated from the gridded dataset include:

1. Maps of temperature, salinity, or ocean current (or anomalies) on a depth level.
2. Vertical sections of temperature or salinity.
3. Time-series of temperature or salinity versus depth at any location.

Examples of these are provided on the next page (Figures 2-5). Other more specialized products such as density, steric height, geostrophic velocity, heat content, and freshwater content can also be generated from the Argo gridded data. The Pacific Marine Atlas will provide easy access for non-specialists to basic products, and will give expert users flexibility to generate any displays needed, including animations. It will allow other marine datasets to be displayed in addition to Argo.

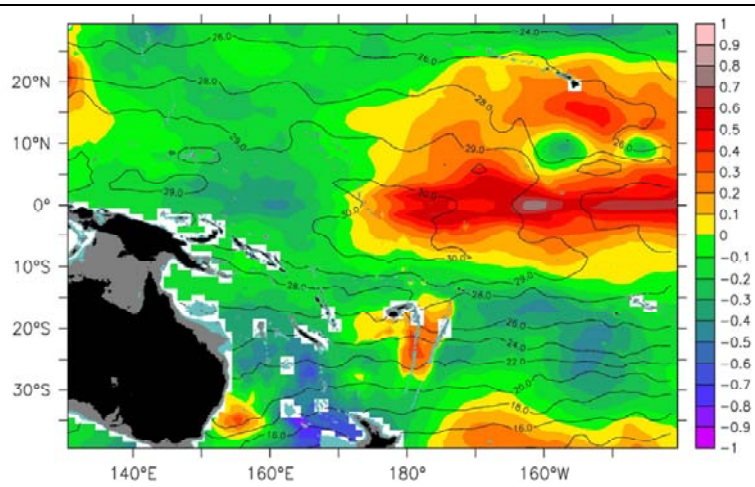

Figure 2: Map of temperature (ºC, contours), averaged from 0 to 50 m depth, in November 2006, and temperature anomaly (colors, compared to the 3-year mean at the same time of year). Vertically averaged temperature in the surface layer is a better measure of heat content than sea surface temperature.

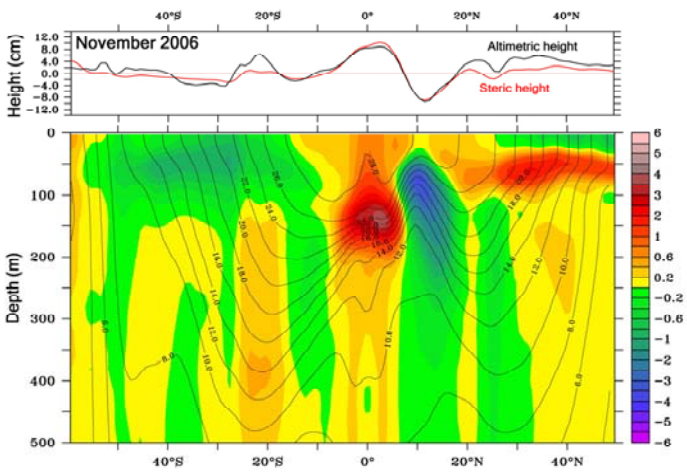

Figure 3: Bottom panel. Vertical section of temperature (contours) and temperature anomaly (colors, compared to the 3-year mean) along 155ºW in November 2006. Note the warm anomaly at 150 m on the Equator during the 2006 El Niño. Top Panel: Anomaly in satellite altimetric height and steric height.

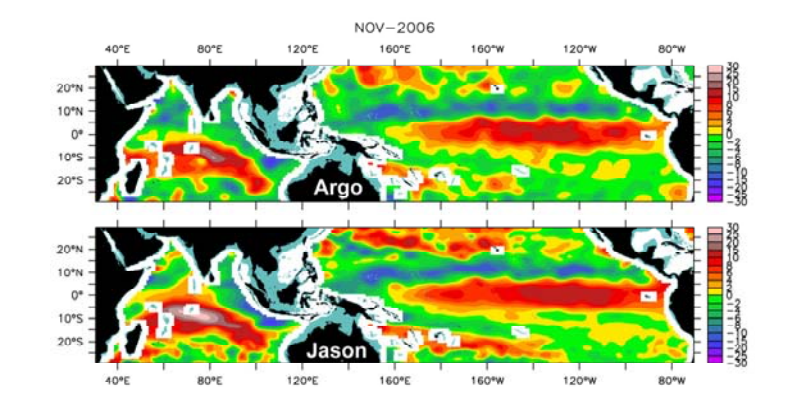

Figure 4: Steric height anomaly, (cm top) and altimetric height anomaly (cm, bottom) for November 2006, compared to the 3-year mean. The band of high surface height during the 2006 El Niño was due to the subsurface temperature anomaly

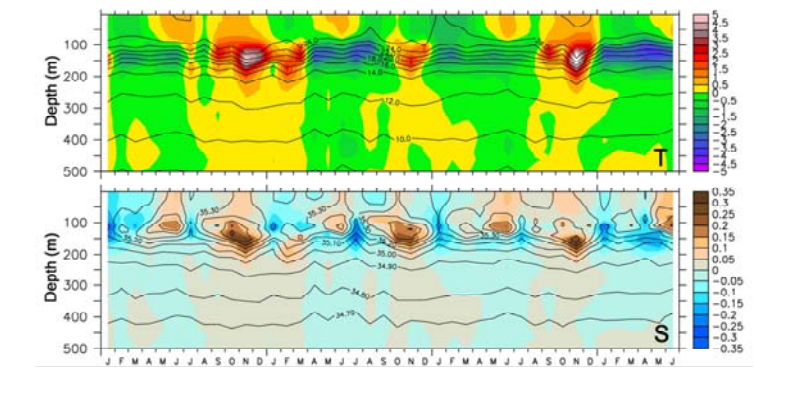

Figure 5: Time series on the Equator at 155ºW of temperature (top panel contours), temperature anomaly (top panel colors), salinity (bottom panel contours) and salinity anomaly (bottom panel colors). Note the warm, salty anomalies during the El Niño episodes in 2004 and 2006.

