ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION 2013

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Prototype Tsunami Evacuation Park in Padang, West Sumatra, Indonesia

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*Science, Technology and Resources Network

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Abstracts included in this volume were received up to the close of business on Wednesday, 11 September 2013. Abstracts received later than this date will be made available in loose leaf format at the meeting rooms on the day of the corresponding presentation and will be published in the Post-session version of this document.

FOREWORD

With SOPAC now established as a Division of the Secretariat of the Pacific Community (SPC), it is timely for members of the STAR network to review the role of STAR over the past 30 years and consider its future. STAR (the Science, Technology and Resources Network) was founded in 1985 in collaboration with the International Oceanographic Commission, to facilitate the continuing provision of advice to SOPAC by the international geoscience community. The first Chair of STAR was Charles Helsley, then Director of the Hawaii Institute of Geophysics. He was succeeded in 1992 by Keith Crook from the Hawaii Undersea Research Laboratory and, in turn, John Collen from Victoria University of Wellington, becoming Chair in 1999.

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

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

When SOPAC became a Division of SPC, the latter organisation gave its full support to STAR, and other regional technical organisations have expressed similar sentiments. Since 2010, STAR sessions have been held jointly with the Circum-Pacific Council for Energy and Mineral Resources and, last year in Noumea and again this year, will link with a technically-oriented SOPAC Division meeting. Further, participants from other Divisions of SPC and from the wider Pacific science community have been invited to the STAR Conference. Thus, the opportunity exists to not only continue the long-term relationship but to widen STAR's endeavours in Pacific science in collaboration with and for the benefit of the SOPAC nations; mechanisms to promote this are something that delegates should consider and discuss during their time in Rarotonga. It is my hope as outgoing Chair that STAR will continue to support the work of SOPAC and associated organisations in the Pacific region and, as in the past at Governing Council meetings, give what support and advice members can to the new Division both at its divisional meetings and, when issues arise, during other times of the year. In that respect, the participation of all STAR delegates as technical advisers during the SOPAC Divisional Meeting that follows this conference is welcomed.

The main theme of this the 30th STAR Conference in the Cook Islands is **"Large ocean states: challenges, opportunities and risks in developing non-living marine and onland natural resources"**. A number of the abstracts in this volume relate to this important topic but, as has become traditional at STAR conferences, also cover a wide range of other research relevant to the Pacific region.

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ABSTRACTS OF PAPERS

BLACKA & OTHERS

Modelling and Mapping the Impacts of Storm Surge and Waves on the Avarua Coastline

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Avarua is the administrative, economic and tourism capital of the Cook Islands, and along the Avarua to Nikao stretch of the Rarotongan coastline are government and police offices, the international airport, the main fuel stores, Avatiu Harbour which processes all incoming freight to Rarotonga and the other Cook Islands, as well as the main shopping and residential districts. Previous cyclones impacting Rarotonga, including the unprecedented five cyclones in 2005, have caused significant damage to buildings and threatened infrastructure along this stretch of coast. This has raised concerns as to the vulnerability of the Avarua area to future cyclone events and the impact that climate change may have. These concerns identified the need for a more in-depth investigation to consider the geophysical processes specific to the Avarua area, and this project has now been completed by the UNSW Water Research Laboratory (WRL) under the Pacific Adaptation Strategy Assistance Program (PASAP).

This paper presents an overview of WRL's investigation which has been undertaken in five separate stages since mid 2012. The project required detailed modelling to better understand wave and storm surge processes specific to the Avarua coastline, and to predict the impacts that these processes may have both now and in the future with ongoing climate change. Throughout the last year a range of aspects have been undertaken including:

- compilation of a library of related reports, data sets, and historical media including photos and videos from previous cyclone events;
- assimilation of existing geospatial data sets for bathymetry, topography, infrastructure etc. into a GIS;
- detailed RTK-GPS survey data collection program to measure bathymetry throughout the fringing lagoon and topography throughout the town, resulting in over 25,000 new elevation data points;
- physical wave flume modelling of various sections of the coast;
- empirical wave, run-up and overtopping modelling;
- numerical dynamic storm surge inundation modelling; and
- mapping of vulnerable areas in a GIS.

As expected, the results of the investigation have identified that significant areas of Avarua are at risk from the effects of storm surge and waves during cyclones however, the detailed modelling results show that the risk is higher than previously understood. The most severe cyclone to impact Rarotonga in living memory (TC Sally, 1987) is considered by most Rarotongans to be the 'worst case scenario'. In actual fact, there is approximately a 5% chance each year of experiencing a similar event, and a significantly larger and more destructive event could be expected approximately once per century. A review of more extensive historical records indeed confirmed that significantly more severe cyclones have impacted Avarua in the past.

As well as providing a significantly more refined digital elevation model, areas of the town that may be subjected to wave and storm surge hazards have been mapped in a GIS for various cyclone scenarios. These maps have been created to guide future climate resilient development, as well as planning for disaster risk reduction and disaster risk management. The aim is for these tools to reduce the future risk from severe cyclone events for the Avarua area.

BOSCHEN & OTHERS

The distribution and connectivity of benthic macrofauna in areas of potential seafloor massive sulphide mining: Preliminary results from studies underway in the New Zealand Exclusive Economic Zone

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Hydrothermal vents are valued biologically for their unique chemosynthetic communities but they also have economic potential for mineral extraction. These minerals are predominantly in the form of seafloor massive sulphides (SMS) which are rich in iron, copper, zinc, silver and gold and occur at both active and inactive sites. Mining for SMS deposits will probably remove all organisms in the immediate area, whilst communities of the surrounding habitat may also be impacted by suspended and deposited sediment resulting from the mining activities. Following exploration for SMS deposits in New Zealand's Exclusive Economic Zone (NZ EEZ), potential sites for SMS mining have been identified. As part of the process of assessing the ecological risk associated with SMS mining, the potential recolonisation of disturbed areas by neighbouring populations from non-impacted areas needs to be assessed. For this purpose, the distribution of benthic macrofauna at potential sites is under investigation using video footage and stills from multiple industry and scientific surveys, and the potential for recolonisation after mining is being assessed. Taxa are identified and their abundances estimated, and basic habitat characteristics (substratum type, morphology, depth, hydrothermal activity) are described. These georeferenced data are used to generate faunal distribution maps and investigate relationships between habitat characteristics and community composition. Results from population genetics studies of key species will be used to determine the connectivity of populations at the study sites, and in the wider region. Combining the distribution maps and connectivity results enables an initial assessment to be made of the vulnerability of the macrobenthic community to SMS mining. This information will be used in an ecological risk assessment and ultimately inform the management of mining SMS deposits within the NZ EEZ.

BURBERY & OTHERS

Lost in microbial space: a technical assessment of how effective coral sands are at attenuating pathogens

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Small, low-lying atolls in the Pacific region have some of the most critical water supply issues in the world. Potable water on the atolls is almost exclusively sourced from untreated shallow groundwater contained within unconfined coral sand deposits. Open defecation is commonly practised on many atolls and toilet facilities often constitute un-lined pit latrines. Poor sanitation and personal hygiene practices can lead to stomach upsets, vomiting and diarrhoea and, in extreme cases, death particularly in young children, elderly, pregnant women and people with underlying health issues. A major water resource management issue on atolls therefore, is the protection of groundwater drinking water supplies from microbial contamination associated with sanitation practices.

Water resource advisors for the Pacific region currently debate the minimum set-back distance that a water-well should be sited from a latrine on atolls as a precautionary measure for managing health risks from microbial pathogens. One of the key input parameters in estimating set-back distances is the ability of coral sands to attenuate (trap) pathogens. Our work provides an initial technical assessment of the attenuation.

Lab-based transport experiments were conducted using *E. coli* J6-2 and MS2 phage microbial tracers, to determine potential rates at which pathogenic organisms are attenuated in a coral sand aquifer environment. The resulting effective microbial removal rates of greater than $10^{3.9}$ /m rank towards the top-end of attenuation rates reported for natural porous media and suggest that coral sand has a high affinity for pathogen removal. Removal rate values were substituted into a mathematical model, developed to simulate pathogen source – transport – receptor pathways on the Bonriki groundwater reserve, South Tarawa (Kiribati), and applied in the set-back distance technical assessment.

Our results suggest a 20 m separation distance is likely to provide a reasonable level of health protection against pathogenic disease. The risk of harm however, will be increased in settings where the aquifer is poorly consolidated or fractured, in which cases microbial removal efficiencies will be compromised by macro porous flow effects; when significant hydraulic or contaminant stresses are put on the aquifer, such as in close proximity to large-scale communal water supplies abstracting large volumes of water or heavily utilised communal toilets, and; in events of significant viral outbreak where the mass loading of pathogens into the aquifer could be expected to increase by several orders of magnitude. *In situ* measurement of microbial removal rates and a quantitative risk assessment are identified as useful areas deserving future investigation.

CLARK & OTHERS

Science requirements for management of environmental effects of seabed mining; a need for collaboration and coordination

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There is rapidly growing interest in offshore minerals exploration in the South Pacific region. A diverse array of resources is involved, with recent or current activity off New Zealand for ironsands, phosphorite nodules, and seafloor massive sulphides (SMS). In addition, SMS exploration is developing off Tonga and is well advanced in Papua New Guinea. Cobalt-rich crust and manganese nodules also occur in the region, and have been the subject of a number of surveys as part of SOPAC-JAMSTEC projects. The focus to date has been on describing the composition and size of the resources. However, one of the major challenges currently facing management agencies in the region is how to facilitate development of potential mining operations while ensuring that environmental integrity is not significantly compromised.

In this presentation, we review what science can provide to support the environmental management of deep-sea mineral exploitation, especially the need for baseline information, a robust monitoring programme, and informing precautionary conservation measures. We will describe work to determine the nature and extent of impacts, and the development of aspects of ecological risk assessment and environmental impact assessment which are helping to guide research and mineral resource management in New Zealand. We stress the need for a strong collaborative approach in the early stages of exploration between governments, minerals companies, researchers, concerned communities and other stakeholders, in order to provide a solid foundation for subsequent environmental management. International agencies such as the International Union for the Conservation of Nature can also contribute expertise, and a new Thematic Group has been established to help facilitate a multidisciplinary and ecosystem approach to deep-sea mining.

