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The Nippon Foundation

Proceedings of International Symposium on Islands and Oceans

January 22 & 23, 2009

Ocean Policy Research Foundation

Foreword

Based on its philosophy of 'coexistence between mankind and the ocean' the Ocean Policy Research Foundation (OPRF) seeks to address a broad range of ocean problems from a global and comprehensive perspective. We foster interdisciplinary cooperation and build networks among social and natural scientists, work to achieve a balance between ocean use and the need to conserve the marine environment, and carry out a variety of research on the new order taking shape on the oceans.

Since 2005, one focus of OPRF's activities has been to address the problems of the maintenance and revitalisation of Okinotorishima, the southernmost island of the Japanese archipelago, from a technical as well as a legal viewpoint. One of the lessons learned from the process is that we should not treat the issue solely as a domestic one, but invite the consideration of the Pacific Island states, Australia, New Zealand and international society at large and carry out joint research in the search for solutions.

As a result, on January 22-23, 2009, OPRF, with the cooperation of ANCORS and SOPAC, held the 'International Symposium on Islands and Oceans' in Tokyo, so as to share and discuss issues related to conservation, revitalisation and management of islands and surrounding ocean areas. Eighteen experts, both national and international, from various social and natural scientific disciplines gathered and made informative presentations on their current research in order to exchange knowledge and opinions on the development of ocean governance.

We are happy to have publish the proceedings from the 'International Symposium on Islands and Oceans'. They include the collection of all the papers presented by the invited experts as well as general information on the symposium. Each paper has insightful perspectives and unique arguments, and are written in a way that enables interdisciplinary discussion, which, we believe, leads to integrated and sustainable approaches for ocean governance. It is OPRF's pleasure to announce that these proceedings will serve as the basis for our future research on islands and oceans and demonstrate the beginning of our future international collaboration.

Ocean Policy Research Foundation

Acknowledgement

The International Symposium on Islands and Oceans was made possible by the generous support of The Nippon Foundation from the proceeds of motorboat racing. We would like to express our sincere gratitude for this support and also acknowledge the Foundation's concern for an understanding of marine and land environmental issues and the life of people living on islands.

Brief Overview

Symposium

International Symposium on Islands and Oceans

Date

January 22-23, 2009

Venue

Nippon Foundation Building (Akasaka, Tokyo, Japan)

Language

English-Japanese simultaneous interpretation

Theme

The "International Symposium of Islands and Oceans" was held to discuss issues on 1) Island conservation and revival initiatives, 2) islands and the problem of sea level rise due to climate change and 3) management of islands and surrounding ocean areas.

Host

Ocean Policy Research Foundation

Co-Organizers

Australian National Centre for Ocean Resources & Security
(ANCORS, University of Wollongong)

Pacific Islands Applied Geoscience Commission (SOPAC)

Programme

January 22, 2009

Day 1

9:30	**Opening**
9:30-9:40	**Opening Address** Mr. Masahiro AKIYAMA, Chairman, OPRF
9:40-10:25	**Keynote Speech** Mr. Hiroshi TERASHIMA, Executive Director, OPRF
	Remarks by Co-organizers Prof. Martin TSAMENYI, Director, ANCORS Dr. Arthur WEBB, Manager - Ocean and Islands Programme, SOPAC
10:25-10:40	Coffee Break

Session I

Island Conservation and Revival Initiatives

This session will discuss technical efforts to protect islands exposed to the elements from natural threats and to facilitate revitalization. In particular, it reviews island preservation, maintenance and revitalization efforts such as bank protection against shore erosion as well as new technologies on island creation using corals and foraminifers.

Chair: Prof. Makoto OMORI (Akajima Marine Science Laboratory)

Presentations

10:40-11:00 Prof. Richard KENCHINGTON (ANCORS)

"Maintaining coastal and lagoonal ecosystems and productivity"

11:00-11:20 Prof. Hajime KAYANNE (University of Tokyo)

"Eco-technological management of atoll islands against sea level rise"

11:20-11:40 Prof. Paul KENCH (University of Auckland)

"Understanding Small Island Environmental Processes: A Basis to Underpin Island Management"

11:40-12:00 Dr. Arthur WEBB (SOPAC)

"Atoll shoreline dynamics"

12:00-12:20 Prof. Kazuhiko FUJITA (University of the Ryukyus)

"Enhancing foraminiferal sand productivity for the maintenance of reef islands"

12:20-13:00 Discussion

13:00-14:00 Lunch Break

Session II

Islands and the Problem of Sea Level Rise due to Climate Change

In the present century, islands which are dependent on the sea are faced with various problems accompanying climate change, such as the increasing intensity of natural disasters, sea level rise, land submersion land, drinking-water shortage, and impacts of salinization on agriculture. These problems were not in the minds of the drafters of the UN Convention on the Law of the Sea (UNCLOS). This session will review these issues posed by climate change and discuss ways and means for adapting to it and mitigating its effects, including legal matters.

Chair: Dr. Arthur WEBB (SOPAC) and Prof. Moritaka HAYASHI (OPRF)

Presentations

14:00-14:20 Prof. Toshio YAMAGATA (University of Tokyo)
"Scientific Aspects of Sea Level Rise in the Central Tropical Pacific"

14:20-14:40 Prof. Joeli VEITAYAKI (University of the South Pacific)
"Pacific Islands and the Problems of Sea Level Rise Due to Climate Change"

14:40-15:00 Dr. Clive SCHOFIELD (ANCORS)
"Against a Rising Tide in the South Pacific: Options to Secure Maritime Jurisdictional Claims in the Face of Sea Level Rise"

15:00-15:20 Prof. Moritaka HAYASHI (OPRF)
"Sea Level Rise and the Law of the Sea: Legal and Policy Options"

15:20-16:00 Discussion

17:30－19:00 Reception

January 23, 2009

Day 2

Session III

Management of Islands and Surrounding Ocean Areas

UNCLOS recognizes the rights of coastal states over the marine resources in their EEZs, while also assigning to them the responsibility for the protection and preservation of the marine environment. Therefore, the management of marine areas surrounding islands should be conducted in an integrated way, including from the perspective of marine conservation. This session will consider related issues and discuss the future development of ocean governance.

Chair: Prof. Martin TSAMENYI (ANCORS)

Presentations

9:30-9:50 Prof. Rosemary RAYFUSE (University of New South Wales)
"Whither Tuvalu? Oceans Governance and Disappearing States"

9:50-10:10 Prof. Yasuhiko KAGAMI (Tottori University of Environmental Studies)
"Environmental Policy for Desert Islands: Beyond "Island or Rock?""

10:10-10:30 Mr. Quentin HANICH (ANCORS)
"Implementing Oceans Governance - Regional Solutions to National Challenges"

10:30-10:40 Coffee Break

10:40-11:00 Prof. Tetsuo YAMAZAKI (Osaka Prefecture University)
"Coming Deep-sea Mining and the Environmental Aspects"

11:00-11:20 Mr. Hiroshi TERASHIMA (OPRF)
"The Need for a Comprehensive Study on the Problems of Islands and Management of their Surrounding Waters"

11:20-12:00 Discussion

12:00-13:30 Lunch Break

Plenary Discussion

Conservation, Revival, and Management of Islands and Surrounding Ocean Area

Chair: Prof. Tadao KURIBAYASHI (OPRF)

Expert opinions

13:30-14:00 Prof. Makoto OMORI (Akajima Marine Science Laboratory)

"Conservation, revival, and Management of Islands and Surrounding Ocean Area: Public enlightenment and coral culture from eggs"

Prof. Martin TSAMENYI (ANCORS)

"Conservation and Management of Islands and Surrounding Oceans: The need to Re-think Capacity Building Approaches and Initiatives in Developing Island States in the Pacific"

Prof. Tomohiko FUKUSHIMA (University of Tokyo)

"How should the economic value of an island be evaluated?"

Discussion

14:00-15:30 All presenters and chairs

15:30-15:45	Coffee Break
15:45-16:00	**Summary**
16:00	**Closing Remarks**
16:15	**Adjourn**

Contents

Maintaining coastal and lagoonal ecosystems and productivity

Richard Kenchington

Abstract

The shallow ecosystems and productivity of mangroves, seagrass beds, coral reefs and inter-reef seabed are critical natural assets for food production, food security, cultural and recreational activities and livelihoods for many people in Pacific Island States. They also provide important ecosystem services in protection of coasts against storm surges and in production of carbonate sands and debris to nourish beaches and maintain islands. These ecosystems are easily damaged through reclamation, drainage, pollution and destruction of critical habitats for fish and other food species. Once destroyed, these ecosystems are not readily or cheaply restored or replaced.

The paper discusses issues that should be addressed through an integrated process of strategic planning and design to ensure proper consideration of environmental, social and economic impacts in any proposal for island protection works.

Introduction

Global attention was drawn to the threat of sea level rise to low lying islands in a dramatic presentation by the President of the Republic of Maldives to the 1992 World Summit on Sustainable Development in Rio de Janiero. The Maldives and other low-lying island and atoll states are especially vulnerable to climate change and associated sea-level rise. In many cases (e.g., the Bahamas, Kiribati, the Maldives, the Marshall Islands), much of the land area rarely exceeds 3-4 m above present mean sea level. Indeed the highest land in the Maldives is 2.4 metres at a point on Wilingili Island in Addu Atoll. (http://zhenghe.tripod.com/m/maldives/index.html).

Global attention has been particularly focussed on the issues of loss of land due to sea level rise and vulnerability of land to increasing frequency and severity of storms. Low lying islands face the prospect of losing most if not all of their land mass. The situation is particularly critical where the islands are coral cays formed from the accumulated limestone skeletons of corals, coralline algae and other shallow marine life. It can be similarly critical for steep-sided rocky islands surrounded by fringing coral reefs and lagoons where the reef and lagoonal structure supports and sustains beaches and coastal land.

The maintenance and growth of such islands depends on the health of the marine environment. They exist because of the accumulation of skeletal carbonate debris produced by calcification in a healthy coral reef community. In a period of stable sea-level, if carbonate production stops or is significantly reduced for a long period, islands are likely to decrease through failure to replace beach materials washed away in severe storms. In a period of sea-level rise the capacity of reefs to grow upwards and to supply sand to maintain and grow existing islands will generally require very high levels of reef health.

The issues of coral island protection present an extreme and sensitive subset of the global issues that identify the need for an integrated and ecosystem-based management approach to management of coastal and marine ecosystems. In a situation with few if any alternatives, human coral island communities and nations depend on the productivity of goods and services by marine ecosystems. As the impacts of the human community reduce the health or productivity of the ecosystem through single or combined impacts such as pollution, unsustainable exploitation and habitat destruction, the health of the marine ecosystem becomes a priority socio-economic issue. As the combined impacts of the human community exceed the productive capacity of the marine ecosystem, the local supply of goods and services reduces. In a situation with few internal resource alternatives, such communities become increasingly dependent on external support and service-based economic activities.

The purpose of this paper is to provide a multidisciplinary introduction to issues of coral island growth and maintenance and some lessons of management experience. This may provide a contribution to developing effective nationally and locally appropriate approaches for integrated management to sustain coral reefs, islands, associated ecosystems and the human communities that depend upon them.

The formation of coral islands

Corals build skeletons through deposition of calcium carbonate in an association with symbiotic algal cells as do some other reef animals including giant clams. Coralline algae also deposit calcium carbonate and some corralline algal species builds reefs by cementing rubble into substantial structures.

As reef structures mature and consolidate they attract species including worms, shellfish and sponges that make secure shelters by burrowing or boring into the reef structure. This and the action of grazing species and physical impacts such as severe storm waves remove carbonate materials and erode reefs. The extent to which a reef consolidates and grows is determined by the extent to which calcification exceeds erosion.

Hutchings and Hoegh -Guldberg (2008) discuss estimates of carbonate production through calcification in the range 1 – 2 metres per century. This is consistent with Pandolfi and Kelley (2008) who suggest that during rising seas healthy coral reefs can grow upwards at rates exceeding 10 metres per thousand years.

Smith and Kinsey (1976) reported carbonate accumulation in shallow, seaward portions of modern mature coral reefs equivalent to a maximum vertical accretion of 0.5 to 5 metres per thousand years. Hutchings and Hoegh-Guldberg (2008) discuss rates of long term reef growth of 0.1-0.2 metres per thousand years calculating that reflects rates of calcification 3 – 10 times higher than the rate of calcium carbonate removal by biological and physical erosion.

Whether sea-level is stable or rising, the extent to which calcium carbonate production exceeds loss through erosion is critical for the maintenance of coral cays, lagoons and beaches. Recently DeAth et al (2009) have reported a calcification decline of 14.2% since 1990. from an analysis of cores from 328 colonies of massive *Porites* corals from 69 reefs of the Great Barrier Reef (GBR) in Australia. They note that the cause or causes are unknown but comment that such a severe and sudden decline in calcification is unprecedented in at least the past 400 years.

The reported calcification decline reported by De'Ath et al (2009) comes on top of other reports of reef condition discussed in a synthesis by Jackson (2008) who commented that many scientists believe that the cumulative forces of overfishing, pollution and climate change are so great that coral reefs may virtually disappear within a few decades.

From the information available for his synthesis, Jackson (2008) found encouragement in the fact that unpopulated, unfished and unpolluted reefs in the central Pacific were healthy with coral cover in excess of 50% but noted that other Pacific reefs had half that coral cover. Where they occur, such declines in coral cover and reef health have major implications in terms of reef island maintenance and decline even in the absence of sea level rise.

Coastal engineering to secure islands and beaches

Coastal engineering has a long history of works to create and protect harbours and to reclaim low lying areas and protect them from salt water incursions. Horikawa (1996) cites reports of harbour works and artificial island construction at Ohwada Domari in 1172 as the first evidence of coastal engineering in Japan. Bijker (1996) discusses the long and continuing history of Dutch engineering to reclaim and protect low lying and subsiding lands from the sea for agriculture and settlement. He cites monastic records of 1105 as the first directly documented evidence and archaeological evidence from 2200 to 2400 years before present. Bijker noted that the archaeological evidence is supported by references in the writing of the Roman Pliny (AD 23-79) to people in living on man-made islands in a low lying coastal area on the northern border of the Netherlands with Germany.

The ongoing history of coastal engineering includes measures to protect existing coastlines from marine flooding and from erosion of coasts and beaches. In low lying areas it includes creation and protection to retain new land. Rising sea-levels give urgency to such works.

There are four basic approaches to securing and developing islands and beaches.

The first involves construction of sea walls of concrete or rock, typically along the extreme high water mark to block the reach of waves that would otherwise remove supratidal sediments or sand dune.

The second involves reclamation by dumping solid material, or fill, comprising rocks, rubble, gravel or sand to build up areas of intertidal or subtidal seabed to a level beyond the reach of the highest tides. The fill is often contained by sea walls to protect it from erosion. This approach is often favoured on economic grounds because, with appropriate design, a reclaimed area can serve as a sea wall while the created land creates an economic asset to offset at least some costs.

The third involves building groynes which are wall-like structures projecting outwards from high tide to below low tide level to slow or prevent long shore movement of intertidal sediments and reduce loss of shallow sediment to deeper water.

The fourth involves construction or placement of intertidal or subtidal structures that can absorb sufficient energy of incoming storm waves so that they do not scour, undermine or erode other protective structures or the area being protected.

Any such works have an immediate local impact by alienating habitat in the area in which they are placed but may have much wider impacts that are not intuitively obvious. These include altering lagoonal water circulation and the flow of nutrients, organic matter and sediments in ways that reduce carbonate productivity; blocking fish migration routes; and destroying breeding or nursery areas of fish or species important to them. Such impacts may be very significant where carbonate sand and rubble from coral reef communities provide the primary source of natural sediment for sustaining islands or beaches. They can also be very significant if they reduce the habitat and productivity of species that are important natural food resources of island people.

The physical dynamics of sediment supply and transport are critical factors in the context of management of rocky and sedimentary oceanic islands. Both are likely to be significantly changed by expected climate-related changes and may be further affected by measures intended to secure islands in the face of such changes.

There is a history of unfortunate and sometimes very serious unintended consequences of coastal and island protection and development initiatives. They include:

- altered flow regimes causing unintended erosion or sand bar accumulation;
- sea walls that trap overtopping water on the “protected” land;

- large scale reclamations removing wetland areas that are important breeding or feeding areas for fished species; and
- impacts of deep foundations and heavy equipment compressing fragile carbonate soils and disrupting natural freshwater flows and storages.

Design and construction of works on coral islands require special skills and understanding of their fragile nature and their linkage to the reefs that formed them.

Strategies for island protection

The prospect of further deterioration of shallow marine environments, whether from expected global climate change, continuing of human impacts or from measures designed to protect land in the face of those impacts, has major implications for island people. There are related economic, social and strategic implications for most nations within or bordering the Pacific and Indian Oceans and the South-East Asian Sea.

Coastal engineering measures are often large scale, costly and disruptive. It is important that all reasonable steps are taken to ensure that they are competent and effective. The risks of unintended social, environmental and economic consequences and costs should be systematically considered and addressed in planning such measures.

There is growing understanding and experience of the interactions of marine and terrestrial ecosystems and of the costs, benefits and unintended consequences that can flow from interventions to address island and coastal protection. The developing practice of integrated coastal and marine resource management (eg Cicin Sain and Knecht, 1998, Rais et al 1999, Lawrence et al 2002, Kay and Alder, 2005) provides a basis for systematic consideration of the social, environmental and economic interactions that should guide selection of the best option for a particular situation.

The concept of ecosystem-based management is particularly relevant in management of coral cays and other islands associated with coral reefs. The core concept is sustainable management designed and conducted within the constraints of the processes and biological diversity of ecological systems. The politics and socio-economics of ecosystem based management of marine resources are complex when maintenance of environmental services constrains or adds significant costs to socio-economic objectives. This is well discussed in a special issue of Marine Ecology Progress Series (Browman and Stergiou KI (eds) (2005))

Each island has a specific set of interactions of social, environmental and economic factors that should be evaluated at a number of scales to select the most appropriate protective strategy. Key considerations are: the health of the marine ecosystem, its role in supplying sediments and protecting the island beaches from storm waves and the socio-economic importance of and community dependence upon local marine resources.

In many islands where protective measures are likely to be needed in the face of sea-level rise, environmental damage has already compromised carbonate productivity. Current economic activity has typically been associated with the growth of human population and, in multi-island nations, migration of people from outlying islands. The development that has occurred to provide homes, health and sanitation services, employment and food for a growing population is often associated with declines in nearshore environments and productivity of natural resources through pollution, overfishing and reclamation.

Development of an appropriate strategy for island protection requires evaluation of the short and longer term social, environmental and economic implications of many linked considerations including:

- The need for and location of and most appropriate form of engineering works needed to protect or build up island level;
- Current impacts on the environment, natural resource productivity and ecosystem services;
- Options for repairing past damage and new construction damage and restoring environmental condition, productivity and resilience;
- Current and likely future socio-economic dependence on local marine resources and environmental services;
- Potential impacts of construction on environment, human amenity and natural resource productivity and ecosystem services on site and more distantly; and
- Requirements for maintenance of completed works

Such issues are most effectively evaluated in the context of development and ongoing implementation of an ecosystem-based plan for ocean and island resources. A key strategic issue in such a plan is to establish specific objectives and a mandatory process of regular review of performance and future prospects in the light of experience and the results of monitoring and research

Restoration and repair of tropical marine ecosystems

In the light of Jackson's (2008) reflections that undeveloped reefs in the Pacific have twice the coral cover of those that are subject to resident human populations, pollution and overfishing, restoration and repair to bring reefs back to good health must be a priority consideration in any sustainable management regime.

Substantial research has been carried out to develop methods for repair or restoration of coral reefs damaged by ship groundings or by events such as coral bleaching or predation by Crown of Thorns starfish. In 2005 the International Coral Reef Initiative (ICRI) became concerned that repair and restoration methods that are effective at small scales were being inappropriately promoted and regarded as means for widespread rehabilitation and replacement of coral reefs. ICRI had two major concerns. The first was that governments and agencies might be induced to spend substantial sums in the expectation that wide-scale accelerated recovery of coral reefs could occur after major and widespread phenomena such as coral bleaching. The second was that a false view was being promoted that coral reefs were easily restored or created so their destruction could be regarded as a minor and reversible cost of development or public works.

Following an ICRI resolution on this topic (ICRI 2005), guidelines intended to inform managers and political decision-makers on reef restoration were prepared by Edwards and Gomez (2007). These guidelines are basd on an authoritative overview of the scientific literature and experience from field applications to advise on the strengths, weaknesses, costs and coverage of restoration options.

In the context of discussion of island conservation and revival the guidelines of Edwards and Gomez (2007) are important because they emphasise that:

- Coral reef restoration is in its infancy.
- We cannot create fully functional reefs.
- Active coral reef restoration has been carried out with some success at scales of up to a few hectares only.
- Although restoration can enhance conservation efforts, restoration is always a poor second to the preservation of original habitats.
- Coral reefs that are relatively unstressed by anthropogenic impacts can often recover naturally from disturbances without human intervention.

Widespread reef restoration of damaged reefs would be required at a scale of tens to hundreds of square kilometres in order to recreate functional carbonate exporting reef systems at the scale needed to sustain islands during modest sealevel rise. This is at best a distant prospect but measures to produce carbonates through local mariculture may develop to play an important role in maintaining islands in the face of rising sea level. Plans for island protection should be based on maintaining healthy coral reefs by reducing or removing human impacts upon them. This is essential to sustain islands and beaches in the face of ocean warming, acidification and sea level rise associated with climate change.

Existing technologies can be rapidly applied to reduce human impacts on reef health. These include advanced land ,liquid and solid waste management to prevent further pollution from silts, agricultural and industrial pollutants, nutrients, and toxic materials.

Engagement and involvement of human communities from the individual to the national level are needed to develop understanding of the issues and personal commitment to actions that may reduce old freedoms of action in order to protect natural resource systems for the future. Education and communication programs that engage different groups within the communities are important in successful introduction of new management approaches.

A further important component of ecosystem based management and community involvement is the establishment of marine sanctuaries or reserves in which human activities of fishing and collecting are prohibited. Other uses may be allowed only if they are consistent with the protection objective. There is typically resistance to the establishment of such areas but when properly managed, they rapidly serve as sanctuaries where people can see large fish and more life than on impacted reefs. When fully established they usually become popular with fishermen who can catch more fish near the borders of protected areas than elsewhere and this can lead to community support for more extensive protection (Ward, 2004).

Measures to reduce and halt human impacts on reef ecosystems should be a central element of planning for island protection. These can rarely be imposed from outside and usually require culturally appropriate engagement of people who will be affected with consideration and consultation on issues at a number of scales from national to individual. Such engagement should be openly undertaken as part of a systematic process to develop an ecosystem-based management plan.

A current example of such a process is the plan being developed for Addu Atoll by the Republic of Maldives through a local process being mentored by the Centre for Maritime Studies of the University of Queensland (CMS, 2009). An example of the range of scales and objectives is provided in Table 1.

Table 1. Scale of planning for the Addu Ecosystem-based Management Plan

Scale	Objectives	Process	Outputs	Verification
Atoll	- Coordinated government approach - Cooperation with local communities	- Policy, institutional design and strategic development	- Agreement and policy contained in economic, marine and land use policies - Climate change adaptation policies	- Vision Addu 2015 - Millennium Goals 2002
Island groups	- Sustainable use of the resources - Minimisation of cumulative impacts	- Strategies planning (government documents)	- Strategic land use plans - Waste management strategy - Infrastructure development strategy - Ground water management strategies	- 7th National Development Plan - National Biodiversity and Action Plan
Lagoon areas	- Specific targeted intervention to off-set impacts from some human activity	- Tactical planning (sustainable resource management planning	- Marine protected areas	- Environmental Protection and Preservation Act - Fisheries Law of Maldives
Near shore oceanic region adjacent to the atoll	- Recognise the impacts from actions outside the atoll	- Tactical planning (marine resource use)	- Regional and international agreements recognised	- Environmental Protection and Preservation Act - Fisheries Law of Maldives
Village	- Targeted management of specific biophysical and	- Site planning (environmental management plans (EMPs))	- Ecosystem reserves - Resource use or harvest plans	- National Solid Waste Management Policy for the Republic

	cultural impacts as a result of human development		- Business and project plans - Site tenure / management plans	of Maldives - Environmental Impact Assessment Regulations 2007 - Population Policy of the Maldives
Households	- Reduction in waste, sediment run-off, coral and sand loss, noise and visual pollution through individual actions	- Promote "best practice" in environmental management and conservation	- Prevention of impacts and pollution at the source	- National Solid Waste Management Policy for the Republic of Maldives - Environmental Impact Assessment Regulations 2007 - Population Policy of the Maldives
Individuals	- Better understanding of actions and individuals on the environment	- Education on the cause and effects of environmental damage	- Better informed community -	

Source CMS (2009)

Synthesis and conclusion

The development and implementation of integrated ecosystem-based coastal and ocean management are probably the most urgent issues facing small island nations that have no significant resource base other than the productivity of their marine ecosystems. The protection of coral islands and maintenance of the health and productivity of coral reefs and associated ecosystems are critical to the wellbeing of many people in small island nations in the Pacific and Indian Oceans and the East Asian and Caribbean Seas.

The protection of islands should be approached as a component of overall integrated ecosystem-based management, drawing upon global experience to develop capacity and planning and management regimes that engage and involve local communities in solutions that are effective and appropriate to the significant and troubling problems predicted from climate and other global change.

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Eco-Technological Management of Atoll Islands against Sea Level Rise

Hajime Kayanne (kayanne@eps.s.u-tokyo.ac.jp, University of Tokyo)

Air view of Fongafale Island, Funafuti Atoll, Tuvalu from north (right hand is the ocean side).

1. Submergence of Tuvalu

Tuvalu has become popular in Japan recently, as it has already been submerging due to sea level rise induced by the global warming. Actually, during "King Tide" period, the highest tide occurred from January to March each year, salty water comes up in the middle of the island of Fongafale, the largest island in Funafuti Atoll (Figures 1 and 2).

The resident people claim that they had never experienced this situation: water comes up to their resident area. And thus, it should be resulted from sea level rise induced by the global warming. Not only popular media (Figure 1), but also scientific journals such as Nature argured that Tuvalu has already been submerged by sea level rise (Patel, 2006).

Figure 1. Salty water comes up during the “King Tide” period in the middle of Fongafale Island, Funafuti Atoll, Tuvalu. I was interviewed by the TV crew from Taiwan during my survey in March 2008.

Figure 2. Sea level reaches only one meter below the land level during the “King Tide” along the lagoonal coast of Fongafale Island, Funafuti Atoll, Tuvalu.

The story is that Tuvalu contributes only tiny amount of CO_2 release, but it is the first sacrifice of the global warming. Before concluding, we need to examine the geomorphology of atoll islands and its relation to the tide level objectively. But Tuvalu just like other atolls in the Pacific has no contour maps. So we first surveyed its geomorphology and elevation by leveling survey, DGPS and aerial photos.

2. Geomorphology of atoll islands

Landform of Fongafale Island consists of coral reef, storm ridge, central depression and lagoonal ridge from ocean to land (Figure 3). These landform units are common among the other atoll islands in the Pacific. Storm ridge and lagoonal ridge reach 4 and 2 meters above mean sea level, respectively. The central depression between the two ridges has an elevation of only one meter. Highest (spring) high tide level in Tuvalu reaches 1.2 m above mean sea level, and thus during the spring tide, the central depression is submerged below the sea even during this normal condition of tide.

Figure 3. Transect and geomorphic units across the island of Fongafale Island, Funafuti Atoll, Tuvalu.

The observed sea level rise due to the global warming for the last 50 years is estimated to be 10 cm from tide gauge data (Church et al., 2006). The central depression had been submerged below the spring tide as inferred from the relation between transect and present tide level. The highest tide level 50 years ago, well before the human-induced sea level rise, is 1.1 m above the mean sea level, which level still inundated the central depression.

Then why local residential people claim that they had never experienced that inundation before.

We found a geologic map of Fongafale Island published in 1905 (one hundred years ago) by

Royal Society of London (1905). The map shows that a swamp fringed with mangroves extended over the central depression at that time (Fig. 4). People lived only on the lagoonal ridge with a population of 200.

The report described that “On Funafuti, the distinction between the ocean ridge and the lagoon mound is sometimes very sharply marked; on the broader parts of Funafuti islet they are not only obviously independent features, but also are widely separated from each other by an intervening plain, the black and rugged surface of which lies somewhat below high-tide level, so that at full “spring” sea-water oozed up through it and gives rise to scattered pools. This plain may be called the “central flat;” (page 13 in Solas, 1904). “Ocean ridge”, “lagoon mound” and “central flat” in the report correspond to “storm ridge”, “lagoonal ridge” and “central depression” in this study, and exactly described the same geomorphology and situation (ooze-up of sea water in the central depression during the spring tide) 100 years ago!

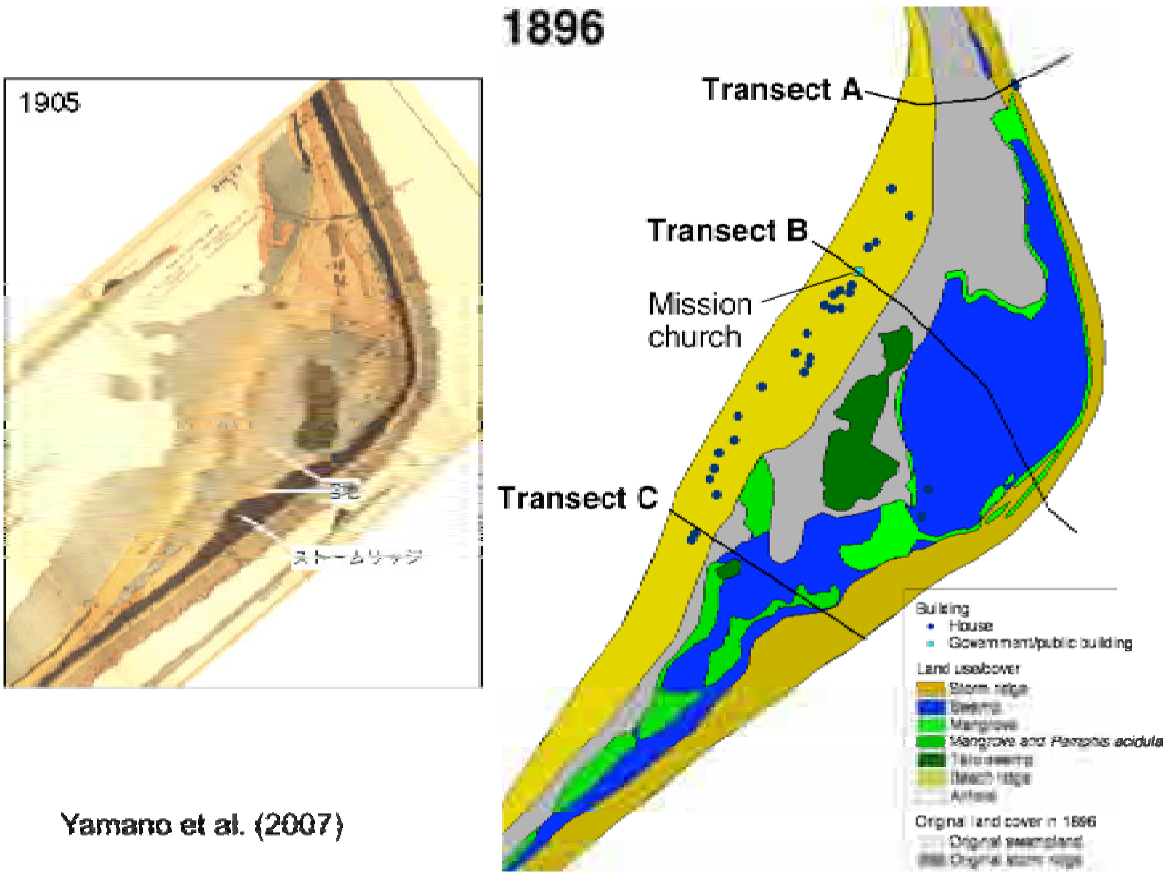

Figure 4. Geological map of Fongafale in 1896 (Royal Society of London, 1905) and its explanation (Yamano et al., 2007).