SEEWALD & Others

Ridge 2000 Research on the Eastern Lau Spreading Centers and Hydrothermal Systems

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Investigation of back-arc seafloor spreading processes at the Eastern Lau Spreading Center (ELSC), including the inter-relationships among rifting, magmatism, hydrothermalism, and deep-sea ecosystems, continues to be an important emphasis within the U.S. Ridge 2000 (R2K) program. Since 2004, five major sea-going expeditions have been funded through the R2K program to the Eastern Lau Spreading Center and four additional expeditions are currently being scheduled for 2008/2009. Past cruises have involved participation of government scientists from Tonga (Akapei Vailea, Rennie Vaiomounga, Sioni Nonu, Sisi Tongaónevai, Apai Moal, Siale Vailea), Fiji (Susana Lalanabaravi, Luna Wong) and a student from the USP (Jeanne De Mazieres) who assisted with processing the geological and biological collections as well as the multibeam surveys. The last cruise of our first wave of inter-disciplinary research was conducted throughout September 2006. This cruise focused on understanding the relation between the changing geology and hydrothermal chemistry documented by the earlier cruises along the ELSC and the changes in the animal communities that are correlated with the abiotic variables. In addition to characterizing the habitats occupied by the major components of the communities, long term temperature recorders and chemical samplers were deployed at four vent sites to monitor

changes in hydrothermal venting and fluid chemistry between the September 2006 cruise and the next cruise which is currently scheduled for 2008.

Many results from the previous cruises have been published, and primary data are available through the open access online Ridge2000 data base (http://www.marine-geo.org/ridge2000/) and have been transferred to the governments of Tonga and/or Fiji as appropriate. Some of the highlights include: Abundant hydrothermal activity discovered along the entire ELSC with new controls on ridge characteristics mediated by the supra-subduction zone environment. Unlike at open-ocean ridges where crustal thickness and composition are relatively uniform, the magmatic productivity and chemistry of the back-arc ELSC changes systematically as the ridge approaches the line of arc volcanoes. Thickening crust and systematic changes from basaltic to andesitic chemistries with arc proximity influence primary ridge characteristics, including overall ridge morphology (which changes from deep valley to a peaked shallow axial high), fault structures, degree and nature of volcanism, seismic characteristics, vent fluid chemistry and vent mineralogy. Geochemical investigations have elucidated a key role for magmatic volatiles during the mobilization of metals and the formation of metal sulfide deposits. At least 15 previously undescribed species of animals have been collected and these are currently being described by experts from around the world. A total of 20 animal communities and associated hydrothermal flow patterns were mapped at cm scale in 2005 and 2006, and will be revisited in 2008 to monitor changes in these very dynamic communities. For the first time, an obligate thermoacidiphilic heterotrophic archaeon that has long been predicted to inhabit acidic vent environments was isolated and cultivated from numerous vent environments along the ELSC.

Four new projects have recently been funded for field work in the Lau Basin beginning in 2008. A seismic experiment will target the structure of the upper mantle, the distribution of melt and pathways of that melt to form oceanic crust along the ELSC. An additional cruise will expand on previous near-bottom hydrothermal and side-scan sonar seafloor mapping with the goal of assessing all significant regional hydrothermal activity and hosting seafloor structures in the vicinity of the Abe and Kilo Moana vent sites. This survey will extend several km onto the ridge flanks to encompass predicted crustal thermal boundaries of the axial zone and associated large faults which may serve to rapidly cool the entire crust. Such structures may host larger, more stable and longer-lived hydrothermal vents than those presently known which are all located within the highly tectonically and volcanically variable neovolcanic zone. One project will revisit the biological communities mapped and characterised in 2005 and 2006 and analyze changes in the communities as well as conduct manipulative experiments to better understand biological interactions within the communities. Another will examine shifts in microbial diversity with a focus on the spatial distribution of thermoacidophilic microbes that live in some of the more chemically and thermally extreme environments on this spreading center. A laboratory based experimental study has also been funded to investigate the extent to which the north-south transition from basaltic to andesitic crust influences fluid-rock reactions that regulate vent fluid chemistry and the genesis of metal sulfide deposits. The Ridge 2000 Program will continue to accept proposals for inter-disciplinary studies in this region and expects that other projects will join these during the next wave of inter-disciplinary studies along this back-arc basin spreading center.

SMITH

An environmental impact assessment of seafloor mineral extraction within the Southwest Pacific

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Nautilus Minerals is exploring seafloor massive sulphide (SMS) deposits for copper, gold, zinc and silver for potential development. Nautilus holds more than 300,000 km^2 of tenement licenses and exploration applications in the territorial waters of Papua New Guinea, Fiji, Tonga, the Solomon Islands and New Zealand along the western Pacific Ocean's Ring of Fire.

Nautilus is conducting the world's first environmental impact assessment (EIA) of seafloor mineral extraction and Nautilus has gained extensive experience conducting environmental studies in subsea environments.

Nautilus is currently working on the Solwara Project in the Bismarck Sea, Papua New Guinea, where high-grade deposits lie at ~1600 m water depth. Conducting an EIA in the deep sea presents some interesting and exciting challenges. Deep sea studies commenced in January 2006 using a remotely operated vehicle (ROV) fitted out with highly specialized scientific equipment to conduct water quality, sediment, biological and oceanographic studies. Earlier in 2007, Nautilus launched a second 30-day ROV program dedicated to environmental baseline studies and during this campaign, over 550 biological, sediment and water samples were collected and over 8,000 seafloor observations were logged. On-board specialists included an international team of experts in the field of deepsea marine science.

Collaboration between industry and scientific research institutions allows data to be collected for the EIA but also provides an extraordinary opportunity for researchers to access sites that might otherwise remain unobtainable to science.

This presentation will review the studies conducted as part of this exciting project.