CRONAN

Recent investigations on manganese nodules and their substrates in South Pacific EEZs and suggestions for further research

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Most of the recent renewed interest in manganese nodule mining has been focussed in the Clarion-Clipperton Zone in the NE tropical Pacific where nodules are rich in Mn, Ni and Cu. However, equally interesting, but compositionally different, nodules occur in the tropical South Pacific. A big difference between the locations of these two groups of nodules is that the CC Zone deposits lie in the International Seabed Area whereas those in the South Pacific lie mainly in the Exclusive Economic Zones (EEZ) of Island States, principally the Cook Islands and Kiribati, although Samoa and Niue also have some potentially interesting deposits. The Cook Islands Exclusive Economic Zone (CIEEZ) is located in the central South Pacific, approximately between

155-168°W and 8-25°S. The Kiribati EEZ comprises the area around the Phoenix and Line Islands in which nodules are locally abundant, and that around the Gilbert Islands in which they are not abundant at all.

Manganese nodule mining in the South Pacific, especially in the CIEEZ, has been thought possible since the 1970s and a number of reports have been written on this. Several things have changed since the last of these reports appeared in 1995. First, new data on manganese nodule composition and abundance have appeared. Second, a recently developed interest in 'rare', 'green' and 'technology' elements has necessitated a re-examination of South Pacific nodule data for information on these elements, and the collection of new data on them. Third, current and possibly future applications to the UN to extend island 'continental shelf' areas necessitate an appraisal of the manganese nodules in these areas. Recent work prompted by these developments has helped to refine our understanding of the distribution and abundance of metals of traditional interest in South Pacific nodules, namely Mn, Co, Ni and Cu, but has also drawn attention to other elements of possible economic interest, including titanium (Ti),vanadium (V) and the rare earth elements (REE).

Most recent work on South Pacific nodules has been done in the Cook Islands EEZ. Nodule abundances vary greatly in the CIEEZ. Large parts of the northern CIEEZ contain nodules in abundances of near or below 5 kg per square metre and thus are of little or no economic interest. Smaller areas of similar nodule abundance occur in the south of the CIEEZ. Furthermore, large parts of the Manihiki Plateau (MP) and southern Cook Islands (SCI) have been poorly surveyed for nodules and thus abundances in these areas are not very well known. Greatest nodule abundances in the CIEEZ occur in the South Penrhyn Basin (SPB) and Aitutaki Passage (AP) where abundances of over 25 kg per square metre are common and reach as much as 50 or more kg per square metre in places.

Compositionally, the Cook Islands nodules can be broadly grouped into two groups,(i) a Mn-Ni-Cu rich group occurring predominantly north of about 10° S, and (ii) a Fe-Co-Ti-REE rich group occurring in the SPB, AP and, to a lesser extent, in the SCI. The nodules enriched in the Fe-Co-Ti-REE group of elements occur in much greater abundances than nodules enriched in the Mn-Ni-Cu group, and thus offer the best prospect for nodule mining in the CIEEZ. However, Fe is of little or no economic interest in nodules, but, recently, Mn has become of greater interest than before due to increasing global steel production. Even though Mn is lower in group (ii) nodules than in group (i) nodules, there is still sufficient of it in group (ii) nodules to be of economic interest. Thus, rather than being considered simply as a Co resource as has been the case in the past, Cook Islands nodules should now be considered as a Co-Mn-Ti-REE resource. Recent estimates of 'in place' quantities of these metals in the CIEEZ nodules exceed older estimates.

Kiribati has not benefited from a recent update of estimates of its manganese nodule resources, abundance and composition, including rare metals in the same way as the Cook Islands has. Published data show Phoenix Islands nodules tend to be Ni and Cu rich in the north of the EEZ and more Co rich in the south. Northern Kiribati Line Islands nodules which are adjacent to the Ni and Cu rich Clarion-Clipperton Zone are also rich in Ni and Cu, whereas southern Line Islands nodules are richer in Co. There are no published reports on their rare metal content, but some data exist. The recent studies in the adjacent Cook Islands EEZ suggest that similar rare metal concentrations might occur in southern Line Islands nodules as in Cook Islands nodules. Further work on Kiribati nodules is needed to bring knowledge on them up to the standard of that in the Cook Islands.

Nodule substrates in the South Pacific have been more poorly investigated than the nodules themselves. This issue has been brought into sharp focus by recent reports from Greenpeace and other environmental agencies, highlighting possible damage to biological communities by nodule mining. Nodule substrates vary considerably in nature throughout the South Pacific and this

means that bottom-dwelling biological communities will also vary. Knowledge on nodule substrates is important for determining both the nature of future nodule mining systems and in assessing the nature of any environmental damage consequent on the mining. Cook Islands nodules rest on pelagic clays in the south of the EEZ and on carbonate/siliceous oozes in the north, and there are vertical variations in composition over the sediment depth interval likely to be disturbed by a manganese nodule mining vehicle. Nodule substrates in the Kiribati EEZ are more variable and not so well known as in the CIEEZ, partly due to their occurring over a much wider geographical area. Much more work on South Pacific nodule substrates is needed, including their grain size distributions, mineralogical and chemical compositions, geotechnical properties, interstitial water content and composition, infauna content and sediment structure. Some CC Zone nodule mining consortia are working on these problems in their reserved areas and they need to be addressed in the South Pacific before nodule mining starts there. Some data and samples are available with which to start this work, but more need to be collected.

A geological/geochemical model has been constructed to help explain the variability in Cook Islands nodules, and to help predict nodule compositions in poorly sampled areas and develop exploration guidelines for them. The main factors determining the compositional variability of Cook Islands nodules are north-south variations in biological productivity affecting metal fluxes to the deposits, and the distance of the nodules from the calcium carbonate compensation depth (CCD). A possible additional factor in the case of cobalt enrichment is its supply from Antarctic Bottom Water (AABW). An appraisal of these factors in other areas of the South Pacific could help to predict the nature of nodules in those areas.

Forstreuter

Needs for and status of capacity for Pacific Coconut Resource inventory

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Measurement of palm height with clinometer, field work in Pohnpei

Since the world copra price collapsed in the 80s, there was no more investment in the coconut resource in terms of management and expansion. Also data, information and management capacity got lost.

Various pilot projects in the Pacific region have shown that coconut oil can replace diesel oil in power generation and, to a limited extent, in transport applications. While the economics of using coconut oil as a substitute fuel are often marginal[1], its use as a niche fuel (in remote island locations with high transport cost for both inbound fuels and outbound copra or coconut oil are high) and its potential to enhance energy security in case of an energy crisis and subsequent supply interruptions are undisputed. The results of the Asian Development Bank trials in Solomon Islands and experiences of the power utilities of New Caledonia and Vanuatu have clearly shown that the use of high quality coconut oil is technically feasible in well-engineered equipment operated by properly trained staff.

[1] ADB 2012: TA 7329- Promoting Access to Renewable Energy in the Pacific, CNO Feasibility Study Auki, Solomon Islands

Revitalising the coconut industries of Pacific Island Countries to the levels of the early 80s would potentially allow the substitution of a significant portion of Pacific island diesel imports. In remote islands, coconut oil for energy generation will be most effective as the diesel has to be shipped to the islands and copra from the outer islands to the main island. Sustainable Energy for All (SE4ALL) is a UN initiative which will be strongly supported by the EU. EU-funded facilities will focus on clean energy access that private sector stakeholders, such as coconut farmers and copra millers can provide as a result of an improved investment environment. However, it is also clear that besides its energy use, coconut oil prices on the world market have once again reached levels where the production of copra and/or coconut oil have become viable options for income generation and improvement of rural livelihoods of the remote Pacific community. This would help to avoid the population drift from outer islands to the main islands.

What is required now is to qualify and quantify the existing palm stocks across the region in order to establish a clear picture of what current stocks can produce over time and where stocks need to be replaced to ensure a sustainable supply of copra and/or coconut oil.

There is no official policy to establish the capacity for coconut resource inventory however, as a regional technical organisation, SPC plans ahead and creates the technical facilities, enabling a clear picture of the still-existing resource in the Pacific.

Required information of the Coconut Resource

Figure 1: *Counting coconuts of the three oldest branches with binoculars, field work in Kiribati*

The ***area*** of the coconut palm cover is the most essential information to estimate the resource, where the area has to be ***stratified*** into different densities. Currently, this is carried out in three strata (i) scattered 25 to 50 palms/hectare, (ii) medium dense 51 to 150 palms/hectare and (iii) dense above 150 palms/hectare. Having the area per stratum, the number of palms can be identified with a known statistical error.

Having the number of palms, the ***coconut production*** per palm has to be estimated. Together with the production, the ***factors which can influence the produ*****ction** have to be known such as: (i) age structure, (ii) amount of hybrids in a stand, (iii) soil/water factor and (iv) pests such as insects, rats or other biotic factors.

If the production figures are known, it does not necessarily mean that this amount of coconut volume can be harvested. ***Infrastructure information,*** such as road network has to be identified for an economic coconut collection and transport to the processing unit.

Finally, it is necessary to identify the amount of ***timber volume*** in the coconut palm area as dead palms cannot be left in the area because it is the basis to spread the rhinoceros beetle. Normally, the most economical way to remove dead palms is to produce sawn timber. The planning of sawmilling activities requires spatial information of timber volume available.

Inventory Methods for Pacific Conditions

At the end of May, it was discussed between SPC-SOPAC and SPC-LRD to create an own ***inventory unit*** able to perform coconut resource, forest and general land cover inventories. The reason is to keep inventory planning, realisation, capacity building and the databases in the Pacific, which is not necessarily the case if consultant companies conduct such inventories. In addition, Pacific conditions require adaptation of inventory methods.

Remote sensing data analysis is normally the most cost-effective way to map larger areas. So far, visual interpretation of satellite image data with sub-metre resolution are used to ***stratify and map*** the coconut palm stands. This satellite data is also utilised to identify the ***number of palms per hectare*** in a statistically sound, semi-automatic approach. For example: through this method, the number of palms complete in Kiribati is known.

The ***coconut palm fertility*** is currently estimated through sample plots where the numbers of coconuts of the three oldest branches are counted and the average is multiplied by 12. This method still needs verification in the Pacific.