During the World War II, an airstrip was constructed by the US army filling up the central depression, and its original landform had become obscure, but it still exists as a lowland (Fig. 5). After the WWII, people continue to live on the lagoonal ridge. But for the last two or three decades, residence area has extended over this area due to population increase particularly after the independence of Tuvalu from U.K. with relocation of the capital island from another one to Fongafale. And now a large population of more than 4000 live in this small island all over the island.

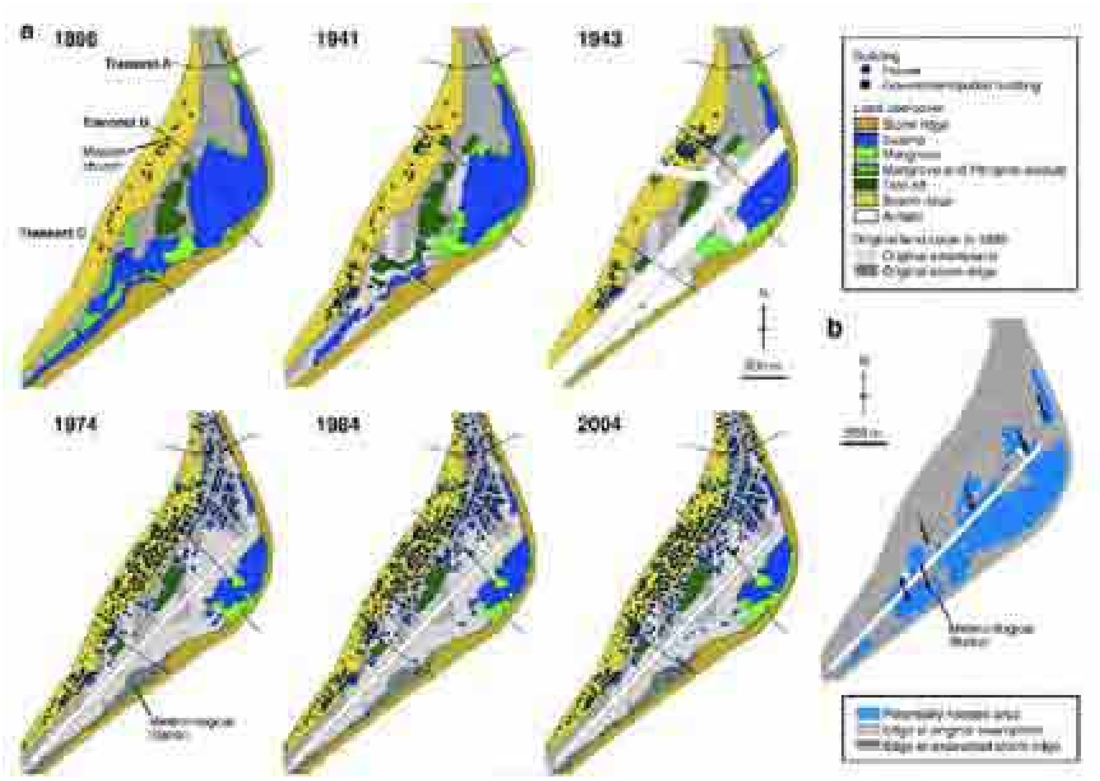

Figure 5. Changes in land use/cover and distribution of buildings in Fongafale Island from 1896 to 2004 based on historical maps, aerial photos, and satellite image (Yamano et al., 2007).

It is concluded that the submergence of Tuvalu at present is not induced by sea level rise due to global warming but by local issues as a result of expansion of residential area into the lowland. Then, are the global issues NOT a great problem in Tuvalu?

3. Projected sea level rise

The projected sea level rise by the end of this century is 18 to 59 cm by IPCC Fouth Report (Fig. 6 left bottom). Based on the relationship between previous projection and actual observation, which tracked the uppermost end of the projection (Fig. 6 right), it is most probable that actual sea level rise would trace the upper line of the projection.

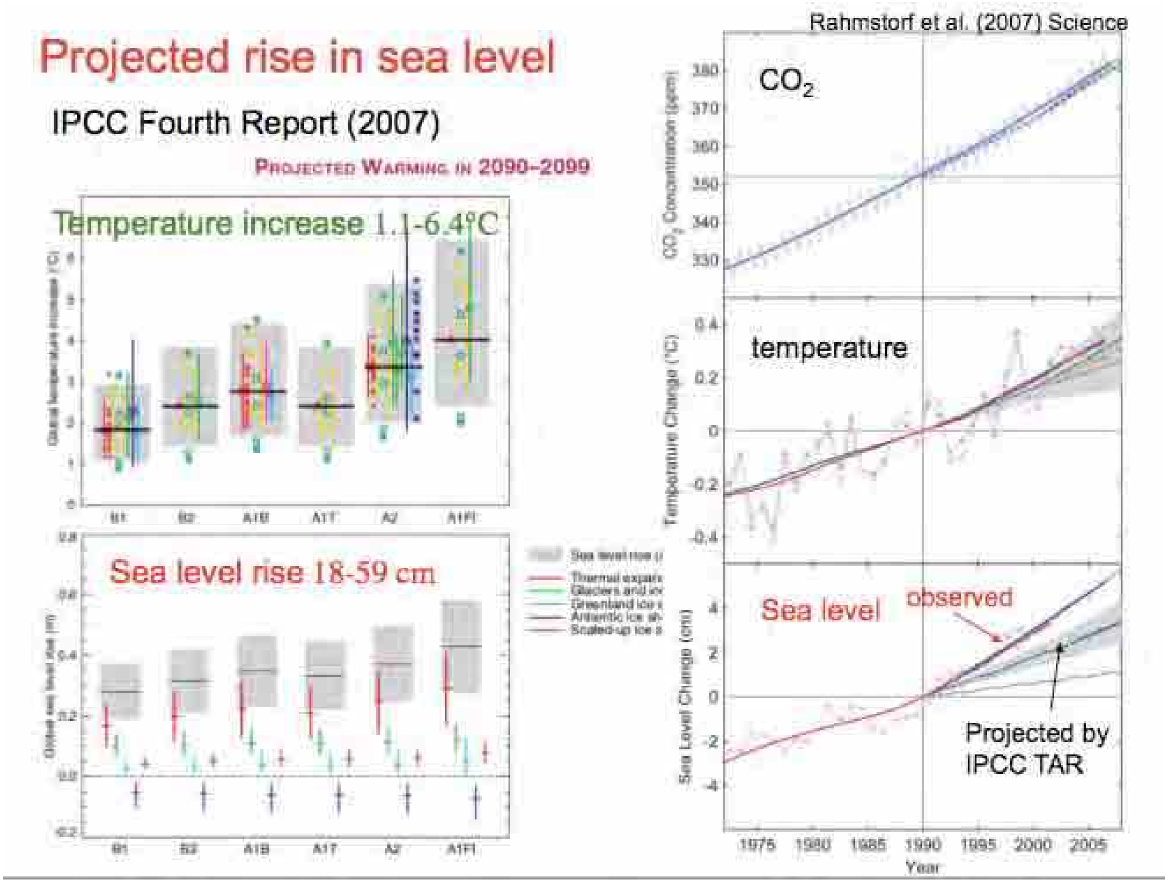

Figure 6. Projected rise in sea level in this century (left bottom), and relation between previous projection and actual observation (right).

If sea level rise of 0.6 m actually occurs, the central depression would submerge even below mean sea level, and even the lagoonal ridge would expose only a few tens of centimeters above high tide (Fig. 7). It is really serious for the Fongafale Island. Only a small height of wave will go directly on land (Fig. 8).

Another problem is loss of coastal vegetation. Formerly, lagoonal coast had been fringed with thick coastal vegetation, which had prevented the wave coming up on land, and stabilized the coastal landforms. But now, the residential area has expanded to the coast with sparse vegetation, and is directly face the sea (Fig. 8).

Figure 7. Highest tide level (red solid line) after a sea level rise of 0.6m.

Figure 8. Highest water level (spring tide) after 0.6m sea level rise along the lagoonal coast.

The other more serious problem in Tuvalu is degradation of coral reef ecosystem probably due to local human stresses. Corals recently dead are covered with green algae in front of the heavily populated area of Fongafale Island. Corals precipitate calcium carbonate skeleton, which pile up to form coral reefs acting as a natural breakwater. Their fragments produce sand and gravels to form island body. The atoll island sediments consist of coral and foraminifera sand and gravels. But the degradation of coral reef ecosystem results in degradation of natural breakwater and sand production potential. The same problems occur, which was quantitatively evaluated in Majuro Atoll, the capital atoll of the Republic of Marshall Islands and is heavily urbanized.

Therefore, present problem of Tuvalu is not as simple as “submergence by sea level rise”, but is mainly induced by local factors of artificial land alteration and population increase, which has increased vulnerability and spoiled resilience of the island against the future sea level rise and global changes (Fig. 9). Countermeasure plans must help to promote natural island maintenance processes (production-sedimentation process, role of traditional land/vegetation management system), and must not conflict with natural resilience potential.

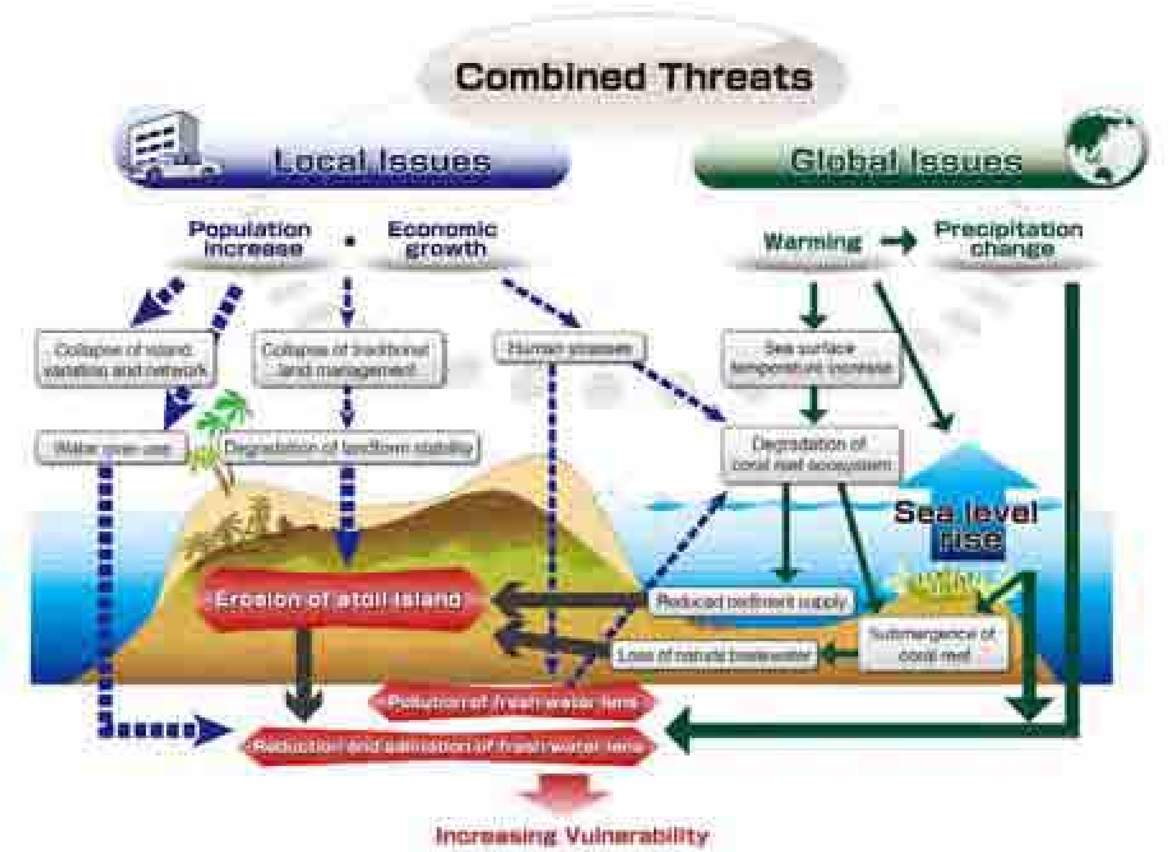

Figure 9. Combined global and local threats upon atoll islands.

We need to construct a zoning plan, in which production, transportation and sedimentation process is shown from ecological as well as coastal engineering point of view. Sand source area must be protected, transportation and sedimentation must not be prevented. Moreover, artificial support for transportation and sedimentation will be established.

In addition to this, enhancement of sand production will be conducted. Eco-technology of coral transplantation and nursery from eggs are now being developed in Japan. In addition to coral, farming of foraminifera, the most important components in the Pacific must be established. If we succeed in establishing eco-engineering management of atoll islands, the technology will be directly adopted and extended to the other atolls, 500 in the world and 400 distributing in the Pacific (Fig. 10).

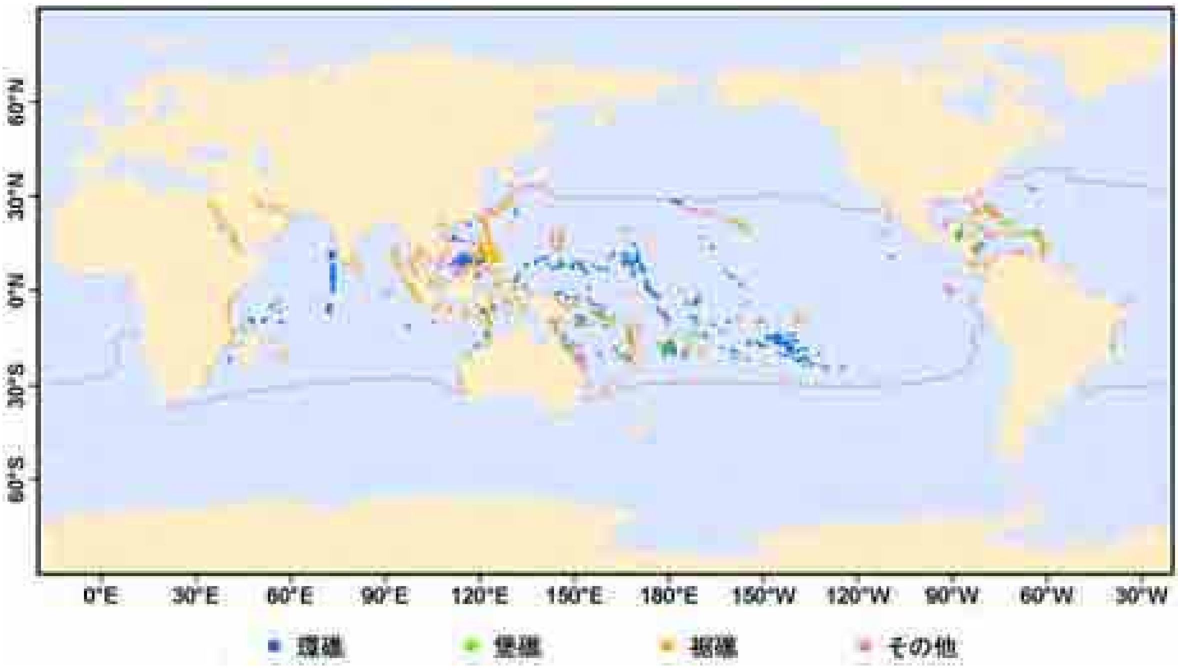

Figure 10. Distribution of atolls in the world ocean (blue dots).

Atoll islands are threatened by climate changes (not only sea level rise but also changes in storm intensity and frequency, sea surface temperature rise, ocean acidity, rain fall and so on) and human impacts. Atoll islands are low-lying with small areas and limited resources. Our scientific studies have found that they support considerable physical and cultural diversity.

A better understanding of the geographical variation in geomorphological and ecological processes offers the potential to increase the adaptive capacity of atoll island systems and the communities that depend upon them. There is a need for research on unresolved issues on modeling island landform, land-human interactions, sediment budget as well as water resources, pollution and garbage problems.

We need to recognize that present landscapes and many existing environmental challenges are a historical product of interaction between humans and the environment. We also need to recognize that environmental stresses and necessary adaptive responses will be significantly different in rural (low human population) and urban (high impact) settings. Estimation of carrying capacity of islands based on the above factors is helpful to estimate the vulnerability of the islands. We need to enhance public awareness both from top-down and from bottom-up directions.

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Understanding Small Island Dynamics: A basis to Underpin Island Management

Paul S. Kench

School of Geography, Geology and Environmental Science
The University of Auckland, Private Bag 92019,
Auckland, New Zealand
p.kench@auckland.ac.nz

Abstract

Small islands are perceived as some of the most physically sensitive landforms on earth. These small islands and their shorelines are susceptible to morphological adjustment in response to changes in the boundary controls on island formation (sediment supply, sea level, wave and tidal processes) as well as anthropogenic influences. Under current projections of sea-level rise over the next century there is widespread concern that many small islands will disappear from the tropical oceans. Concerns about perceived island instability and the pressures of high population densities have resulted in the proliferation of engineered structures to combat erosion and maintain island shorelines. In many instances the introduction of hard-engineered structures has exacerbated island erosion and degraded ecological processes. Reasons for these negative environmental consequences relate to the appropriateness of the design and placement of these structures. The materials used and the mode of construction employed by many small island nations contravene most standard measures of sound engineering design. Sound design is also constrained by the absence of environmental information on local coastal processes (e.g. waves, currents). As a result management solutions are often inappropriate with respect to natural coastal processes and dynamics of small island shorelines. This paper establishes a framework to assist managers to improve decision making in situations of constrained environmental knowledge. Data gathered from field experiments in the Maldives and simplistic modelling of islands and shorelines in Kiribati and Fiji have established a set of examples to illustrate the natural dynamics of small island shorelines. Results depict the different styles of shoreline change that may be expected in the future including washover deposition of the coastal margin and whole island migration. In summary, islands have a range of physical mechanisms that allow morphological adjustment to changing boundary conditions. Such physical responses necessitate reconsideration of classic concepts of island instability and erosion. The results have significant implications for future approaches to island maintenance. It is proposed that island maintenance will be best achieved by ensuring that management solutions safeguard the integrity of natural geomorphic processes. This approach requires the replacement of the prevailing paradigm of islands as 'static landforms' with the recognition and incorporation in planning of each island's natural dynamism. This approach places an emphasis on understanding the natural processes of small islands and provides new challenges for managers to seek planning alternatives to conventional *ad hoc* engineering solutions.

1.0 Introduction

Coral reef islands are low-lying accumulations of sand and gravel deposited on coral reef platforms through the focussing of wave and current processes. Scattered throughout the Indian and Pacific oceans these islands provide the only habitable land in mid-ocean atoll nations such as Tuvalu, Kiribati and the Maldives. These small islands are morphologically sensitive to changes in boundary conditions (sea level, waves and currents) at a range of timescales. The combination of their low elevation (< 4m maximum elevation), small size and sensitivity to change has aroused international concern over their vulnerability to catastrophic natural hazards such as the recent Indian Ocean tsunami and projected global climate change (Mimura et al., 2007).

Shoreline erosion (loss of land) is perceived as one of the most pervasive environmental problems in small island nations and is expected to be exacerbated with the spectre of sea-level rise and climatic variability (Leatherman, 1997). Indeed widespread erosion and island instability is forecast under current scenarios of climate-induced sea-level rise. However, erosion of island shorelines is triggered by a range of natural processes (e.g. changes in wave conditions or sediment supply) and anthropogenic actions (reef dredging, sediment extraction, causeway building). The combination of perceived instability of islands, high population pressures on some islands, development activities and anticipated impacts of future sea-level rise has promoted the widespread use of engineering solutions to 'stabilise' or 'protect' island shorelines from erosion.

Confronted with unstable or eroding island shorelines management responses have typically included the standard suite of hard engineering solutions to stabilise shorelines and maintain island size and volume (Fig. 1). Development pressure on small islands has also lead to the use of a range of structures (causeways, boat channels, reclamation) in the coastal environment that interact with environmental processes (Fig. 1). Introduction of these structures is known to have a high failure rate in small island settings. There are a number of reasons for their poor performance. First, the design and materials used in construction, together with the mode of construction contravene most standard measures of engineering 'best practice' (Kench, 2001, 2005). Structures are commonly designed and built *ad hoc* by local communities using locally available materials (coral blocks and beach sand). Second, there is a general lack of environmental information (waves, currents, sediment transport) to support appropriate design. Consequently, the choice of structure, its physical design and construction materials are selected without detailed knowledge of the coastal processes and in particular extreme energies at the shoreline.

Figure 1. Examples of typical engineering structures and anthropogenic modifications of shorelines in small islands. A) Sand bag seawall in Tarawa, Kiribati. B) Vertical coral block wall in Majuro, Marshall Islands. C) Boat harbour development and breakwater design in the Maldives. D) Use of groynes to stabilise a small island in the Maldives.

Adoption of shoreline structures is also known to promote adverse environmental consequences including aggravated island erosion and reef degradation (Maragos, 1993; Kench, 2001). It is important to note that hard engineering interventions seldom solve the root cause of an erosion problem. Consequently, background erosion continues with the physical effects transferred to neighbouring locations. In the context of small islands this implies transferring the erosion problem alongshore.

Ultimately, the failure of specific solutions and the promotion of adverse environmental consequences arise from conventional engineering solutions being incompatible with the natural processes and dynamics of reef island shorelines. An improved understanding of the timescales and spatial scales of island change are necessary to underpin a new approach to the maintenance of reef islands. This paper synthesises existing knowledge of the time and space scales of island change. In particular it examines the mode and magnitude of island adjustment to changing boundary conditions (sea level, waves) from geological to event timescales. This synthesis is used as a basis to reconsider the approach to managing unstable island shorelines.

2.0 Temporal and Spatial Scales of Island Change

Over the past decade geomorphic studies of reef islands have begun to document changes in reef island morphology (size and elevation) and location on reef platforms in response to short-term changes in wind and wave processes and to longer-term shifts in sea level. The following sections summarise understanding of reef island dynamics ranging from geological to event timescales.

2.1 Reef Island Formation and Persistence: Geological Timescales

Underpinning assertions of future morphological change of reef islands is sea level, which is seen as the primary control on shoreline stability. However, this assertion oversimplifies a complex relationship between long-term controls on landform development that include: *sea level change* which governs gross coral reef development; *accommodation space* which defines the available volume for sediment deposition as controlled by reef elevation and sea level; *relative wave energy* to transport sediments; and *sediment supply,* which is further controlled by reef productivity and sediment generation processes.

A summary of studies that have examined the formation of reef platform islands is presented in Table 1. The data highlights a number of factors relevant to consideration of island stability. First, reef islands are geologically young having formed in the mid to late Holocene (last 5,000 years). The earliest dates for island formation are 5,500 to 4,000 years ago in the Indian Ocean and eastern margin of the Pacific Ocean and are younger (3,000 – 2,000 years ago) in the central Pacific. Second, there appears considerable variation in the onset and period of accumulation of reef islands. For example some studies indicate that islands formed in discrete depositional episodes, whereas others indicate continual and ongoing island accumulation. Third, islands have persisted on reef platforms over the past 4,000 to 2,000 years.

Of interest to future stability of reef islands with sea-level change is the relationship (timing) of sea level change, reef growth and landform accumulation. Conventional theory suggests that sea-level stabilisation, completion of vertical reef growth and landform accumulation occurred sequentially. Evidence for this model is apparent in the Pacific and eastern Indian

Ocean, where sea level has been at or slightly higher than present level for the past 6,000 years. In this setting vertical reef growth was rapid and broad reef flats were developed, which became emergent as a consequence of late Holocene sea-level fall (Woodroffe et al., 1990; McLean and Woodroffe, 1994). These reef flat surfaces provided the foundation for sediment accumulation and island building in the mid to late-Holocene. The apparent synchronisation of land formation with late Holocene sea-level fall has caused some researchers to suggest that land building was triggered by sea-level fall (Schofield, 1977; Dickinson, 1999). The implication from this model is that sea-level rise will force morphological instability as water depths over reefs increase.

Table 1. Summary of studies of reef island formation.

Location	Atoll/Island	Age of Island deposition (yrs B.P.)	Reference
Pacific Ocean			
Kiribati	Makin	2,500-present	*Woodroffe & Morrison, 2001*
Tuvalu	Funafuti	2,000-1,000	*McLean and Hosking 1991*
Fiji	Nadi Bay	2,000-1,000	*McCoy, Kennedy, Kench 2009*
Torres Strait	Warraber	3,000-present	*Woodroffe et al. 2007*
Great Barrier Reef	Lady Elliot Island	3,200-present	*Chivas et al. 1986*
Great Barrier Reef	Bewick Island	4,600 – 1,600	*Kench et al. submitted*
Great Barrier Reef	Multiple sand cays	4,380 – 3020	*Stoddart et al., 1978*
Indian Ocean			
Maldives	South Maalhosmadulu	5,500-4,000	*Kench et al. 2005*
Cocos (Keeling) Isld.	West Island	4,000-2,000	*Woodroffe et al. 1999*

However, regional differences in Holocene sea level dynamics and reef growth histories have provided contrasting boundary conditions for the onset and accumulation of islands. Recent studies in the Maldives have shown that reef islands there developed in the mid-Holocene (5,500 to 4,000 years ago) prior to reefs reaching their maximum vertical growth limit. In this model islands formed across submerged reefs, in latter stages of 'catch-up' growth mode, and over infilled lagoons (Kench et al., 2005). Furthermore, recent evidence from the Maldives indicates that sea level rose 0.5 m above present level 2,000- 4,000 years ago, which post-dates island formation (Kench et al., in press).

Collectively, these studies from differing reef regions provide critical insights into the controls on island formation and their geological robustness. First, islands have persisted on reefs for the past 4,000 – 3,000 years. Second, island formation has occurred under differing sea level change histories including rising sea level. Third, geological analogues exist from the Maldives indicating reef islands can withstand increases in sea level similar in magnitude to those predicted over the next century.

2.2 Decadal to Seasonal Dynamics of Reef Islands

Projections of instability and mass inundation of reef islands and coastal margins with sea-level rise are commonly founded on inappropriate considerations that such landforms are morphologically static. However, islands are in continual readjustment to changes in climatic and oceanographic boundary conditions (waves). Such process changes and island adjustments occur at decadal to seasonal timescales.

At the decadal scale, shifts in prevailing wind fields and their influence on wave propagation (direction and energy) control erosion and accretion patterns on reef islands resulting in island migration (e.g. Verstappen, 1954; Flood, 1986). The Pacific Decadal Oscillation and its effect on modulating storm frequency has been found to control multi-decadal fluctuations in longshore sediment transport resulting in erosion and accretion patterns of +/- 100 m on the Kihei fringing reef shoreline, Maui (Rooney and Fletcher, 2005). Inter-annual El-Nino Southern Oscillation variations, and their influence on wave climate, have also been implicated in shoreline erosion and accretion patterns in Kiribati (Solomon and Forbes, 1999).

At seasonal timescales, Kench and Brander (2006) examined the morphological sensitivity of 13 islands in the Maldives to predictable changes in wind and wave conditions controlled by the oscillating monsoons. Summary results (Fig. 2) show that islands can exhibit rapid and large changes in shoreline position (up to 60 m of beach change) between seasons. These large planform changes in beach position equate to up to 20,000 m^3 of shoreline sediment being mobilised and redistributed twice each year. Furthermore, experiments in the Maldives showed that zones of shoreline erosion and deposition around the perimeter of islands appear to be balanced across annual cycles suggesting island shorelines are in near morphological equilibrium (Fig. 2). Results also indicate that the magnitude of morphological change and sensitivity of islands to change varies between islands as a function of reef platform shape, which controls wave refraction patterns. Circular islands were most sensitive to changes in incident wave patterns.

2.3 Event-Scale Dynamics of Reef Islands

At event timescales storms and hurricanes have both constructional and erosional impacts on reef islands. These contrasting responses reflect differences in storm frequency and texture of island building materials (Bayliss-Smith, 1988). In settings with low storm frequency landforms are typically composed of sand-size sediments, which are susceptible to erosion during extreme events. Stoddart (1963) reported mass destruction of some reef top islands in Belize as a result of Hurricane Hattie. Large differences in island loss were reported depending on the presence or absence of natural littoral vegetation. However, in reef settings with high storm frequency islands are commonly composed of rubble on their exposed margins, while leeward shorelines and islands are composed of sand-size material. In such settings, large volumes of rubble can be generated in single storm events from coral communities on the outer reef. In a well-documented example Hurricane Bebe (1972) deposited an extensive storm rubble rampart on to the reef flat and islands of Funafuti atoll, Tuvalu (Maragos et al., 1973). Subsequent storms have reworked this rampart on to island shorelines showing that the hurricane and subsequent storm processes added approximately 10% to island area (Baines and McLean, 1976). Sequential storm deposition of rubble ridges has also been identified in the late Holocene evolution of gravel islands in the Great Barrier Reef (Chivas et al., 1986; Hayne and Chappell, 2001).

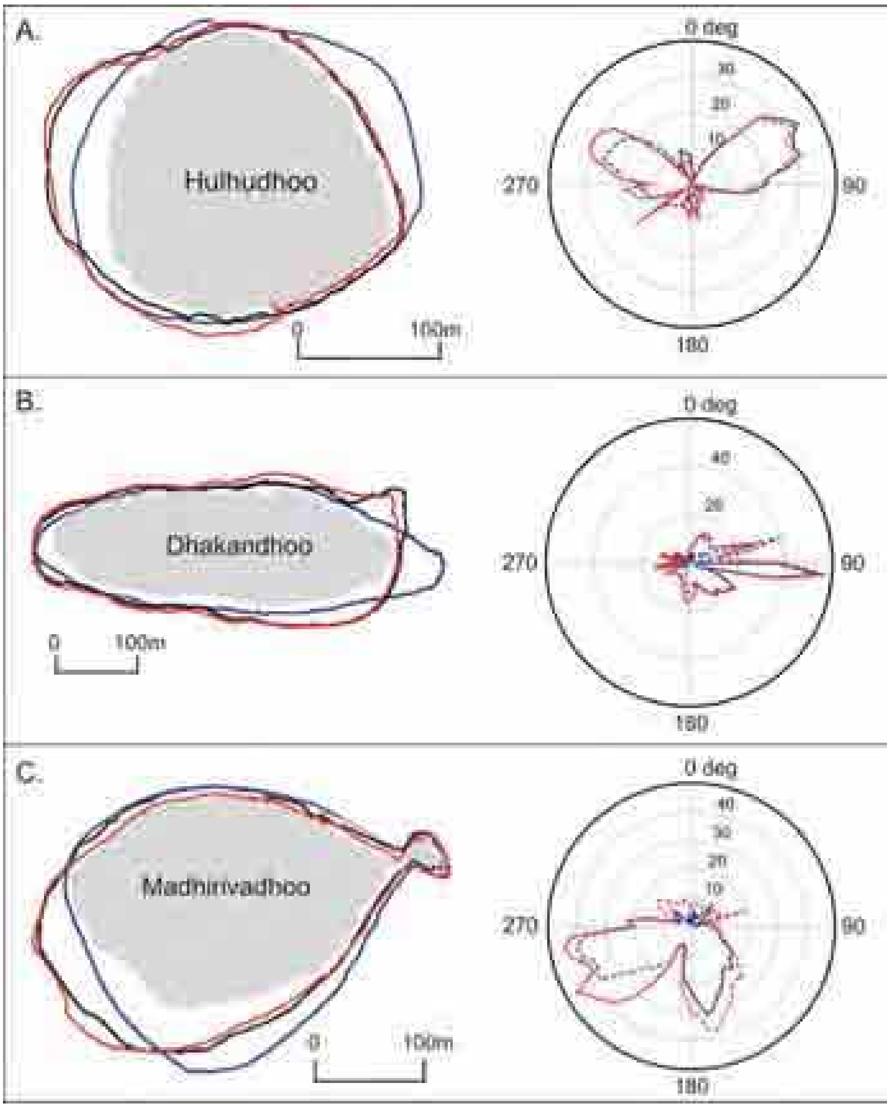

Figure 2. Summary results of seasonal dynamics of three reef islands in South Maalhosmadulu Atoll, Maldives. Grey shaded area represents vegetated island core. Encircling lines depict the position of the mobile beach between seasons: February 2002 (black line), June 2002 (blue line); February 2003 (Red line). Polar plots on right-hand side of each panel highlight which sectors of the island shoreline experienced deposition (solid lines) and erosion (dashed lines) from Feb 2002 to June 2002 (blue lines), and June 2002 to February 2003 (red lines).