SUETSUGU

Seismic Imaging of the South Pacific Superplume

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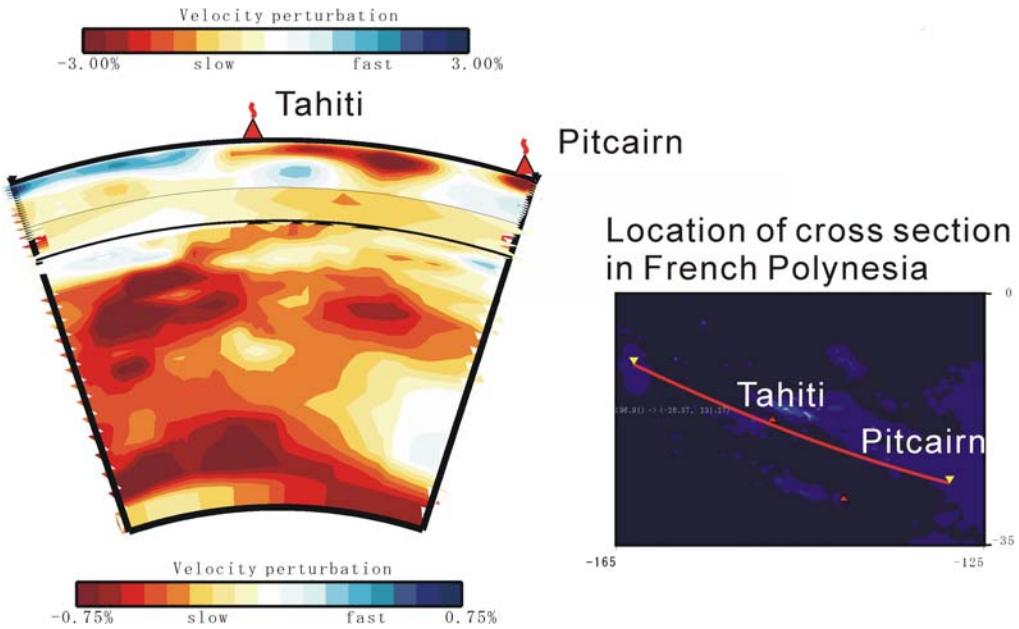
Seismic structure beneath this region had not previously been well explored in spite of its significance for mantle dynamics. The region is characterized by a topographic high of more than 700 m, a concentration of hotspot chains (*e.g.* Society, Cook-Austral, Marquesas, and Pitcairn) whose volcanic rocks have isotopic characteristics suggesting deep mantle origin, and a broad low-velocity anomaly in the lower mantle revealed by seismic tomography. These previous observations suggest the presence of a large-scale mantle flow from the bottom of the mantle beneath the region, which is called a 'superplume'.

However, the seismic structure has been only poorly resolved so far and the maximum depth of anomalous material beneath the hotspots has not yet been determined, mainly because permanent seismic stations in the region have heretofore been deployed only on a few oceanic islands and not on the seafloor.

We conducted broadband ocean bottom seismic (BBOBS) observations on the French Polynesian seafloor from 2003 to 2005 to image the mantle structure beneath the South Pacific superswell. The BBOBS has been developed by Earthquake Research Institute of University of Tokyo since 1990s. The superswell region has many hot spots and low seismic velocity anomalies in the lower mantle and may be a site of major mantle plumes. The obtained seismic image indicates: (1) narrow mantle plumes in the upper mantle beneath most of the hot spots in the superswell region; (2) narrow plumes exist only beneath some of the hot spots (the Society hot spot) in the mantle transition zone and the top of the lower mantle; (3) broad upwelling in the mid-lower mantle beneath the superswell region. We compared the seismic image with analog experiments of plumes to discuss the nature and evolution of mantle plumes beneath the South Pacific.



Mantle cross section made from P-wave tomography for lower mantle (Tanaka et al., 2007), S-wave tomography for upper mantle (Isse et al., 2006), and S-wave tomography for mantle transition zone (Ritsema and Heijst, 2000).

SUREN

PAC-SHMAK: a system to measure and assess stream health in Fiji

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Population development and associated land-use activities in small Pacific island countries are threatening freshwater ecosystems. Such activities are obvious in Fiji, where increased urban development, logging, and agricultural practices are occurring with implications for freshwater ecosystems. Adverse impacts on streams are exacerbated by the fact that there is a general lack of awareness as to the effects of human activities on stream health, and no programme is monitoring this throughout the country. Once degraded, it is difficult and expensive to restore streams to their former state. NIWA, in collaboration with the Fiji Institute of Technology (FIT),

has been funded by NZAID to develop a stream health monitoring kit (PAC-SHMAK) for use in Fiji. Students from FIT were trained to collect biological samples from 154 streams throughout Fiji, including reference sites (dominated by undisturbed forest) and impact sites (dominated by disturbed forest, agricultural activities, or urban development). The most commonly collected invertebrate animals were midges, caddisflies, mayflies, shrimps and snails. Two biotic indices were developed to assess stream health, based on the relative abundances of different invertebrates in each stream. Tolerance values were developed for each invertebrate taxa, and used to derive two biotic metrics, the Fijian Biotic Metric (FBI) and its quantitative variant (QFBI). Both the FBI and QFBI were significantly higher in reference than impact streams, reflecting differences in the invertebrate communities between these streams. These metrics are thus useful to assess the ecological health of Fijian streams. A range of different physical factors at each stream were also measured, including geomorphology, (depth, velocity and % riffle, run and pool), water quality (pH, conductivity and clarity), substrate conditions and stream organic matter, dominant land use and riparian vegetation. Statistical analyses examined relationships between environmental variables and biological data, and nine variables were finally selected that were shown to influence invertebrate communities. These variables included descriptions of land use, streamside vegetation, river morphology, and measurements of water clarity and conductivity. Sensitivity scores for these variables were created so that habitat quality of a stream could be assessed by assigning a score to the field-based measurements. A habitat condition index (HCI) was calculated by summing these scores. This score allowed a particular stream to be assigned to either an excellent, very good, good, poor, or very poor habitat condition. Significant relationships existed between the HCI and biological health, as measured by the FBI and QFBI. This material is being incorporated into the Fijian PAC-SHMAK. A major end user of PAC-SHMAK will be the NGO "Live and Learn", who have a River Care programme operating throughout the country. Once the kit has been produced for Fiji, it is hoped to modify it where necessary for use in other south Pacific countries.