Figure 2: *Base station of 80 cm accuracy GPS, field work in Kiribati*

The ***height of the palm trunk*** is required to estimate the age and the timber volume. Currently, this figure is measured by recording the angle to bottom and top of the trunk and the distance. This method could be replaced by laser based instruments, allowing the measurement of angle and distance in one go. The ***palm age*** is estimated by measuring the height of 11 leaf scars and then dividing the trunk height by this number. This method does not work to perfection as (i) it assumes that leaf scar density is the same over the complete trunk which is not the case and (ii) also assumes that palms have the same number of leaves independent from all soil conditions which is apparently not the case.

The diameter at breast height (**DBH**) is a parameter on which tree volume calculation is based on. The DBH is currently measured with a diameter tape at 1.3 m height. ***Additional***

parameters are recorded, such as standing or lying dead palms, number of young palms, insect or mouse damage on leaves of coconuts, etc.

Currently, all parameter calculation such as palm height, palm volume, number of living and dead palms per hectare, etc. is performed with small programs in a ***database,*** keeping all information. Calculations in the field are avoided.

A ***high accuracy GPS*** system records the corner coordinates from every plot. Later, the location of each palm will also be recorded in selected plots in dense coconut stands to verify the accuracy and possibly establish a correlation between palms counted in the field and with satellite image data.

Remote sensing data is also utilised to map the ***transport distance*** of coconuts collected. Buffer zone building in GIS environment allows stratifying the area around the roads in zones of economic and uneconomic coconut collection. The same will apply collection of old palms for utilisation in transportable sawmills.

Capacity Building in the Pacific

Currently, most Pacific Island Countries do not have the technical capacity to conduct coconut resource inventories. The newly created inventory group at SPC can already assist the member countries and carry out inventory work for them. However, as described above, methods have to be refined. For some questions, even research is necessary. Skills within the inventory group have to be enhanced as well.

The Federated States of Micronesia have already decided to establish their own coconut inventory group for conducting the field work by themselves, where satellite image analysis and database handling, including the parameter calculation is supposed to stay at SPC. It is essential to train sufficient people to first provide statistically sound information about the still-existing Pacific coconut resource. Then the resource has to be monitored.

GARDNER & OTHERS

What can genetic connectivity tell us about the resilience and recovery of deep-sea vulnerable marine ecosystems?

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There is increasing interest in the prospect of deep-sea mining at active and inactive hydrothermal vent sites that contain sulphide deposits. Some deposits are of a tonnage and mineral grade comparable to land deposits and are attractive to mining companies. Mining activity may commence in the near future in the PNG EEZ, possibly followed by mining in the NZ EEZ. Associated with deposit sites are biological communities that may be rare, are specifically adapted to the local environment, and host endemic species. The characteristics of these communities make them vulnerable to disturbance. Whilst measures will be put in place by industry to mitigate impacts of mining, when such activity commences it is expected to result in localised high-level disturbance that will remove all or nearly all of the biota at the mine site. Very little is known about the nature and extent of recovery of these biological communities across the range of sites proposed for mining. One approach to address this question is to look at patterns

of genetic connectivity among sites that can act as stepping stones across deep-sea environments. This will help understand where new recruits come from and at what rate. The identification and protection of source populations may be particularly important and it is therefore, crucial that these populations be identified before they are affected by mining activity. In this paper, we review patterns of genetic connectivity among deep-sea taxa, discuss these in the context of current flow among sites, and provide an introduction to the role that molecular biology, in conjunction with other disciplines, may play in providing information for the environmental management of deep-sea mining and the conservation of vulnerable marine ecosystems.

Southern Ocean storms can disrupt lagoon circulation

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A multi-year study of the lagoon system at Palmyra Atoll revealed water stratification in the absence of a strong pycnocline (Gardner et al. 2011). Surface waters are oxygen-saturated but bottom waters are sulphidic and anoxic, with high H_2S and elevated ammonia, and decreased pH, temperature and chlorophyll a concentration. The persistence of this stratification in such a shallow system (maximum depth 52 m) with no pronounced density barrier was hypothesized to result from the dominant wind-driven westward water flow restricted to the upper water column and facilitated by a dredged ship channel at the west end of the atoll. During late summer 2011, large swells originating from a particularly large storm centre in the Southern Ocean passed across the atoll. The elevated water levels altered the dynamics of tidal exchanges, forcing denser ocean water into the lagoons and fully oxygenating the water column. Nine months later (June 2012), density measurements indicated that stratification typical of the lagoon system prior to summer 2011 was becoming re-established and oxygen levels at depth had declined from ~100% to 50-60% saturation. By August 2012, oxygen saturation had declined to near zero in the deeper basins of the lagoon system and density profiles were similar to pre-storm conditions and, by June 2013, conditions were typical of those preceding the storm. These observations confirm that in the absence of a strong pycnocline atoll lagoon systems are vulnerable to storm-driven ‘turnover’ events on perhaps decadal scales, with ’recovery times’ on the order of 2 years. Short-term release of bottom water from the lagoon basins onto surrounding coral reef systems is occurring episodically at Palmyra, but the significance of negative impacts, if any, remains unknown.

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GLEDHILL

Enhanced Pacific Tsunami Warning System alerting information based on forecast models

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The Pacific Ocean basin is the largest, most diverse, and most tsunami-prone of any of the Earth's ocean basins. Pacific Ocean nations face and must be prepared for distant and local tsunami threats. The South-west Pacific sub-region has experienced a number of damaging tsunami over the last decade (27 tsunami, of which 5 caused deaths - 1998, 1999, 2007, 2009, 2013). Tsunami have impacted communities, physical infrastructure, social well-being and livelihoods.

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

Over the last decade, very good forecast models have been developed and tested which can indicate the possible size of a tsunami at a given location. These modelling tools can be used to provide Member States with a more realistic estimate of the level of threat they can expect from earthquake induced tsunami. The new alerts are potential threat-based rather than based strictly upon magnitude thresholds and time or distance to impact. Several levels of tsunami threat are established, and forecast threat levels are assigned to segments of extended coastlines or to island groups. These improvements greatly reduce the number of areas warned unnecessarily.

Starting in May this year (2013), the Pacific Tsunami Warning Center in Hawaii began issuing the enhanced products on an experimental basis (in parallel with current official messaging). Also, a large number of training and consultation workshops have been held throughout the Pacific. In our region, two such workshops have taken place, the first in Apia, Samoa in July 2012, and the second in August this year in Wellington, New Zealand. Feedback from these workshops and the two recent Pacific Wave exercises (PacWave'11 and PacWave'13) has been used to improve the usefulness and clarity of the text and graphical products. These new enhanced tsunami alerting products will be discussed at the next PTWS Intergovernmental meeting in September 2013 in Vladivostok, Russian Federation with the objective of introducing them as the official PTWS alerting products (issued by PTWC) in October 2014 (the date endorsed by the recent workshop in Wellington).

GREENE & NISHENKO

Assessment of seismic and tsunami hazards of critical Pacific infrastructures in the aftermath of the Fukushima Tsunami

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In the aftermath of the Fukushima tsunami critical Pacific coastal infrastructures are being assessed for their ability to withstand seismic and tsunami-related hazards. Not only are the immediate impacts such as shaking and tsunami inundation of concern, but long-term impacts such as marine debris that can cover beaches, foul water intakes and clog harbors are also of interest. State-of-the-art technologies such as ultra high-resolution 3D seismic-reflection profiles and multibeam echosounder images are being applied to better define the subsurface and seafloor conditions in the vicinity of power plants and other critical infrastructures that are located within coastal seismic zones. Data collected, using such techniques allow for detail mapping of piercing points along faults that can be used to determine slip-rates that are needed for seismic sensitivity studies. The technique being used in central California will be described and images presented that show the usefulness of such methodology and its application to Pacific Islands needs will be discussed. In addition, the methods used to address tsunami marine debris impacts along Pacific beaches and coastal areas will be presented with examples from Alaska along with the benefits and impacts of such a phenomenon.

HEIN & OTHERS

An estimate of the critical metals resource for manganese nodules from the Cook Islands EEZ

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Manganese nodules from the Cook Islands (CI) Exclusive Economic Zone (EEZ) are compositionally different from other nodule fields. CI nodules have relatively high cobalt concentrations and low nickel, copper, and manganese concentrations (e.g. Hein and Petersen, 2013). This reflects the predominantly hydrogenetic (seawater source) origin for metals in the CI nodules versus dual seawater-pore water sources for most other nodule fields. The concentrations of many critical metals have not been previously analyzed for CI nodules, so comparisons with other nodule fields have been limited. To address this, we analyzed a set of nodules distributed throughout the CI EEZ for a complete set of 67 elements, including all metals that may be of economic interest, such as the rare earth elements (REEs), yttrium, tellurium, niobium, zirconium, tungsten, titanium, and others (selected elements in Table 1).

Table 1. Manganese nodules from the Cook Islands EEZ: Average composition for selected elements (hygroscopic water-free data: 0% H_2O^-)

	This study		Compiled Average*	
	Mean	n	Mean	n
Fe wt.%	16.2	26	16.1	1142
Mn	17.5	26	16.1	1142
Ti	1.28	26	1.15	46
H_2O^-	16.6	26	16.6	26
H_2O^+	7.80	26	7.80	26
As ppm	142	26	140	41
Ba	1190	26	1190	26
Bi	11	26	11	26
Co	3817	26	4124	1142
Cr	95	26	95	26
Cu	2656	26	2268	1142
Li	61	26	61	26
Mo	303	26	275	59
Nb	92	26	90	39
Ni	4444	26	3827	1129
Pb	917	26	873	186
Te	23	26	23	26
Th	34	26	37	39
Tl	138	26	138	26
V	505	26	505	26
W	59	26	67	39
Zn	529	26	559	206
Zr	567	26	588	39
∑REE+Y	1633	26	1707	31-41
Pt ppb	244	12	210	25

*Data from Japanese cruises in 1985, 1986, 1990, and 2000 (JICA/MMAJ, 2001), n=5 to 956; This study, n=26, 12 for PGM; Landmesser et al. (1976), n=13; Usui and Mita (1994), n=147

In addition, we recalculated the tonnages of nodules and contained metals from nodule abundance areas (in square kilometers) determined by GIS ArcMap calculations based on JICA/MMAJ (2001) nodule distributions. The nodule tonnage calculated and summed from each abundance sector yields a total inferred resource estimate of 9.66 billion tonnes of nodules covering an area of 1.21 million square kilometers; using a cut-off of 6 kilograms of nodules per square meter, yields a median tonnage of 8.59 billion tonnes of nodules covering 687,647 square kilometers (Table 2).