In recent studies Kench et al. (2006; 2008) evaluated the physical impact of the Sumatran tsunami on reef islands in the Maldives. The Sumatran tsunami generated a series of waves that overtopped island surfaces over a 12-hour period following the Sumatran earthquake. Detailed comparison of pre- and post-tsunami shorelines identified two principle island responses. First, all study islands showed evidence of erosion of the vegetated island core (Fig. 3A-C). This ranged from 1% to 9% of island area with a mean loss of 4%. Erosional evidence consisted of vertical erosion scarps and scour of root systems at the island margin (Fig. 3A-C). Second, all islands showed evidence of continuous washover sedimentation layers. These layers consist of sand-size material that extend up to 60 m landward of the edge of islands and tapered from a maximum thickness of 0.3 m at the island edge (Fig. 3). Formation of these layers occurred as the tsunami waves interacted with beaches, entraining sediment which was carried over the island ridge and draped across the island surface. Significantly, these washover deposits represent a permanent addition to the island surface and represent net vertical building of the outer margins of islands.

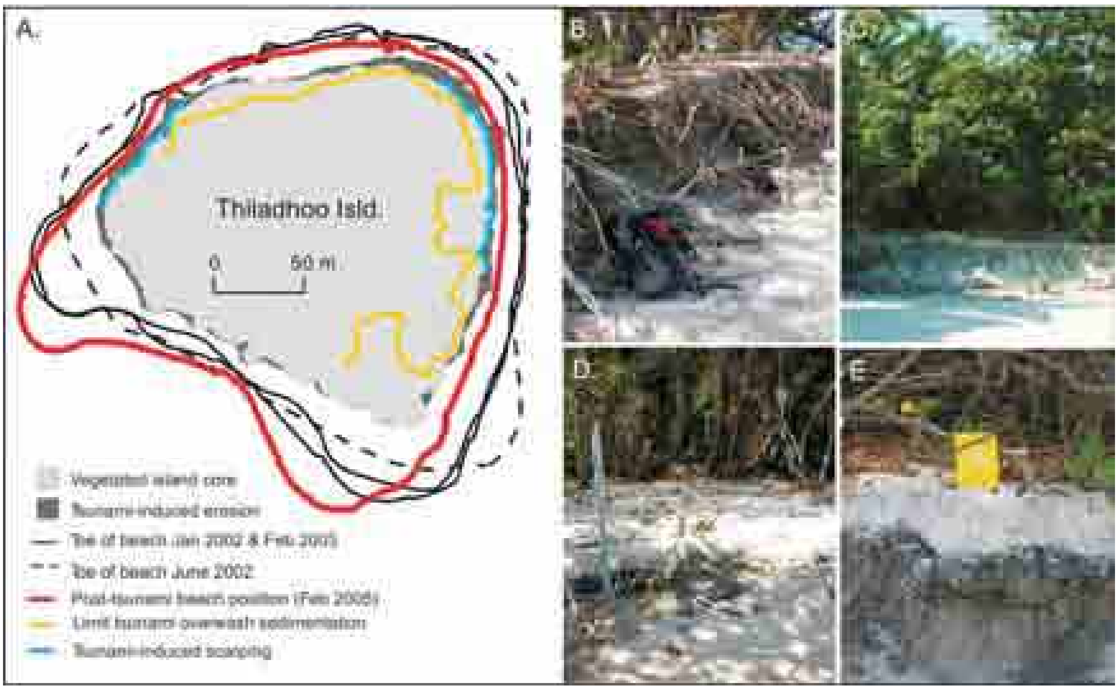

Figure 3. Summary of tsunami impacts on Thiladhoo Island, Maldives. A) Global Positioning System surveys of pre- and post-tsunami shoreline positions. GPS plot also shows extent of tsunami-induced erosion and overwash sedimentation. B), C) Show tsunami-induced scarping of island shorelines. D) Continuous washover sedimentation of island surface. E) Thickness of washover deposit at island margin. After Kench et al. 2006.

2.4 Modelling Future Morphological Adjustment of Islands

In order to explore the mode and magnitude of morphological change expected on low-lying reef landforms Cowell and Kench (2001) adapted and applied the Shoreface Translation Model (STM). This geometric profile model takes explicit account of land building processes (wave runup elevation and sediment supply) and allows morphological equilibrium to be achieved through cut and fill of sediment according to accommodation space constraints and sediment volume. In particular, the model assumes that the maximum height of island building is controlled by the maximum vertical limit of wave runup, which is modulated by sea level. Model simulations undertaken in Kiribati, Fiji and the Maldives yielded first order estimates of the likely magnitude of reef island change in response to sea-level rise. All simulations identified morphological change of islands, with estimates of shoreline movement ranging from 3 to 15 m for a 0.5 m increase in sea level (Kench and Cowell, 2001).

Model simulations also identified a range of potential modes of reef island morphological change (summarised in Fig. 4). While most simulations identified horizontal displacement of the shoreline, such changes do not necessarily imply erosion. Overwash of entire island surfaces on small islands and inlet bypassing promotes migration of islands on reef platforms while conserving or building the sediment volume (Fig. 4A). Field evidence for overwash sedimentation as a process of island geomorphic adjustment has been demonstrated in a number of studies of storm and tsunami impacts on reef islands (Bayliss-Smith, 1988; Kench et al., 2006, Fig. 3). Furthermore, the lagoonward migration of islands has been reported from Belize, where sea-level rise has been implicated for the abandonment of beachrock and migration of islands toward and across reef lagoon slopes (Stoddart et al., 1982). As indicated earlier, overwash deposition provides a mechanism to raise the level of coastal ridges as storm runup processes are elevated by sea-level rise. On wider islands overwash can produce horizontal displacement of the shoreline that reduces island width whilst also conserving the total sediment volume (Fig.4C).

Model simulations also indicated that the magnitude and mode of morphological change is likely to be highly variable and dependent on initial morphology (elevation, sediment volume) and accommodation space. Higher elevation coastal deposits and landforms with larger sediment volume are more resilient to morphological change than lower elevation islands with limited sediment reservoirs.

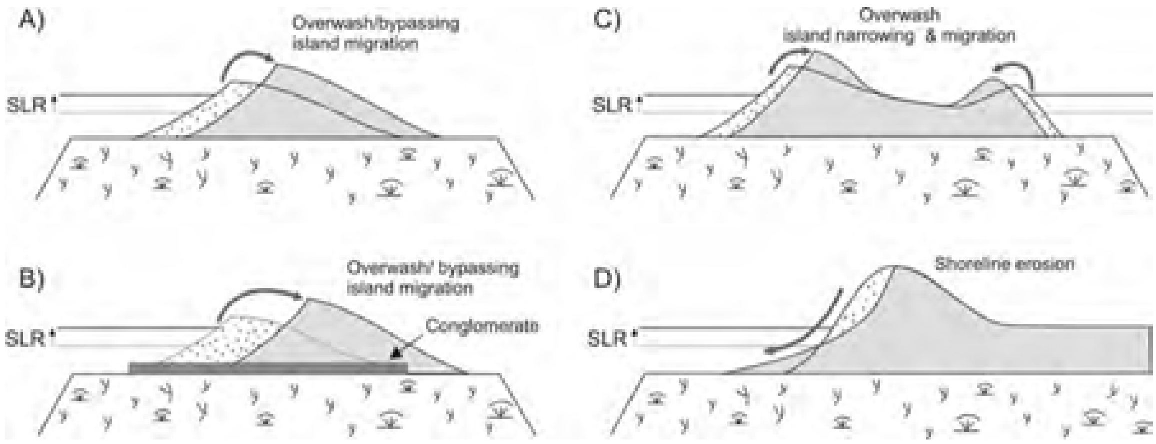

Figure 4. Summary of model simulations of the modes and relative magnitude of reef island shoreline response to increased sea level. After Kench and Cowell, 2001.

3.0 Conclusions

Field observations and initial attempts to model reef island morphodynamics highlight differences in the stability of small islands dependent on the timescale of interest. Over the long-term (millennia) reef islands appear geologically robust landforms that have persisted on reef platforms. However, over medium to short timescales (decades to days) islands can exhibit significant morphological change in response to extreme events and annual to decadal variations in climatic processes. Field studies also confirm modeling projections that islands can exhibit a range of styles of morphological change. These include whole island migration, washover and vertical land building, as well as island narrowing (erosion).

Collectively geomorphic studies indicate that reef islands have an inherent physical resilience. This resilience is dependent on the ability of islands to change their morphology and position on reef surfaces. Consequently, the secret to long-term resilience of islands relies on geomorphic processes being unconstrained so that sediment can be remobilized and island morphology can adjust to a new process equilibrium.

This geomorphic understanding of island change necessitates reconsideration of conventional notions of ‘erosion’ and island ‘stability’ with respect to island management. Island migration and washover are mechanisms that promote island morphological adjustment but may maintain island size and sediment volume. Indeed washover process can enhance future resilience through vertical land building. Net loss of land (erosion) is only one possible outcome of island morphological change.

The limited land area of reef islands and their morphological instability pose significant management problems for island communities. How can island communities co-exist with dynamic landforms? The challenge for management is to recognize that islands are not static landforms and that management strategies should be based on the intrinsic capacity of the natural system to adjust, supplemented by planned adaptation, which may include coastal protection or other social and infrastructural changes. It must be recognised that there is a spectrum of different island types from those that are essentially urban centres with high population densities (e.g. Male in the Maldives and Betio in Tarawa atoll, Kiribati) to those that are uninhabited. In heavily urbanised islands the natural processes that afford intrinsic geomorphic resilience have been compromised. In such settings ongoing engineering and structural solutions are likely to be the preferred option to sustain viable socioeconomic functions. However, in many non-urban islands and uninhabited islands the integrity of geomorphic processes has been maintained. In these islands alternate solutions to island maintenance should be sought. Reef islands exhibit a degree of physical resilience, and it is important to understand shoreline behaviour so that it can be enhanced by various levels of cultural or socioeconomic adjustment by atoll communities.

New solutions for physical island maintenance should be underpinned by the following principles:

- Best management practice needs to protect or enhance the intrinsic morphodynamic resilience of islands.
- Increased effort is necessary to define/refine understanding of nearshore processes and natural island dynamics. There is still comparatively little research that has attempted to elucidate the mode and magnitude of island change.
- Use of traditional engineering solutions should be adopted with extreme caution and only be used where they do not interfere with natural geomorphic processes.

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Coastal Vulnerability & Monitoring in Central Pacific Atolls.

SOPAC- Secretariat of the Pacific Islands Applied Geoscience Commission

Arthur Webb - Ocean & Islands Programme

Accelerated sealevel rise is routinely cited as the reason behind coastal erosion in the SW Pacific region however, quantitative, empirical data which supports this premise is almost non-existent. SOPAC advocates accurate ongoing shoreline monitoring and assessment using multi-temporal image techniques as a valuable approach to the pressing issue of shoreline erosion in atolls and assessment of the causes and appropriate mitigation strategies.

Introduction

Given current IPCC 2007 advice and predictions, the premise that low-lying atolls and the cultures and communities they sustain are in an extremely vulnerable position can not be over emphasised. Predicted climate change impacts of shifting weather patterns, accelerating sea level rise and the distinct possibility of perturbation of tropical reef ecosystems through change in physiochemical parameters of surface water quality (e.g. temperature and CO_2 concentration) provides a sobering vision of the future for atoll environments.

Significant progress has been achieved in efforts to understand and monitor weather patterns and sealevel across our region. Additionally, important parameters such as, sea surface temperature and oceanic currents are also being routinely monitored largely due to advances in remote sensing technology. (e.g. SEAFRAME, TOPEX / Poseidon-Jason, NOAA systems, etc.).

Whilst the information these systems supply has (and continues to) greatly advance understanding of Pacific and global oceanic and weather systems, its direct relevance to small communities of the developing Pacific Island nations may not be readily apparent. An issue of central importance to all Pacific coastal communities especially on atolls is how these changing processes are affecting their shorelines, scant land resources and vulnerable groundwater systems.

At this point in time there is no systematic or regional approach to monitoring shoreline change and erosion, and otherwise accepted predictive modelling approaches to erosion appear inappropriate, particularly in atoll situations. SOPAC advocates accurate ongoing shoreline monitoring and assessment using multi-temporal image techniques as the most beneficial and appropriate approach to the pressing issue of shoreline erosion in atolls (and other low-lying Pacific communities)

SOPAC's approach to coastal processes & erosion

SOPAC, like Cooper & Pilkey (2004), advocates recognition and acceptance that we cannot actually predict shoreline retreat related to sea level rise at this time – it's just too complex. And whilst it is recognised that modelling is the primary tool with the potential to eventually predict what shoreline response to sealevel rise may be, all models are necessarily a mathematical simplification of the real environment and can only be as good as our understanding of the function of any particular shoreline system.

Throughout the tropical Pacific many coasts are “living” features, as found on atolls, and are among the most complex shoreline systems on Earth. Composed entirely of material which is biogenic (the skeletal remains of once living reef organisms) they are therefore greatly influenced by any changes to reef productivity, biological composition and ecology.

Sediment on these coasts is delivered to atoll shores by waves whose energy is dictated by weather and oceanic conditions (these alone are vastly difficult to predict and understand in terms of climate change). However, on atolls, the manner in which wave energy moves from the ocean, over reef crests and flats and ultimately to shorelines, is further controlled by the shape and elevation of living fringing reefs and associated algal ridges. The response of these living features to climate change is unknown but any change in terms of productivity, composition, shape or elevation, will in turn influence the manner in which wave energy travels from the ocean to the shoreline and thus also imposes great influence over shoreline sedimentary processes.

Reliable prediction of changing weather or marine conditions at a resolution appropriate to a single island remains at this time beyond our reach. And the prediction of natural variation in shorelines let alone the additional broader implications of physical and chemical changes in surface waters to tropical reef function (i.e. increased sealevel, CO_2 concentration and sea surface temperatures) is also presumably some time away.

In the apparent absence of adequate modelling systems and understanding of even present existing variability in tropical Pacific shoreline processes, SOPAC advocates monitoring of these systems to clearly and dispassionately quantify how atoll shores are responding to sealevel rise and other possible climate change related stress as well as local human induced change. A deeper, data-based understanding of these processes will conclusively inform atoll Governments and communities of how their environment maybe changing and will provide an excellent ongoing tool for coastal vulnerability, management, planning and mitigation responses. Further, data which empirically explains variability and change in these environments will ultimately allow more appropriate modelling approaches to be developed.

CASE STUDY – South Tarawa

Innate environmental sensitivity, swelling populations and resource scarcity are also contributing to the vulnerability of atoll coastal systems to climate change impacts. Betio Islet, Kiribati (figure 1) is one of South Tarawa atoll’s larger land masses and hosts the main port of entry and is the National centre of trade and commerce;

- Betio has a land area of approximately 1.5km^2 giving an average population density of 1,430 people / km^2.
- The islet is on average between 1 and 1.5m above the average high water mark.
- Every year, 70,000m^3 of sand and gravel is mined from South Tarawa’s sensitive and vulnerable beaches (Pelesikoti, 2007), this is approximately equivalent to the area of land above the low tide water mark, within the red circle.

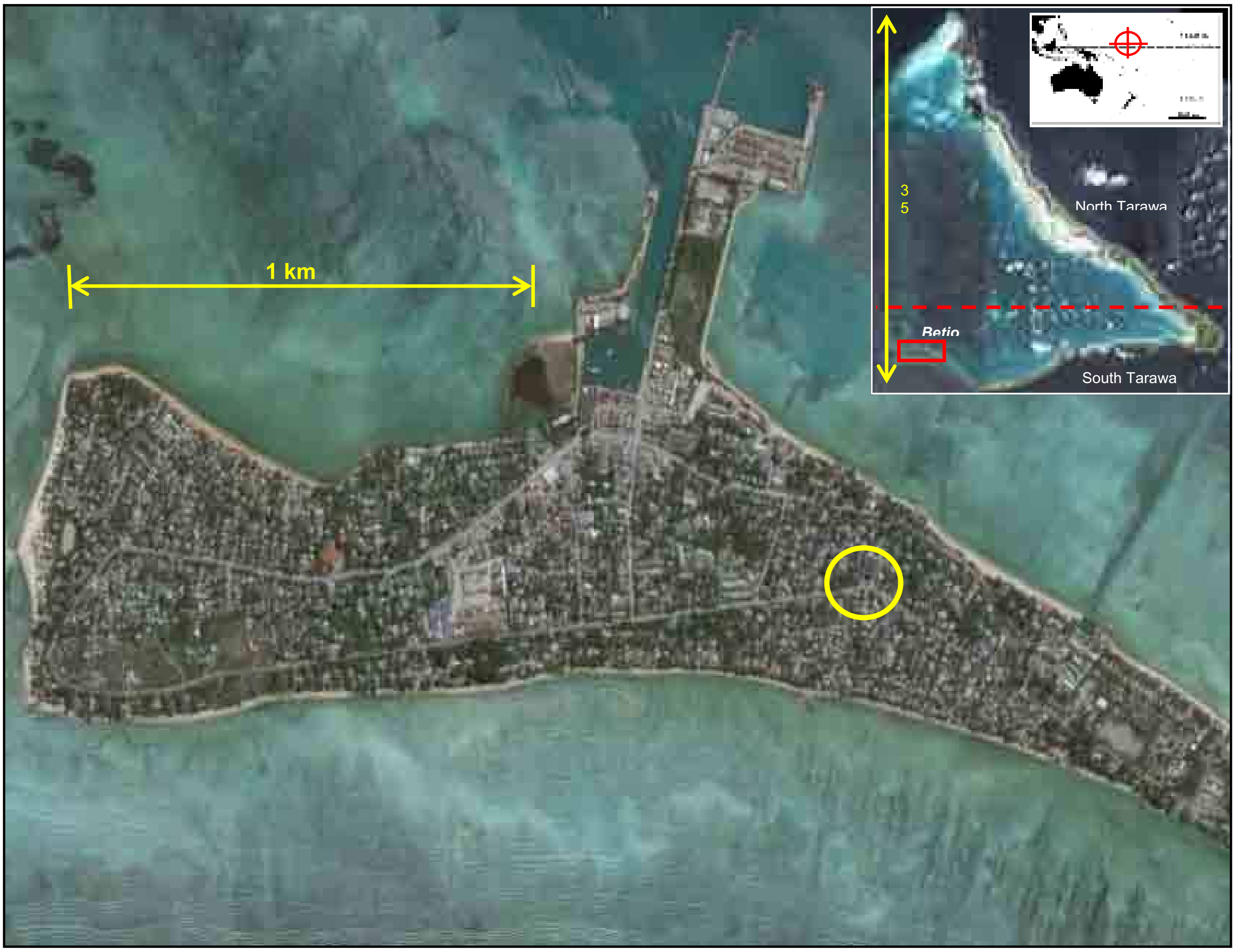

Figure 1. Betio Islet and Tarawa location map. Note that yellow circle approximates the volume of sand (70 000m^3) mined from South Tarawa beaches annually for use as construction aggregates.

Whilst there can be little doubt that the community on Betio and other parts of South Tarawa are extremely vulnerable to climate change stress and associated sea level rise and they do already suffer greatly during normal or expected adverse weather events and the reason for this can not be linked to climate change alone.

Intense over-crowding and competition for space has lead to settlement of extremely marginal and unstable shoreline areas and ad hock, poorly designed reclamation proliferates. Any form of property or dwelling built in such areas or protected by poorly engineered and constructed seawalls, are extremely vulnerable to even mild weather shifts or events. Even ongoing natural sediment transport processes result in hardship and property loss under these conditions (Webb and Biribo, 2007).

SOPAC's coastal assessment work in Betio is a graphic example of this phenomena. Despite a long history of requests to assist on issues of coastal instability and erosion in Betio and South Tarawa, our recent image comparison work shows a pattern of significant increases in land area rather than erosion (see figure 2).

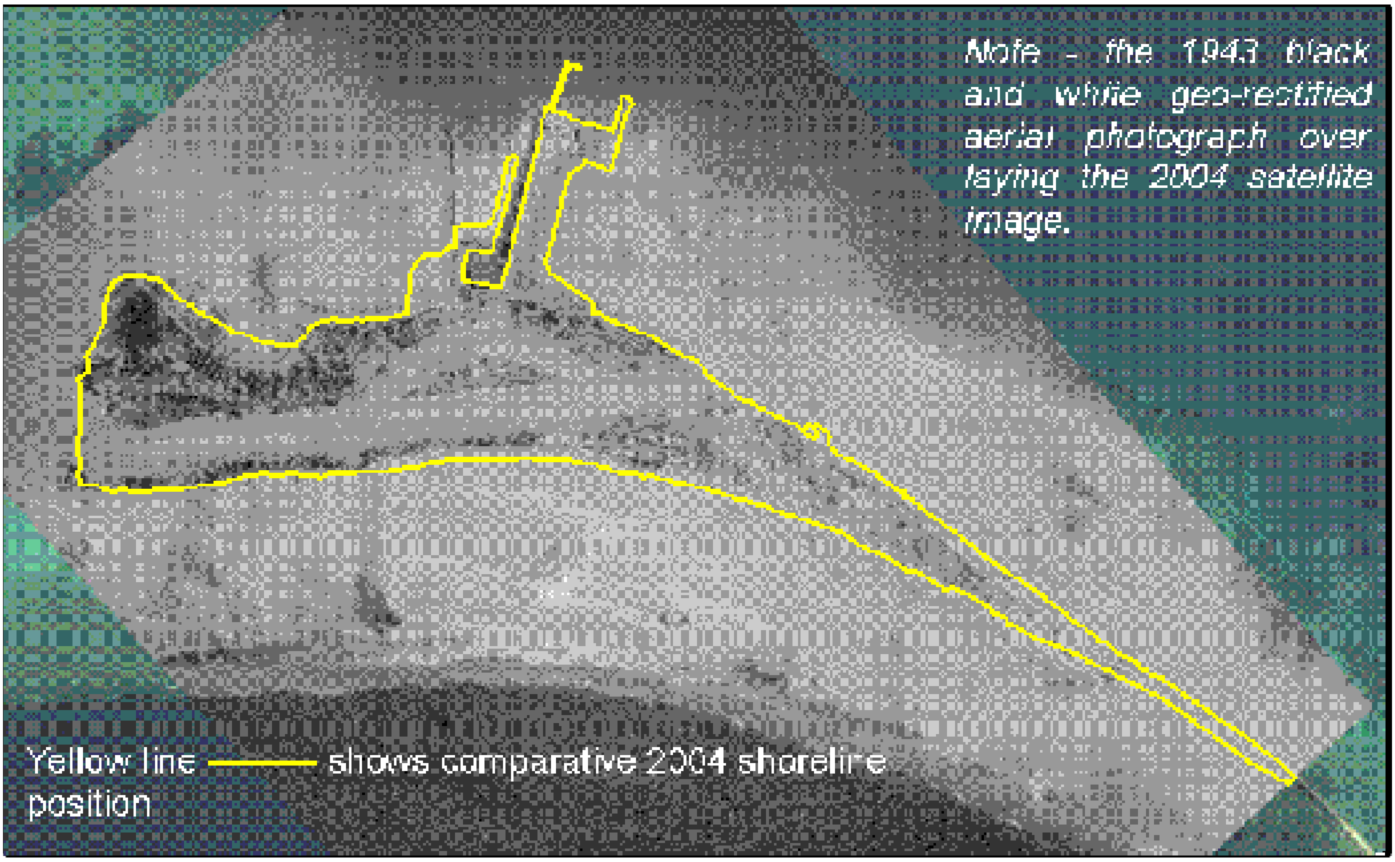

Figure 2. The first of the images above shows Betio in 2004 (IKONOS satellite image) with a red line indicating the comparative historical 1943 shoreline. The second image alternatively shows the geo-rectified 1943 aerial photograph (blank and white) with a yellow line showing the comparative 2004

shoreline.

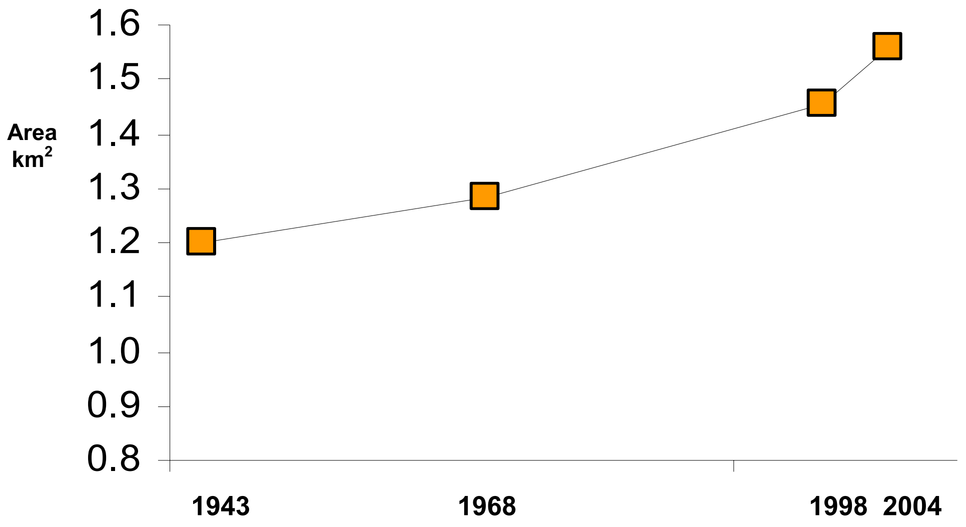

Figure 3. Betio land area change 1943 to 2004 (Webb & Biribo, 2007)

Images from 1943, 1968, 1998 and 2004 were available to develop this analysis of land area change in Betio. These showed that despite the huge pressures on this tiny sand islet the land area has steadily increased over time - equivalent to about 30% growth over the last 60 years. Whilst a significant proportion of the increase is due to reclamation (note the wharf structure) a greater amount is due to on going sand accretion (Webb & Biribo, 2007).

According to models such as the Bruun Rule (Bruun, 1962) (which incidentally is still advocated by UNESCO – http://www.unesco.org/csi/pub/info/info410.htm) island area increase should not have occurred, as it is estimated than mean sealevel has risen 10 ± 5cm over the last 50 years in this region of the Pacific (Church et al, 2006). The 2007, SPSLCMP (South Pacific Sea Level & Climate Monitoring Project) report indicates a 13 year sealevel trend of +4.7mm yr^{-1} at Betio, however it is recognised that it is too early for trends from the SPSLCMP array to be considered reliable.

Given that sealevel rise has and is occurring, such examples of net islet growth counter established thought, non-scientific reports in the popular media and modelling (e.g. Bruun, 1962). It is also instructive to note that additional assessments on other atolls including islets and locations where direct human disturbance does not artificially contribute to increases in land area, also show net gains in land area (Webb, 2006). These results suggest that shoreline response in these environments is complex and does not necessarily follow current thought with regards to soft shore erosion and sealevel rise.

It is not known when sealevel rise and / or other climate change related stresses may result in net land area reduction in Central Pacific Atolls. However, in the absence of data or monitoring we have no way of knowing when or if such a threshold will be reached. As such, it is of crucial importance to atoll and other low-lying coastal communities that empirical shoreline assessment and monitoring approaches are promoted. And in particular, the use of accurate historical comparisons to develop an understanding of present coastal processes in the context of past ongoing trends is an invaluable tool to both researchers and on the ground decision makers. It is also of crucial importance to inform atoll communities with the facts regarding their islands and how they maybe responding in the face of climate change.

Notes and references

SOPAC (Secretariat of The Pacific Island Applied Geoscience Commission) is an intergovernmental organisation mandated to assist some 18 developing Pacific Island Nations. Through its Ocean & Islands Programme it offers - research, development and management of non-living resources in ocean, coastal and island systems addressing issues relating to seabed resources, hydrodynamics, monitoring of ocean and coastal processes and maritime boundary delimitation (www.sopac.org).

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Enhancing foraminiferal sand productivity for the maintenance of reef islands

Kazuhiko Fujita

Department of Physics and Earth Sciences,
University of the Ryukyus,
1 Senbaru, Nishihara, Okinawa 903-0213, JAPAN

Introduction

If you observe reef sand, you may find either many star-shaped sands or disc-shaped sands. These are shells of foraminifers. Foraminifers are unicellular shelled organisms living in coral reefs. This organism is very small, but the shell is abundantly included in reef sands. Thus, foraminifers are now being recognized as important sand producers for the maintenance of reef islands. The purpose of this paper is to introduce the importance and contribution of foraminifers as sand producers, and also to show pilot studies to enhance foraminiferal sand production.

Threats to reef islands

Reef islands are mainly formed on reef flats of atolls. These islands are generally low-lying, flat, and small. Sediments of these islands consist mainly of unconsolidated bioclastic sands and gravels. Particularly, the upper part of subsurface sediments and surface sediments are mainly composed of foraminiferal sands.

At present, people living in reef-island countries are threatened by the loss of islands, which is caused by sea-level rise related to global warming. These people are also threatened by the loss of their own land due to coastal erosion, inundation, and other coastal hazards (e.g., Tsunami, and catastrophic storms).

Importance of foraminiferal tests for reef-island sedimentation

In most of western and central Pacific atolls, foraminifers are one of the main components of reef-island sediments, exceeding more than 50% of sands. Their shells are mainly coarse-grained sand (0.5-2 mm) in size, therefore being prone to transport and accumulate into onshore environments. They are found very abundantly in some parts of reef flats, which result in high production rates. In addition, their life span is about one year and they reproduce sexually and asexually. Thus those abundant shells are produced every year. After death, their shells are very robust and resistant to abrasion and breakage, therefore remaining as sediments. For these reasons, foraminifers are called as “direct sediment producers”. Particularly, four genera *Baculogypsina*, *Calcarina*, *Amphistegina* and *Marginopora* are important sand producers on central and western Pacific reef flats (Fig. 1).