TALIA & Others

The Geological and Geomorphological Mapping of Savai'i Island, Samoa 2005 – 2007

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The coasts of small islands in the Pacific Ocean are vulnerable to sea-level rise and extreme tropical cyclones that may be climate change related. During the last century the trend of sea-level rise has been about 1 mm/year in the tropics and is forecasted to be 2-7 mm/year in this century due to global warming. The UN IPCC (Intergovernmental Panel on Climatic Change) scenario, that sea level will rise to about 3 feet, and the National Geographic, is about 4 inches of rise until 2100 (National Geographic, 2004, Sept., p.22; Coastal, NOAA Coastal Ocean Program Decision Analysis Series No. 21, p.48). So even with the different scenarios, it is clear that erosion is at an unprecedented rate.

The geological mapping of Savai'i Island is a priority because of its increased coastal erosion, and it has most of Samoa's well-preserved natural environment and infrastructure development; and is a significant cultural heritage.

The geological mapping is a methodology applied by geological practitioners to gauge the degree of degradation or erosion as well as to easily identify features that enable mitigation strategies to

be made to combat coastal negative impacts and coastal hazards. There are some areas where a net gain in land reclamation is seen.

TARANU & Others

The 2006 Volcanic Crisis in the Sulu Range, Central New Britain, Papua New Guinea

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In July 2006, very considerable and unusual earthquake activity commenced in the Sulu Range area, Central New Britain, Papua New Guinea. This region has not been active in historic times. Reports were received of muddy water in the rivers, disturbances in the sea, booming noises coming from the Sulu Range and unusual activity in the hot springs in the Silanga area to the west. Fearing the possibility of volcanic eruption and possibly tsunami the residents of villages in the Sulu Range area were evacuated.

To locate these earthquakes more precisely, portable digital seismographs were installed by Rabaul Volcanological Observatory and Geoscience Australia at five sites surrounding the region of activity. Approximately 2000 events were recorded per day during the peak of the activity. Prior to the deployment, several larger events were recorded by regional stations, culminating in a magnitude 6.4 event northwest of the swarm area.

The majority of the events of the earthquake swarm are concentrated below the Sulu Ranges up to a depth of about 9 km. The earthquakes decrease in numbers and deepen towards the south west, where they are confined to the northeast of a plane which passes through the location of the magnitude 6.4 event. It is inferred that this demarcation marks the location of a major strike-slip fault trending northwest-southeast. A detailed analysis of the swarm is being undertaken to understand the tectonics, and to constrain the location of an intrusion of magma below the Sulu Range which has been inferred from the US Geological Survey regional earthquake data and radar interferometry.

TAWAKE

Reducing vulnerability through the identification of alternative sources of sand on the Island of Upolu, Samoa

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The construction industry in Samoa has been experiencing persistent growth in the last decade, which has resulted in increased demand for aggregate resources (sand and gravel). This in turn places pressure on shorelines (particularly near urban and peri-urban areas), as beach mining

serves as a primary source of construction aggregate in Samoa, Upolu Island and many other Pacific Island Countries (PICs).

Rapid development and urbanisation have resulted in unsustainable rates of beach aggregate removal and this practice contributes to coastal erosion and shoreline degradation. Destruction of naturally-formed beach systems reduces the resilience of natural shorelines to storm events and can greatly exacerbate erosion and damage to coastal infrastructure. Furthermore, degradation of natural beach berm systems (high landward part of the beach) increases the risk of wave overtopping and seawater inundation. In areas, local communities have been forced to respond by constructing seawalls along the foreshore of some popular mining areas. However, this replaces the natural "free" defensive beach system will a hard shore which has significant establishment and maintenance costs.

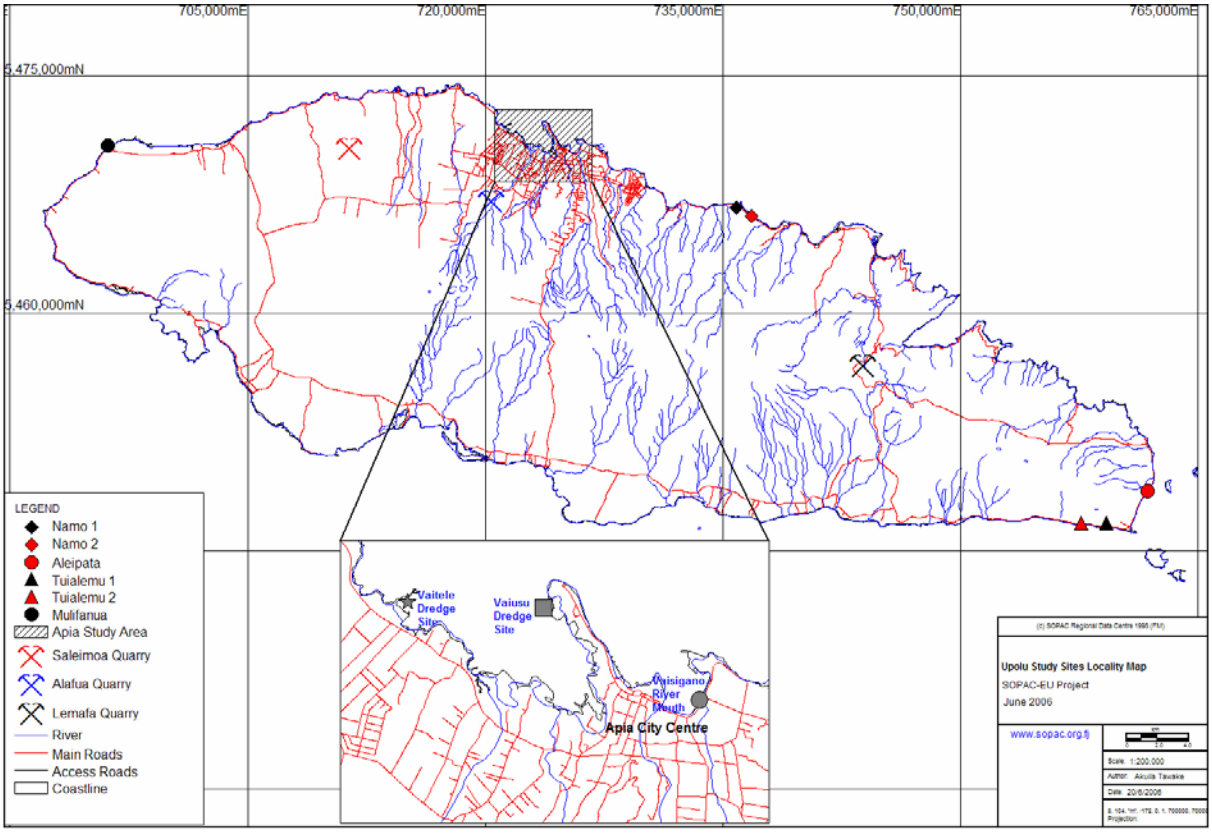

Figure 1. Study and dredge sites in Upolu.