Table 2. Inferred resource estimates of dry tonnes of nodules and tonnage of contained metals, Cook Islands EEZ, compared to CCZ nodules and terrestrial reserves

	All CI Nodules (area 1,208,560 km^2)		CI Nodules >6 kg/m^2 (area 687,647 km^2)	CCZ nodules*	Terrestrial Reserves*
	Median	Maximum	Median	Median	Tonnes
Nodules (T)	9.66×10^9	12.2×10^9	8.59×10^9	21.1×10^9	--
Manganese	1,555,260,000	1,964,200,000	1,382,990,000	5,992,000,000	630,000,000
Titanium	111,090,000	140,300,000	98,785,000	67,000,000	414,000,000
Cobalt	39,838,000	50,313,000	35,425,000	44,000,000	7,500,000
Nickel	36,969,000	46,689,000	32,874,000	274,000,000	80,000,000

Copper	21,909,000	27,670,000	19,482,000	226,000,000	690,000,000
ΣREE+Y	16,483,000	20,817,000	14,657,000	1,715,000	--
Vanadium	8,887,000	11,224,000	7,903,000	9,400,000	14,000,000
Zirconium	5,680,000	7,174,000	5,051,000	6,000,000	38,500
Molybdenum	2,657,000	3,355,000	2,362,000	12,000,000	10,000,000
Thallium	1,333,000	1,684,000	1,185,000	4,200,000	--
Niobium	869,400	1,098,000	773,100	460,000	3,000,000
Tungsten	647,200	817,400	575,500	1,300,000	3,100,000
Tellurium	219,300	276,900	195,000	80,000	20,000
Bismuth	105,300	133,000	93,630	180,000	300,000
Platinum	2,029	2,562	1,804	2,274	~30,000

*From Hein et al. (2013)
Hygroscopic water free data (0% H_2O^-); Total area of CI EEZ ~2.5 million square kilometers

Several assessments of contained metal tonnages for CI EEZ nodules have been made (e.g. Clark et al., 1995; Kingan, 1998; JICA/MMAJ, 2001; Cronan, 2013; Hein and Petersen, 2013). Most of those assessments considered only a few metals. Here, we present new estimates for the tonnages of 14 contained metals of economic interest as well as total rare earth elements plus yttrium (Table 2), based on the grades listed in Table 1. Manganese, titanium, cobalt, and nickel are the four highest tonnage metals of potential economic interest.

A comparison of our new CI data with data from the Clarion-Clipperton Zone (CCZ) nodules (Hein et al., 2013) shows that CI nodule grades are 2-6 times greater (in decreasing order) for tellurium, niobium, titanium, thorium, and total REEs; and 1.1 to 1.9 times greater for platinum, zirconium, cobalt, yttrium, bismuth, and vanadium. CCZ nodules have slightly more tungsten and 1.4 to 4.0 times greater (in decreasing order) copper, nickel, lithium, molybdenum, manganese, and thallium (Fig 1).

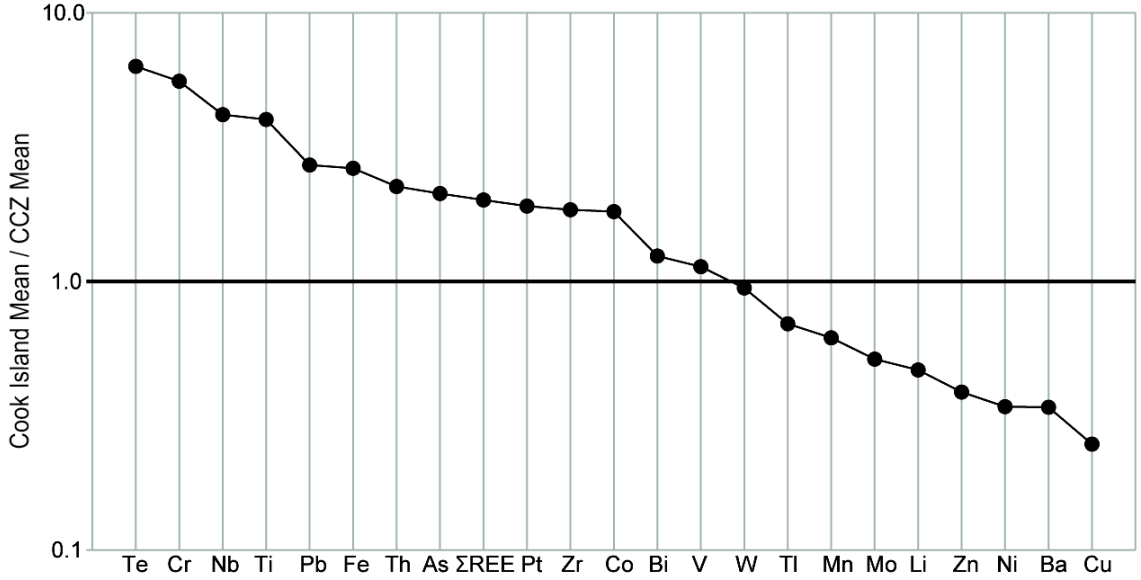

Figure 1. Comparison of Cook Islands (CI) nodule grades with those from the Clarion-Clipperton Zone (CCZ) nodules. Metals above the 1.0 line are enriched in CI nodules and those below the line are enriched in CCZ nodules.

The large global demand and increasing prices for manganese, copper, and nickel make the CCZ nodules very attractive, especially since they have high molybdenum grades. However, the high grades of cobalt, titanium, REEs+Y, niobium, tellurium, platinum, and zirconium in CI nodules

should also be of economic interest especially considering the relatively large area (135,400 km^2) within the CI EEZ containing remarkably abundant (>25 kg/m^2) nodules. The CI nodules have significantly more cobalt, zirconium, tellurium, and manganese than the global terrestrial reserves, and about a quarter of the titanium.

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HOEKE & OTHERS

Wave-driven extreme sea levels at oceanic islands: historical events, future implications and predictive challenges

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Local sea-level extremes generally occur from some combination of three components: astronomical tides; seasonal or longer-term fluctuations due to changing wind, pressure and ocean temperature patterns (such as El Niño Southern Oscillation (ENSO)); and short-term events due to weather (such as wave setup and storm surge). The steep bathymetry and high wind-wave exposure of most oceanic islands result in more rapid wave dissipation (through breaking and friction) and higher wave-setup relative to continental shelf coasts. This has a number of implications, not least of which is unusually high contribution of wave-setup, run-up and associated hydrodynamics towards local sea level extremes and coastal inundation at many locations. To illustrate this, we present a number of historical inundation events caused primarily by wind-waves generated either by remote mid-latitude storms or by locally impacting cyclones. Although future changes to wave climate remain uncertain, climate change-related sea-level rise will tend to increase the frequency and severity of such events.

Clearly at most locations, the prediction of future inundation events must include wave processes at most locations. Great progress has been made hindcasting and forecasting ocean basin-scale wind-wave generation and propagation in the last few years. However, owing primarily to the aforementioned steep and often complex nearshore bathymetry at oceanic islands, significant challenges remain in predicting the local dissipation of these waves and associated hydrodynamic response. This is illustrated through the presentation of numerical modelling case studies. Ongoing efforts to better characterise extreme sea-level risk through decomposition of sea levels into combinations of astronomical tides, low frequency (annual and interannual) sea level variability, and higher-frequency phenomena such as storm surges and waves will also be described.

JOHNSON & OTHERS

Leptospirosis and rainfall: does it tell us enough?

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Leptospirosis is a water-borne, bacterial zoonotic disease of global importance with human infection occurring either when an individual comes into direct contact with the urine of an infected animal, or a urine-contaminated environment. It is difficult to diagnose due to a diverse array of clinical manifestations. Consequently, it is often misdiagnosed and under-reported. Incidence in the Pacific is estimated to be the highest in the world with 66.4 cases per 100,000 in the Western Pacific region alone compared to 5 per 100,000 globally (WHO, 2011). Although it is emerging as an important public health problem, it remains poorly understood and is classed as a neglected disease. Previous research has demonstrated a complex of controlling factors for the disease, with a number of studies demonstrating a direct correlation between leptospirosis diagnosis and rainfall in the preceding months (Desvars et al., 2011; Robertson et al., 2010). To better understand and respond to this disease, Small Island Developing States (SIDS) face significant challenges from both diagnostic and public health perspectives. The aim of this study is to provide a predictive statement for public health by determining whether meteorological data can be useful in elucidating incidence patterns of leptospirosis in the Pacific, and if this can represent the first step in public health planning and decision making. It seeks to answer the questions: (i) can rainfall alone be used as a predictor of incidence in the Pacific; and (ii) what are the imperatives for data collection in the future?

LAMARCHE & OTHERS

Seafloor mineral resources in New Zealand's EEZ: Developing activities and environmental management framework

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There is growing interest for seafloor mining in the Pacific, from coastal iron sand to deep sea minerals. Deep sea mineral resources include seafloor massive sulphides, phosphate and

manganese nodules and cobalt-rich ferromanganese crust. In New Zealand, several offshore resources have been identified as economic and two of these are currently nearing regulatory application. Scientific research can support mineral exploration and seafloor mining by providing geological, biological and environmental data for e.g., quantitative assessment of the resource, baseline pre-mining information, robust monitoring programmes, and precautionary conservation measures. Science can also help identify and quantify the nature and extent of impacts, and form an integral component of environmental impact assessment and ecological risk assessment. A strong collaborative approach in the early stages of exploration is occurring between New Zealand minerals companies and researchers, which is providing a solid foundation for subsequent environmental management.

McINNES & OTHERS

Climate change impacts on tropical cyclones and extreme sea levels – An example for Fiji

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More frequent and severe inundation events associated with climate-change related sea level rise is often cited as the biggest single threat to coastal communities. Assessing this threat requires a baseline understanding of local extreme sea levels and their drivers, including astronomical tides, low frequency (annual and interannual) sea level variability, and higher-frequency phenomena such as storm surges. Knowledge about which of these components dominate and how the latter two may change with a changing climate will be important for successful adaptation and mitigation strategies to rising sea levels.