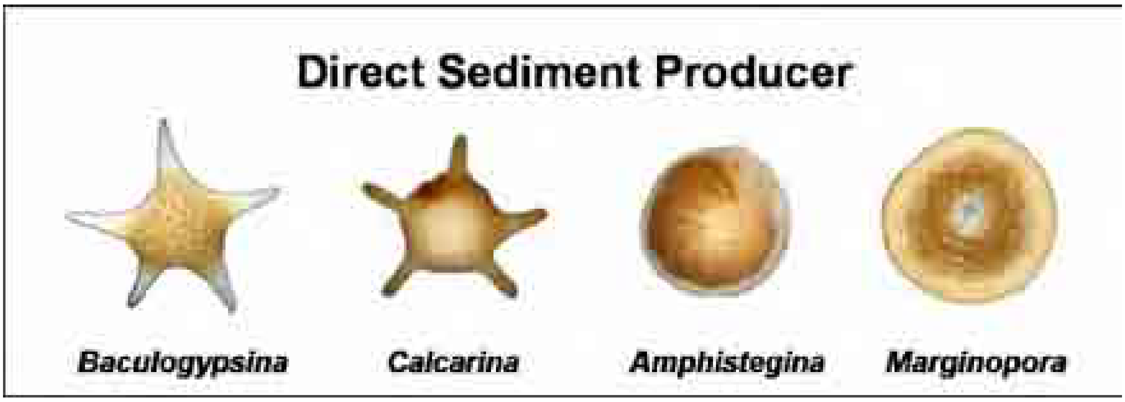

Fig. 1. Foraminifers dominant in reef-flat environments on central and western Pacific atolls.

Distribution and sediment production of living foraminifers around reef islands

Studies of the distribution and productivity of living foraminifers are important to understand the sources and rates of sediment production by foraminifers around reef islands. Therefore we studied foraminiferal distribution and production on reef flats of Majuro Atoll, Marshall Islands. The purposes of the study are to understand where foraminifers live and how much foraminifers produce sands every year.

Fig. 2 shows results of foraminiferal production on reef flats of a windward reef island. Foraminifers are very rare on the lagoonal reef flat, being only found on offshore sand bottom (10^{-5} m^3 100 m^{-2} yr^{-1}). In contrast, foraminifers are very abundant on the ocean reef flat, particularly in algal turf and *Turbinaria* zones around a low tide level. The maximum production rates are more than 1 m^3 100 m^{-2} yr^{-1}.

Foraminifers are also abundant in a channel between reef islands. Production rates are similar to those on ocean reef flats (~1 m^3 100 m^{-2} yr^{-1}).

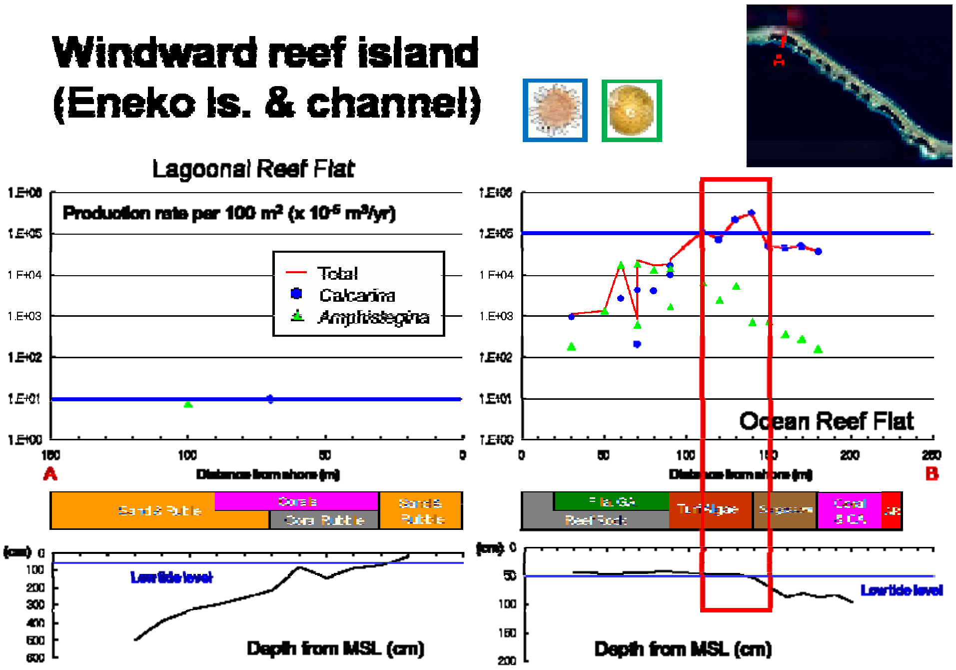

Fig. 2. Topography, ecological zones, and population densities of large benthic foraminifers on reef flats of a windward reef island (Eneko Island, Majuro Atoll).

Figure 3 shows results of foraminiferal production on reef flats of a leeward reef island. Foraminifers are common on algal turfs and offshore macroalgal zones on the ocean reef flat. The maximum production rates (10^{-2} m^3 100 m^{-2} yr^{-1}) are much lower than those on a windward ocean reef flat. On the lagoonal reef flat, foraminifers are found only in offshore coral and rubble zones. The maximum production rates (10^{-3} m^3 100 m^{-2} yr^{-1}) are lower than those on the ocean reef flat.

Figure 4 shows the summary of maximum sediment production rates by foraminifers on Majuro Atoll. The highest productive site is windward ocean reef flats and inter-island channels. Production rates on windward ocean reef flats are two orders of magnitude higher than those on leeward ocean reef flats. Production rates on ocean reef flats are up to fifth orders of magnitude higher than those on lagoonal side in the same island. Production rates in windward ocean reef flats near densely populated islands are three orders of magnitude lower than those near sparsely populated islands.

Therefore, our results from Majuro Atoll suggest that the distribution and production of foraminifers were mainly influenced by a combination of natural environmental factors, including water motion, water depth/elevation relative to the lowest tidal level, and the distribution of suitable substratum.

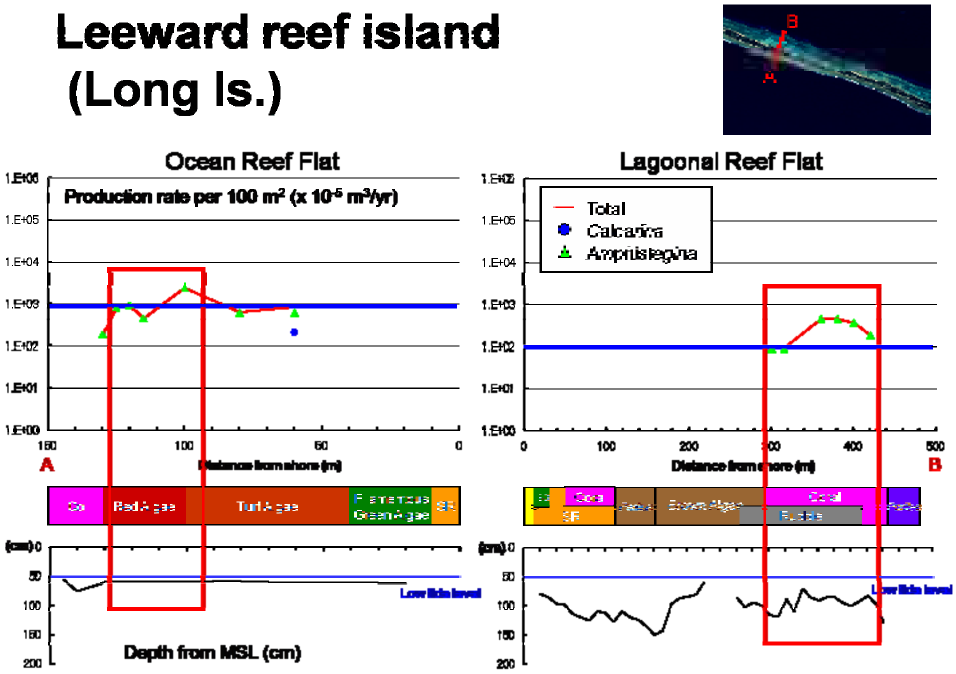

Fig. 3. Topography, ecological zones, and population densities of large benthic foraminifers on reef flats of a leeward reef island (Long Island, Majuro Atoll).

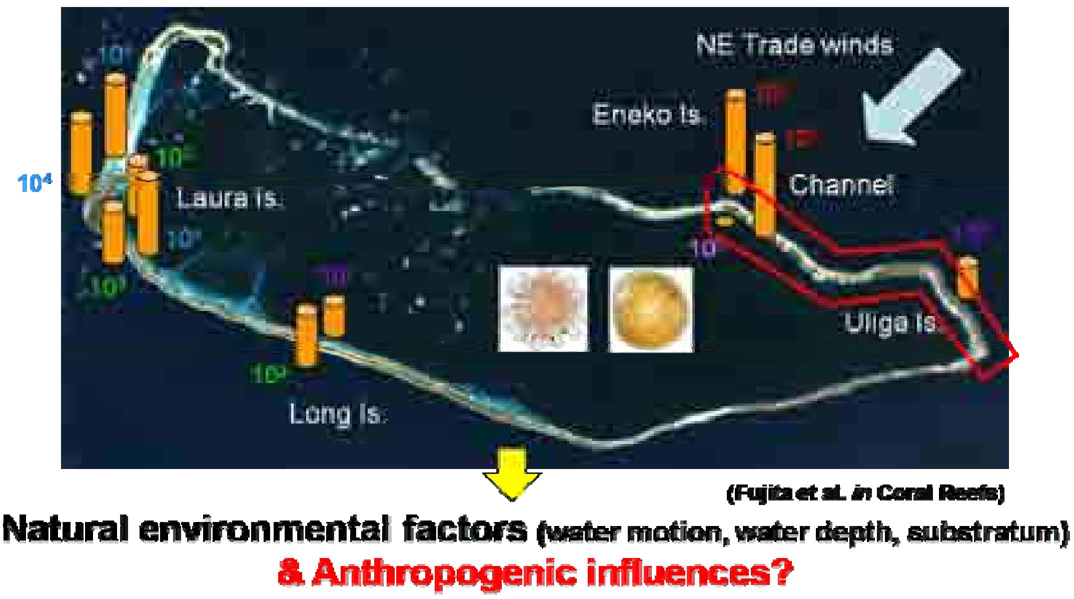

Fig. 4. Sediment production rates of large benthic foraminifers on reef flats of Majuro Atoll, the Marshall Islands (unit: $\times 10^{-5}$ m^3 100 m^{-2} yr^{-1}).

Present status and causes of foraminiferal declines in populated area

It is noted in Figure 4 that ocean reef flats of Eneko and Uliga Islands have similar physical environments such as topography and wave influences. However, production rates are much lower in densely populated Uliga Island than sparsely populated Eneko Island. This result suggests that foraminiferal production may be declining due to human influences.

To confirm foraminiferal decline in populated area, we studied the northeast area of Majuro Atoll in detail. We selected 14 study sites on ocean reef flats from Eneko Island to Delap Island to study foraminiferal population density. Figure 5 shows foraminiferal density in algal turf zone from sites near sparsely populated islands (<10 populations) to densely populated islands (>10,000 populations). We can clearly see a decrease of foraminiferal density. Particularly, *Calcarina* disappears around the tip of densely populated area. Results of foraminiferal density in inter-island channels also show a decreasing trend from sparely populated area to populated area. These foraminiferal trends are inversely proportional to an increase in human population in this area.

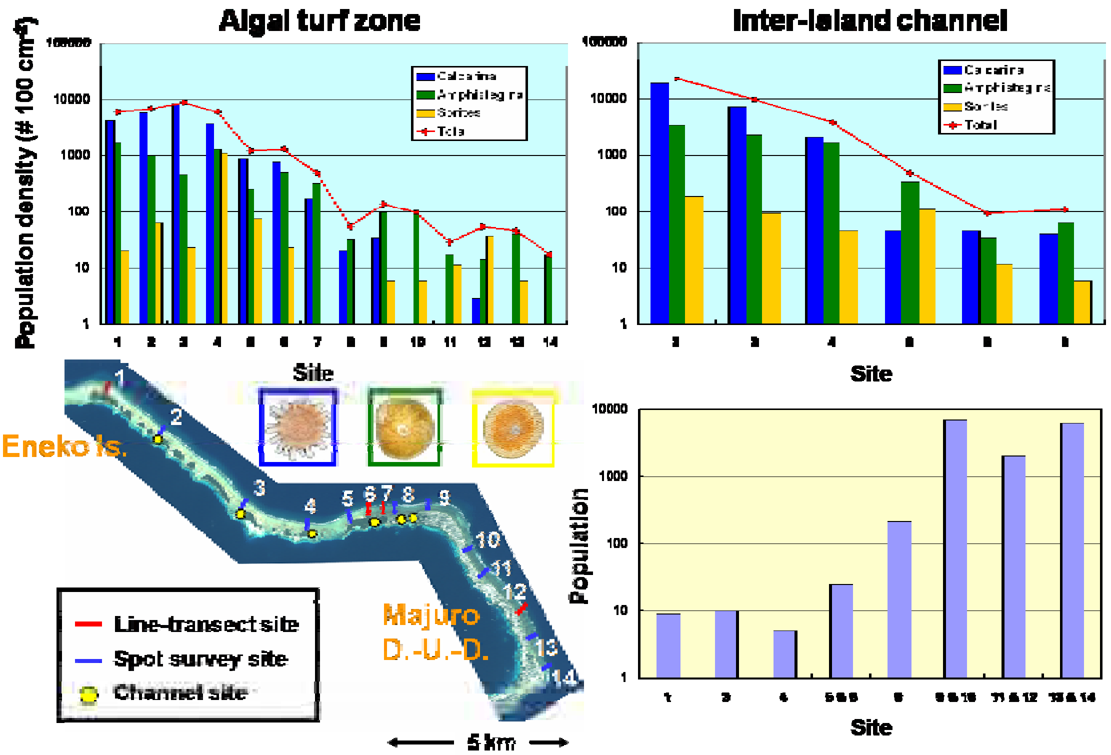

Fig. 5. Lateral variations in foraminiferal population density and human population in the northeast area of Majuro Atoll.

We suspect water quality as the main cause of declining foraminiferal density. Therefore we measured water quality of groundwater in reef islands. Figure 6 shows a result of nutrient (NO_3^-) concentrations in groundwater. Nutrient concentrations are much higher in the downtown than in Eneko Island. Some data in the downtown exceed standard level determined by the WHO. Thus water quality in groundwater is deteriorating in populated islands and we consider that water quality affects nearshore reef ecosystems.

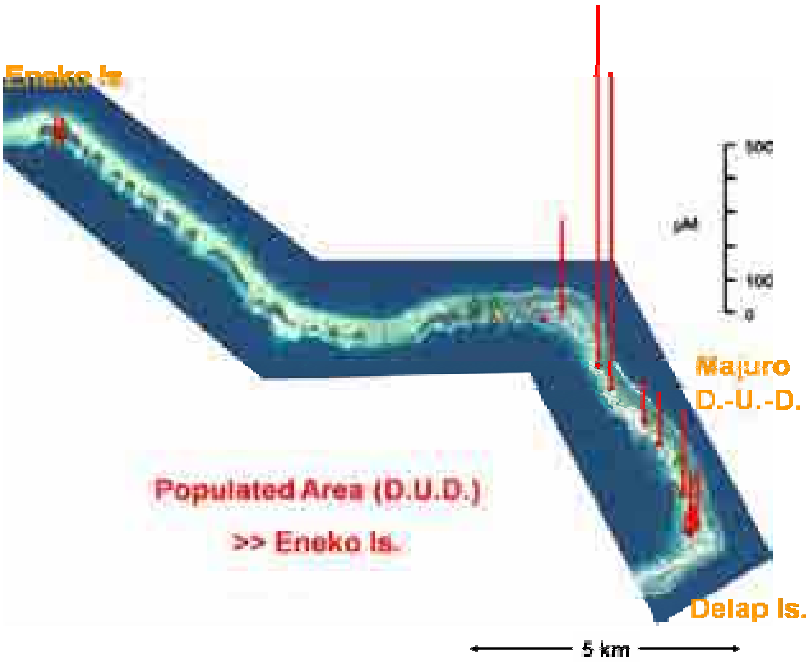

Fig. 6. Nutrient concentrations in groundwater in the northeast area of Majuro Atoll.

We found that increasing populations result in increasing nutrients in groundwater through drainage. Nutrient-enriched groundwater runs into nearshore environments and is assimilated by macroalgae and probably other reef organisms. High nutrients probably have direct and indirect negative effects on distribution, reproduction, growth and mortality of foraminifers. We need further research to confirm causes of foraminifer decline in populated area.

To enhance foraminiferal sand productivity

In order to enhance foraminiferal sand production, environments suitable for habitation, growth, and reproduction of foraminifers should be preserved (Fig. 7). Such environmental conditions will increase population density and production rates, which will result in increasing foraminifer sand supply,

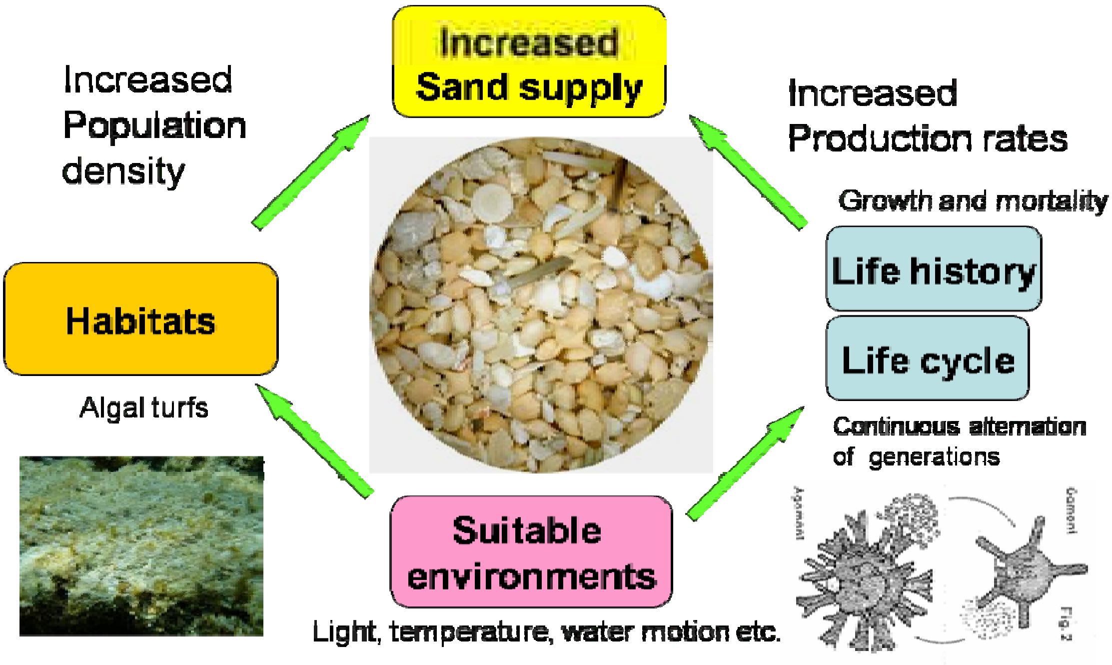

Fig. 7 Flowchart for enhancing foraminiferal sand productivity

Results of a field colonization experiment conducted by the author (Fujita, 2008) may contain some hints for increasing foraminiferal sand supply (Fig. 8). The author has conducted a field colonization experiment in a reef-crest algal turf zone, using three surface types of bricks (smooth surfaces, surfaces with small holes, and surfaces covered with artificial turf). After 10 weeks, the abundance of most of foraminiferal species on artificial turf substrata was comparable to that in natural habitats (algal turfs and reef rubble). The abundance of foraminifers in the dense, entangled three-dimensional substratum is probably explained by the presence of many attachment sites and refuges from strong water motion and high light intensity.

More refined pilot study using artificial turfs has been conducted by the Ocean Research Policy Foundation. Three different types (lengths of shoots and materials) of artificial turfs were prepared. These turfs were placed near algal turf zone and recovered two and four months later. Fig. 9 shows results of foraminiferal abundance at different sites and water depths after two and four months later, respectively. Foraminiferal abundance on artificial turfs was similar to those in natural algal turfs. Foraminiferal abundance after four months was generally higher than those after two months. There were no differences of foraminiferal abundance among different types of artificial turfs.

These results suggest three-dimensional habitats may enhance foraminiferal colonization and population density.

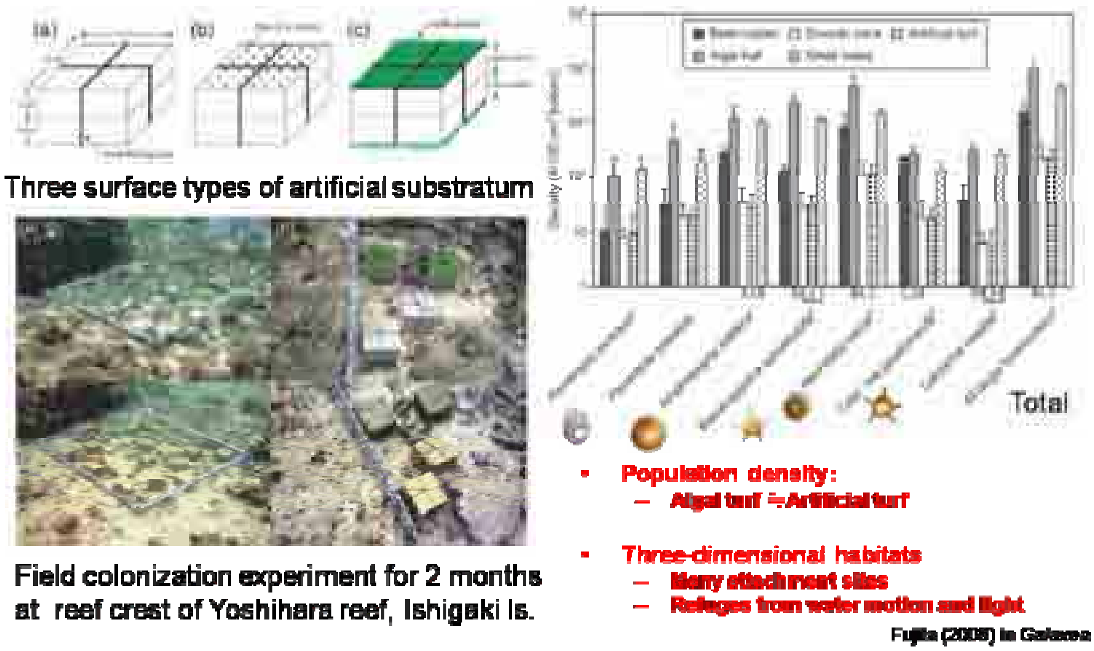

Fig. 8. A field colonization experiment using artificial substrates (Fujita, 2008)

Summary

1. Foraminifers have a high potential to produce sands directly and effectively for the maintenance of reef islands.
2. Distribution and production of foraminifers are mainly influenced by a combination of natural environmental factors (water motion, water depth/elevation relative to the lowest tidal level at spring tide, and the distribution of suitable substratum).
3. Increased anthropogenic factors (mainly water pollution) may adversely affect foraminiferal distribution and production.
4. To enhance foraminiferal sand production, environments suitable for habitation, growth, and reproduction of foraminifers should be preserved.

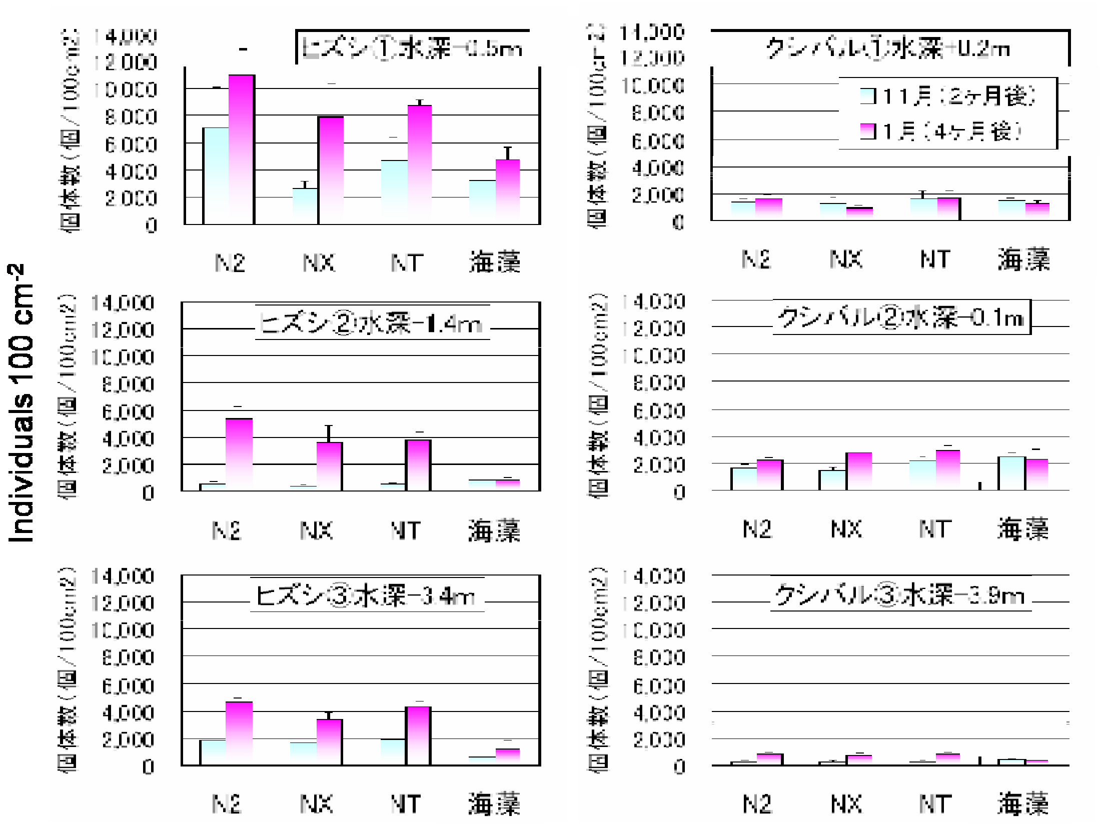

Fig. 9. Long-term colonization experiments conducted by the OPRF at Akajima Island

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Scientific Aspects of Sea Level Rise in the Central Tropical Pacific

Toshio Yamagata
Graduate School of Science, University of Tokyo, Tokyo 113-0033, Japan

Abstract

Sea level change has received much attention under the global warming stress. A report of Working Group I of the Intergovernmental Panel on Climate Change projects sea level rise of 0.18-0.59m in accord to global average surface warming of 1.8-4.0 °C at the end of the 21st century. Major processes to cause such sea level rise are i) thermal expansion of sea water and ii) loss of land ice. Since models used to obtain those estimates do not take into account full effects of changes of ice sheet flow, uncertainties may be larger. Those figures provide us with general indication of what we face *globally* in the expected global warming trend. In order to be well prepared against the expected disaster, we need to understand how sea level variations occur *regionally* under the global change. It is often reported that the sea level rise due to global warming is encroaching on low-lying coastal regions and islands. Actually, two small islands of Kiribati have already been consumed by the encroaching Pacific Ocean. Tuvalu is believed to be one of the first nations to disappear. However, this view is too simplistic. In recent decades, the tropical Pacific is in a strange state from a climate dynamicist's viewpoint; we often observe a warm sea surface temperature (SST) anomaly associated with high sea level and low atmospheric sea level pressure anomalies in the central tropical Pacific. Interestingly, this warm SST anomaly is sandwitched between two cold SST anomalies with low sea level in the eastern and western Pacific. This pattern shows a marked difference from the conventional El Niño and we call the anomalous ocean-atmosphere condition El Niño Modoki (Pseudo El Niño). We believe that the frequent occurrence of El Niño Modoki is a true identity of the encroaching ocean in the central tropical Pacific. Predicting strength, frequency and period of this anomalous climate signal by use of a coupled ocean-atmosphere model is necessary to adapt to the expected sea level rise due to the global warming trend.

1. Introduction

Sea level change has received much attention under the global warming stress. A report of Working Group I of the Intergovernmental Panel on Climate Change projects sea level rise of 0.18-0.59m in accord to global average surface warming of 1.8-4.0 °C at the end of the 21^{st} century. Major processes to cause such sea level rise are i) thermal expansion of sea water and ii) loss of land ice. Since models used to obtain those estimates do not take into account full effects of changes of ice sheet flow, uncertainties may be larger. Those figures provide us with general indication of what we face *globally* in the expected global warming trend.

In order to be well prepared against the expected disaster, we need to understand how sea level variations occur *regionally* under the global change. It is often reported that the sea level rise due to global warming is encroaching on low-lying coastal regions and islands. Actually, two small islands of Kiribati have already been consumed by the encroaching Pacific Ocean. Tuvalu is believed to be one of the first nations to disappear. However, this view is too simplistic.

In recent decades, the tropical Pacific is in a strange state from a climate dynamicist's viewpoint; we often observe a warm sea surface temperature (SST) anomaly associated with high sea level and low atmospheric sea level pressure anomalies in the central tropical Pacific. Interestingly, this warm SST anomaly is sandwitched between two cold SST anomalies with low sea level in the eastern and western Pacific. This pattern shows a marked difference from the conventional El Niño and we call the anomalous ocean-atmosphere condition El Niño Modoki (Pseudo El Niño).

We believe that the frequent occurrence of El Niño Modoki is a true identity of the encroaching ocean in the central tropical Pacific. Predicting strength, frequency and period of this anomalous climate signal by use of a coupled ocean-atmosphere model is necessary to adapt to the expected sea level rise due to the global warming trend. Efforts in this direction are underway.

In this short article, we describe El Niño Modoki for better understanding what is really happening in the tropical Pacific. To have a correct scientific view of our planet must be the first step to consider policies for mitigating possible threats of the global change.

2. El Niño Modoki

It is written in a report of Working Group I of the Intergovernmental Panel on Climate Change that global sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. It is also written that the rate was faster over 1993 to 2003: about 3.1[2.4 to 3.8] mm per year. However, these values are too small compared to commonly accepted threats in the central Pacific islands.

In order to appreciate this apparent discrepancy, we must first appreciate the conceptual difference between climate variations and climate change. Climate change is due to external origins that influence our climate system and has time scales of centuries or even more. Because of such long time scales, it appears as a weak trend in time series with a shorter time span. One typical example is the reoccurrences of the glacial/interglacial period with 40 thousands to 100 thousand years. It is widely accepted that the cause is due to changes of the solar radiation. Another example is the recent global warming trend most probably due to the anthropogenic increase in global warming gases. The change in the atmospheric composition may also occur owing to changes in land processes, volcano activities, etc. All those are due to events outside the ocean-atmosphere system. In contrast, climate variations, which have much shorter time scales from seasons to decades and often much larger variability compared to that of the climate change, are characterized by internal origins that are inherent in our ocean-atmosphere system. Those are natural variations in both atmosphere and hydrosphere even if their occurrence frequency and magnitude could be influenced by the climate change. The climate variations are actually generated by natural climate modes that have clear spatial structures and life cycles, as typified by El Niño and Indian Ocean Dipole in the tropics.

Using various ocean/atmosphere datasets mainly for the period from 1979－to 2005, we have recently suggested that the existence of a new climate mode that is different from the conventional El Niño in the central tropical Pacific. The unique central Pacific warming is associated with a horse-shoe SST pattern, and is flanked by a colder anomaly on both sides along the equator (Fig. 1). Such a zonal SST distribution results in anomalous two-cell Walker circulations over the tropical Pacific (Fig. 2). Both ITCZ and SPCZ expand poleward, forming a warm wet region in the central tropical Pacific. The region is also associated with high sea level anomalies. Conventional EOF analysis of monthly tropical Pacific SSTA shows that the new mode is represented by the second mode that explains 12% of the variance.

Since the mode cannot be described as one phase of El Niño evolution, we suggest that the phenomenon should be called El Niño Modoki[1] (Pseudo-El Niño). The El Niño Modoki involves ocean-atmosphere coupled processes, indicating the existence of a unique atmospheric component during the evolution, which is analogous to the Southern Oscillation in case of El Niño. Thus the total entity should be called ENSO Modoki.