One of the major objectives of the SOPAC-EU Project has been the promotion of sustainable aggregate resource development. This work has been undertaken with the direct intention of: 1) reducing beach mining and therefore enhancing the natural resilience of shorelines and coastal communities; and 2) ensuring that an environmentally appropriate alternative resource is developed, as ready access to competitively priced aggregate underpins PIC's ability to develop infrastructure. It is also recognised that beach mining can only be discouraged if there is community understanding of the associated impacts of beach mining and grassroots support to prevent and replace such activities.

At the request of the Government of Samoa, the SOPAC-EU Project initiated an investigation of alternative selected shallow marine and terrestrial aggregate sources on the major islands of Upolu and Savai'i. This study has identified a number of sites for potential aggregate extraction and at the same time highlighted a number of issues that need to be addressed if these

resources are to be exploited. An additional important side issue which became apparent during site visits was the rather "ad hoc" approach to the development of new aggregate resources. This has the potential to lead to another suite of environmental issues, as well as geotechnical problems regarding resource quality, etc.

Samoa does not have large deposits of naturally-occurring river sand that occur in bigger volcanic island countries like Fiji and the Solomon Islands. However, the Project surveys identified a number of terrestrial rock formations at specific sites which have potential as an adequate supply of reasonably good quality coarse aggregate in Samoa. Sand supply is more problematic though, as terrestrial-based sand (crushed volcanic materials), are not only expensive (twice the price of dredge sediment) but the production level is often low and does not keep up with demand.

Therefore the Project has recommended that the focus for sand supply should shift to appropriately-managed offshore marine resources (dredging at Vaiusu and Aleipata). These locations not only have the potential volumes of sand needed to supply demand but geotechnical quality is also adequate for most needs. It was also found that, other potential dredge sites, such as Mulifanua and Vaitele do contain massive amounts of extractable material but this is of poor quality and is not recommended for construction.

In conclusion, beach mining is recognised as a destructive practice and efforts to develop alternatives have been pursued. There is potential to develop terrestrial course aggregate resources and dredging at selected location can meet sand supply needs in terms of quantity, quality and competitive pricing. There are challenges however to ensure offshore dredging operations are carried out in a controlled, environmentally sustainable manner. Even though there has been increased activity to develop offshore sand supply alternatives beach sand mining remains an issue. Ultimately the complete replacement of beach sand mining will depend on the ability of alternative suppliers keeping their product competitively priced; and on ongoing efforts to inform the community of the ills of beach mining.

References:

Tawake, A. K. and Talia. L. 2007. Technical Report on Aggregate Sources Assessment in Selected Parts of Upolu and Savai'i Islands. *EU EDF8 – SOPAC Project Report 74.*

Tawake, A. K. 2007. Samoa Country Mission and Technical Advisory Report: Aggregate Assessment in Selected Parts of Savai'i and Upolu Islands. *EU EDF8 – SOPAC Project Report 77.*

Tawake A. K and Lui. S. 2007. Proceedings of the Samoa National Aggregates Workshop: "Towards a Sustainable Aggregates Industry in Samoa". *EU EDF8 – SOPAC Project Report 98*.

THOMAS & Others

Preliminary Assessment of Tsunami Hazard in the Southwest Pacific: A Geoscience Australia – SOPAC collaboration

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In order to enhance the capability of countries in the Southwest Pacific to respond to tsunami information, Geoscience Australia is collaborating with SOPAC in an AusAID-funded effort to build capacity for the assessment of tsunami hazard and risk in the Southwest Pacific region. Such a risk assessment is needed in order to provide national governments in the Southwest Pacific with

the information they need to make informed decisions about tsunami mitigation measures, including development of a warning system.

The tsunami threat faced by Pacific island countries consists of a complex mix of tsunami from local, regional and distant sources, whose effects at any particular location are highly dependent on variations in seafloor shape between the source and the affected area. These factors complicate the design of an effective warning system for the Southwest Pacific, because so many scenarios are possible and each scenario's impact on different islands is so varied. The preliminary hazard assessment described in this presentation has involved modelling suites of earthquake-generated tsunami that might affect the region. These models are used to predict maximum wave amplitudes offshore, at a water depth of 50 metres. These offshore tsunami heights are categorized in a coarse scale ranging from 1 (< 25 cm) to 5 (> 250 cm) that can be used to help prioritize areas to be assessed in more detail in a subsequent phase of the project.

The nations in the study having the highest potential to be affected by tsunami include Vanuatu, Papua New Guinea, Guam, Solomon Islands and Tonga. This is due to the proximity of these countries to the subduction zones and the orientation of the fault lines that act to direct the tsunami towards these nations. Other countries can be expected to experience more moderate tsunami impacts due to both regional and far-field sources.

UNSWORTH & Others (Poster)

What is the financial value of seagrass fishery standing stocks? A case study of MPA management from Indonesia

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Inshore fisheries such as those from seagrass beds are currently suffering unprecedented levels of exploitation, whilst these and other habitats are becoming increasingly threatened by anthropogenic activities. Unsustainable practices often result from fishers, stakeholders, managers and industry having limited appreciation for the economic value of a habitat, and the potential monetary benefits of effectively managing it. This poster describes how placing a monetary value on the standing stock of a seagrass fishery using ecological and socio-economic data can provide information pertinent to habitat management. We determined that seagrass habitats are a vitally important fishing resource and calculated that the mean value of the fisheries resources of unmanaged seagrass beds is US$ 1072 ± 430 ha^{-1}. Modelling of our locally-determined values indicates that MPA management and fisheries spillover could significantly increase the value of fisheries resources. Placed into a wider context we estimated that unmanaged seagrass fisheries resources in Indonesia are worth approximately US$3.2 billion to the nation. Our study demonstrated the potential economic benefits of a small MPA on the value of a fishery standing stock, and we concluded that the provision of small-scale financial value estimates for natural resources can provide vital information for local and national marine management planning decisions.