Efforts are currently underway to improve the understanding of how the short-term signal can influence extreme sea levels through high spatial resolution numerical modelling projects. Ultimately, these projects will lead to improved overall understanding and therefore, prediction of sea-level variability and inundation events under projected climate change scenarios for Pacific and Indian Ocean island nations. In this study, we combine stochastic cyclone modelling with hydrodynamic modelling to build a more complete picture of extreme sea level hazard along the coastline of Fiji. We then use this approach to investigate how future projected changes to ENSO, tropical cyclones and sea level rise may influence coastal storm tide risk around this coastline. It is anticipated that such studies can provide guidance on the relative importance on storm tide risk of factors such as ENSO variability, sea level rise and tropical cyclone intensity and frequency change, which may assist in the prioritisation of their consideration in impact studies, given the large uncertainties around projected changes to these influences in coming decades.

MOSUSU & OTHERS

Preliminary results of two sampled geothermal fields of Papua New Guinea

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As part of a World Bank-funded program, the Geological Survey Division of the Mineral Resources Authority carried out sampling programs in the West New Britain and Milne Bay Provinces in 2012 and 2013 respectively.

In the West New Britain Province, a total of 35 sites were sampled of its water, gas and rock samples. These sites are only some of the many sites which make up four main high-temperature geothermal fields of West New Britain Province (Lahan, 2013).

In the West New Britain Province, field mapping of the geothermal features indicate that they are confined to the Quaternary Kimbe Volcanics and in the low-lying alluvium. The geothermal features of the area are characterized by hot springs, mud pools, mud pots, mud geysers, geysers, fumaroles, hot and altered ground and formerly active areas (Lahan, 2013, Mosusu, 2002). The features appear to be controlled by deep-seated structures (Lahan, 2013) that are observable in Talasea but may be concealed in the thick sedimentary cover in the Hoskins area. Measured temperature ranged from 62 to >100 °C. Most thermal waters in the Talasea area measure low pH value compared to the Hoskins area, which measured neutral to basic pH values.

Laboratory analysis on these samples was conducted by GNS Science (GNS), New Zealand. Four main types of geothermal waters were identified from the results:

- Lake Dakataua and Rongo were identified as peripheral immature waters
- Magilae, Matagele, Wudi, Wavua and Taliau were identified as steam-heated immature waters
- Tabero and Galu are volcanic immature waters
- Rabili, Talasea Station, Magouru and Bakama are partially equilibrated matured chloride waters with a calculated geothermal reservoir temperature ranging between 300 – 320 °C, except for Bakama which has a calculated geothermal temperature of 240 °C
- Sakalu and Kasiloli were identified as the only fully equilibrated matured chloride water with calculated geothermal temperature of 300 °C

In the Milne Bay Province, 6 features were sampled in the two main geothermal areas of Deidei and Iamalele (Irarue, unpublished). The geothermal manifestations of the Deidei area are characterized by geysers, mud pools and hot streams that lie within the Pleistocene-Holocen Sebutuia Volcanics. These volcanic sequences were deposited by Pleistocene volcanoes that lie immediately to the south, north, and one which appears to have collapsed, forming Numanuma Bay immediately to the east. The geothermal waters measured temperatures of 75- 103 °C and acidic to neutral pH of 3-7. The volcanic sequence which hosts the Deidei Hotsprings is terminated by a north-east trending fault several kilometers to the west. The iamalele geothermal area, in contrast, is hosted by Pliocene – Pleistocene Kukuia Volcanics, consisting predominantly of rhyolite and rhyolitic obsidian. Here the geothermal features are predominantly fumaroles and mud pools with hot springs. The geothermal water here is more acidic with pH of 1 and temperatures of between 93 – 98 °C. Analytical results are still being interpreted to determine maturity of the geothermal waters and also calculate the geothermometric temperature of the geothermal reservoir.

It is anticipated that a resistivity and magnetotelluric survey will be conducted in West New Britain before the end of 2013, to define the depth of the heat source and the up flow areas.

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MOUNTJOY & OTHERS

Tsunami hazard assessment for Wallis and Futuna

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Although only ~230 km apart, the Horn Archipelago and the island of Wallis (French Territory of Wallis and Futuna), between Samoa and Fiji, present two contrasting geomorphological and geodynamic environments. Wallis (176°10'W, 13°18'S) with a population of ca. 8000, consists of a ~70 km2 low lying island, surrounded by a lagoon delimited by a barrier reef. The atoll is located on the Pacific Plate, away from the seismically active Pacific-Australia plate boundary. In contrast, the islands of Futuna (83 km^2) in the Horn Archipelago, with a population of ca. 4500, are located on the highly active North Fiji Fracture Zone, and are mountainous with low-lying fringing reef. In both archipelagos, the majority of the population lives within close proximity to the coast and have a strong cultural and economic link with the sea. Historical tsunamis and climatic hazards have demonstrated that the threat is real for the two islands. Between 2009 and 2013, we have undertaken a multidisciplinary tsunami hazard assessment in the territory, funded by the French Pacific Fund, the EU, SPC-SOPAC and supported by the territorial administration.

To assess the tsunami hazard of these islands we have:

1) Undertaken a paleotsunami study on both islands by searching for geological evidence of rapid/catastrophic marine invasions on the coastal fringe and on the small reef islands. Multiple trenches were dug and sampled to provide material for identification of marine invasion and dating;

2) Surveyed the impact of the 2009 South Pacific Tsunami on Futuna; and

3) Completed numerical tsunami propagation and inundation models for a number of regional and distant tsunamis. This required the development of a detail bathymetric and topographic grid of the coastal areas, and the characterisation of trans-pacific, regional and local tsunami sources. The results indicate sources that are the most likely to affect Wallis or Futuna, e.g. the faults along the Chile/Peru coast or along the northern Tonga Trench.

We have developed a public information brochure that has been presented to the Territorial Authority in Wallis to ensure that the hazard information is conveyed to the local community, customary leaders and NGOs on the islands.

QUIGLEY & OTHERS

Water balance modelling approach to rainwater augmentation, Honiara, Solomon Islands

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Secure water supply is essential for human health and wellbeing, and is a challenge for Small Island Developing States (SIDS), where water resources may be limited and increased risks are emerging due to climate change. In Honiara, Solomon Islands, a number of factors have constrained access to fresh water including: rapid population growth and urbanisation, neglected water infrastructure, the ethnic tensions, sole reliance on groundwater and poor supporting electrical infrastructure. Within this context, and the broader implications of climate change, the case for using rainwater tanks as either the primary source, or a feasible augmentation of domestic water supply has been explored. A water balance model has been developed and run over various scenarios to determine the reliability of rainwater tanks over a 30-year period. The development of this model has highlighted both opportunities and limitations that can be used to inform decision-makers and planners in water resources management.

SIKIVOU & OTHERS

Strategy for disaster and climate resilient development in the Pacific

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While disaster and climate-related risks do not always relate to the same natural hazards, such as in the case of earthquakes and volcanoes, management of the risks overlaps in many respects. Even when responding to geophysical hazards, or reducing greenhouse gas emissions, there are often synergies with adaptation to climate change. An integrated approach is often more effective and efficient of scarce resources, given that it can reduce the risks to sustainable development from multiple hazards or phenomena, whether climate-related or geophysical, and whether of sudden or slow onset.

This presentation and subsequent discussion provides an opportunity for the STAR network, and representatives of Pacific Island Countries and Territories (PICTs) attending the STAR 2013 meeting, to contribute to the development of a Strategy for Disaster and Climate Resilient Development for the Pacific. This will replace the current separate policy frameworks for DRM and Climate Change, namely the Pacific Disaster Risk Reduction and Disaster Management Framework for Action 2005–2015 (also known as the Regional Framework for Action or RFA) and Pacific Islands Framework for Action on Climate Change 2006–2015 (PIFACC).

The process of preparing the new strategy is termed the 'Roadmap'. The Roadmap process was developed and endorsed in 2011 by the Pacific Platform for DRM, the Governing Council of the Secretariat of the Pacific Regional Environment Programme (SPREP) and the Committee of Representatives of Governments and Administrations (CRGA) of the Secretariat of the Pacific Community (SPC). The process recognises the integration efforts already ongoing at national and

regional level, in consultation with a broad range of development partners and donors, in addition to DRM and climate change stakeholder groups within PICTs. It has received widespread support at international, regional and national levels in the Pacific. The Pacific will be leading the way on this process, as it will be the first region in the world to fully integrate DRM and climate change considerations into a single overarching policy framework.

In 2013, a major consultation on the Roadmap took place during the 2013 Joint Meeting of the Pacific Platform for DRM and the Pacific Climate Change Roundtable, held in Nadi, Fiji from 8–11 July. The consultation during the STAR meeting is a further opportunity to influence the formulation of the new strategy which will be presented to Pacific Leaders for approval at their meeting in 2015.

The Roadmap process has three major outputs. The first is the new Strategy for Disaster and Climate Resilient Development. The second is a regional synthesis progress report of the implementation of the RFA and the PIFACC, and the third output is a compendium of case studies of DRM and Climate Change.

Some of the key questions that STAR will be asked to consider are:

1. What are some of the key issues facing Pacific island countries and territories with respect to managing disaster and climate risks?
2. What are the priorities in these areas, and why?
3. What changes are necessary to improve the leadership and implementation of DRM and climate change at national and regional levels?

SINCLAIR

Water Resource Assessments in the outer islands of Kiribati (KIRIWATSAN)

Peter Sinclair
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Ground water resources are the main water supply for most communities in the Gilbert Islands group. The 16 islands covering 281km^2 with more than 117 islets are spread north and south of the equator and accessible by irregular flights and boat. The communities through necessity are self sufficient with limited support from the National government based in South Tarawa.

Groundwater in these cash poor, subsistent communities often provides a reliable and easily accessible freshwater source, with shallow water tables and sandy soils wells can be dug by hand and constructed from local or easily sourced materials. As many of these wells are located close to the house they are subject to contamination from toilets, pigs, and other household contamination sources, and may be brackish especially during dry conditions.