The Modoki's impact on the world climate is very different from that of ENSO (and IOD). Possible geographical regions for droughts and floods influenced by Modoki and ENSO are compared. Interestingly, the Modoki's influences over regions such as the Far East including Japan and the western coast of USA are almost opposite to those of the conventional ENSO (Fig. 3).

3. Summary

The difference maps between the two periods of 1979-2004 and 1958-1978 for various oceanic/atmospheric variables suggest that the recent weakening of equatorial easterlies related to weakened zonal sea surface temperature gradient led to more flattening of the thermocline, inducing also high sea level anomalies in the central tropical Pacific. This appears to be a cause of more frequent and persistent occurrence of the Modoki event during recent warming decades; the ENSO Modoki has a large decadal background while ENSO is predominated by interannual variability. Sea level rise reported by Working Group I of the Intergovernmental Panel on Climate Change is too small compared to commonly perceived threats in the central Pacific islands. This apparent discrepancy is understood by the frequent occurrences of the Modoki in recent decades.

To know what is going on in the real world is the first step to discuss future steps. Appreciating not only the conceptual difference between climate variations and climate change but also the existence of two different climate modes in the tropical Pacific will contribute to reducing the uncertainty in the climate-related debate on the sea level rise in the central Pacific islands.

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[1] "Modoki" is a classical Japanese word, which means "a similar but different entity".

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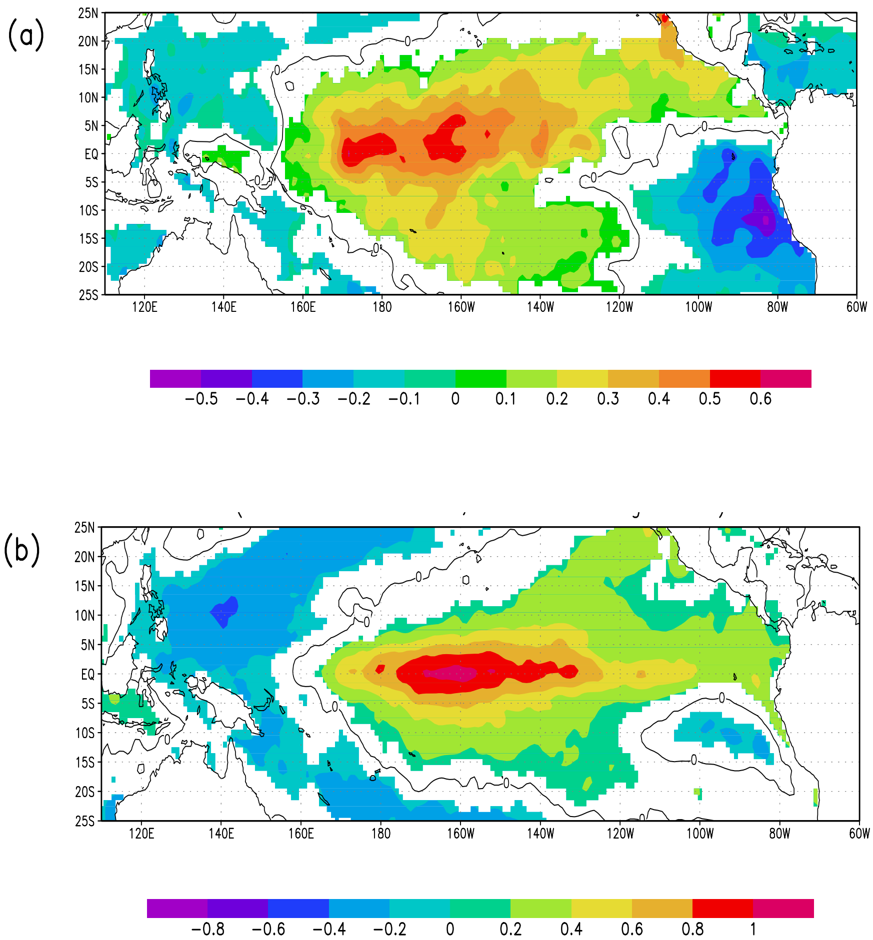

Figure 1: Composite SSTA in ºC during strong positive El Niño Modoki events averaged over (a) seven boreal summers, namely JJAS seasons of 1986,1990, 1991, 1992, 1994, 2002 and 2004 and

(b) 8 boreal winters, namely DJF seasons of 1979-80, 1986-87,1990-91, 1991-92, 1992-93, 1994-95, 2002-2003 and 2004-05. Significant values above 95% confidence level from a two tailed Student's t-test are shaded.

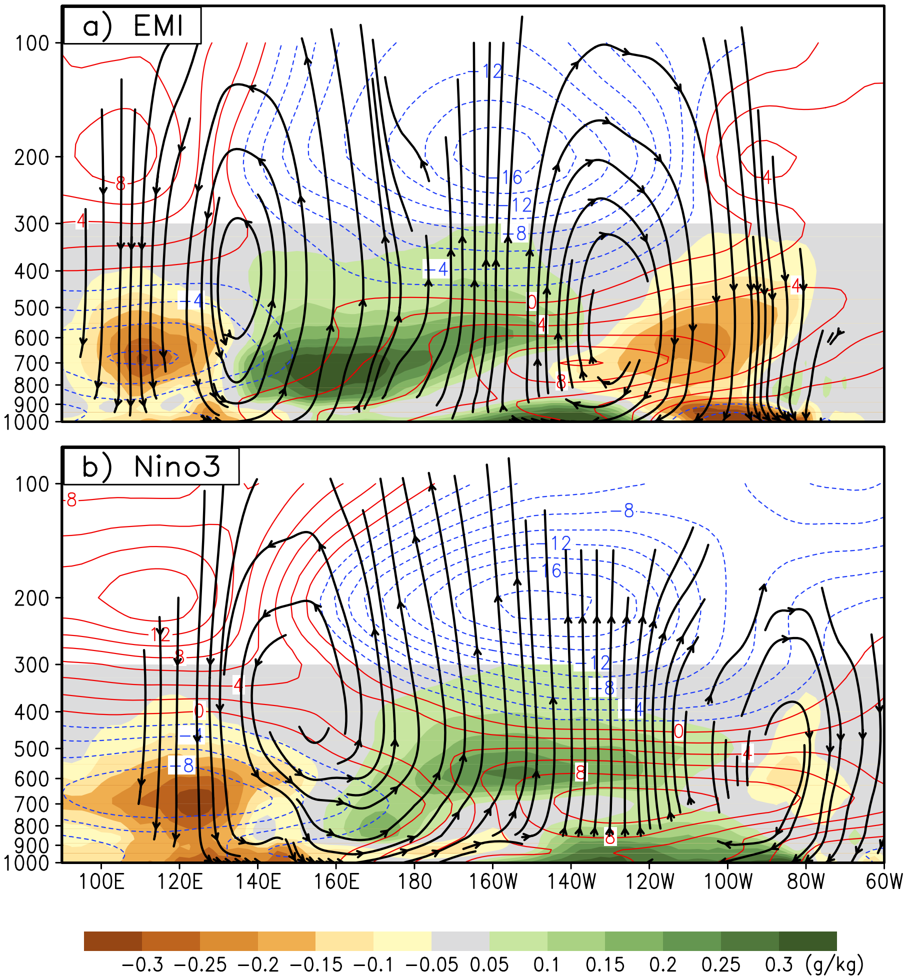

Figure 2: Anomalous Walker Circulations (10S -10N) between 90E and 60W based on partial regression for a) El Niño Modoki Index (EMI) introduced suitably using zonal SST differences and b) Niño3 Index. The vertical velocity at the pressure levels ismultiplied by a factor of -50 to give a better view. The regressed specific humidity is shaded. The contours are for the regressed velocity potential (unit: $10^5 m^2 s^{-1}$). The units labeled in the regression patterns are actually the units per standard deviation of the index being regressed. The standard deviations for EMI and Niño3 in JJA are 0.504˚C and 0.553˚C, respectively.

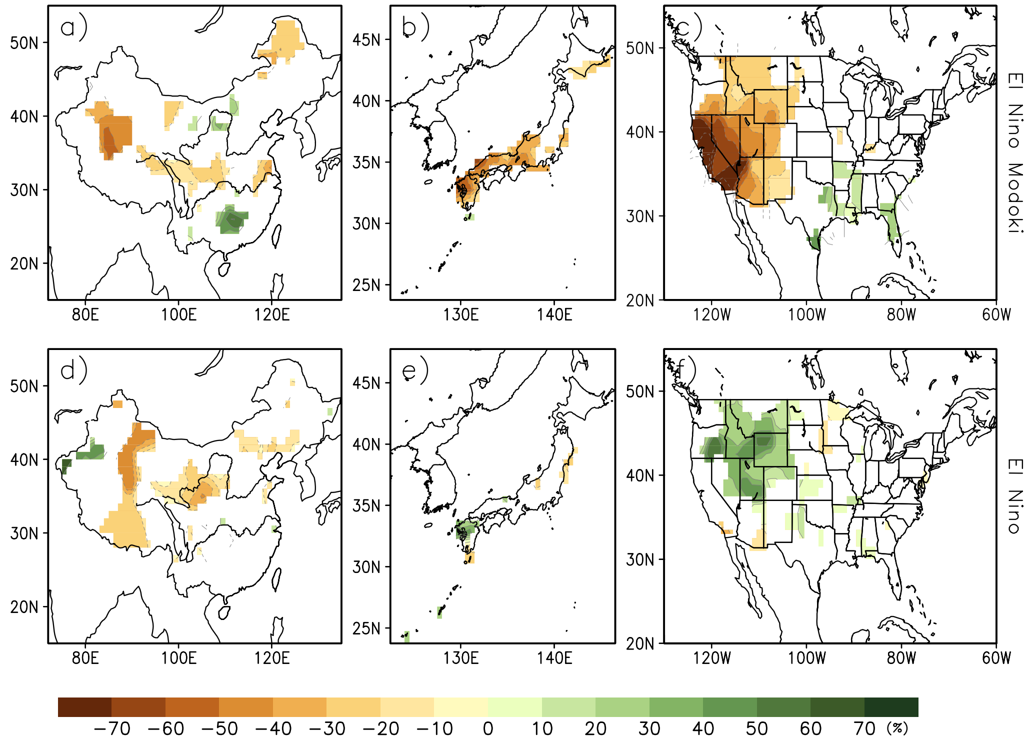

Figure 3: Composite JJA rainfall patterns (anomaly percent of normal: %) for the three largest El Niño Modoki events (1994, 2002, and 2004) in a) China, b) Japan, and c) the United States, and those for the three larges El Niño events (1982, 1987, and 1997) in d) China, e) Japan, and f) the United States. The values with significant levels less than 80% are omitted.

Pacific Islands and the Problems of Sea Level Rise Due to Climate Change

Joeli Veitayaki[i], Pio Manoa[ii] and Alan Resture[iii]

ABSTRACT

Pacific Islands consist of a wide variety of island types ranging from the large continental ones, to coral atolls and sand cays that scatter over 30 million km^2 of the Pacific Ocean with their corresponding terrestrial, freshwater and marine ecosystems. These islands are diverse in their geography, demography and development state but share similar experiences and face common problems. Although some of the larger island groups have significant mineral, forestry, fisheries and agricultural resources, most Pacific Island do not. All Pacific Islands depend on the sustainable use of natural resources for their survival and development.

The problems associated with sea level rise due to climate change are serious in the Pacific because of the small islands involved. The restricted sizes of these island and their limited terrestrial resources make them amongst the first and worst victims of sea level rise with not even the mean to address it in some instances.

However, Pacific Islanders have extensive experience living in these small and isolated islands for generations and have formulated worthwhile local survival knowledge, skills and practices that offer useful lessons to contemporary societies on how to address climate change and sea level rise. In this paper, we examine some of the characteristic features of these islands, some of the associated issues relating to sea level rise due to climate change, some of the options for addressing the above issues in the Pacific Islands and propose a strategy for addressing the challenges of living in an island world affected by these phenomenon. Some areas where changes can be considered include appropriate coastal management and protection, adaptation in land use and living practices and new options such as aquaculture and sustainable living at community level.

INTRODUCTION

The Pacific Islands are scattered over an area of about 30 million km^2 of the world's largest ocean. The islands are small except for Papua New Guinea (PNG) but there is alot of geographic, demographic and developmental diversity (South *et al.*, 2004). Detailed descriptions of the islands are provided in Annex 1. Differences in climate,

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[i] University of the South Pacific staff on Erasmus Mundus External Cooperation Window Programme Lot 10 at Universidade do Algarve, Campus da Penha, Faro.
[ii] University of the South Pacific staff currently at the Pacific Islands Forum Fisheries Agency, Honiara
[iii] Institute of Marine Resources, Faculty of Science, Technology and Environment, University of the South Pacific, Suva

geological resources, topographical features, soil types, mineral and water availability, extent of coral reefs and diversity of terrestrial, freshwater and marine flora and fauna are features of the region.

Although some of the larger island groups have significant mineral, forestry, fisheries and agricultural land resources, most Pacific Islands do not. The options for economic development are therefore extremely limited for the majority of the countries. Important social and economic issues in the Pacific Islands include high population growth rates, urban drift, breakdown of traditional lifestyles, a strong dependence on aid, and the rapid adoption of the cash economy. Political instability has been common and has caused a breakdown in social and environmental ethics in some countries such as the Solomon Islands. The major concerns for the Pacific Islands are: global changes, freshwater shortage, unsustainable exploitation of fisheries, habitat and community modification, and pollution (South *et al*., 2002).

According to the IPCC Third Assessment and the Fourth Assessment reports, what is to be expected by 2100 in terms of sea level rise due to climate change is established with the only uncertainty relating to the timing and the magnitude of the changes (IPCC 2007). These impacts are already evident in the Pacific Islands through coastal flooding, erosion, salt water intrusion into ground water sources and increased storm damages. The situation is so bad now in the Pacific Islands that the countries are continuously in a state of repair and reconstruction after major extreme events that seemed to be getting more and more regular. In addition, the Pacific Islands are also under threat from their rapidly increasing population that needs services and facilities.

Pacific Islands must commit resources for the short and long term to address sea level rise due to climate change because they are amongst the worst victims. At present, these islands that have done little to cause the problem and can do little to address it are continually recovering from the destructive effects of sea level rise due to climate change. Natural extreme events such as cyclones, floods, droughts and storm surges are common and destructive. Unfortunately, Pacific Islands have also lost their independence and resilience that enabled their people to recover from these eventualities in the past. Pacific Islands now lack the resources to mitigate and undertake adaptive responses and rely on external assistance to fund the recovery process. Unlike the industrialized countries that have comprehensive response and adaptation options, Pacific Islands are limited by their restricted resources. This is the reason why the industrialized countries ponder over their loss of employment, crops and industries while Pacific Islands are consider the loss of land, emigration and resettlement in foreign land.

However, Pacific Islanders have extensive experience living in these small islands for generations and have traditional knowledge and wisdom that can be the basis of response and adaptation policies, strategies and actions to address sea level rise issues (Veitayaki, 2002). Pacific Islands need to pool their resources and expertise to map a regional strategy for addressing sea level rise and climate change challenges. This requires innovations, good planning and the involvement of all stakeholders at all levels of society. Pacific Islands need to forge partnerships and collaboration locally and internationally to ensure that their sea level rise and climate change responses and adaptations are appropriate. The solutions must not be too sophisticated and costly but cost effective and proven. Some areas where changes can be considered include appropriate coastal protection, adaptation in land use and living practices and new options such as aquaculture and sustainable living at community level..

There are four other sections to the paper. The first is an overview of the Pacific Islands, which highlight some of the unique features. The second section examines some of the issues that are related to sea level rise due to climate change. The third section introduces the strategy that Pacific Islands can adopt to address the problems of sea level rise due to climate change. The paper concludes with some reflections on the future.

PACIFIC ISLANDS

The Pacific Islands are dominated by the ocean, which has social, spiritual, cultural and ever increasingly, economic significance (Figure 1). Land accounts for only 2 percent of the region's total area of approximately 550,000 square kilometres. The largest of the islands is PNG with 84 percent of the region's land area. Seven islands have land areas of over 700 square kilometres while four have less then 30 square kilometres each. Fifteen territories are either made up wholly atolls or largely of atolls and coral islands. Others, with the exception of Samoa, have a combination of both high volcanic islands and low atolls (South *et al.*, 2004).

The scarcity of land-based resources in many Pacific Islands particularly in the atolls means that the focus is on the resources of the oceans to sustain livelihoods. This dependence on the resources of the ocean over the years has had serious impacts on the marine resources that made it necessary to put in place management structures to monitor and control the use of the ocean's resources.

According to SPC's estimates (Haberkorn, 2004), the population of the Pacific Islands reached 8.6 million in 2004, representing an increase of approximately 1.7 million people over the past 10 years. The five largest island countries and territories (those comprising Melanesia) account for the vast majority (86.4%) of the regional population, followed by the much smaller island countries and territories of Polynesia (7.4%) and Micronesia (6.2%). With an annual population growth rate of 2.2 per cent per annum; there will be a doubling of the Pacific Island population in 32 years.

Half of the 22 Pacific Island countries already have a larger proportion of their population living in urban rather than rural areas. With an annual urban growth rates of between 3 and 4 per cent, population doubling times range from 17 to 23 years. In South Tarawa, for instance, with its current estimated growth rate of 5.2 per cent per annum, the population will double in just 13 years. Given the enormous population-resource pressures at present, it is inconceivable to see how South Tarawa's economy, its society and environment will be able to cope with an additional 36,700 people in nine years (Haberkorn, 2004). Already the population density in cities such as Funafuti, Tarawa and Majuro rival those in Hong Kong and other densely populated cities in Asia.

Other important social and economic issues in the region include the slow economic growth rates, urban drift, breakdown of traditional lifestyles, a strong dependence on aid, increasing poverty and the rapid adoption of the cash economy. Political instability has also figured prominently in recent year as exemplified by the situation in Solomon Islands, Fiji, French Polynesia and Tonga.

Loss of land is a major concern throughout the Pacific Islands. Even in the higher and larger islands, the loss of land associated with any increase in sea level is devastating in the coastal areas. In the atolls, where the average height of the landmass is less than 5 m, the loss of land or whole islands will mean catastrophic changes. At the moment, the effects of higher sea level are evident in cultural sites such as villages, gardens and burial grounds.

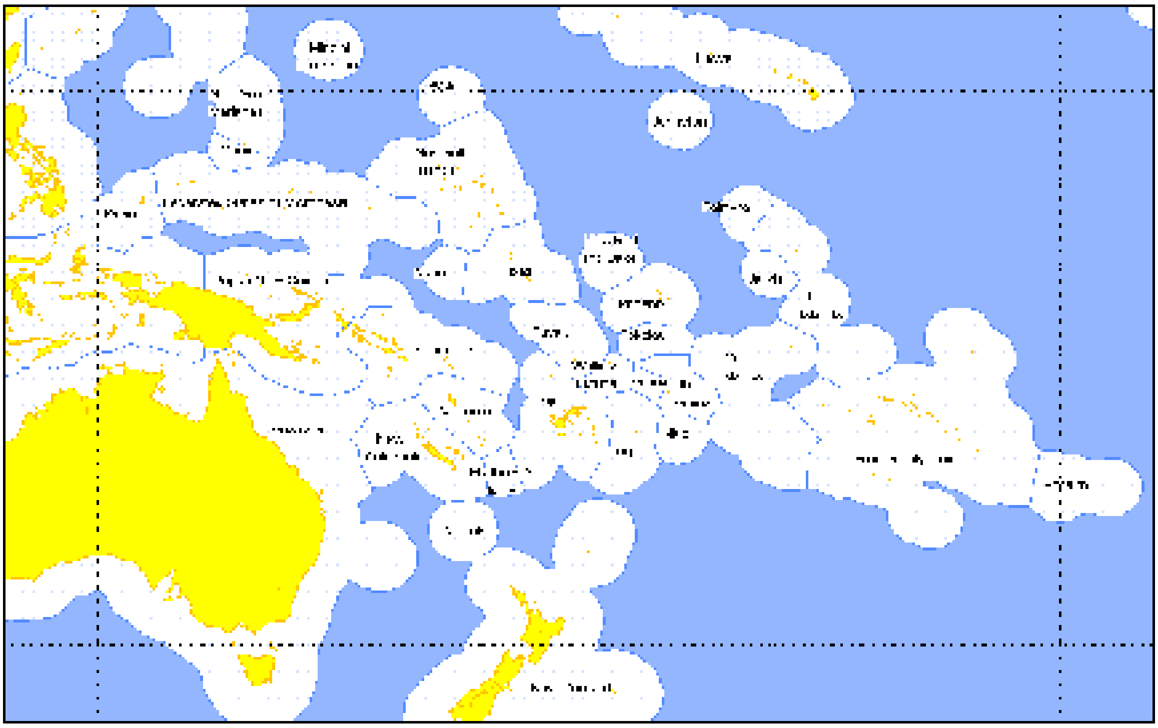

Figure 1. SOPAC's map of the Pacific Island showing their EEZ boundaries

In Tuvalu, people have to avoid funerals at high tide because there was one occasion when the coffin started to float to the surface due to high tide. While this was seen as a horrible manner to send off loved ones, the options are limited. In most of the Pacific Islands, cremation is not accepted as Resture reported. "I had difficulty putting this idea across to the elders in Tuvalu when I conducted a workshop on community empowerment and mobilization" (Alan Resture per.com 7th Feb, 2007).

The implications of loss of land and islands in areas where they already ssmall are immense. The loss of land and islands diminishes areas under national jurisdiction and impact heavily on the economic and subsistence status of the islands. In all Pacific Islands, local communities have traditional, cultural and spiritual attachments to the sea, particular species, reefs, islands and natural formations. Moreover, the sale of fishing licenses was a major source of foreign exchange. In the Kiribati, the sale of fishing licenses within the countty's EEZ was worth $A29.4 million some years ago (Borovnik 2006). This situation makes the disappearance of land and islands significant as it also influences the demarcation of maritime boundaries. Samoa, a sea locked country will enjoy an extended maritime zone if some of its neighbouring atoll nations disappear because of sea level rise.

ISSUES RELATING TO SEA LEVEL RISE DUE TO CLIMATE CHANGE

Pacific Islands are highly vulnerable to sea level rise due to climate change but have a large natural resilience that is increasingly impaired by human pressures. This is the reason why sea level rise related issues are regarded differently by each state and territory, which has its own set of priorities, strategies, and responses to the different issues. All Pacific Islands are vulnerable to the effects of sea level rise due to climate change but the atolls and coastal and low lying areas are most at risk. Many coral atolls do not rise over five metres above sea level and can be uninhabitable due to inundation, which could be caused by natural as well as human activities. The challenge for the Pacific Islands is to design and institute management plans for extreme events at the regional, national, district and local levels.

The impacts of climate change affect all sectors of the economy in the Pacific Islands. Extreme weather conditions are becoming regular and are causing millions of dollars to recover from. For instance, the 2009 flood in Fiji is expected to cost over $60 million in damages. It is also expected that changes will occur in rainfall patterns and soil moisture, prevailing winds and short-term variations in regional and local sea levels and wave action patterns. The only uncertainty at the moment will be the duration and the magnitude of the changes. Potential impacts are also expected in the distribution and abundance of offshore fish, productivity of inshore fisheries and fish breeding sites, marine ecosystems and more extreme weather patterns. Coral bleaching are expected to increase and to negatively affect the coral reefs while the health and distribution of mangroves and sea grasses beds are also expected to change. This is why the Pacific Islands need to address the issues of global warming at the local, national, regional and international levels.

Pacific Islands and their regional organisations have demonstrated commitment in undertaking proactive actions to address the effects of sea level rise due to climate change. Most countries have ratified the UN Framework Convention on Climate Change 1992 (UNFCCC) and are attempting to identify relevant cause of action to combat the impacts of this global phenomenon. Regional initiatives like the National Environment Management Strategies (NEMS) focussed on policies and strategies for sea level rise due to climate change and promoted integrated coastal management plans but these need to be implemented locally within the communities, the countries and the region. Likewise, the Pacific Islands Climate Change Assistance Programme (PICCAP) assisted countries with their reporting obligations under the UNFCCC but action was needed at the local and national levels.

Changes in sea level are expected to affect the coastal states that have declared their maritime zones. Pacific Islands like all coastal states must demarcate their maritime boundaries and the alterations because of sea level changes need to be incorporated. Such an exercise is costly but crucial for Pacific Islands because of the development prospects of both living and non-living resources. Maritime boundary delimitation is a sovereign responsibility under the United Nations Convention on the Law of the Sea. Pacific Islands have all declared their maritime boundaries; with some of the reference points being on some very low islands and reefs. Some of the boundaries still need to be formalised. Furthermore, 45 common boundaries between Pacific Islands need to be finalised while countries such as the Federated States of Micronesia, Papua New Guinea, Fiji, Solomon Islands and Tonga need to claim continental shelf extensions. For this to happen, these Pacific Islands need to commit resources to conduct research and field surveys to prove that they have continental shelves.

The loss of island territory because of storm surges and sea-level rise is a threat to claims and existing maritime jurisdiction of Pacific Island. Numerous islands claimed by Pacific Islands are in remote areas and are uninhabited. For example, in the Phoenix Group in the Republic of Kiribati, only one island (Kanton Island) is inhabited. Moreover, while some of other islands in the group were inhabited in the past, the departure of the inhabitants over the last few years was caused by the unavailability of portable water. Can traditional, cultural and spiritual attachments validate and affirm a coastal states claim over remote islands or natural formations? Are these attachments enough on their own? The shift from island to non-island status (and vice versa) is another interesting issue. Where the land is submerged, what happens to existing maritime boundaries? Can the claim over existing maritime boundaries stand despite the loss of island territory used as a baseline for delimitation? Can there be special dispensation/exemptions granted for island States in this predicament? Should the special dispensation account for the geological composition of small islands and atolls and their vulnerability to the effects of sea-level rise? These are interesting and relevant questions that need to be addressed through good research.

Where a Pacific Island is severely impacted by sea level rise,, there will be an inclination to reconstruct islands with the use of sand, coral, rocks or other material. For small low islands and atolls built from coral or limestone, materials used would be limited to what is available. This would raise questions on whether this activity is considered reinforcement or the construction of an artificial island? Would the situation be different if there was a pre-existing island which was lost by sea-level rise or wave action?

Marine scientific research (MSR) is crucial in determining the impacts of sea level rise due to climate change as well as the options available for local preventative and adoptive measures. Marine scientific research is the responsibility of coastal states that can determine not only the seabed mining and marine resource sustainability issues but also the other potential uses of marine resources. Pacific Islands have little or no MSR capability and rely heavily on regional organisations such as the Pacific Islands Forum Fisheries Agency (FFA), South Pacific Applied Geoscience Commission (SOPAC), University of the South Pacific (USP), Pacific Regional Environment Programme (SPREP) and Secretariat of the Pacific Community (SPC) and competent international research organisations. Marine scientific research can provide information vital for addressing the impacts of sea level rise due to climate change.

SOPAC leads the delimitation of maritime boundaries in the Pacific Islands and is the depository for data obtained from research conducted on coastal processes; coastal, nearshore and offshore minerals, hydrocarbon and wave energy potential, and marine geology and geophysics. The SPC conducts long term scientific research and monitoring of the fisheries, assessment of stocks, data collection, synthesis and analysis and advice member countries on the management and development of oceanic and coastal fisheries at national, regional and international levels. The USP as the premier education institution in the region conducts applied research and training on education, development, environmental change, aquaculture, post harvest fisheries and marine resources management.

Discoveries of cobalt-rich manganese nodules within the EEZ of the Cook Islands; cobalt rich crust within FSM, Marshall Islands, Kiribati and Tuvalu; and gold-bearing sulphide deposits on the seafloors of Fiji, Tonga and PNG provide exciting new opportunities for Pacific Islands. However, few nations have formulated policies and legislation on offshore mineral development and need to ensure that their marine environment is not destroyed if seabed mining is undertaken.

At the moment, the blasting and dredging of coral reefs and mining of coral aggregate are common in Pacific Islands where they cause serious impacts. Coastal mining in the Pacific Islands is serious providing in some cases the only sources of construction materials in countries such as the FSM, Kiribati, Marshall Islands and Tuvalu. Dredging is done in rivers, beaches and shallow coastal waters while individuals often mine the beaches for sand and aggregates for their domestic use. In Fiji, an extensive dredging programme has been undertaken to deepen the rivers and reduce flooding in the river mouths. The dredging has been associated with the loss of wetlands and the destruction of marine fisheries that the villagers rely on for food and income.

The degradation of reefs and erosion of coastal areas are prevalent in the Pacific Islands where about 41 percent of the reefs are under medium to high pressure from human development. The destruction of coastal ecosystems such as coral reefs, mangrove forests and sea grass beds are associated with beach and coastal mining, construction of coastal structures, land-based and marine-based pollution, fishing, natural disasters and poor development planning. The implications for Pacific Islands suggest the need to study natural systems, examine the response of nearshore systems to any sea-level change, develop appropriate coastal protection systems, and formulate policy on accommodation and adaptation options.

Increased coastal developments of infrastructure and settlements contribute to serious coastal problems. With urban centres such as South Tarawa, Majuro, Funafuti, Nukualofa and Suva having very high populations for their sizes, the pressures on coastal environment and resources worsens. Consequently, most of the ports in the Pacific Islands are badly polluted.

The use of pit latrines in some of the urban centres such as Funafuti and Tarawa cause problems because eventually new pits will be required. Where land is limited, this may become a major stumbling block. In addition, septic tanks in atoll environments, especially in built-up areas, perform less effectively than in other places because effluent drainage lines are short due to small allotment sizes and the porous soil combined with a high water table, which means that nutrient-rich waste quickly enters the groundwater. In addition, sludge from septic tanks must be pumped out periodically while suitable treatment and disposal arrangements are not available (Resture 2006).

Training, education, and public awareness are cross cutting issues and are conducted at different levels by all of the regional organisations and national agencies. The USP is responsible for formal training but applied research is also conducted by other technical organisation. A lot more community education is required to publicise the reasons why changes need to be allowed into how people relate to their natural environment. These changes in the manner in which people live, utilise their resources and prepare for extreme events must be undertaken at all levels to reduce vulnerability in the Pacific Islands. The management of data is also critical for the sharing of experience that is needed. The Pacific Islands Marine Resources Information System (PIMRIS) provides assistance for accessing data within the region. Research information from Pacific Islands must be shared to facilitate their use by others.

RESPONSE AND ADAPTATIONS IN PACIFIC ISLANDS

With their financially weak economies and lack of resources, Pacific Islands need to design responses and adaptations that are appropriate for their people. It is therefore not wise and practical to have high-tech and expensive responses and action. On the other hand, Pacific Islands can utilise their traditional knowledge and customs to organise themselves and be prepared for the impacts of sea level rise due to climate change. The important thing is for the people to undertake individual activities that are required to ensure the communities cope with the changed environment associated with the altered conditions.

Pacific Islands need to have the best climate change and sea level related information on their islands. These can be done by collating relevant information from different parts of the country and setting up a unit or an institution to coordinate the response and adaptation to sea level rise. The information should enable the countries to better understand how their different areas will be affected by the changing climate and sea levels. Simulations and various scenarios can be applied to explore anticipated impacts. The information should aid in planning and decision making on emergency evacuation plans and centres.