WESSEL & KROENKE

Reconciling Late Neogene Pacific absolute and relative plate motion changes

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New models of Pacific absolute plate motion relative to hotspots and models of relative plate motion involving the Pacific plate all agree there was a significant change in the Late Neogene (Chron 3A, ~ 5.89 Ma), reflecting a more northerly absolute motion than previously determined. As Pacific absolute plate motion became slightly more northerly, left-stepping transform segments came under compression.

Some left-stepping segments became micro-plates with clockwise rotation; others show clear evidence of compressional deformation. Conversely, right-stepping transforms came under tension and many developed intra-transform spreading centers or show similar evidence for transform magmatism. Several large left-stepping transform offsets represent portions of the Nazca plate protruding into the Pacific and as such act as obstacles to the more northerly Pacific absolute plate motion. We suggest these obstructions act to enhance the generally tensile equatorial Pacific stress regime caused by distant slab pull. As a consequence, the greater French Polynesia region has experienced diffuse volcanism that increased considerably following the Chron 3A plate motion change. We propose that since the Hawai'i-Emperor Bend time, the distant Pacific slab pull and the friction between the large, buoyant Ontong Java plateau and the northern margin of the Australia plate have produced episodes of increased tensile stresses in the equatorial Pacific. We believe these stress excursions are responsible for much of the intraplate volcanism observed in a wide triangular region from Samoa to the East Pacific and Pacific-Antarctic Rises.

WHYTE

Environmental Toxicology of *Perna canaliculus*

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Many communities are concerned about the impact of pollution on marine environments. Although the use of shellfish as an indicator of marine environmental health is well established in some parts of the world (particularly North America and Europe) few studies have been conducted within New Zealand and the wider Pacific region. The need to develop methods to monitor the environment, protect ecosystems and safeguard human health led to the development of the current research project in collaboration with Ngāti Kahungunu and Ngāpuhi. Using proteomic profiling coupled with gene sequencing techniques, several unique markers of heavy metal toxicity were detected in the New Zealand greenshell mussel (*Perna canaliculus*). These protein biomarkers appeared to be associated with the presence of heavy metals in mussels under both field and laboratory conditions and could potentially be used as indicators of heavy metal exposure for bio-monitoring purposes.

Based on the average concentrations of metals detected in green mussels from the Bay of Islands (Northland, New Zealand), the amount of metal consumed through a "typical diet" containing shellfish would be below the provisional tolerable weekly intake (PTWI). However, anecdotal evidence suggests that Māori, Pacific Island and Asian populations resident in New Zealand consume a greater quantity of seafood than the general public. Preliminary risk assessment calculations imply that the PTWI for cadmium could be exceeded in some instances. A survey of the frequency, amount and species consumed by these groups is suggested to enable an adequate risk assessment to be made.

WONG & LAL

Fiji's claim under UNCLOS Article 76 for Continental Shelf Territory beyond 200 nautical miles

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Under UNCLOS Article 76, Fiji is in the process of claiming Continental Shelf Territory beyond 200 nautical miles in the South Fiji Basin area and this claim has to be lodged with the United Nations by May 2009. For the preparation of the submission to the United Nations any claim presented to the UN Commission on the Limits of the Continental Shelf must be supported by:

- modern unambiguous legislation; and
- modern survey data based upon a modern geodetic datum (WGS84).

The current baseline coordinates were directly determined from British Admiralty Chart 2691 which depended upon hydrographic surveys undertaken more than 150 years ago and is based on the World Geodetic System 1972 (WGS72) datum. The WGS72 datum is now obsolete and has been replaced by the WGS84 datum.

For the lodgment of the claim for the extended continental shelf beyond 200 nautical miles, it is essential that Fiji prepare a basic chart at appropriate scale showing the final validated latitude and longitude coordinates of all relevant baselines based on the WGS84 datum, the final 200 nautical miles limit, the 350 nautical miles constraint, and the hypothetic and/or agreed upon median lines between Fiji and New Zealand; and Fiji and Tonga, respectively.

Fiji completed a geodetic baseline survey of the southern part of the Fijian Archipelago. Ten sites were occupied simultaneously by Static GPS receivers and data collected continuously over a period of six days. Kinematic GPS receivers were used for the reef delineation to define the seaward edge of a number of reefs, which will be critical in the definition of maritime boundaries yet to be negotiated and agreed with New Zealand and Tonga in the South Fiji Basin.

WOODRUFF

Are renewable energy technologies a cost-effective option for promoting rural electrification in Pacific island countries?

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The global use of renewable energy technologies (RETs) has expanded rapidly over the past two decades as their technological feasibility, reliability and cost-effectiveness has been successfully demonstrated in a number of niche markets.

Due to large distances, small and isolated populations and low per-capita demand for energy, traditionally supplying energy services to rural areas has been very costly. As a result approximately 70% of the population in Pacific islands countries lacks access to electricity, despite its importance for promoting sustainable development in the region. In remote areas, where electricity is available, services are generally expensive and unreliable.

The reason for the high cost of energy services in the region is due to high dependence on imported oil-based fuels, despite the abundance of renewable energy resources. With recent oil price rises, petroleum product imports, which are the single largest import item for most Pacific island countries, now account for a significant portion of countries' national income. In many countries, fuel imports exceed total merchandise exports. This has significant implications for national development in many countries.

In this paper, cost-effectiveness analysis is used to compare the overall life-cycle costs of selected renewable energy technologies with conventional diesel generators in particular rural settings. Case studies include the Ha'apai Solar Electrification Project in Tonga, the Bulelavata community micro-hydro electricity project in the Solomon Islands, the Mangaia wind project in the Cooks Islands, and the Fiji Biofuel Programme.

This study finds that in remote Pacific island settings, RETs can provide the most cost-effective sources of electricity. However, it is important to note that no single technology is least-cost, and that it is very much dependant on local conditions and renewable resource availability. In addition, hours of service and energy loads that can be supported at any one point in time vary considerably between different energy options.