The KIRIWATSAN project aims to increase access to safe and sustainable water and sanitation, and through improved hygiene practices to reduce the prevalence of water, sanitation and hygiene (WASH)-related diseases.

Water resource assessments are an integral part of this objective. Groundwater resources are being mapped for water quality and thickness, rainwater harvesting potential is identified, and the impacts from inappropriate sanitation practices are being recognised. The detailed information resulting from these assessments will be used to guide designs to implement

improvements for water supply and sanitation during a second phase of the KIRIWATSAN project towards the end of 2014.

The water resource investigations are also an opportunity to look at the interaction between science and community in the context of development. The survey work utilises and interacts with the local community to map infrastructure and identify how water is used providing insight into household life and needs.

Science is often used to introduce improvements resulting in social change. Identifying these potential social impacts is of course an important component into the design of options and how activities are introduced and implemented. The ability for isolated, self reliant, and subsistent communities to sustain introduced technologies and the potential social impact are as important as providing the best scientific options.

The assessment work being undertaken by SPC has been designed to link with accepted practices, and the socio economic setting of households living in isolated subsistent communities. Working within the constraints of land boundaries, sites for water supply systems ranging from improved household wells to more communal water supplies are identified and presented to the community to jointly determine what type of improvements best match their situation with regard to social, economic and environmental considerations. Similarly, a combined approach of understanding the impacts to water quality from existing land use and sanitation practices, and identifying the best location and types of technologies available, will help inform the behavioural change process required to improve sanitation practices.

Assessing Vulnerability and Adaptation to Sea Level Rise, Lifuka, Ha'apai, Tonga: A Water Resources perspective

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In May 2006, Lifuka island in the Ha'apai Group of Tonga experienced an earthquake that generated 0.23m of subsidence. The obvious impact to the island has been coastal erosion and impacts to infrastructure due to inundation.

In light of this and in consideration of potential future scenarios such as increased wave impacts, inundation, changing rainfall patterns, and increased threats and demands to groundwater resources the Government of Tonga identified the need to support informed and responsive adaptation measures to address current impacts and future challenges. AusAID under the Pacific Australia Climate Change Science and Adaptation Planning Program (PACCSAP) in collaboration with Government of Tonga and SPC developed a multi-disciplinary assessment approach to better characterise these vulnerabilities and impacts with a view to developing solutions and adaptation responses for community consideration and action.
As part of this work, SPC modeled the potential inundation in Lifuka from storm surge and run-up associated with a severe (1 in a 100 year) tropical cyclone event. Coupled with projected scenarios for sea level rise and rainfall, it was found that seawater inundation of up to 5m above today's mean sea-level might be expected. This would potentially impact 79% of existing infrastructure and homes, as well as the groundwater resources.

Assessments from households indicated that although 92% of households relied on and preferred rainwater for their drinking water, groundwater still appeared to account for 80% of all water

needs and is currently provided by the Tonga Water Board through a reticulated system as well as through individual and communal wells.

Results from the groundwater assessments confirm that the fresh groundwater appeared for the most part to be restricted to the unconsolidated sand sediments of the western coastal fringe underlying the villages of Koulo, Holopeka, Pangai and Hihifo.

The sealevel rise in response to the earthquake of 0.23m was observed in two monitoring bores, LIF 7 and LIF9, and corresponds to a rise in water levels of 0.45 and 0.55m respectively. It is interesting to observe that these two bores also indicate a increase in the freshwater lens thickness of about 0.5m. This suggests that the rise in the freshwater lens, whilst causing the water table to become shallower, also allowed the lens to become thicker. It is considered that 0.5m increase in freshwater thickness is a combination of both the higher water table moving into more favourable geology for the development of a thicker freshwater lens, and an increased period of rainfall.

Current abstraction accounts for 46% of the sustainable yield, estimated at 213,318m3/year. It should be noted that current abstraction occurs from 4 tonga Water Board wells or galleries and is not spread across the freshwater lens area, suggesting abstraction rates for some wells will be too high, causing localised overabstraction impacts of increased salinisation during dry periods, as indicated by the measured salinity readings at some TWB wells.

It was found that unsealed or bottomless septic tanks, a large proportion of domestic pigs and dogs and the lack of protection of the area immediately surrounding the public water supplies were the main causes of contamination of the groundwater, accounting for E coli presence being found in 95% of wells sampled.

A “no regrets” approach to climate adaptation with respect to the water resources has been identified for Lifuka. This recognises the value of activities such as:

- Improving rainwater harvesting collection and storage;
- Protecting groundwater resources with setback zones and bunding around pumping stations;
- Introducing adaptive pumping strategies based on salinity of groundwater from the different town water supply wells;
- Reducing water losses from the water supply system;
- Investigating supplementary water supplies from outside the potential inundation area; and
- Improving monitoring of the water quality.

Combined, these activities can assist to improve availability and protection to fresh groundwater supplies and provide greater consistency in the quality of groundwater supplied to the residents of Lifuka.

TIRAA & OTHERS

Climate Engineering: What does it mean for the Pacific?

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Climate Engineering (also known as geo-engineering) refers to deliberate attempts to reduce the impacts of climate change by either removing carbon from the atmosphere (Carbon Dioxide Removal, CDR) or limiting global warming through Solar Radiation Management (SRM). While many approaches are largely in the realm of science fiction (e.g. giant mirrors orbiting the earth), research is currently being undertaken in several developed countries to assess the feasibility of other more feasible possible climate engineering actions. However, there are concerns that an increased focus on climate engineering will distract from global efforts to reduce Greenhouse Gas (GHG) emissions.

The first *Open Discussion Workshop about Climate Engineering: Perspectives from Pacific Small Island States* was held in Suva, Fiji, from August 21-23. Twelve Pacific Island Countries and Territories were invited to the Suva workshop, at which experts from the Institute for Advanced Sustainability Studies (IASS), based in Potsdam, Germany gave presentations on technologies being considered. The legal frameworks (or lack thereof) to govern climate engineering were discussed, along with the moral and ethical issues that the international community will face as these technologies mature and become realistic options.

This presentation will give a brief overview of topics covered at the Suva workshop and discuss the outcomes of the workshop. The participants noted that each of their governments need more information on this emerging issue, and that the Pacific needs to have a clear and cohesive voice as this topic develops in the international arena, as not all climate engineering options may have a positive impact in this region.

TOKALAUVERE

Land Cover Mapping of Pacific Island States

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Land cover maps provide the necessary tools for development, planning and management of Pacific Island Countries.

The Land cover mapping at SOPAC was initiated and made possible in late 2011 through the SPC and GIZ programme 'Coping with climate change in the Pacific Island Region Programme'. The mapping was first done for Fiji at a scale of 1:50, 0000 for Viti Levu and Vanua Levu. The 1:10,000 land cover mapping is currently underway and is financed by the SPC/USAID 'Enhanced climate change, Resilience of Food Production System Project'. The same Project is also financing the 1:50, 000 land cover mapping of Solomon Islands.

The visual interpretation was favoured due to several reasons. Firstly, the atmospheric conditions in the Pacific are very different to other parts of the world; in certain areas, it is very difficult to get image data that is haze or cloud free. Secondly and most important, the interpretation is carried by the technical staff from government departments, namely Lands, Forestry and Agriculture as the technical field knowledge is vital in the mapping activity. The interpretation is carried out at the SOPAC Division by the officers as part of on-the-job training. At the end of the training, the imagery and data is used by the government ministries.

The interpretation is carried out in map sections which are 10 x 10 km areas, where 12 of the sections cover one map sheet. The interpreter toggles between the natural colour, the false colour IR, false colour IR red edge and the vegetation index.

Before the image interpretation atmospheric correction and ortho-correction is performed on the images. Atmospheric correction assists in reducing the atmospheric differences related to relief and local haze whereas ortho-correction is a geometric image correction which takes a DEM or a digital surface model DSM into account, which is essential to eliminate relief displacements. Visual interpretation was still necessary for parts of the images affected by haze. The pan-sharpening process, which joints the colour image information with the higher resolution black and white channel, is carried out in-house at SOPAC. This new task was necessary as atmospheric correction cannot be performed with pan-sharpened images. SOPAC now purchases original images, does the atmospheric correction and then pan-sharpens the image data. Through this way, interpreter have better image data for the land cover delineation.

The current mapping activity provides a standard baseline to use in determining effects of climate change on vegetation. With various government ministries and departments involved in the interpretation, this facilitates collaboration and product consistency important for aggregating multi-scale vegetation data from local planning units to regional and national scales. For example, in the beginning of the mapping, it was found out that the Department of Agriculture has been mapping the gallery forest as shrubs; this was corrected when liaising with the Department of Forestry.

For the first time ever in Fiji, the Department of Forestry and Agriculture are collaborating to produce a same land cover map, after agreeing on a common forest and non–forest boundary. This further facilitates communication and data sharing of vegetation and land cover information between government departments.

Very high resolution imagery means more detail and therefore, longer time in interpretation. A solution had to be found in speeding up the mapping. As a result, we are currently using image segmentation in ERDAS IMAGINE 2013. However, visual interpretation is still of the process, the polygons produced in the segmentation will be checked and adjusted by the technical officers. A field verification exercise is carried out after analysis in the office, and this allows the interpreter to compare image data and what is really on the ground. The technical officers who have a vast knowledge and experience in field work are also involved in the field verification.

TUCKER

Prototype Tsunami Evacuation Park in Padang, West Sumatra, Indonesia

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Padang, Indonesia, a city of some 900,000 people, half of whom live close to the coast and within a five-meter elevation above sea level, has one of the highest tsunami risks in the world due to its close offshore thrust-fault seismic hazard, flat terrain and dense population. There is a high probability that a tsunami will strike the shores of Padang, flooding half of the area of the city, anytime during the next 30 years. If that tsunami occurred today, several hundred thousand people would die, as they could not reach safe ground in the ~30 minute interval between the earthquake's occurrence and the tsunami's arrival. Padang's needs have been amply demonstrated: after earthquakes in 2007, 2009, 2011 and 2012, citizens, thinking that those earthquakes might have triggered a tsunami, tried to evacuate in cars and motorbikes, and created traffic jams that prevented them from reaching safe ground in 30 minutes.