Pacific Islands must undertake the following activities to be prepared for the impacts of sea level rise due to climate change. They must:

- gather and improve information on the impacts of sea level rise on all human and natural systems in the islands
- build capacity in specific areas by collaborating with competent organisations and institutions
- develop strategies for responses and adaptation using traditional and appropriate contemporary methods
- ratify climate change-related instruments and incorporating these into national legislation
- promote awareness programmes on useful lessons
- foster collaborations with developed and industrialised countries
- improve early warning systems and back-up facilities to reduce vulnerability and improve response time
- encourage appropriate reforms in the policies and measures to reduce greenhouse gas emissions
- promote clean development technology.

The response strategies available to Pacific Islands come under three major categories: retreat, accommodation and protection and enhancement. Retreat means the abandonment of the vulnerable areas and the relocation of the activities to planned sites away from these areas. The major challenge with this option is the lack of land so the response may be implemented only in the larger islands. The ownership of land will hinder relocation of some coastal communities as the less vulnerable areas will be owned by other groups. In the atolls, this option is not likely to be used.

Resture (2006) described the magnitude of the problem in Tuvalu. He noted that almost 4,000 people or 43 percent of the total population are squeezed into the main islet of Fogafale, Funafuti, which has an area of only 2.79 square kilometres. A third of the total land area is uninhabitable because it is used as the airport or the excavated borrow pits that were used in its construction. Even with the land area of 2.79 square kilometres, the population of 4,900 (in 1996) on Funafuti results in a population density of 2,634/km^2. The density is higher than this amount if the uninhabitable area is taken into consideration. This situation places tremendous pressure on government resources.

Fisheries are the main source of protein in the diet of Tuvaluans. According to an ADB (1994) survey, each person eats about 500 grams of fish per day; which is equal to 2,000 kg per day or 730 tons per year across the population of Funafuti. With this type of demand, there is little hope of the environment keeping up, which means that the supplies have to be brought in from other areas.

Resettlements internally and externally will be the main option if life as currently undertaken is no longer possible in the islands and there need to be political, social and cultural arrangements made for this eventuality. In Tonga, Perminow (1993) reported the internal movement of people into Kotu because of better opportunities compared to all its neighbouring islands. Similar resettlement took place in Papua New Guinea

(Allen *et al.*, 1993) and Fiji. In these cases, there were some social and cultural relations that allowed for these resettlements. Tuvalu has secured an agreement with New Zealand (under the Pacific Access Category and the Temporary Labour Scheme) for the resettlement of 75 of her citizens to New Zealand each year. A similar application to Australia has been refused.

Accommodation is the strategic option where the alteration is made to the use of the area but the people continue their activities in the same area. This is a more appropriate option in the major centres in small atolls. In Tuvalu, houses on piles are now built in the water-covered “borrow” pits (Figure 1). Similarly, the Marine Studies Facilities at the University of the South Pacific (USP) is designed to allow water to flow through without causing too much problems (Figure 2). Pacific Islands should encourage changes in the design of building, building standards and other measures to accommodate the expected changes in sea level. There must be evacuation and emergency plans and shelters that people are made to know. The governments may also set up insurance and other incentives to encourage people to take the risk of establishing their operations in the vulnerable areas.

In addition, new activities that are considered more appropriate given the expected changes must be pursued. Identification of drought and salt tolerant crops or even newer uses of resources such as mariculture and marine-based ecotourism can be considered. Settlements in these ‘artificial’ locations need to be fully supported by others through the market. Moreover, the people must consider riding bicycles and motor bikes instead of cars and trucks which would reduce the need for wider roads.

The production of new commodities such as the coconut furniture and products can provide excellent opportunities in the Pacific Islands. Attention should be devoted to new technology that will enhance the health of the environment to spare people from the ravages of sea level rise. Compost toilets, smokeless stoves and fish aggregation devices are all examples of simple technology that can reduce human impact on the island environment. Other technologies such as the use of renewable energy and the better treatment of waste can ensure the maintenance of the health of the environment that will in turn protect and provide for coastal communities.

The third and last response strategy is to protect and enhance the known vulnerable areas. Protection and enhancement can come in terms of hard structure such as seawalls, dikes, groins, flood gates, tidal barriers and detached breakwaters or soft structures such as beach filing, beach nourishment and the maintenance of healthy and vibrant ecological systems such as coral reefs, sea grass beds, mangrove forests and wetlands. The hard structures as those used in Japan are effective but expensive and out of the reach of Pacific Islands. Hard structures also change the nature of coastal processes and often have to be used around the whole island. On Nukufetau, Tuvalu for example, the construction of seawall on one end of the island eroded the other end completely. The construction of the causeway on Tarawa, Kiribati interfered with the natural flow of currents and was blamed for the disappearance of Bikenman, an islet opposite the causeway. In some of the Pacific Islands, the absences of fringing reefs and continental shelves make the task of protecting the coast difficult. In many cases, the protections have to be built on the reefs, which is not very healthy. In other places, the

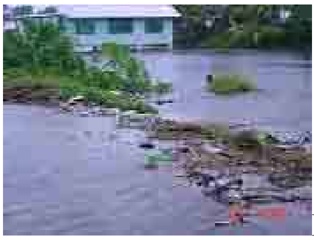
Figure 1. Using all available space by building in flooded borrow in Funafuti

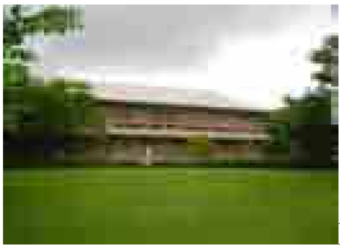
Figure 2. Preparing for sea level change, the Marine Studies Facilities, USP


Figure 3. Stone wall for coastal protection in Naovuka, Vanuaso Tikina, Gau Island, Fiji

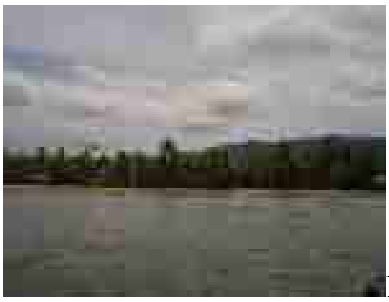
Figure 4. Rehabilitated littoral vegetation to provide shelter in Nacavanadi Village, Vanuaso Tikina, Gau Island, Fiji

Figure 5. Rehabilitated mangroves to provide coastal protection and nursery for fish in Malawai Village, Vanuaso Tikina, Gau Island, Fiji

depths outside the reefs forbid any kind of construction that can withstand strong wave and wind actions. Furthermore, there is a lack of building materials like sand and gravel, which add to the expenses. On the other hand, soft structure can be undertaken with minimal costs if people undertake to look after their natural environment so that these are healthy and capable of providing the services that they normally provide.

Adaptation options also must be appropriate for Pacific Islands. This is where the use of traditional knowledge and practices that have been formulated over centuries of survival on these islands can help. Pacific Islanders own their coastal resources and can make difficult decisions about their resources if they are convinced of the reasoning behind the actions that they are to take. In their community-based work, the local communities in the Solomon Islands, Vanuatu, PNG, Cook Islands, Samoa and Fiji, have demonstrated their commitment to undertaking resource management activities when they are convinced that these actions are necessary. In the villages in Vanuaso Tikina in Fiji, local communities are already trying to address these issues as part of their resource management activities (Figures 3, 4 and 5). The villagers are aware that there own survival is threatened and are trying to protect the resources that they depend.

Traditional resource conservation used by the Tuvaluans include restrictions on the type of fishing gear used, and prohibitions on fishing by villagers during the spawning run of flying fish, bonefish and mullet. Mulching was used extensively for subsistence farming, and many of the trees with cultural and utilitarian values were protected. On the island of Nukufetau, the island elders have the final say in deciding when to harvest giant clams and the size restrictions (Resture, 2006).

Public education and awareness are required to promote the need for adaptation to the impacts of climate change and sea level rise. With the increasing information and case studies available, the lessons should be evident. These knowledge and practices should be publicised widely to all parts of the region because individual countries need not start from scratch. There are enough lessons to learn from to allow the countries to decide on the response and adaptation strategies and action that best suit them.

Pacific Islands can meet their obligations to undertake marine scientific research through joint research and site visits with regional and international research institutions. This arrangement can provide Pacific Islanders access to technology and expertise as well as opportunities for funding and the sharing of experiences and capacity. To be effective at this, Pacific Islands need to be ready to collaborate with competent research partners. As a first step, Pacific Islands need to implement the international conventions and treaties that they have agreed to. These international agreements should now be enforced in all the countries across the region. Individual countries need to demonstrate commitment to their collective agreements. Regional agreements need to be ratified and implemented by the countries, which in turn, should translate these to actions.

THE FUTURE

The Pacific Islands are now at the cross road because sea level rise and climate change are no longer a future phenomenon; they are taking place now and require more concerted effort. The islands biggest resource, its people, should now be mobilized to prepare for the eventualities. Pacific Island need to act individually and collectively to address the problems at all levels of society. The people today have the responsibility to shape the future of life in the islands and they should do it properly while they have the time.

All Pacific Islands have ratified the Kyoto Protocol while the industrialized countries have not made much progress. There is little else to do expect to appeal to the big countries to do the right thing. One lesson, that should now be clear to all is that what ever is done to the environment will be reflected in its service to humanity. Humanity cannot be independent of the environment and must do all in its power to ensure that it leaves within the bounds and limit posed by the natural systems.

The challenge in many Pacific Islands would be to secure adequate funds to enable adaptation, protection and enhancement. Marine scientific research will be required to provide the necessary information. Given the high costs, Pacific Islands need to be innovative in how they address this sovereign obligation. The islands must explore avenues to foster equitable collaboration with competent international organisations.

The proposed research on Okinotorishima by Japan is relevant to Pacific Islands and must be supported. If corals are successfully grown to enhance the maintenance of small islands and coastal areas as the Japanese scientists are proposing, the impacts in the Pacific Islands would be huge. Research is needed on the reinforcement of islands and natural formations claimed by coastal states. For Pacific Islands, sea-level rise and the loss of coastal areas within the region are very real issues. Should Small Islands Developing States vulnerable to sea-level rise and other human induced or natural phenomena be permitted to reinforce their islands? In the cases of Pacific Islands, this option may attract a great deal of attention given the use of many small islands for settlements, coastal development and baseline references. The research will offer new hope to the Pacific Island and boost their resolve to maintain their communities in these islands. Of course, closer collaboration with Japan and other countries will be a necessary first step to benefiting from this possibility.

Developing new technologies and alternatives require good research programmes that many of the Pacific Islands do not have. This has to be addressed because a lot more benefit will accrue from good research programmes that are forward looking and innovative. Salt resistant crops, new uses of existing marine resources and new resources can all be obtained through good research and can be sources of new opportunities in Pacific Islands.

Development policies and adaptation approaches must emphasise proactive, anticipatory plans, projects and programmes. The viability of long-term investments in infrastructure and development activities must focus on the sensitivity of projects to the effects of sea level rise due to climate change. Large scale projects must have an EIA, which should determine the suitability of the project. There are ample examples today where after having made the development and knowing the results and the impacts, the countries involved are not so sure about having made the right choices. Such costly mistakes must be avoided and coastal protection needs to be thoroughly assessed for its potential adverse effects. In a number of cases such as with the construction of seawalls, the adaptive measures may have been more destructive because they tempered on the dynamics of the coastal processes.

This is why the Madang Guidelines suggest that Pacific Islands have marine mineral development policy that is sensitive to fisheries development. The biologically diverse nature of the fishery, its wide coverage of the marine environment and the impact marine mining can have on a wide range of fishing operations ranging from subsistence fishers to purse seiners must be recognized.

Development of national expertise in specific areas should be encouraged to support ongoing research. Capacity building and institutional development should be ongoing with follow-up programmes. Pacific Islands need to promote the conduct of foreign MSR in their waters, improve their own scientific capabilities and use the assistance of regional organizations.

Sea level rise due to climate change is no longer the question. Recent events and evidence point to their eventuality. The question now is how well prepared Pacific Islands will be in a world affected by these global changes. Pacific Islands have existed for thousands of years and must work to be part of the new world.

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Against a Rising Tide:
Ambulatory Baselines and Shifting Maritime Limits in the Face of Sea Level Rise

Clive Schofield

Introduction

This paper addresses a critical issue for many coastal States: rising global sea levels. While the causes of climate change still excite controversy and debate, it is now widely accepted that significant sea level rise is taking place and that this trend appears likely to accelerate in the future. This phenomenon raises a number of important challenges for coastal and island States. Among these threats is the likely impact of rising sea levels on national claims to maritime jurisdiction. Significant changes to coastlines and therefore baselines and the potential submergence of key basepoints may potentially lead to the loss of broad national claims to maritime jurisdiction. The loss of significant areas, even all, of the maritime jurisdictional zones claimed by certain coastal States is likely to have profound economic consequences as jurisdictional rights over the valuable resources within these maritime spaces would also necessarily be lost. Certain generally low-lying Pacific Island States, notably Kiribati, Marshall Islands and Tuvalu, which also have geographically restricted territorial extents, appear to be especially vulnerable to these threats. Some of the options to address these potentially dire threats are then briefly addressed.

Rising Tides – the Threat of Global Sea Level Rise

There is mounting evidence that not only is the global sea level rising, but that the rate at which it is doing so is accelerating.[1] While debates continue as to the causes of this phenomenon (and are beyond the scope of this paper), many commentators link the rise in the world's ocean to anthropogenically-induced global climate change.[2]

The major potential sources of significant sea level rise are from the thermal expansion of the oceans and the disintegration of land-based ice sheets. The first of these, the so-called 'steric effect', occurs as a consequence of the increasing atmospheric temperatures associated with global warming. As air temperatures rise so, gradually and incrementally, the oceans also warm. As they warm, surface waters expand and this in turn translates to a rise in sea level rise.

With regard to the loss of land-based ice – the melting of glaciers and potential destabilisation and disintegration of major ice sheets such as those in Greenland and Antarctica – while it would in all probability take a considerable time for major

1 See, for example, Church, J. A., and White, N. J. (2006) "A 20th century acceleration in global sea-level rise", *Geophysical Research Letters*, 33, L01602, doi:10.1029/2005GL024826, 2006.

2 Although the evidence for global warming appears to be compelling, some scientists and commentators point to long term cyclical processes rather than anthropogenically inspired causes to explain this phenomenon. With regard to the Arctic see, for example, See "NASA sees Arctic Ocean circulation do an about-face", available at <www.physorg.com/news114189626.html>.

bodies of ice to disintegrate, collapse and melt, the consequences in terms of sea level rise were they to were they to do so are dire. The disintegration of major ice sheets has been described as "the greatest threat of climate change to human beings" with the potential to result in sea level rise well in excess of one metre by the end of the present century, with sea level potentially rising by around that figure every two decades.[3] In this context it is worth noting that there are strong signs of increased melting on the Greenland ice sheet and that there is enough water locked in the Greenland ice sheet alone to equate to sea level rise of the order of six metres were it to collapse and melt completely.[4]

For its part the United Nations Intergovernmental Panel on Climate Change (IPCC), in its most recent report, dating from 2007, estimated the range of sea-level rise at between 0.38 to 0.59 metres.[5] The key reason for the IPCC's relatively moderate predictions, which includes a mid-range prediction of sea level rise of the order of 40 centimetres, is that it the IPCC's methodology does not take into account the potential disintegration of the major ice sheets mentioned above, largely due to the considerable uncertainties that exist in respect of how swiftly such events might take place. This has led to the IPCC's predictions being criticised as being "remarkably conservative" and the victim of reaching "lowest common-denominator conclusions."[6]

Whilst there is mounting evidence that sea level rise is a very real concern and that the rate of sea level rise is accelerating, it is important to acknowledge that considerable uncertainties remain and that sceptical voices exist that view the predictions of sea level rise outlined above as improbable.[7] Nonetheless, even the relatively modest sea level rise envisaged by the IPCC would have significant consequences and pose major challenges for coastal States, most notably those that are low-lying such as Bangladesh and those composed of low-lying islands such as Kiribati and Tuvalu in the Pacific Ocean and the Maldives in the Indian Ocean.

Baselines and the Limits of Claims to Maritime Jurisdiction

The interface between the land and sea for maritime jurisdictional purposes are a coastal State's baselines. Such baselines are of fundamental importance to coastal State claims to maritime jurisdiction as they provide the starting point from which these claimed zones are measured. While often termed "territorial sea baselines", such baselines are fundamental to claims not only to the territorial sea, but all other maritime zones – the contiguous zone, exclusive economic zone (EEZ) and continental shelf are all measured from relevant baselines (see Figure 1).

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3 Hansen, J. (2006) "The Threat to the Planet", *The New York Review of Books* (13 July).

4 *Ibid*. Hansen notes that the area of Greenland subject to melting in summer has increased by in excess of 50 per cent in the last 25 years, that the volume of icebergs being discharged from Greenland has doubled in the last ten years and that the annual number of "icequakes" caused by major shifts by parts of the ice sheet (a sign of destabilisation) doubled in the 1990s and redoubled by 2005.

5 See, the IPCC's Fourth Assessment Report (AR4), available at, <http://www.ipcc.ch/#>.

6 McKibben, W. (2007) "*Warning on Warming", The New York Review of Books* (15 March).

7 See, for example, Morner, N.-A. (2007) *The Greatest Lie Ever Told*, (printed and distributed by the author).

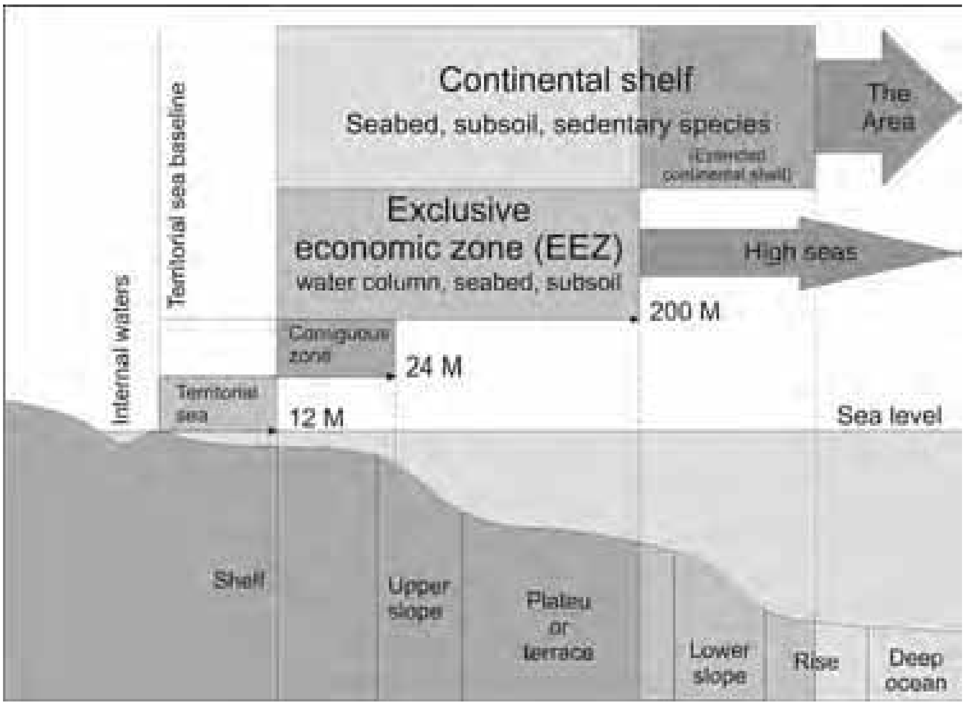

Figure 1 Baselines and Claims to Maritime Jurisdiction

The location of a State's baselines is therefore directly linked to defining the limits of its zones of maritime jurisdiction, as it is essential to determine the points from which the specified breadths of such zones are measured.[8] Baselines are also important because, just as baselines provide the starting line for the measurement of maritime zones offshore, equally they also represent the outer limit of a State's land territory[9] or internal waters landward of the baseline.[10] Baselines are also frequently crucial to the delimitation of maritime boundaries. This is the case because baselines have a direct bearing on the construction of an accurate equidistance or median line and the majority of maritime boundaries concluded to date have been based on equidistance. Equidistance lines are commonly constructed at least as a as a means of assessing a maritime boundary situation or as the starting point for discussions in the context of maritime boundary negotiations and such lines have also frequently been adopted as the basis for the final delimitation line.

Normal Baselines

The international law rules concerning baselines, maritime claims and the delimitation of maritime boundaries are largely codified the United Nations Convention on the Law of the Sea (LOSC) of 1982,[11] and its predecessors, notably the Conventions of

8 This issue is somewhat more complex when claims to 'extended' or 'outer' continental shelf rights are under consideration. Nonetheless, distance measurements from baselines, especially the 200 and 350 nautical miles limits are crucial to the determination of the limits of these claimed sovereign rights.

9 Where the low-water line, normal, baselines are used.

10 Where straight baselines and closing lines are applied.

11 United Nations, *United Nations Conventions on the Law of the Sea*, U.N. Sales No.E.97.V.10 (1983). *See* 1833 UNTS 3, entered into force 16 Nov. 1994, *available at* <http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm>

1958.[12] Under usual circumstances and in the absence of other claims, a coastal State will have "normal" baselines. The rule in accordance with Article 5 of LOSC, is that the coastal State will possess "normal" baselines, which coincide with "the low-water line along the coast as marked on large-scale charts officially recognized by the coastal State."[13] Normal baselines represent the predominant type of baseline worldwide and, in effect, represent a state's 'default' baselines. The vast majority of baselines worldwide consist of normal baselines.[14]

The key issue in this regard is which of many possible low-water lines to use as the normal baseline. The low-water line is dependent on the choice of vertical datum. That is, the level of reference for vertical measurements such as depths and heights of tide. A source of uncertainty associated with Article 5 of LOSC is that it does not specify a particular vertical datum and thus low-water line to be used. Consequently, there is no 'wrong' answer and the choice is left up to the coastal State.[15]

Most coastal States and charting authorities have selected particularly low vertical datums, such as lowest astronomical tide (LAT), as their preferred chart datum. The key reason why such low vertical datums are favoured relates to the primary purpose of nautical charts – to act as an aid to navigation. The advantage of a low vertical datum in this context is that this will necessarily mean that any potential hazards to navigation are shown on the chart – something that is clearly advantageous from the mariner's perspective.

Charts are, however, also used in the law of the sea context and, in particular as a means of showing the normal baseline from which maritime jurisdictional claims are measured. This can prove advantageous to coastal States as the lower the low-water line selected, the further seaward the normal baseline will lie. As this serves to advance the starting point for maritime claims offshore 'further down the beach', as well as increasing the area designated as 'land' or internal waters landward of the baseline, choice of a particularly low low water line will tend to maximise maritime (and terrestrial) claims. The impact of selecting a lower vertical datum on the extent of maritime claims tends to be limited, however, unless there is a significant tidal range or the coastline in question shelves particularly gently. Where the gradient on a coastline is especially shallow, however, minor changes in the choice of vertical

12 Of the four conventions that were concluded following the first United Nations Conference on the Law of the Sea (UNCLOS I), held in Geneva in 1958, the Convention on the Territorial Sea and Contiguous Zone is of direct relevance to baselines. See, Convention on the Territorial Sea and Contiguous Zone, opened for signature 29 April 1958, 516 UNTS 205 (entered into force 10 September 1964) (hereinafter "1958 Convention").

This represents a near verbatim repetition of Article 3 of the 1958 Convention on the Territorial Sea and Contiguous Zone.

14 See, Prescott and Schofield, 2005: 94-97.

15 See, Carleton, C.M. and Schofield, C.H. (2001) *Developments in the Technical Determination of Maritime Space: Charts, Datums, Baselines, Maritime Zones and Limits*, Maritime Briefing, Vol.3, no.3, (Durham: International Boundaries Research Unit): 21-25. Having made that observation, it is nonetheless the case that the International Hydrographic Organization (IHO) favours use of lowest astronomical tide as the vertical datum for the construction of modern nautical charting. See, International Hydrographic Organization (with the International Oceanographic Commission and the International Association of Geodesy) (2006) *A Manual on Technical Aspects of the United Nations Convention on the Law of the Sea, 1982*, Special Publication no.51, 4th edition, (Monaco: International Hydrographic Bureau) (hereafter TALOS Manual, 2006).

datum may result in dramatic horizontal shifts in the location of the low water line, especially where this impacts on the status of low-tide elevations, and this can have significant ‘knock-on’ impacts in terms of the limits of maritime claims.

Ambulatory Baselines

Choice of a particularly low vertical datum may, however, have negative implications in the case of unstable coasts and also in an era of sea level rise. By virtue their especially low-lying nature the low water normal baselines on which coastal States rely to measure their claims to maritime jurisdiction are potentially unstable and likely to be especially susceptible to inundation as sea level rises.

The traditional and generally accepted linkage between ambulatory normal low-water baselines and the limits of maritime zones of jurisdiction dictates that as normal baselines change, so the limits of the maritime jurisdictional zones measured from these baselines will correspondingly shift.[16] Thus, as normal baselines recede as a consequence of sea level rise, so the maritime zones measured from them will also retreat leading to potentially significant diminution in the scope of the coastal State’s maritime claims.

This is by no means a new phenomenon or problem. It has long been recognised that coastlines are dynamic, so normal baselines can change significantly over time or “ambulate” and this necessarily has an impact on the generation of the outer limits of claims to maritime jurisdiction.[17] In this context it is, however, important to note that not all of a coastal State’s baseline contributes towards the construction of the outer limits of its maritime claims. Maritime limits are commonly constructed through the ‘envelope of arcs’ method.[18] Consequently, only certain basepoints along the normal baseline will be relevant to the limits of the relevant maritime zone with the length of the arcs from the contributing basepoints being determined by the breadth of the maritime zone for which the outer limit is being constructed.[19] This has potential implications for the preservation of particular, critical basepoints.

Ephemeral Islands?

Sea level rise also has the potential to threaten the insular status of certain features, that is whether a particular feature can be properly regarded as an island, a low-tide elevation, or a fully submerged part of the sea floor. This, in turn, can have significant

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16 This view can be reached through negative implication. As UNCLOS provides for certain maritime limits to be fixed, notably in respect of the presence of deltas and other natural conditions (UNCLOS, Article 7(2), see below) and in relation to the outer limit of the continental shelf beyond the 200 nautical mile limit (UNCLOS, Article 76(8)), the implication is that other maritime limits are *not* fixed. See, for example, Caron, D.D. “Climate Change, Sea Level Rise and the Coming Uncertainty in Oceanic Boundaries”, in S.-Y. Hong and J.M. Van Dyke (eds) *Maritime Boundary Disputes, Settlement Processes, and the Law of the Sea*, Publications on Ocean Development, Volume 65 (The Hague: Martinus Nijhoff).

17 Reed, M.W. (2000) *Shore and sea boundaries: the development of international maritime boundary principles through United States practice*, (Washington D.C.: US Department of Commerce): 185; Prescott and Schofield, 2005: 100-101.

18 Carleton and Schofield, 2001: 62.

19 A maximum of 12 nautical miles for the territorial sea, 24 nautical miles for the contiguous zone and 200 nautical miles for the exclusive economic zone (EEZ). However, while the EEZ extends out to 200 nautical mile from relevant baselines, it is actually usually only 188 nautical miles in breadth because the EEZ only begins at the limit of the territorial sea which is commonly 12 nautical miles.

implications in terms of the capacity of a particular feature to generate extensive maritime claims to jurisdiction. For example, while an island may, in accordance with LOSC Article 121(2), generate a full suite of maritime zones in an identical fashion to mainland coasts, Article 121(3) states that "Rocks which cannot sustain human habitation or an economic life of their own shall have no exclusive economic zone or continental shelf." This distinction between islands and rocks has enormous implications in terms of potential maritime claims. If an island had no maritime neighbours within 400nm, it could generate 125,664 sq.nm (431,014km^2) of territorial sea, EEZ and continental shelf rights. In stark contrast, if deemed a mere "rock" incapable of generating EEZ and continental shelf rights, a territorial sea of 452 sq. nautical miles (1,550km^2) could be claimed.

With regard to low-tide elevations, as provided by LOSC, Article 13, these may be used as a territorial sea basepoint, but only if they fall wholly or partially within the breadth of the territorial sea measured from the normal baseline of a State's mainland or island coasts. A low-tide elevation's value for maritime jurisdictional claims is therefore geographically restricted to coastal locations.[20] With respect to the ambulatory nature of normal baselines and the maritime jurisdictional limits measured from them it can be observed that low-tide elevations are often key culprits. This is because low-tide elevations, by virtue of their near low-tide level status and the fact that they are often composed of soft depositional material which may readily change over time, tend to appear on one survey but not the next, resulting in revisions in the related charts and thus in maritime jurisdictional limits associated with them.

Implications

Opting for a very low vertical datum and thus low water line inevitably means that often ephemeral features, such as low-tide elevations, are used as critical basepoints for the generation of claims to maritime jurisdiction. The loss of critical basepoints/islands, or the reclassification of an isolated feature from being an "island" capable of generating EEZ and continental shelf claims to a mere "rock" incapable of doing so or even to a low-tide elevation with even more restricted capacity to generate maritime claims or a sub-surface feature with no such capacity can have an enormous impact on the scope of claims to maritime jurisdiction. For example, the United Kingdom's 'roll-back' of its maritime claims to the northwest of Scotland as a result of reclassifying Rockall as a "rock" in line with Article 121(3) resulted in a loss to the UK of around 60,000 square nautical miles of previously claimed fishery zone.[21]

It is also the case that such features may be important in terms of the delimitation of maritime boundaries where maritime claims overlap. For example, in the course of the negotiation of the maritime boundary between Belgium and the United Kingdom, the United Kingdom was forced to abandon one of its key basepoints, a drying bank called the Shipwash, when a new hydrographic survey revealed that the feature had eroded to the extent that it no longer dried and could no longer be regarded as a low-

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[20] See, Carleton and Schofield, 2001: 38 and Prescott and Schofield, 2005: 107-108.

[21] Rockall itself now merely generates a 12nm territorial sea claim as evidence of its "vestigial insular status in international law." See, Symmons, C.R. (1998) "Ireland and the Rockall dispute: an analysis of recent developments", *Boundary and Security Bulletin*, Vol.6, no.1 (Spring): 78-93.

tide elevation.[22] It has, however, been long established that international maritime boundaries, once agreed, are not subject to change except through agreement among the parties concerned.

Furthermore, it is the case that where maritime limits are potentially constantly in flux because of shifts in the location of the normal baseline, and this raises implications in terms of maritime enforcement if maritime jurisdictional limits are similarly always changing. Recent Dutch experience in relation to fisheries enforcement off the Zeeland Banks as a consequence of the disappearance and reappearance of certain low-tide elevations provides an excellent example of the potential problems involved.[23] From the point of view of enforcement agencies, clarity, stability and certainty in respect of maritime jurisdictional limits is highly desirable and the ambulatory nature of such limits is unwelcome as it has the potential to undermine confidence in those limits and cause confusion. Overall, the fact that baselines and thus maritime limits are capable of shifting has the potential to result in jurisdictional uncertainty, disputes and conflict.

Concluding Thoughts: Options to Counter the Threat of Sea Level Rise

So what is to be done in the face of these threats to critical basepoints and related zones of maritime jurisdiction, the marine resource within which are often crucial to the economic well being of small island State? Doing nothing and letting coastlines and normal baselines find their natural equilibrium is one 'option', but is certainly unattractive, especially from the perspective of small island States with severely restricted territorial extents and thus little scope for coastlines to retreat. An alternative option with a long pedigree in the context of unstable coasts is an interventionist policy designed to protect the coastline from erosion through the construction of sea defences. Such measures to physically protect the coast from sea level rise are, however, likely to prove prohibitively expensive and generally unrealistic in light of the sheer scale of the challenge. Exceptions may, however, be made in exceptional circumstances for critical basepoints.[24]

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22 Carleton, C.M. and Schofield, C.H. (2002) *Developments in the Technical Determination of Maritime Space: Delimitation, Dispute Resolution, Geographical Information Systems and the Role of the Technical Expert*, Maritime Briefing, Vol.3, no.4 (Durham: International Boundaries Research Unit): 59-61.