WRIGHT

The New Zealand Continental Shelf Project and Article 76

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The New Zealand Continental Shelf Project is approaching completion after 10 years of marine survey work and analysis. This paper will review the various stages of the New Zealand Continental Shelf Project, and explain how that process has been guided by Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS). The project has been complicated by the fact that New Zealand is the first coastal state to submit from an active convergent

margin. The New Zealand region has been astride an evolving plate boundary for at least 80 million years, and this dynamic tectonic history has resulted in a continental margin characterised by numerous large submarine plateaus and ridges extending from the landmass. The New Zealand landmass and continental margin are an amalgamation of accreted and transposed terranes, volcanic rocks associated with the evolution of the plate margins, and rift blocks varyingly rifted from the landmass.

The practical application of the terms and formulae of Article 76 during the data collection and analysis phases of the project have required the Project Team to address a number of technical and legal issues. These issues include continental prolongation, continent-ocean transition, finding the foot of the continental slope, application of the method of maximum change in gradient at its base, establishment of sediment continuity, and the use of bridging lines. The talk will give examples of these issues.

STAR 2007 Programme

Wednesday 21st November evening – Registration

Thursday November 22nd
Venue: Faónelua Convention Center – Main Hall

Time	Theme	Authors & Presenter	Title
09:00-09:20	STAR Opening	John Collen, Chair, STAR & Cristelle Pratt, Director, SOPAC	
	Session 1		
09:20-09:40	Extended Continental Shelf	Lal, A. & Artack, E.	The Pacific Islands Regional Maritime Boundaries Project (PIRMBP)
09:40-10:00		Buleka, J.	Development and partnership trends in the Pacific through Delimitation Project beyond 2007
10:00-10:20		Lal, A. & Artack, E.	The Pacific Islands Regional Maritime Boundaries Project (PIRMBP): tackling Extended Continental Shelf (ECS) issues
10:20-10:50	Refreshment break		
10:50-11:10	Extended Continental Shelf	Wong, H.L. & Lal, A	Fiji's claim under UNCLOS Article 76 for continental shelf territory beyond 200 nautical miles
11:10-11:30		Reo, R., Lal, A.,& Artack. E.	Republic of Kiribati Maritime Boundaries project
11:30-11:50		Lafoy, Y. & the ZoNéCo & EXTRAPLAC Working Groups	The complementary ZoNéCo, FAUST and EXTRAPLAC programmes: An integrated approach for the SW Pacific
11:50-12:10		Alcock, M.	Australia case study - extended continental shelf submission
12:10-12:30		Malologa, F.	The Tuvalu situation
12:30-14:00	Lunch		

Joint Session 2A – Main Hall

Time	Theme	Authors & Presenter	Title
14:00-14:20	Extended Continental Shelf	Wright, I.C. & the N.Z. Continental Shelf Project Team	The New Zealand Continental Shelf Project and Article 76
14:20-14:40		Nidung, M.	The Coordination of the Tripartite Submission Concerning the Ontong Java Plateau between Papua New Guinea, Solomon Islands and the Federated States of Micronesia
14:40-15:00	Minerals	Johnston, M.D.	Deep Sea Mineral Extraction - Potential benefits for SW Pacific Nations from a non-utilized resource
15:00-15:20		Smith, S	An environmental impact assessment of seafloor mineral extraction within the SW Pacific
15:20-15:50	Refreshment break		
15:50-16:10	Tectonics	Wessel, P. & Kroenke, L.W.	Reconciling Late Neogene Pacific Absolute and Relative Plate Motion Changes
16:10-16:30		Suetsugu, D.	Seismic imaging of the South Pacific superplume
16:30-16:50		Martinez, F., Baker, E.T. & Resing, J.A.	Exploring the off-axis distribution of hydrothermal activity and its geological controls at the back-arc Eastern Lau Spreading Center, Tonga
16:50-17:10		Pelletier, B. & the Vanuatu Arc Project Team	The « Vanuatu Arc» project: eruption dynamics and the seismic cycle in the Vanuatu arc
17:10-17:40	STAR Business Meeting		

Joint Session 2B – Lounge

Time	Theme	Authors & Presenter	Title
14:00-14:20	Coastal	Ratiram, A., Kahsai, K. & Terry, J.P.	Identifying sources of abundant coarse bedload sediments that form the Jourdain River braidplain on Santo Island, Vanuatu – preliminary results
14:20-14:40		Tawake, A.K.	Reducing Vulnerability through the Identification of Alternative Sources of Sand on the Island of Upolu, Samoa.
14:40-15:00		Forstreuter, W.	RTK GPS for establishing beach profiles at 1:10,000 scale
15:00-15:20		Talia, L., Taape, S., Chang, S.W., Kim, S.P. & Chang, J.H.	The Geological and Geomorphological Mapping of Savaii Island, Samoa 2005 – 2007
15:20-15:50	Refreshment break		
15:50-16:10	Coastal	Collen, J.D., Garton, D.W. & Gardner, J.P.A.	Historical shoreline changes and sediment redistribution, Palmyra Atoll
16:10-16:30		Gardner, J., Garton, D.W., Collen, J.D., Allen, J. & Clark, O.	Dissolved oxygen stratification in a compartmentalized lagoon complex: Palmyra Atoll, northern Line Islands
16:30-16:50		Ramsay, D.L.	Are seawalls a long term adaptation option for atoll environments? Examples from Tokelau of the role they may play
16:50-17:10		Forstreuter, W. & Lomani, E.	Checking geometric accuracy of pan-sharpened Quick-bird images