Since 2008, GeoHazards International (GHI) and Stanford University have studied a range of options for improving this situation, including ways to accelerate evacuation to high ground with pedestrian bridges and widened roads, and means of 'vertical' evacuation in multi-story buildings, mosques, pedestrian overpasses, and Tsunami Evacuation Parks (TEPs), which are man-made hills with recreation facilities on top. TEPs proved most practical and cost-effective for Padang, given the available budget, technology and time.

GHI has acquired permission to build a prototype TEP in the northern part of Padang that would accommodate about 25,000 people during the time of a tsunami. This would cost about $2.4 million to construct, amounting to a cost-per-life-saved of ~US$100, far lower than the *per capita* cost of the other options. The cost of replication should be less.

This interdisciplinary, international effort demonstrated that TEPs offer the best option for Padang because they have the potential to save thousands of lives, are relatively simple to build and maintain, invite everyday recreational use by the community, and have attracted strong Indonesian Government support as a possible means to manage the country's tsunami risk.

TURUA

MOE-DRM: Incorporating DRM in Curriculum

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Email:

The Ministry of Education responds to Disaster Risk Management (DRM) at both a strategic and operational level. At the strategic level, DRM does not sit alone but aligns with other initiatives around Education for Sustainable Development, Climate Change Education and Renewable Energy. Disaster Risk Management is considered within the governance and management of the education sector. With over 4000 young people at school every day and more than 300 staff across 31 sites, managing risk has not been left to chance.

In forming policy and operating practices in relation to DRM, the Ministry considers mitigation, preparedness and response as well as the contribution that the education sector can make to the wider national picture of DRM.

Mitigation includes consideration of infrastructure, personal behaviours, training and awareness and the environments in which Ministry agencies operate. In our country, we realize that one size does not fit all and that a school's development of mitigation strategies will be specific to that school and its community. The Cook Islands Curriculum provides multiple opportunities and a range of approaches that schools can use to integrate this into their programmes.

Preparedness addresses practice in the lead up to an event. Clear lines of both intra and inter agency communication and the roles and responsibilities of different stakeholders are considered. The preparedness of structures and protection and safety of physical and human resources are paramount.

Post event, the Ministry addresses the safety, security and health and wellbeing of education environments and physical and human resources. It works immediately with EMCI and other agencies, including international bodies such as UNICEF and UNESCO, to address the needs of young people. Assessment and consideration of recovery alternatives are short-term responses while required rebuild plans are agreed.

The Ministry also contributes to the wide national response to DRM. We are a conduit of information before, during and after an event between EMCI and school communities, our buildings often act as shelters for those whose own homes are at risk or made uninhabitable and we assist in the development and provision of community education and awareness.

WHITE & OTHERS

Loss of resilience in water supply in atolls in the Maldives following the 2004 Tsunami: Lessons for the Pacific?

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The Indian Ocean Republic of Maldives has very dispersed small island populations. About 350,000 people live on around 192 very low-lying islands together with nearly 200 resort islands located in 26 coral atolls. About 100,000 people reside on the capital island, Male'. The maximum natural land surface elevation in the Maldives is 2.5 m above mean sea level and the country is extremely vulnerable to sea level changes. This paper studies the long-term impacts on resilience in water supply in outer islands of the Maldives due to major disaster relief programmes that followed the devastating December 2004 Indian Ocean tsunami. It also suggests ways of restoring lost island resilience.

Fresh water in the Maldives is sourced from household and community rainwater storages, household and community wells drawing water from thin, shallow freshwater lenses underlain by seawater and also from desalinated seawater in more densely populated islands. Average annual rainfall, driven by two monsoons, ranges from 2,300 mm in the southern-most atoll, with a 2-month dry season, to 1,700 mm in the north, with a 4-month dry season. Seasonal and annual rainfalls show a 50-year declining trend despite increasing sea surface temperatures in the Indian Ocean.

Prior to the 26 December 2004 tsunami, outer-island populations relied on wet season rainfall and sometimes used groundwater in the dry season to augment potable water supply. However, on few islands such as HA, Utheem, ground water was preferred over rainwater for drinking, although tests revealed contamination from discharge septic tanks and pit latrines. Traditionally, in the outer islands, rain water was used as a premium water source available during the rainy season but limited by the size of the household rain containers of 50 to 80 L.

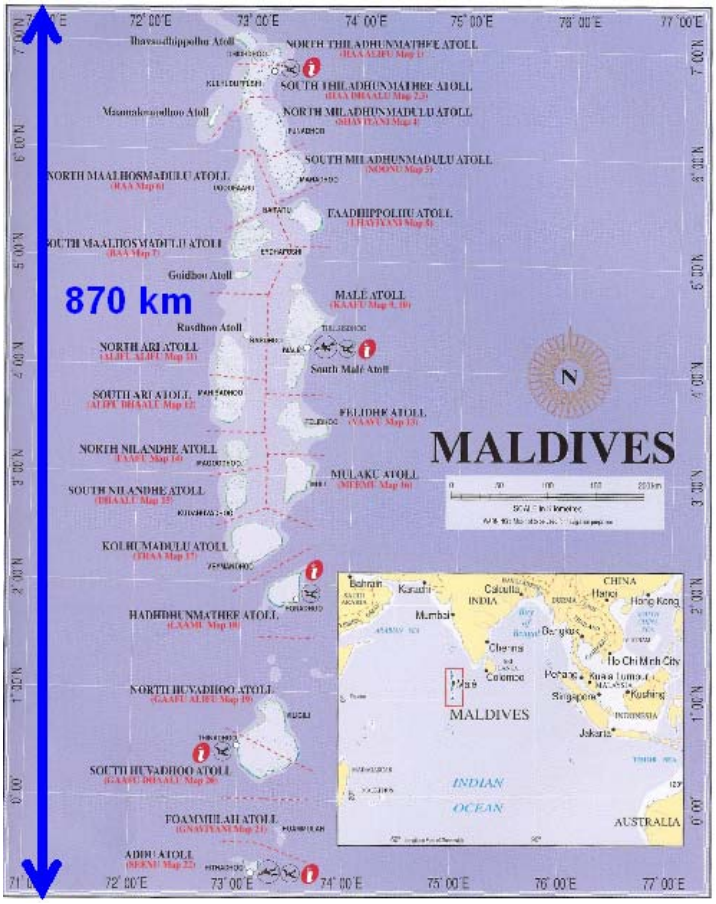
The 2004 tsunami inundated at least 50 inhabited outer islands, salinising groundwater lenses and contaminating them with the contents of destroyed household septic tanks and petroleum storages. Over 10% of inhabited islands were so badly affected that their entire populations were permanently relocated. Remaining island communities were warned that groundwater was unfit for use. A massive international aid response led to the provision of a 2.5 kL rainwater tank for every outer-island household, over 50 desalination units in selected islands and a variety of island sewerage systems with diverse treatment systems. Eight years after the tsunami, less than 50% of the desalination plants and only one of the sewage treatments works were operational. In addition, not all of the rainwater tanks have been installed or adequately connected.

Government authorities have continued to assume that, in any inhabited island, septic tank discharges have polluted the local groundwater, making groundwater bacteriological tests unnecessary. This is despite some islands having large groundwater reserves with low salinity, away from the inhabited areas, worth protecting for public use. No national systematic monitoring of outer island groundwater resources has occurred since the tsunami and the Government's official stance remains that groundwater is too polluted for use, despite its continued widespread use in outer islands for bathing and washing.

As a consequence, over 100 outer islands now request that very expensive 'emergency' desalinated water supplies be shipped by the Government from Male' during regular dry seasons, and have done so since 2005. This situation is unsustainable. Estimates of the rainwater tank capacity needed to provide potable water to households through the dry season show capacities in the south need to be increased to 5 kL and in the drier north to 10 kL. A revolving could be used, as in the past, to help fund household purchases. Use of infiltration galleries for groundwater extraction from protected areas, as recommended in previous studies, should be trialled, particularly in agricultural islands.

In order to restore resilience and self-reliance in outer islands it is necessary to firstly reform water governance and engage island communities in management of their water sources. The Maldives has no inter-agency coordination mechanism, no national water policy, no national water law, no planning system which identifies and protects groundwater sources, minimal community participation and more than two decades of draft water plans and frameworks, most of which have not been implemented. There is no legal protection for groundwater from pollution and over-extraction. The lead water agencies are based solely in Male' and have no capacity for regular, systematic, water resource monitoring throughout the country. A national groundwater assessment and monitoring program needs to be established. Potential areas for safe groundwater harvesting need to be identified and protected and the community engaged in local management to increase island resilience and reduce reliance on 'emergency' dry season water supply. Some of the lessons learnt in the Maldives appear directly applicable to atoll island nations in the Pacific.

It is concluded that major disaster relief responses, successful in the short-term, can lead to long-term, broad-scale, loss of resilience in water supply if local hydrology, local experience, and capacity are not taken into account and systematic monitoring is not continued.



Barriers to improved water governance: customary land ownership rights in Pacific and Indian Ocean island countries

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This paper uses studies from Kiribati, Tonga, Nauru, the Maldives and Solomon Islands to examine impediments to improved water governance in Pacific and Indian Ocean island countries and to suggest strategies for addressing them.

In many Pacific and Indian Ocean island states, customary land ownership is fundamental to life, culture, society coherence, prestige and power. Traditional land ownership by extended families, clans, villages, nobles or kings infers rights and ownership over associated resources, particularly adjacent streams and especially groundwater and minerals. For subsistence communities in the Pacific and Indian Oceans, this system has been a more or less successful social strategy for between 3 and 12 thousand years.

As island communities transition to developed economies, and particularly translocate to urban environments, problems frequently arise which pose significant challenges to effective water management. Traditional land owners can refuse public access to water sources, or over-extract

groundwater or pollute water sources though land clearance and land use. Some demand exorbitant compensation for public access to land and water which challenge the viability of public water supplies.

In some cases, these actions have forced the abandonment of desperately needed reliable water supply or hydro-power sources. Developed-world constitutional and legal solutions appear rational strategies to cope with the transition to urbanised societies. It is sometimes overlooked however, that many of these have only evolved over the last 200 years. In those countries which have appropriate constitutions, policies, plans, relevant laws and regulations however, implementation and enforcement is largely ineffective. A pragmatic, eco-compensation approach, in which the cost of alternate technology specifies the upper bound of compensation appears an attractive first step, along with partnership agreements providing recognition of land owners in a long-term process of behavioural change.