23 Award of the economic police court in the case against Marijs, gebroeders H. en B., V.O.F., of 29 June 2007 cited in Dorst, L. and Elema, I. (2008) "The Effects of Changing Baselines on the Limits of the Netherlands in the North Sea", paper presented on 17 October 2008 at the Advisory Board on the Law of the Sea (ABLOS) Conference on Difficulties in Implementing the Provisions of UNCLOS, 15-17 October 2008, Monaco, at p.6. Available at, <http://www.gmat.unsw.edu.au/ablos/ABLOS08Folder/ablos08_papers.htm>.

24 Japan's construction of sea defences around Okinotorishima at a cost in excess of US$200 million providing an excellent example of this practice. On Okinotorishima see, for example, J. Brown, A. Colling, D. Park, J. Phillips, D. Rotehery, and J. Wright, Case Studies in Oceanography and Marine Affairs, (Oxford: Pergamon Press, 1991): 84-85. Prescott and Schofield, 2005: 84-85; A.L. Silverstein , "Okinotorishima: Artificial Preservation of a Speck of Sovereignty", *Brooklyn Journal of International Law*, 1990, Vol. XVI, 2: 409-431; Y.H. Song, "Okinotorishima: A "Rock" or an "Island"? Recent Maritime Boundary Controversy between Japan and Taiwan/China, pp.145-176 in S.-Y. Hong and J.M. Van Dyke (eds) *Maritime Boundary Disputes, Settlement Processes, and the Law of the Sea*, Publications on Ocean Development, Volume 65 (The Hague: Martinus Nijhoff, 2009); and, J. Van Dyke, "Speck in the Ocean Meets Law of the Sea", letter to the editor, *New York Times* 21 January

Rather than attempting stabilise and protect coastlines and normal baselines by intervening physically – something that may well prove unrealistic in the context of significant sea level rise – a number of legal measures may provide for the retention of existing maritime jurisdictional claims. While it is recognised that such approaches will not resolve the central problem of the inundation of vulnerable low-lying areas, they are not without merit.

At the Third United Nations Conference on the Law of the Sea it was generally not anticipated that sea level rise would engender such radical shifts in normal baselines and changes in insular status. Consequently, LOSC does not necessarily provide mechanisms to deal with these novel problems. The drafters of the Conventions were not averse to the permanent fixing of certain baselines and boundaries.[25] The goal of retaining existing maritime claims could be achieved by fixing the normal baseline or the limits of the maritime jurisdictional claims of coastal States. Regarding the former option it should be emphasised that normal baselines are dependent on choice of chart – a choice that is left up to the coastal State. The coastal State is therefore at liberty to choose a chart advantageous to it although over time tensions would inevitably arise between charts chosen by the coastal State for maritime jurisdictional purposes and (increasingly) reality. The latter option would essentially see the limits of maritime claims decoupled from ambulatory normal baselines.

Ultimately, therefore, there may be a need for a new rule and regime providing for the fixing of normal baselines. This might develop through State practice, with coastal States choosing particular charts for maritime jurisdictional purposes as outlined above or simply declaring the location of the limits of their maritime claims. Alternatively, the institution of such a departure from the traditionally accepted norm may call for multilateral negotiations as explored in Professor Hayashi's paper.

1988, available at <http://query.nytimes.com/gst/fullpage.html?res=940DE3D9163DF932A15752C0A96E948260&sec=&spon=#>.

25 For example, LOSC, Article 7(2) provides that: "Where because of the presence of a delta and other natural conditions the coastline is highly unstable, the appropriate points may be selected along the furthest seaward extent of the low-water line and, notwithstanding subsequent regression of the low-water line, the straight baselines shall remain effective until changed by the coastal State in accordance with this Convention." Similarly, the outer limits of the continental shelf may be "final and binding" in accordance with LOSC, Article 76(8).

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Sea Level Rise and the Law of the Sea: Legal and Policy Options

Moritaka Hayashi

I. Introduction

It is widely believed that due to climate change sea level will rise from 0.18 to 0.59 meters over the next century. Such a rise could have significant impacts on the baselines currently established by coastal States and the extent of the various maritime zones they claim on the basis of such baselines.

Other speakers in the Symposium have focused on such impacts and problems arising from them. This paper therefore will not repeat those aspects of sea level rise issues. It addresses instead legal measures that the international community can and should take in the future in order to avoid or mitigate adverse effects of sea level rise on coastal States, including island States. The main legal problems caused by sea level rise under existing law of the sea involve, in short, the obligation of the affected coastal State to adjust its baselines to geographic changes, and consequently it must adjust also the outer boundaries of maritime zones it claims as measured from such baselines. Such adjustments may include in the case of the territorial sea the loss of its sovereignty over part of it, and in the case of the exclusive economic zone (EEZ), the loss of its sovereign rights over part of the natural resources. In a more serious case, baselines of a small island may disappear when it is submerged completely, and thus the territorial sea and the EEZ it has generated may be lost[1]. Moreover, such "ambulatory" baselines that are to be adjusted to sea level rise remain inevitably unstable and uncertain, and particularly in areas rich in natural resources could become a source of dispute with neighboring States.

Various physical measures have already been or are being taken by coastal States to protect against coastal erosions. Such adaptation measures, however, cannot always be an effective permanent solution against the massive force of nature caused by climate change. This paper explores possible long term legal and policy measures to cope with adverse impacts on coastal States' maritime zones. These options will be discussed in Section II below. Then Section III will examine the possible procedures and legal forms or instruments for pursuing one of such options, i.e., adoption of new rules of international law.

II. Legal and policy options for mitigating effects of sea level rise

Several long-term legal and policy options are available for coastal States to mitigate

[1] With regard to the effects on the continental shelf, which are more complicated, see Section II, 1 (2) below.

the negative impacts caused by sea level rise on their maritime zones. These options may be divided into two categories: those which could be taken under the existing international law regime by making full use particularly of UNCLOS provisions, and those which go beyond the existing law, thus requiring the emergence of new rules of international law. These options will be discussed below, together with the options for special cases of island States which face the possibility of total submergence or of losing the capacity to sustain human habitation.

1. Wider use of existing rules of international law

UNCLOS, which is generally considered to reflect the current law of the sea, contains a number of technically detailed provisions for drawing baselines and fixing the outer limits of maritime zones. Coastal States, including archipelagic States, may make wider use of particularly the rules relating to straight baselines and low-tide elevations. Coastal States may also permanently fix the outer limits of their continental shelf with a view to securing as much maritime space not affected by sea level rise as possible. In addition to UNCLOS, numerous bilateral agreements regulate the delimitation of maritime boundaries, fixing in many cases permanently such boundaries irrespective of subsequent geographic changes affecting baselines. Wider use of such agreements is therefore another means available for avoiding adverse effects of sea level rise in relation to maritime boundaries with neighboring States.

(1) Use of straight baselines

Article 7 (1) of UNCLOS provides that in localities where the coastline is deeply indented and cut into, or if there is a fringe of islands along the coast in its immediate vicinity, the method of straight baselines joining appropriate points may be employed in drawing the baseline. Where such conditions exist, straight baselines may be drawn to and from rocky or other prominent points unlikely to suffer erosion from sea level rise. Once such lines are legally drawn, subsequent changes in the low water mark for normal baselines along the coasts situated within the straight baselines would have no effect on the baseline for measuring maritime zones[2]. It should be stressed, however, that in view of the fact that the use of straight baselines has often been abused and invited protests from other countries, States should be cautious and follow strictly the rules set out in Article 7[3].

Normally, straight baselines cannot be drawn to and from low-tide elevations. However, exceptions are made where lighthouses or similar installations which are permanently above sea level have been built on the low-tide elevations or in instances where the drawing of baselines to and from such elevations has received general international recognition (Art. 7 (4)). Similarly, an archipelagic State may draw straight archipelagic

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[2] See S. P. Menefee, "'Half Seas Over': The Impact of Sea Level Rise on International Law and Policy," *UCLA Journal of Environmental Law and Policy*, vol. 9 (1991), p. 212, citing Bird and Prescott, "Rising Sea Levels and National Maritime Claims," *Marine Policy Reports*, vol. 1 (1989), p. 193.

[3] See J. A . Roach and R. Smith, "Straight Baselines: The Need for a Universally Applied Norm," *Ocean Development and International Law*, vol. 31 (2000), p. 47.

baselines to and from low-tide elevations where lighthouses or similar installations which are permanently above sea level have been built on them (Art. 47 (4)). Thus, where conditions under Articles 7 and 47 are met, coastal States and archipelagic States could construct lighthouses or similar installations on appropriate low-tide elevations in order to enable them to be used as straight baseline points.

(2) Establishment of outer limits of the continental shelf

UNCLOS defines the outer limit of the continental shelf as either the outer edge of the continental margin or the line at a distance of 200 miles from the baseline where the continental margin does not extend to that distance (Art. 76 (1)). Where a coastal State claims extended continental shelf beyond 200 miles, relevant information must be submitted to the Commission on the Limits of the Continental Shelf (CLCS), and the limits of the shelf established by the coastal State on the basis of the Commission's recommendations "shall be final and binding" (Art. 76 (8)). UNCLOS further provides that the coastal State shall deposit with the UN Secretary-General charts and relevant information, including geodetic data, "permanently describing the outer limits of its continental shelf" and the Secretary-General shall give due publicity thereto (Art. 76 (9)). This implies that when a coastal State deposits with the Secretary-General the outer limits of its continental shelf, such limits must be described as *permanent* for not only those of the extended shelf, but also those of the 200 mile limit[4]. The permanent nature of the 200 mile limit would mean that if the baselines for measuring that limit recede in the future due to sea level rise, and as a consequence the outer limits of the territorial sea move landward, the breadth of the continental shelf, which lies adjacent to the territorial sea, increases[5]. The same conclusion can be drawn for those outer limits of the extended shelf which are fixed at a distance of 350 miles from the baselines in accordance with Article 76 (5). These effects of the permanent nature of the continental shelf limits are of particular importance for remotely-located small islands which are likely to be submerged or become uninhabitable when sea level rises. Some of such islands could be regarded as "rocks" under Article 121 (3) of UNCLOS, thus losing the continental shelf as well as the EEZ the islands have generated.

It is accordingly advantageous for coastal States to follow the above-mentioned procedure to establish permanently the outer limits of their continental shelf for both the 200 mile limit and the outer edge of the continental margin which lies beyond that limit. This is of crucial importance particularly in the case where an island State becomes inhabitable or submerged completely due to sea level rise, as discussed later in this paper.

(3) Bilateral delimitation agreements

It is a fundamental principle of international law that *pacta sunt servanda*, i.e., treaties

[4] A. H. A. Soons, "The Effects of a Rising Sea Level on Maritime Limits and Boundaries," *Netherlands International Law Review*, vol. 37 (1990), p. 216.

[5] See *ibid.* Soons considers this provision is remarkable since such a provision has not been included for the outer limit of the EEZ, even though the regime of the EEZ includes jurisdiction over seabed resources. *Ibid.*

are binding on their parties[6]. Exceptions are made to this rule, however, when a party invokes a "fundamental change of circumstances" from those which existed at the time when the treaty was concluded. That party may in such a case unilaterally terminate the treaty, provided that the conditions set out in the Vienna Convention on the Law of Treaties are met[7]. It may well be argued that a rise of sea level is regarded as such fundamental change when the sea level rise substantially affects the baselines that have been drawn by using ambulatory system, rather than by permanently fixed points described on charts or specified by geographical coordinates. There is, however, an explicit provision in that Convention to exclude a treaty which "establishes a boundary" from the application of this rule of fundamental change of circumstances[8]. It is therefore prudent for a State wishing to avoid any future change in maritime boundaries when major sea level rise occurs to conclude bilateral agreements using permanently fixed points for drawing boundary lines.

2. **Adoption of new rules of international law**

The options under existing law of the sea regime for avoiding or mitigating adverse effects of sea level rise, as discussed above, are quite limited. Indeed, during the Third UN Conference on the Law of the Sea, there was no widespread recognition of the possible problems of sea level rise and negotiators did not anticipate that there would be a significant global regression of coastlines[9]. There is thus no provision in UNCLOS to deal with possible rise in sea level or major changes in coastlines, except for the unique case of highly unstable coastlines in a delta and similar area, covered by Article 7 (2)[10]. It is therefore concluded that the only general legal solution of the problems of maritime zones caused by sea level rise is to be found in the emergence of new rules of international law.

What, then, should be the contents of such new rules of international law? In the last two decades, a few authors have made suggestions of such new rules. According to David Caron, e.g., UNCLOS provides that, in situations other than those covered by Article 7 (2), the outer boundary of the maritime zones of coastal States, including islands, is ambulatory in that they will move with the baselines from which they are measured[11]. He argues that the present law of baselines has the effect of encouraging nations to expending wasteful funds to preserve baselines, and also leads to uncertainty as to the boundaries of some maritime zones. He suggests therefore that the present law

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6 Vienna Convention on the Law of Treaties, Art. 26.
7 *Ibid.*, Article 62 (1).
8 *Ibid.,* Article 62 (2) (a).
9 D. Freestone and J. Pethick, "Sea Level Rise and Maritime Boundaries," in G H. Blake, ed., *Maritime Boundaries* (1994), p. 79; D. Caron, "When Law Makes Climate Change Worse: Rethinking the Law of Baselines in Light of a Rising Sea Level," *Ecology Law Quarterly*, vol. 17 (1990), p. 636.
10 Article 7 (2) provides that in such a case the appropriate points may be selected to draw straight baselines along the furthest seaward extent of the low-water line, and that notwithstanding subsequent regression of that line, the straight baselines shall remain effective until changed by the coastal State in accordance with the Convention. This provision was based on a draft originally proposed by Bangladesh for application to such areas as the Ganges delta.
11 Caron, *ibid.*, p. 635.

should be replaced by a system under which the boundaries of all maritime zones, in particular the territorial sea and the EEZ, are fixed on the basis of presently accepted baselines[12]. Caron argues that such fixing of maritime boundaries would be fair and equitable since it does not affect the allocation agreed to at the Third UN Conference on the Law of the Sea because it merely freezes the present division of authority over the oceans, and that if maritime boundaries are thus fixed, States do not gain any additional portion of the surface of the Earth even if baselines recede subsequently due to sea level rise[13].

In a similar vein, Judge (currently President) Jesus of the International Tribunal for the Law of the Sea (ITLOS) considers it reasonable for the sake of stability and for promoting orderly relations over oceans resources and uses that, once the baselines have been established in accordance with relevant provisions of UNCLOS, and given publicity thereto under Article 16 (2), such baselines should be seen as permanent baselines, irrespective of changes as a result supervening phenomenon such as sea level rise. Judge Jesus would apply this argument also to new-born islands and future qualification of rocks under Article 121[14]. He considers it legitimate that a substantial rise in sea level should not entail the loss of a State's ocean space and its rights over maritime resources already recognized by UNCLOS and by the community of nations. Moreover, his suggestion would not conflict with established maritime zones and resources of any country, nor would the international seabed or the high seas commons be affected[15].

A slightly different suggestion, though with the same objective with the above two authors, was made by A. Soons, who focuses on the outer limits of maritime boundaries rather than the position of baselines. He calls for a new general rule according to which coastal States are entitled, in the case of landward shifting of the baseline as a result of sea level rise, to maintain the outer limits of the territorial sea and of the EEZ where they were located at a certain moment in accordance with the general rules in force at that time. He cites Article 76 (9) of UNCLOS relating to the outer limits of the continental shelf, which serves as a precedent in support of the acceptance of such a rule[16].

The three authors cited above call for replacing the ambulatory baselines and/or outer limits of the territorial sea and the EEZ under UNCLOS with the permanently fixed ones. All of them have the same goal of fixing the outer limits of the maritime zones as the coastal State establishes in accordance with UNCLOS provisions before sea level rise actually obliges it to re-draw baselines landward. For reaching this goal, Caron and Jesus advocate the freezing of baselines, whereas Soons argues in favor of fixing the

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[12] *Ibid*., pp. 623, 640-641.
[13] *Ibid*., p. 648. See also D. Caron, "Climate Change, Sea Level Rise and the Coming Uncertainty in Oceanic Boundaries: A Proposal to Avoid Conflict," in S. Y. Hong and J. Van Dyke, eds., *Maritime Boundary Disputes, Settlement Process and the Law of the Sea* (in press).
[14] J. L. Jesus, "Rocks, New-born Islands, Sea Level Rise and Maritime Space," in J. Frowein, *et al*, eds, *Verhandeln für den Frieden. Negotiating for Peace* (2003), pp. 602-603.
[15] *Ibid*., p. 602.
[16] Soons, *supra* note 4, p. 225. See also Freestone and Pethick, *supra* note 9, p. 76.

outer limits, leaving the baselines ambulatory. While the goal is common, these two approaches imply an important difference in the legal status of the shore area newly submerged due to sea level rise. The fixing of baselines would mean that the future submerged area becomes internal waters, whereas fixing only the outer limits of maritime zones would expand the breadth of the territorial sea landward to the extent of the shifting of baselines. According to this latter approach, the newly submerged area would thus be subject to the regime of innocent passage. Between the two approaches, the former is more justifiable since the newly submerged area was once part of the land territory of the coastal State and the submerging is caused with no fault of that State. In addition, it has the merit of not changing the rules on the breadth of the territorial sea and the EEZ as stipulated in Articles 3 and 57, respectively. Moreover, according to the latter approach, it is not clear where the new baseline would be located in a case where the entire island in mid-ocean has been submerged.

Some doubts have been expressed regarding the idea of freezing the current baseline system. Referring to the cases of abuse of a number of countries in establishing straight baselines allegedly in violation of the rules in Article 7 of UNCLOS, Palmer argues that the freezing of the existing system would perpetuate the excessive claims without a hope to revise them[17]. He suggests that other measures could include further refinements of the parameters for the establishment of straight baseline systems in particular[18]. Palmer's view, however, is limited to the drawing of straight baselines only, which in no way leads to general solution to the problems caused by sea level rise.

From the foregoing discussion, it is submitted that the idea of freezing, and thus fixing permanently, the baselines and consequently the outer limits of various maritime boundaries has considerable merits and is worth pursuing further in order to find ways and means for its formal adoption by the international community. In summary, the suggestion is fair and equitable since it would enable a coastal State to keep the newly submerged space as internal waters to compensate for the loss of land territory caused by sea level rise, and also to retain its sovereignty or sovereign rights over the maritime zones it claims lawfully, including those generated by islands, even after the islands become submerged or uninhabitable. The suggestion would not deprive any other State of any of its maritime space nor would it reduce the area of the high seas. Furthermore, the proposal would contribute to the stability and orderly relations involving maritime borders of neighboring countries, and thus to "the strengthening of peace, security, cooperation and friendly relations among all nations," which is a major objective of UNCLOS as enshrined in its preamble.

In pursuing further the idea of freezing the baselines and outer limits of maritime zones, it would be useful to clarify exactly at what moment they should be frozen. Various options exist for this purpose, including the time of entry into force of UNCLOS, and the establishment of baselines by each State according to the relevant provisions and the publicity given thereto under Article 16 (2). The better option should be the latter, since

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[17] T. Palmer, "Sea level Change and Baselines," in Proceedings of the Canadian Hydrographic Conference and National Surveyors Conference 2008 (http:// pac.chs.gc.ca/files/session_2A/2A-2_Palmer.pdf), p. 4.

[18] *Ibid.*, p. 9.

it is the explicit obligation of the coastal State to show its baselines on charts or indicate geographical coordinates of baseline points, and give due publicity to them, with a copy to be deposited with the UN Secretary-General[19]. There is, however, no time limit for States Parties to fulfill this obligation and many have not done so yet[20]. This option may well have an additional effect of encouraging States to expedite their efforts to establish their baselines.

The proposal advanced here for new rules of international law may be formulated in relatively simple provisions in an appropriate instrument, which should be adopted in the future as discussed later in this paper. The core provision of such new rules might read something like the following:

> *A coastal state may declare the baselines established in accordance with the relevant provisions of UNCLOS as permanent once it has shown them on charts of an adequate scale or described them by a list of geographical coordinates, and given due publicity thereto, notwithstanding subsequent changes in geographic features of coasts or islands due to sea level rise.*

3. Policy Options for Submerging Island States

The above discussion relating to baselines applies generally to small islands. However, the special case of total submerging of all the islands constituting a State, including the case of near submergence where an island State becomes totally uninhabitable, due to sea level rise, deserves additional consideration. According to general international law, a defined territory and a people are the essential components of a State, together with a sovereign government[21]. Therefore, the permanent fixing of baselines would make no sense if the State itself ceases to exist due to the loss of population or land territory which generates maritime zones. On the other hand, if the State continues to exist somewhere else, permanent fixing of baselines before the submergence or near submergence would enable that State to continue to exercise its sovereignty or sovereign rights over the maritime zones and the resources therein. This would include the continental shelf up to 200 miles from the original baseline, as well as extended continental shelf, if any, should that State have permanently established its outer limits in accordance with Article 76 of UNCLOS.

At least three options are available for an island State to pursue in order to preserve its rights over the maritime zones once it has secured them by fixing their limits permanently. First, the island State may obtain a portion of territory from another State,

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[19] Articles 5 and 16. For the continental shelf, Art. 76 (9) requires the coastal State to deposit the Secretary-General "charts and relevant information", permanently describing the outer limits. Where the outer limit is drawn at a distance of 200 nm from the baselines, it is assumed that such "relevant information" includes position of the baselines.
[20] According to the UN Office for Ocean Affairs and the Law of the Sea, as at the end of 2008, "only a relatively small number of States Parties have fully or partially complied with their deposit obligations."
http://www.un.org/Depts/los/LEGISLATIONANDTREATIES/backgroud_deposit.htm.
[21] R. Jennings and A. Watts, eds., *Oppenheim's International Law*, 9th ed., vol. I (1996), pp. 121-122.

into which the government and population of the former migrate, thus continuing its status as an independent State. This could be done, e.g., through a treaty of cession or purchase[22]. This would be a best solution for the island State. In practice, however, it appears to be rather unrealistic today for any State to donate or sell part of its territory fit for human settlement to another State.

Secondly, it is possible at least theoretically for a submerged island State to be recognized by the international community as an international person *sui generis* and maintain its right to exercise sovereignty or sovereign rights over the maritime areas[23]. Obviously in such a case, the government together with the population must have been migrated into the territory of another State, without keeping its complete independence as a State. Although the Royal Order of Malta[24], was mentioned as an example[25], it appears hardly possible for an international person without a defined territory or population to actually exercise sovereignty or sovereign rights over maritime areas.

A third option, which appears to be the best solution, is for the island State, through a treaty, to establish a fusion with another State[26], or form some kind of federation with another State[27], and the entire population migrates into the new territory. Arrangements should be made for the new united State to become the successor of the island State including the latter's rights over the maritime zones. Depending upon the terms of the treaty, the rights over the submerged maritime zones would be exercised either by the central government of the union or federation, or by the government of the former island State which becomes a component of the union or federation.

III. Procedural Options to Adopt New Rules

In Section II, 2 above, it was concluded that a best general legal approach for mitigating the effects of sea level rise is for the international community to adopt new rules which would permit fixing permanently the baselines and outer limits of various maritime zones as they are established by the coastal State in accordance with UNCLOS. This Section examines what options are available as a procedure to adopt or establish such new rules. Broadly speaking, such procedures are either the development of customary international law or the adoption of treaties. Treaties may take various forms such as protocol under an existing treaty, or amendment or agreement supplementary to UNCLOS.

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22 See Soons, *supra* note 4, p. 230.

23 Freestone and Pethick, *supra* note 9, p. 80.

24 The Royal Order of Malta, or the Sovereign Military Order of Malta, is based in Rome, Italy, has its own "government", an independent magistracy, bilateral diplomatic relations with 102 countries and is granted the status of Permanent Observer in many international organisations, such as the United Nations. The Order issues its own passports and stamps and creates public institutions, endowed with independent juridical personality. See http://www.orderofmalta.org/site//struttura.asp?idlingua=5. It is a religious order engaged mainly in medical and humanitarian services.

25 Freestone and Pethick, *ibid.*

26 See *ibid.*

27 Caron, *supra* note 9, p. 650.

1. Development of customary international law

Some authors have advocated the development of customary international law as a best means to incorporate new rules on the effects of sea level rise[28]. For this purpose, it would be necessary for coastal States concerned to maintain in practice their original baselines and outer limits of their maritime zones despite sea level rise and to attempt to gain approval of such practice in the relevant international forums[29]. Such practice must become widespread and be accepted by the international community in general in the form of a legal conviction (*opinio juris)* as reflecting new rules. This approach, therefore, would normally require a considerable period of time before new rules are established. In addition, the approach may not always be practical since by the time when sufficient amount of State practice accumulates, some island States may have been submerged, and thus it would be too late even if new rules of international law emerge.

2. Adoption of a Protocol to the Climate Change Convention

The Coastal Zone Management Subgroup of the Intergovernmental Panel on Climate Change (IPCC) proposed in 1990 to adopt a protocol to the UN Framework Convention on Climate Change, and this was supported by some authors as useful means to incorporate new rules[30]. The State Parties to the Convention are indeed competent to adopt a protocol[31], as they have done for the Kyoto Protocol, on any matter relating to the Convention, which presumably include sea level rise. Such a protocol, however, would be a treaty totally separate from UNCLOS and since it would inevitably touch upon law of the sea aspects, it could introduce complicated legal relationship between the two treaties. It would therefore be best for any additional agreement relating to UNCLOS be negotiated within the framework of UNCLOS or the General Assembly, as discussed below.

3. Modification or expansion of UNCLOS provisions

The European Commission suggested that with the projected major changes such as receding coastlines and submergence of large areas resulting in possible loss of territory, "there might be a need to revisit existing rules of international law, particularly the Law of the Sea, as regards the resolution of territorial and border disputes"[32]. Revisiting the law of the sea may take one of the three approaches: formal amendment of UNCLOS provisions, their *de facto* amendment by a decision of the Meeting of States Parties to UNCLOS, or adoption of a supplementary agreement for the modification or implementation of its provisions.

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[28] Soons, *supra* note 4, p. 225; Caron, *supra* note 9, p. 651;

[29] See Soons, *ibid.*, p. 231, who stresses the need to maintain original outer limits of maritime zones.

[30] Freestone and Pethick, *supra* note 9, p. 76.

[31] Article 17.

[32] *Climate Change and International Security*. Paper from the High Representative and the European Commission to the European Council, S113/08 (14 March 2008) p. 4. http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/reports/99387.pdf. (accessed 29 Sept. 2008)

(1) Amendment of UNCLOS provisions

According to the established procedure under UNCLOS[33], any State Party may, by written communication to the UN Secretary-General, propose specific amendments to its provisions and request him/her to convene a conference to consider such amendments. The Secretary-General must convene the conference if not less than half of the States Parties reply favorably within 12 months after the date of the circulation of the request.

Alternatively, a State Party to UNCLOS may propose an amendment to be adopted by the "simplified procedure" without convening a conference and request the Secretary-General to circulate the proposal to all States Parties. If no State Party has objected to the proposed amendment or to the proposal for its adoption by the simplified procedure within 12 months from the date of its circulation, the amendment shall be considered adopted[34].

Amendments adopted by the conference or the simplified procedure and entered into force in accordance with these procedures shall be binding only on the States Parties which have ratified them[35].

These amendment procedures have so far not been used. One reason for this may be the importance of the fact, in the belief of the States Parties, that UNCLOS was adopted through a "package deal", and the General Assembly's reaffirmation repeated every year of "the unified character of the Convention and the vital importance of preserving its integrity."[36] Any formal proposal for amendment would thus be likely to invite immediate reaction for the sake of preserving the integrity or balance achieved as a result of the package deal. Additionally, the simplified procedure would not be an attractive method since only one Party can block the whole process.

It may therefore be concluded that for dealing with the effects of sea level rise, the formal amendment procedures of UNCLOS are not likely to achieve easy success.

(2) Decisions of the Meeting of States Parties to UNCLOS

Apart from these procedures for formal amendment, the Parties to UNCLOS have actually amended *de facto* some of its provisions by way of consensus decision of the Meeting of States Parties (SPLOS). This has happened in four occasions. Thus, in 1995, SPLOS decided to postpone until 1 August 1996 the first election of the judges of ITLOS, which was stipulated in Article 4 (3) of Annex VI to the Convention to be held "within six months of the date of [its] entry into force"[37]. Later in the same year, SPLOS similarly postponed until March 1997 the first election of the members of CLCS, which

[33] Articles 312 and 316.
[34] Article 313.
[35] Article 316.
[36] Eg., General Assembly resolutions 62/215, para. 2, and 63/111, para. 2.
[37] *Report of the Meeting of States Parties* (Doc. SPLOS/3 (1995)), para. 16. The last day "within six months" was 16 May 1995.

Article 2 (2) of Annex II to the Convention specified to be held "as soon as possible but in any case within 18 months after the date of entry into force of this Convention"[38]. In 2001, SPLOS decided that the time limit for a coastal State to make submission of its claimed limits of continental shelf beyond 200 nm to CLCS "shall be taken as having commenced on" 13 May 1999, in derogation from the requirement in Article 4 of Annex II to the Convention to do so "within 10 years of the entry into force of this Convention for that State."[39] Lastly, in 2008, revisiting this 2001 decision, SPLOS decided that "[i]t is understood that the time period referred to in article 4 of annex II to the Convention …and [the above-mentioned 2001 decision] may be satisfied by submitting to the Secretary-General preliminary information indicative of the outer limits of the continental shelf… and a description of the status of preparation and intended date of making a submission."[40]

With respect to these four decisions of SPLOS, there was no agreement among States Parties or among commentators as to their legal nature, particularly whether they are amendments or "understanding" of the specific provisions of UNCLOS.[41] It is however clear that they do have the legal effect of changing the clear letters of the relevant provisions. Nevertheless, it is also clear that such changes are limited only to those provisions which relate to certain time limits for States Parties to take action. These provisions are certainly not comparable with the provisions relating to baselines and the status of islands, which are designed to lay down substantive rules affecting, *inter alia,* the exercise of sovereignty or sovereign rights of coastal States.

Whether SPLOS is legally competent to deal with such issues of substance will be further discussed below together with other possible forums for negotiating and adopting an agreement supplementing UNCLOS.

(3) Agreements supplementary to UNCLOS

Agreements which are aimed at supplementing, interpreting or implementing UNCLOS may be negotiated and adopted in various forums. The main forum could be a meeting

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38 *Report of the Third Meeting of States Parties* (Doc. SPLOS/5 (1996)), para. 20. The last day of "the 18 months" was 16 May 1996.

39 SPLOS, *Decision regarding the date of commencement of the ten-year period for making submission to the Commission on the Limits of the Continental Shelf set out in article 4 of Annex II to the United Nations Convention on the Law of the Sea* (Doc. SPLOS/72 (2001)).

40 SPLOS, *Decision regarding the workload of the Commission on the Limits of the Continental Shelf and the ability of States, particularly developing States, to fulfil the requirements of article 4 of annex II to the United Nations Convention on the Law of the Sea, as well as the decision contained in SPLOS/72, paragraph (a)* (Doc. SPLOS/183 (2008)), para. 1 (a).