Evening – Meetings of Working Groups

Friday November 23rd
Joint Session 3A – Main Hall

Time	Theme	Authors & Presenter	Title
09:00-09:20	Energy & Resource Economics	Biribo, N.N., Pelesikoti, N. & Webb, A.	The Role of Socio-Economic Information in Integrated Coastal Area Management in Kiribati
09:20-09:40		Woodruff, A.	Are renewable energy technologies a cost-effective option for promoting rural electrification in Pacific island countries?
09:40-10:00		Matakiviti, A., & Mario, R.	Strategic Energy Planning and Policy – A Tool for Fostering Economic Growth
10:00-10:20		Forstreuter, W. & Zieroth, G.	Pan-sharpened QuickBird image data for coconut resources estimation in Rotuma
10:20-10:50	Refreshment break		
10:50-11:10	Disaster Risk Reduction & Disaster Management	May, J.	Pacific Disaster Net
11:10-11:30		Bonte-Grapentin, M. *et al.*	The Navua Flood Warning System
11:30-11:50		Penaia, A. *et al.*	Reducing Flood Risk – From Science to Policy: The Samoa Process - 2 slots needed
11:50-12:10		Penaia, A. *et al.*	Reducing Flood Risk – From Science to Policy: The Samoa Process
12:10-12:30		Heron,D., King A., Bell R. *et al.*	RISKSCAPE: A multi hazard modelling and risk assessment tool
12:30-14:00	Lunch		

Joint Session 4A – Main Hall

Time	Theme	Authors & Presenter	Title
14:00-14:20	Disaster Risk Reduction & Disaster Management	Biukoto, L.	Application of GIS for geo-hazard management
14:20-14:40		Newsome, P. *et al.*	GeoSource Tonga: a spatial information system for hazards, land management and development
14:40-15:00		Glassey, P., Heron, D. & Cousins, J.	Geosource Tonga: Using GIS for hazard modelling and risk assessment
15:00-15:20		Bonte-Grapentin, M., Billy, D. & Krüger, J.C.	Landslide Risks following the Solomon Islands Earthquake on 2 April 2007

Friday November 23rd
Joint Session 3B – Lounge

Time	Theme	Authors & Presenter	Title
09:00-09:20	Coastal	Ramsay, D.L., Abraham, S. & Jackson, R.	Returning the sand to the Sandy Beach Hotel on Kosrae
09:20-09:40		Forstreuter, W.	New space-borne image data for Pacific Island Countries
09:40-10:00		Greene, H.G.	Sea Floor Substrate and Habitat Maps as a Management Tool: Examples from the Pacific Northwest
10:00-10:20		Bell, J., Gardner, J.P.A., McKellor, S., Smith, D.J. & Unsworth, R.K.F.	Coastal zone management in the Wakatobi Marine National Park, Indonesia: monitoring, marine protected areas (MPAs) and habitat connectivity
10:20-10:50	Refreshment break		
10:50-11:10	Oceans & Environmental	Roemmich, D., Gilson, J. & Scanderbeg, M.	Ocean temperature, salinity and circulation from the Argo Project
11:10-12:30		D'Adamo, N., Meyers, G., Dexter, P., Smith, N., Brassington, G. & Schiller, A.	Ocean Observations (*Integrated Marine Observing System*) and modelling (*Bluelink*) in Pacific Waters off Australia
11:30-11:50		Mitchell, W., Cooper, D.T. & Lal, A.	South Pacific Sea Level & Climate Monitoring Project
11:50-12:10		Whyte, A.	Environmental toxicology of *Perna canaliculus*
12:10-12:30		Eagar, S.H.	Pacific Island freshwater ostracods
12:30-14:00	Lunch		

Joint Session 4B – Lounge

Time	Theme	Authors & Presenter	Title
14:00-15:20	Environmental	Suren, A.	PAC-SHMAK: a system to measure and assess stream health in Fiji
14:20-14:40	Water	Whippy, E.L.	Establishment of a Geographic Information System in the Water and Sewerage Department in Fiji
14:40-15:00		Kleppen, M.H., Mistry, P. & Siohane, A.	Water Demand Management for Pacific Island Water Utilities: Case study: Niue
15:00-15:20		Ngau Chun, M.	Expansion of the Hydrometric Network for Upolu – surface water site selection

15:20-15:50	Refreshment break		
15:50-16:10	DRR	Prasad. R.	RSMC Nadi
16:10-16:30	Oceans	Kitazawa, K.	Current status of ocean observations from ARGO float
16:30-16:50	Earthquakes & Tsunami	McAdoo, B.G., Krüger, J.C. *et al.*	Geologic Survey of the 2 April 2007 Solomon Islands Earthquake and Tsunami
16:50-17:10	POSTER SESSION		
17:10-17:30			

15:20-15:50	Refreshment break		
15:50-16:10	Water	Kamal Khatri	Water Safety Plans progress for Tonga
16:10-16:30		Kupa, L.	The Pacific Water Association
16:30-16:50		Fatai, T.	Tongatapu's groundwater monitoring network
16:50-17:10	POSTER SESSION		
17:10-17:30			

Evening Presentation – Jutta May: Introduction to the Pacific Disaster Net

Saturday November 24th

Session 5 – Main Hall

09:00-09:20	Earthquakes & Tsunami	Cummins, P. & Baba, T.	Modelling of Seismic and Tsunami Waveforms for the 3 May, 2006 Tonga (Mw=8.0) and the 1 April 2007 Solomon Islands (Mw=8.1) Earthquakes
09:20-09:40		Bernard Pelletier	Tsunami in New Caledonia & Vanuatu: study by swath mapping and modelling
09:40-10:00		Thomas, C., Burbidge, D., Cummins, P. & Pearce, H.	Preliminary assessment of tsunami hazard in the Southwest Pacific: A Geoscience Australia-SOPAC collaboration
10:00-10:20		Pearce, H.	Tsunami hazard assessment in SW Pacific: Availability of data and options for tsunami inundation & risk modelling
10:20-10:50	Refreshment break		
10:50-11:10	Earthquakes & Tsunami	Inoue, H., Vuetibau, L.& Mafi,K.	Upgrading Seismic Networks of Fiji and Tonga
11:10-11:30		Fritz, H.M. & Kalligeris, N.	1 April 2007 Solomon Islands tsunami reconnaissance
11:30-11:50		Taranu, F., *et al.* & Cummins, P.	The 2006 Earthquake Swarm in the Sulu Range, Central New Britain, Papua New Guinea
11:50-12:10		Vuetibau, L.	Tsunami Simulation for the Fiji, Tonga and Vanuatu sub region
12:10-12:30		Rick Bailey	Australian tsunami warning system

Saturday 24th afternoon	Meetings of Working Groups

Sunday 25th	Picnic & Volleyball Tournament