WILES

The Pacific Islands Global Ocean Observing System

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As noted by the theme of the 2012 Pacific Islands Forum Meeting, which was 'Large Ocean Island States', Pacific island leaders are increasing the emphasis on their oceans. Significant international efforts are being made to monitor the Pacific Ocean, usually with a focus on processes such as El Niño and La Niña which have well-established global impacts. While these observations have direct benefits for the Pacific islands, there is a lack of understanding of these data and their potential to assist resource management and planning in the region. There are also gaps in the Ocean Observing for processes such as ocean acidification and island scale ocean dynamics which have relevance for island countries.

The Pacific Islands Global Ocean Observing System (PI-GOOS) is the Pacific branch of the Intergovernmental Oceanographic Commission's (IOC) Global Ocean Observing System (GOOS) network. This presentation will highlight the components of the ocean observing system in the Pacific and its applications.

WILKS

CBA of storm surge hazard mitigation in Rangiroa, Tuamotu Islands of French Polynesia

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The Pacific Islands are renowned for their natural beauty and oceans. Nevertheless, the geographic features and tectonic settings of these relatively small and isolated islands produce a range of natural hazards, including storm surges and coastal inundation and, when communities are sufficiently vulnerable, these can cause devastating natural disasters.

In order to assist Pacific overseas countries and territories to further develop resilience to these hazards, the European Union (EU) has commissioned the SOPAC division of SPC to work alongside Overseas countries and territories (OCTs) to increase protection and management of the coastal environment.

This analysis forms part of the work undertaken for French Polynesia. Specifically, this document will provide an economic cost benefit analysis of the different adaptation options available to the Government of French Polynesia in combatting coastal flooding in Rangiroa, in the Tuamotu Archipelago.

The Government of French Polynesia is interested in reducing the risk posed by storm surges with a significant wave height of 12 metres, expected to occur once in every 50 years. These waves have been modelled in detail in order to provide estimates of the depth and speed of water inundation at each point in the Rangiroa study area. Using these models, this document analyses 13 different adaptation scenarios that the Government of French Polynesia could pursue in order to reduce the negative impacts of a 1-in-50 year storm surge event. These scenarios can be grouped into four categories of adaptation option; the construction of a sea wall, the implementation of a setback zone, the elevation of buildings to 1 m and the replacement of buildings with MTR (kit houses).

ATTACHMENT

PROGRAMME as at 11 September 2013 (check daily at the meeting venue for updates)

Programme for 30th STAR Conference
Rarotonga, Cook Islands 2013
Edgewater Resort

Time	Theme	Authors & Speaker	Title	Chair
Saturday October 5th Edgewater Resort Hotel, Rarotonga Conference registration from 08:00 at Edgewater Resort Hotel				
09:00-09:40	**Opening of STAR**			
09:40-10:20	Deep Sea Mining	Hein, J.R., Spinardi, F., Tawake, A., Mizell, K. & Thorburn, D.	An estimate of the critical metals resource for manganese nodules from the Cook Islands EEZ	JC
10:20-10:40	**Refreshment break**			
10:40-11:00	Climate change issues & infra-structure	Tuivaga, W.	Strengthening the resilience of our island communities to climate change	
11:00-11:20		Ngari, A.	The Climate Early Warning Information System for the Cook Islands	
11:20-11:40		Akaruru, J.	Climate proofing initiatives - infrastructure planning and designs for infrastructure projects, for the Cook Islands	
11:40-12:00		Sinclair, P.	Assessing vulnerability and adaptation to sea level rise, Lifuka, Ha'apai, Tonga: a water resources perspective	
12:00-13:00	**Lunch break**			
13:00-13:20	Climate change issues & infra-structure	Pirake, P.	The Office of the Electrical Inspectorate	
13:20-13:40		Tangianau, O.	Outer Islands local government initiatives	
13:40-14:00		Tiraa, A.	Climate engineering: what does it mean for the Pacific?	
14:00-14:20		Sinclair, P.	Water resource assessments in the outer islands of Kiribati (KIRIWATSAN)	
14:20-14:40		Tokalauvere, V.	Land cover mapping of Pacific Island states	
15:00	**Transport leaves to recreation, volleyball competition and dinner**			

Sunday October 6th
Free day Working group and committee meetings

Monday October 7th Joint Circum-Pacific Council/STAR Meeting				
08:30-08:50	Deep Sea Mining	Cronan, D.S.	Recent investigations on manganese nodules and their substrates in South Pacific EEZs and suggestions for further research	Gary Greene
08:50-09:10		Clark, M.R., Rowden, A.A., & others	Science requirements for management of environmental effects of seabed mining; a need for collaboration and coordination	
09:10-09:30		Boschen, R. E., Rowden, A. R., Clark, M. R. & Gardner, J. P. A.	The distribution and connectivity of benthic macrofauna in areas of potential seafloor massive sulphide mining: preliminary results from studies underway in the New Zealand Exclusive Economic Zone	
09:30-09:50		Gardner, J.P.A., Boschen, R.E., Rowden, A.R. & Clark, M.R.	What can genetic connectivity tell us about the resilience and recovery of deep-sea vulnerable marine ecosystems?	
09:50-10:10		Lamarche, G., Mountjoy, J. & Clark, M.R.	Seafloor mineral resources in New Zealand's EEZ: Developing activities and environmental management framework	
10:10-10:30	**Refreshment break**			
10:30-10:50	DSM Cont.	Mackenzie, T.	Social and governance aspects of mineral development: involving communities	
10:50-11:10	Disaster Risk Management	Arioka, P.	The benefit of a GEO PORTAL in disaster risk management and climate change	
11: 10-11:30		Arnold, F.	Legislative analysis for DRM_DRR_CCA – "Climate & Disaster Compatible Development Policy 2013 – 2016"	
11:30-11:50		Teiti, L.	Building code data processing and review	
11:50-12:10		Sherburn, S.	Improving volcanic hazard mitigation in Vanuatu with lessons for other Pacific Island countries	
12:10-12:30		Turua, A.	Incorporating DRM in curriculum	
12:30-13:30	**Lunch break**			
13:30-13:50	DRM Tsunami	Mountjoy, J., Lamarche, G., & others	Tsunami hazard assessment for Wallis and Futuna	
13:50-14:10		Tucker, B.	Prototype tsunami evacuation park in Padang, West Sumatra, Indonesia	
14:10-14:30		Gledhill, K.	Enhanced Pacific Tsunami Warning System alerting information based on forecast models	
14:30-14:50		Carlson, C.	The use of tsunami modelling in determining tsunami disasters in the Cook Islands	
14 :50- 15 :10		Greene, G. & Nishenko, S.	Assessment of seismic and tsunami hazards of critical Pacific infrastructures in the aftermath of the Fukushima Tsunami	
15:10-15:30	Refreshment break			
15:30-17:30	DRM Strategy	Sikivou, M., Casella, C., Pratt, C. & Hay, J.E	Strategy for disaster and climate resilient development in the Pacific	
17:30-18:00	STAR Business Meeting			

Tuesday October 8th				
08:30-08:50	DRM Tsunami	White, I., Falkland, T. & Bari, R.	Loss of resilience in water supply in atolls in the Maldives following the 2004 Tsunami: lessons for the Pacific?	
08:50-09:10	DRM Storm effects	Samuel, R.	Cook Islands Red Cross - disaster risk reduction initiatives	
09:10-09:30		Mataroa, K.	DRM-DRR-CCA - MOIP role and responsibilities - cyclone and tsunami emergency response plans	
09:30-09:50		Blacka, M., Flocard, F., & others	Modelling and mapping the impacts of storm surge and waves on the Avarua coastline	
09:50-10:10		Wilks, A.R.	CBA of storm surge hazard mitigation in Rangiroa, Tuamotu Islands of French Polynesia	
10:10-10:30	**Refreshment break**			
10:30-10:50	Storm effects	McInnes,K.L., Hoeke, R.K. & O'Grady, J.	Climate change impacts on tropical cyclones and extreme sea levels – An example for Fiji	
10:50-11:10		Hoeke,R.K., McInnes, K.L. & Colberg, F.	Wave-driven extreme sea levels at oceanic islands: historical events, future implications and predictive challenges	
11:10-11:30		Gardner, J.P.A., Garton, D.W., Collen, J.D. & Zwartz, D.	Southern Ocean storms can disrupt lagoon circulation	
11:30-11:50	Renewable energy	Mosusu, N.T., Irarue, P., Lahan, M. & Verave, R.	Preliminary results of two sampled geothermal fields of Papua New Guinea.	
11:50-12:10		Tereapili, T.	REDD Division - Office of the Prime Minister (Renewable Energy Programs)	
12:10-12:30		Heather, T.	Renewable energy challenges - Te Aponga Uira	
12:30-13:30	**Lunch break**			
13:30-13:50	Resource mapping	Forstreuter, W.	Needs for and status of capacity for Pacific Coconut Resource Inventory	
13:50-14:10	Maritime boundaries & marine parks	Mataora, V.	The Cook Islands Extended Continental Shelf submission at DOALOS and Outstanding Maritime Boundaries Zones	
14:10-14:30		Ponia, B.	Cook Islands oceans management	
14:30-14:50		Wiles, P.	The Pacific Islands Global Ocean Observing System	
14 :50-15 :10		Iro, K.	Cook Islands Marine Park	
15:10-15:30	**Refreshment break**			
15:30-15:50	Water resources & waste management	Burbery, L., Weaver, L., Gregor, J. & Dumbleton, B.	Lost in microbial space: a technical assessment of how effective coral sands are at attenuating pathogens	
15:50-16:10		Quigley, N., Beavis, S. & White, I.	Water balance modelling approach to rainwater augmentation, Honiara, Solomon Islands	
16:10-16:30		White, I., Falkland, T. , & others	Barriers to improved water governance: customary land ownership rights in Pacific and Indian Ocean island countries	
16:30-16:50		Teotahi, A.	Water supply and network distribution and Pacific waste, Water Association	
16:50-17:10		Herrmann, T.	WATSAN Initiatives incorporating IWRM (Demonstration pilot IWRM Projects in collaboration with the Waste Management Initiative)	