41 For detailed analysis of these decisions, see A.G. Oude Elferink, "Reviewing the Implementation of the LOS Convention: the Role of the United Nations General Assembly and the Meeting of States Parties", in A.G. Oude Elferink and D.R. Rothwell, eds., *Ocean Management in the 21st Century: Institutional Frameworks and Responses* (2004), p. 295; T. Treves, "The General Assembly and the Meeting of States Parties in the Implementation of the LOS Convention", in A.G. Oude Elferink, ed., *Stability and Change in the Law of the Sea: The Role of the LOS Convention* (2005), p. 55; A.G. Oude Elferink, "Meeting of States Parties to the UN Law of the Sea Convention," *International Journal of Marine and Coastal Law*, vol. 23 (2008), p. 769.

of its States Parties, but a conference open for all interested States, or the UN General Assembly could also adopt such agreements.

First, can SPLOS, which has adopted certain decisions *de facto* modifying some UNCLOS provisions as discussed above, serve as a forum for negotiating a supplementary agreement? UNCLOS has no provisions regarding the adoption of agreements or protocols. It is generally understood that under Article 319, SPLOS meetings are convened by the Secretary-General only "in accordance with the Convention" and UNCLOS specifically assigned to such meetings the tasks for electing members of ITLOS and CLCS, as well as administrative and financial matters of these institutions[42]. States Parties appear to be divided on whether SPLOS has the mandate to deal with matters of a substantive nature relating to the implementation of UNCLOS[43], which presumably include the adoption of a protocol or similar agreement. Since SPLOS is a body consisting of all the Parties to UNCLOS, however, there should be no legal obstacle for it to decide, particularly by consensus, to convene an *ad hoc* conference of the States Parties specifically to negotiate and adopt a protocol or other agreement for the interpretation or implementation of, or for supplementing, provisions of the Convention[44]. After a thorough analysis of various amendment procedures under UNCLOS, Freestone and Oude Elferink conclude that "international law does not preclude State Parties to a treaty amending it by agreement", and that "such an agreement may presumably take the form of a decision of a meeting of States Parties"[45].

Secondly, a conference may be convened, typically by the General Assembly, to which all interested States, including non-parties, are invited to negotiate and adopt an agreement relating to UNCLOS. This is the procedure that was actually followed when the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks was convened and adopted the Agreement for the Implementation of the Provisions of the UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement). The Agreement does not amend UNCLOS provisions, but supplements and expands them with detailed rules and strengthens the basic principles[46]. One of the advantages of this option is the possibility of the conference to include as full participants not only the parties but also non-parties to the Convention.

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42 See, eg., Annex II, Art. 2; Annex IV, Arts. 4, 18 and 19.
43 *Report of the eighteenth Meeting of States Parties*, *13-20 June 2008* (Doc. SPLOS/184), para. 118.
44 The Parties must however respect Article 311 (3), which provides *inter alia* that such agreements shall not relate to a provision derogation from which is incompatible with the effective execution of the object and purpose of the Convention and that they shall not affect the application of the basic principles embodied therein.
45 D. Freestone and A. Oude Elferink, "Flexibility and Innovation in the Law of the Sea – Will the LOS Convention Amendment Procedures Ever be Used?", in A. Oude Elferink, ed., *supra* note 41, p. 209.
46 See M. Hayashi, "The 1995 Agreement on the Conservation and Management of Straddling and Highly Migratory Fish Stocks: Significance to the Law of the Sea Convention," *Ocean and Coastal Management*, vol. 29 (1995), p. 51.

Thirdly, the General Assembly itself may adopt the text of an agreement after it is negotiated in its subsidiary forum like a special committee or working group, or in another body or informal consultations outside the Assembly. Once the text of the agreement is completed by such a forum, it is then submitted to the General Assembly normally in the form of an annex to a draft resolution. In such resolution the Assembly typically encourages Member States to sign and ratify the agreement. This is the formula followed by the Assembly when it adopted the Agreement relating to the Implementation of Part XI of the UNCLOS, the text of which had been negotiated in informal consultations convened at the initiative of the Secretary-General. Although in its title the Agreement purports to "implement" Part XI provisions, in fact it contains a number of provisions to drastically change them, including the suspension of their application. This process was unique in that all substantive negotiations were conducted in informal meetings, which enabled any interested States to participate in the actual re-negotiation of formally adopted provisions without forcing committed States to lose their face. Another important factor contributing to the successful *de facto* revision of UNCLOS was the fact that fundamental changes in political and economic situations which had not been foreseen occurred since the adoption of its text some ten years earlier.

IV. Conclusions

Various measures are being taken or contemplated by coastal States in order to cope with sea level rise that is already happening or about to happen. Such measures are, however, mostly physical, and can never be a long-lasting solution for those coastal areas or small islands which would be seriously affected. Although limited to the questions of baselines and maritime boundaries, the new legal rules discussed above to freeze the baselines and boundaries now permitted under UNCLOS would ensure the affected States to maintain, despite future sea level rise, the rights over the maritime zones they have legally established.

Three possible approaches for adopting such new rules are discussed above. The best approach is clearly the modification of, or supplementing, UNCLOS provisions. For that purpose, three possible procedures are identified. All of such procedures are available, together with the combination of their various elements, for negotiating an agreement on sea level rise. The first procedure, i.e., a meeting or conference of the States Parties, appears to be certainly a best procedure should it become possible for its non-parties, particularly the US, to accede to the Convention or for the conference to find a way to allow their *de facto* full participation. Unless that possibility realizes, the second procedure, i.e., a conference open for full participation of all interested States to negotiate and adopt an agreement, would be more appropriate. The third procedure, i.e., adoption of an agreement by the General Assembly after negotiation in its subsidiary bodies or informal consultations, appears to be also attractive since sea level rise may be considered to be a fundamental change of circumstances like the one that prompted the re-negotiation of UNCLOS Part XI. The informal consultations would be particularly useful if a future sea level rise agreement is aimed at revising *de facto* some of the UNCLOS provisions since a revision or amendment would be too delicate to raise at formal meetings and may risk the re-opening of negotiations on other provisions.

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Panel III – Management of Islands and Surrounding Ocean Areas

W(h)ither Tuvalu? Oceans Governance and Disappearing States

by
Rosemary Rayfuse[*]

Introduction

Not since the demise of the fabled state of Atlantis has the world witnessed the actual physical disappearance of a state. Certainly, states have come and gone as a result of conflict, conquest or politics continuously changing the geopolitical map of the world. However, with a few minor exceptions of islands and other areas emerging or disappearing, the geophysical map has remained constant over the past millennium. This now looks set to change, with climate change induced sea level rise threatening to redraw the physical geographical reality of the world, radically altering coastlines, creating new ocean areas, and potentially inundating entire nation states.

The effects of sea level rise and the threats it poses for coastal states and international governance have been the subject of extensive study and commentary since the 1980s. Sea level rise – whether caused by natural or anthropogenically induced or exacerbated climate change – will affect food and water security, health and sanitation, and will seriously threaten the lives and livelihoods of people around the world, leading ultimately to displacement and migration. The extreme vulnerability of low-lying coastal areas and islands to sea encroachment is now notorious with the most serious threat being to the continued viability and actual existence of island states such as Tuvalu, Kiribati, the Marshall Islands and the Maldive Islands.

[*] Professor of International Law, Faculty of Law, University of New South Wales, Sydney, Australia

While the possibility of 'disappearing' states has been recognized since the late 1980s, the issue has thus far been dealt with predominantly as one involving 'climate' or 'environmental refugees' requiring relocation to protect them from the rising waters. This focus on 'environmental refugees' has, however, been heavily criticized as lacking in intellectual, theoretical and empirical rigour, and as a distraction from the real issues of mitigation and adaptation to climate change, poverty eradication, sustainable development and conflict resolution.[1] Indeed, far from protecting the rights of persons displaced due to sea level rise, the use of the pejorative, essentially negative concepts of refugee law serves only to conclusively disempower the persons being displaced.

This paper examines an alternative, and potentially more constructive, approach to the issue of disappearing states by focusing on analysis of the issue of sea level rise and the possible inundation of vulnerable island states as one of oceans governance involving questions of entitlement to and jurisdiction over maritime spaces.

Sea Level Rise and Maritime Jurisdiction

International law relating to entitlement to maritime zones is set out in the 1982 Law of the Sea Convention. While jurisdictional rights over the territorial sea, contiguous zone, exclusive economic zone and continental shelf may differ, the outer boundary of each of these zones is measured from a common baseline. According to Article 5, except where otherwise provided in the LOSC, the normal baseline is the 'low-water line along the coast as marked on large-scale charts officially recognized by the coastal state'. In certain circumstances, straight baselines drawn in accordance with the specific rules set out in Article 7 may be used. However, with the exception of deltaic baselines provided for in Article 7(2) and the outer boundary of the extended continental shelf which is arguably permanently fixed by operation of Article 76(9), the LOSC does not indicate whether the outer boundary of maritime zones moves as baselines – or the low-water mark on which

[1] Richard Black, 'Environmental Refugees: myth or reality', *New Issues in Refugee Research*, Working Paper No, 34, available at http://www.unhcr.ch/refworld/pubs/pubon.htm; Stephen Castles, 'The International Politics of Forced Migration' 43(3) *Development* (2003) p 15; David Corlett, *Stormy Weather: The Challenge of Climate Change and Displacement*, (UNSW Press, 2008) pp 47-55

they are based – move. Rather, the question is left to be dealt with by negative implication based on textual interpretation with commentators such as Alexander,[2] Caron[3] and Soons[4] concluding that outer boundaries of the territorial sea, contiguous zone, and exclusive economic zone must, as a result of this negative implication, be ambulatory.

The difficulty with the theory of ambulatory baselines is immediately apparent. Applying the ambulatory interpretation, if the baseline moves the outer boundary of the zone moves. All coastlines, and hence the delimitation of all maritime zones, will thus be affected. Of particular concern, permanent inundation of low-tide elevations and fringing reefs which had been within 12 nautical miles of shore and thus used as basepoints in accordance with Articles 13 and 6 of the LOSC would result in significant loss of width of all maritime zones. Even greater shifts would occur in the case of islands. While an island can generate all maritime zones, 'rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf'.[5] Thus, once rendered uninhabitable by sea level rise, uninhabitable islands would lose their exclusive economic zone and their continental shelf. Should the island disappear entirely, it would lose its territorial sea as well.[6] Apart from the uncertainty as to the location of maritime boundaries and zones thus created, as Khadem puts it: 'changes of this magnitude could provide a fertile source of inter-state conflict and spark disputes over navigation rights and more particularly sovereignty rights to living and non-living resources'.[7]

Admittedly states might seek to reinforce basepoint features to preserve them from inundation or erosion by wave action. Japan's attempts to preserve Okinotorishima are an

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[2] Alexander, 'Baseline Delimitations and Maritime Boundaries' 23 *Virginia Journal of International Law* 503 (1983) p 535

[3] David D Caron, 'When Law Makes Climate Change Worse: Rethinking the Law of Baselines in Light of a Rising Sea Level' *17 Ecology Law Quarterly* (1990) 621-653, p 634

[4] Alfred H. A. Soons, 'The Effects of a Rising Sea Level on Maritime Limits and Boundaries' 37(2) *Netherlands International Law Review* (1990) 207-232, pp 216-218

[5] LOSC Art 121(3)

[6] Soons p 216-217

[7] Alain Khadem, 'Protecting Maritime Zones from the Effects of Sea Level Rise' 5(3) *IBRU Boundary and Security Bulletin* (Autumn 1998)

oft-cited example. According to Soons, artificial conservation of coastline and islands through construction of shoreline protection, reinforcement, and sea defences, is fully permitted under international law. He argues that a natural feature thus enforced should not, by virtue of that reinforcement lose its status as a base point even if the natural feature itself is no longer above water. However, as he notes, both the costs and the technical challenges associated with such projects may prove insurmountable.[8] As Caron notes, artificial conservation of baselines for the purpose of preserving maritime entitlements leads inexorably to economic ineffiency and waste, potentially diverting assets from the more pressing task of funding more appropriate and effective climate change mitigation and adaptation activities that will allow a state to continue to develop sustainably.[9]

One argument raised to rebut the ambulatory interpretation suggests that the practical effect of marking the low water line on a chart as required by Article 5 may be to 'fix' that baseline as against coastal regression and the claims of other states, at least until such time as new charts are produced.[10] However, as Caron notes, this is a practical matter which does not resolve the legal question of whether the LOSC intended baselines to be fixed or ambulatory in the case of coastal regression.[11] Indeed, except for the two specific cases already referred to and positively addressed in the LOSC (deltaic baselines and the limits of the outer continental shelf), the issue of the effect of coastal regression on the location of baselines and the delimitation of maritime zones does not appear to have been in the contemplation of the drafters of the LOSC.

Hindsight is always 20/20. With hindsight it is easy to suggest that the LOSC negotiators should have considered the effects of sea level rise on the legal regime they were crafting and provided rules covering its eventuality. That the issue was not considered in the 1970s is, however, no reason not to consider it now, in light of changing circumstances,

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8 Soons p 222-223. See also, Barbara Kwiatkowska and Alfred H.A. Soons, 'Entitlement to Maritime Areas of Rocks Which Cannot Sustain Human Habitation or Economic Life of Their Own' 21 *Netherlands Yearbook of International Law* 139-181, p 172

9 Caron pp 639-640

10 D. Kapoor and A. Kerr, *A Guide to Maritime Boundary Delimitation* (1986) p 31

11 Caron p 634

and to examine the risks that might flow from adopting the ambulatory interpretation of the rules on baselines. The imperative for this consideration is highlighted by the increasing evidence of both real and projected global sea level rise, the effects of which will be felt on coastlines everywhere, but most particularly where low-tide elevations, fringing reefs or islands have been used as baseline points, and especially in the case of island states.

To counter the potential for economic waste and potential conflict that the assumption of the ambulatory theory of baselines implies, both Caron and Soons propose rejecting the ambulatory theory and developing a new rule of customary or conventional law freezing the outer limits of maritime zones 'where they were located at a certain moment in accordance with the general rules in force at the time'.[12] This is not to suggest that all disputes over entitlement to and delimitation of maritime zones would thus be resolved. Like the freeze on disputed sovereignty claims in Antarctica, freezing existing maritime zones would not imply acceptance of disputed basepoint and island claims. Pre-existing disputes over the status of rocks and islands or the location and legitimacy of straight baselines would persist until resolved through the normal processes. However, pending resolution of any such outstanding disputes, a freezing of the outer limits of all maritime zones accepted at the relevant moment – whenever that might be – would be consistent with, and would significantly assist in, the promotion and achievement of the LOSC objectives of peace, stability, certainty, fairness, and efficiency in oceans governance. Ultimately, as Caron suggests, a freeze on the outer limits of maritime zones would also be a valuable climate change adaptation strategy in that resources could be directed to substantive adaptation needs rather than the artificial preservation of baselines merely for the purpose of preserving maritime entitlements; new wetlands and coastal ecosystems could be created to replace those lost to rising seas thereby assisting in the relocation and conservation of species and habitats under threat; and the prime asset of many coastal states, in particular of small island and developing states would be preserved.[13] This becomes particularly important in the case of disappearing states.

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[12] Soons, p 225. See also Caron, p 650
[13] Caron pp 642-50

Sea Level Rise and Disappearing States

Even assuming a freeze on the outer limits of maritime zones, however, this does not entirely dispose of the problem of maritime zones in the context of disappearing states. Only states are entitled to claim maritime zones. Thus, the existence of maritime zones depends on the existence of a state. The traditional international law criteria for statehood include the fundamental requirements of territory and a permanent population. As the territory of a threatened island state disappears beneath the waves, the criteria of territory will no longer be met and the claim to statehood will fail. Of course, disappearance is most likely to be a gradual process with the territory being rendered uninhabitable and the population having fled long before the territory's total physical disappearance. In this case, too, the criteria for statehood will cease to be met from the time of evacuation and the state will cease to exist. The now former state's maritime zones and boundaries will therefore lapse, reverting either to high seas and the Area or, where geographical conditions permit, to areas under the jurisdiction of neighbouring states.[14]

Once considered an almost fanciful scenario, the reality of increasingly severe ocean encroachment causing loss of landmass and potable water and rendering islands uninhabitable is already blamed for displacement of at least two populations. In 2006 the residents of Lohachara island in the Bay of Bengal moved to a nearby island to escape their rapidly disappearing island.[15] In 2007 residents of Papua New Guinea's Cateret Islands were evacuated to nearby Bourgainville.[16] While these relocations have been intra-state, the problem of the disappearing state requires consideration of the *modus operandi* for what will ultimately be the wholesale relocation of the entire population of a state; an issue which has concerned governments of vulnerable island states such as Tuvalu, Kiribati and the Maldives since the 1980s.

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[14] Caron, p 650 and Soons, p 230

[15] G. Lean, 'Disappearing World: Global Warming Claims Tropical Island' *The Independent* (24 December 2006)

[16] J. Stewart, 'Rising Seas Force Cataret Islanders out of Home' Lateline, ABC television (5 February 2007). Transcript http://www.abc.net.au/lateline/content/2006/s1840956.htm

One possibility, alluded to by Soons, is for the disappearing state to acquire new territory from a distant state by treaty of cession.[17] Like the Alaska purchase, sovereignty over the ceded land would transfer in its entirety to the disappearing state which would then relocate its population to the new territorial location. The continued existence of the state would now be secured in accordance with traditional rules of international law. The pre-existing maritime zones of the state would continue to inure to the relocated state regardless of geographical proximity in the same way that any state currently claims maritime zones in respect of oceanic islands forming a part of its territory.

From a legal perspective, the acquisition of title to and sovereignty over new territory by purchase and/or treaty of cession undoubtedly represents the most straightforward and appealing solution. Indeed, precedent exists for this approach to responding to environmental catastrophes. During the 1870s tens of thousands of Icelanders were driven out of Iceland as a result of crushing poverty exacerbated by a devastating volcanic eruption that destroyed half the island. The Canadian government entered into an agreement with these settlers granting them a suitably large piece of land for their new colony, providing them with funding and livestock to assist in their resettlement, and guaranteeing their rights both as citizens of Canada and of Iceland for themselves and their descendants. The colony of New Iceland was run by a government committee elected from amongst the settlers. Located in what is now southern Manitoba, New Iceland eventually joined the province of Manitoba becoming fully integrated into Canada.[18]

However, from a practical perspective it is difficult to envisage any state now agreeing, no matter what the price, to cede a portion of its territory to another state unless that territory is uninhabited, uninhabitable, not subject to any property, personal, cultural or other claims, and devoid of all resources and any value whatsoever to the ceding state.

[17] Soons, p 230
[18] See, eg, Elva Simundsson, *Icelandic Settlers in North America* (Winnipeg: Queenstown House Publishing, 1981); Thorstina Walters, *Modern Sagas* (North Dakota Institute for Regional Studies, 1953); Nelson S. Gerrard, *Icelandic River Saga – A History of the Icelandic River and Ísafold Settlements of New Iceland* (Winnipeg, 1985); W. Kristijánsson, *The Icelandic People in Manitoba* (Winnipeg, 1965); W.J. Lindal, *The Icelanders in Canada* (Ottawa/Winnipeg, 1967); and Sigtyggur Jónasson, *The Early Icelandic Settlements in Canada,* Historical Society of Manitoba: Transaction No 59 (Winnipeg, 1901)

The political, social and economic ramifications of ceding valued and/or inhabited territory may simply exceed the capacities – and courage – of existing governments.

Another alternative suggested but not elaborated on by both Soons and Caron, is for the disappearing state to merge, possibly into some form of federation, with another state.[19] The population of the disappearing state would then be physically relocated within the territory of the other 'host' state. Again, pre-existing maritime zones would continue to remain effective. However, these zones would now inure to the 'host' state. At the domestic level, international human rights law and the rules relating to internal self determination would provide protections for the relocated population within the 'host' state. At the international level, however, it would be the 'host' state which would represent their interests. In other words, the disappearing state would cease to exist and have no further say in the exploitation and management of its former maritime zones. The disappeared state would basically have purchased its relocation with its maritime zones.

While this, too, may seem like a straightforward, pragmatic and legally sound solution to the problem of disappearing states, the rationale for and manner in which such a merger would take place also gives rise to a number of concerns. A merger of this type would ultimately require the absorption and relocation by the 'host' state of the total population of the disappearing state. States have already shown their unwillingness to engage in such wholesale population absorptions. When, in 2001, Tuvalu approached Australia and New Zealand about the possibility of taking its population in the case of total loss of its territory, Australia flatly refused, while the most New Zealand would agree to was a 30 year immigration program which accepts up to 75 Tuvaluans per year who must be 'of good character and health, have basic English skills, have a job offer in New Zealand, and be under 45 years of age'.[20] With a current Tuvaluan population of approximately 11,000, this still leaves nearly 9000 people to find resettlement elsewhere or drown. Moreover, the equity and fairness of a solution that requires those who are least to blame

[19] Soons, p 230; Caron, p 650
[20] Ministry of Pacific Islands Affairs, *New Immigration Category for Pacific Migrants*, (2002) http://www.minpac.govt.nz/publications/newsletters/nl0mar02/immigration.php

for climate change being obliged to relinquish jurisdiction and control over their vast and potentially extremely lucrative maritime zones to states who may well be among those most to blame for climate change must be questioned.

Ultimately, a more equitable solution may lie in recognition of a new category of deterritorialised state. While a full analysis of this issue is beyond the scope of this paper, the following sections outline the precendential basis, rationale and parameters of the concept of deterritorialised state and then examine its application in the context of disappearing island states and the management of their maritime zones.

Sea Level Rise and Deterritorialised States

Before going any further, it is important to note that nothing proposed here is intended to suggest a new category of international personality available to peoples, however defined, raising current or future self determination claims in the context of existing states. The discussion here focuses solely on possible options for island states whose territory will become wholly uninhabitable as a result of sea level rise.

It is true that international law generally stipulates the requirement of territory as a necessary precondition for statehood. However, the concept of the deterritorialised state is neither new, nor is it rejected under current international law. The most famous example of a deterrritorialised state is the Sovereign Order of the Military Hospitaller Order of St John of Jerusalem, of Rhodes and of Malta (also known as the Order of St John or the Knights of Malta) which has historically been considered a sovereign international subject, recognised by a large number of states and enjoying the rights of active and passive legation, treaty making and membership of international organizations, despite having lost its territory when rejected from Malta by Napoleon in 1798.[21]

[21] Costas M Constantinou, 'Irregular States or the Semiotices of Knight Errantry' 17 *Revue International de Sémiotique Juridique* (2004) 229-244. See also Aldo Pezzana, *The Juridical and Historical Foundations of the Sovereignty of the Military Hospitaller Order of St John of Jerusalem, of Rhodes and Malta* (Rome: The Sovereign Military Order (no date given); Gerald Draper, 'Functional Sovereignty and the Sovereign Military Hospitaller Order of St John of Jerusalem, of Rhodes and of Malta' *Annales de l'Ordere Souverain Militaire de Malta* (1974), pp 78-86; Guy Stair Santy, 'The Order of Malta, Sovereignty, and International Law' http://www.chivalficorders.org/chivalric/smon/maltasov.htm; R. Jennings and A. Watts (eds) *Oppenheim's International Law*, Vol 1: Peace (London: Longman, 1996), p328-329; Malcolm Shaw,

Similarly, although regularized by the grant of sovereignty over Vatican City to the Papal See in the Lateran Treaties of 1929, the Papal See was recognized as a state despite possessing no territory between 1870, when the Papal States were annexed by Italy, and 1929.

International law also recognizes the notion of functional, or non-territorial, sovereignty. Historically such claims have been recognized in the context of 'governments-in exile' or in the context of communities either made diasporic by processes of invasion and colonization as, for example, in the case of the Palestinians, or overrun and internally dislocated or formally deterritorialised as, for example, in the case of indigenous nations such as the Maori, the Inuit and the Tibetans. In some instances there have been attempts to re-establish or re-assert sovereignty through the re-establishment of a homeland in or near the original site (Palestine). In others, a virtual enclave has been created within the newly created encompassing nation (Maori within New Zealand or Nunavut in Canada).

More recently, international law has also recognized the right of other entities such as Taiwan and the European Union to exercise aspects of functional sovereignty on the international level despite either not being recognized as a state or not fulfilling the criteria for statehood. Of particular relevance in the context of a discussion on oceans governance, the terminology of 'other entity' is now utilized in numerous law of the sea treaties, including the UN Fish Stocks Agreement. In short, international law already recognizes that sovereignty and nation may be separated from territory. International law is thus fully capable of responding to the problem of disappearing states in a way that positively recognizes their sovereign rights without further victimizing them by the loss not only of their territory but of their sovereign existence as well.

In the context of disappearing states, the deterritorialised state entity would therefore consist of a 'government' or 'authority' elected by the registered voters of the deterritorialised state. In essence, this 'authority' would act as a trustee of the assets of the state for the benefit of its citizens wherever they might now be located. The maritime

International Law (Cambridge: Cambridge University Press 2003), p 218; and Ian Brownlie, *Principles of Public International Law* (Oxford: Clarendon Press, 1990), p 66 zones of the disappearing state would continue to inure to and be managed by that 'authority' such that the resource rents from their exploitation could be used to fund the relocation and continued livelihood of the displaced population – whether diasporic or wholly located within one other 'host' state. Although not having sovereignty over its new property acquisitions the 'authority' would continue to represent the state at the international level and the rights and interests of its citizens vis-à-vis their new 'host' state or states. These rights could include the right to maintain their original personal, property, cultural, linguistic and nationality rights for themselves and their descendants while simultaneously being granted full citizenship rights in the new 'host' state or states.

This deterritorialised state approach appears to be precisely what the governments of Tuvalu and the Maldives are now contemplating. According to press reports the Prime Minister of Tuvalu held secret talks with Australian officials in October 2008 aimed at obtaining Australia's agreement to accept the entire Tuvaluan population if and when it is forced to evacuate.[22] Given current projections of sea level rise by up to 0.8 metres by 2100,[23] evacuation could be necessary before the end of this century. Key to Tuvalu's position is the desire to retain its sovereignty, culture and traditions – including sovereignty over its maritime zones. Similar sentiments have been expressed by the President of the Maldives. Clearly, a strategy that sees international agreement on the freezing of baselines, at least in the case of island states facing inundation, will be a key element in a disappearing state's ability to utilize its maritime zones as both a bargaining chip and as a means of supporting its continued 'sovereign' existence as well as the continued livelihood of its displaced population.

Deterritorialised States and the Management of Maritime Zones

Assuming agreement on the freezing of baselines and the continued adherence of maritime zones to newly deterritorialised states, it is also necessary to consider the position of deterritorialised states from an oceans governance perspective and the effect of this new category of state on the continued management and exploitation of maritime

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[22] Brad Couch, 'Sinking Tuvalu Wants Our Help as Ocean Levels Rise', *The Daily Telegraph,* 5 October 2008, http://www.news.com.au/dailytelegraph/story/0,22049,24448958-5005941,00.html
[23] IPCC Fourth Report

zones. The advantages of this approach have already been noted as contributing to the promotion and achievement of the LOSC objectives of peace, stability, certainty, fairness, and efficiency in oceans governance. Moreover there is no reason in principle, why management should be any more problematic for a deterritorialised or disappeared state as opposed to a state in possession of distant islands. Analogous examples would include the Falkland Islands and South Georgia, Australia's Heard, McDonald and Macquarrie Islands, and the French sub-Antarctic islands of Keurguelan and Crozet.

Admittedly, the challenges of monitoring, control, surveillance and enforcement would be great. However, these challenges can be met with the ongoing development of increasingly sophisticated satellite and other MCS technologies and regimes and through cooperation and coordination with regional fisheries management organizations, the International Seabed Authority, the International Maritime Organization and other relevant international organizations.

Equally great will be the challenge of ensuring prompt, adequate and effective payment for resources taken and the establishment of effective structures for ensuring appropriate conduct by the authorities of the deterritorialised state of their obligations including the conservation and sustainable management of the resources and the receipt and distribution of funds to the beneficiaries. In this respect international oversight of the processes may be useful. Indeed, it is possible to envisage a revivified and modified role for the Trusteeship Council (or a revised version thereof) as the central coordinating international authority for deterritorialised states.

Nevertheless, in an international community still based on the Westphalian notion of states, it may not be appropriate or realistic to envisage the permanent establishment and continuing existence of deterritorialised states *ad infinitum*. Rather, it may be useful to view this status as transitional, lasting perhaps one generation (30 yrs) or one human lifetime (100 yrs), by which time it is likely that much else in the international legal regime, including the existing law of the sea regime, will have to be reconsidered and reconfigured, in any event. In the meantime, however, freezing existing baselines and accepting the notion of the sea level affected deterritorialised state would give certainty and security to those states which fear inundation and allow them to concentrate on the tasks of sustainable development and adaption for as long as they can.

Environmental Policy for Desert Islands - Beyond "Island or Rock"

Yasuhiko KAGAMI
Tottori University of Environmental Studies

Our world itself is an island.

- Preamble, Constitution of the Federated States of Micronesia

I. Introduction

Under the United Nations Convention on the Law of the Sea (UNCLOS), coastal states can extend their Exclusive Economic Zone (EEZ) 200 miles from their baselines. Based on this regime, desert islands – for the purpose of this paper, small islands including remote islands with no or virtually no population – play a critical role in expanding maritime jurisdiction. For example, the total land area of the South Pacific island states is about 500,000 sq km, which is equal to the land area of mainland France, but their maritime jurisdiction is equal to the size of Europe as a whole.

However, not all islands can claim an EEZ. Article 121 (3) of the UNCLOS provides that "rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf". This provision is a compromise that leaves the relationship between desert islands and EEZ ambiguous. Professor E.D. Brown called this paragraph "a perfect recipe for confusion and conflict[(1)]."

For example, what does "human habitation" mean? How many people must live there? Is it correct to interpret the stationing of trained military personnel on an island as habitation? Is self-sufficiency required? Furthermore, what does an "economic life of their own" mean? Must economic activities be performed on the islands and by the people living on such islands? Do fishing activities in the territorial seas satisfy this criterion? No authoritative answers exist to these questions.

To date, only two insular formations see themselves as a "rock" under Article 121 (3). One is the Alijos Rocks (Rocas Alijos in Spanish) of Mexico. This is a group of tiny, steep and barren volcanic islets or above-water (as well as below-water) rocks situated about 300 km west of the mainland. The largest of them is South Rock, which is a barren rock, 34 meters high with a diameter of only 14 meters. Mexican *Law Regulating the Eighth Paragraph of Art. 27 of the Exclusive Economic Zone 1976*[(2)] has virtually the same provision as Article 121 (3) of the UNCLOS, and the Mexican government does not draw an EEZ around the Alijos Rocks. This implies that the Alijos Rocks are classified as a "rock" under Article 121 (3)[(3)].

The other is Rockall Island off the UK. This granitic rock is 61 meters in diameter and 21 meters high, located 314 km east of the nearest landmass, St. Kilda Island. The UK established a 200-mile Fishery Zone (about 23,150 sq km) under the Fishery Limits Act of 1976. Iceland, Ireland and Denmark protested the right of Rockall to generate a 200-mile zone in favor of the UK[(4)].

On 21 July 1997, Foreign Secretary Robin Cook announced the decision to accede to the UNCLOS in the House of Commons and that "the United Kingdom's fishery limits will need to be redefined, based on St. Kilda, since Rockall is not a valid base point for such limits under Article 121 (3) of the convention[(5)]." The press release on that decision said that "Rockall is incapable of sustaining human habitation[(6)]."

Leading authors in this field, Soons and Kwiatkowska (1990), acknowledge the limited interpretation of this article and conclude that only state practice and case law are capable of clarifying Article 121 (3)[(7)]. Just ten years later, Elferink (2000) analyzed state practices and case law and concluded, a "review of state practice and the case law indicates that in the delimitation of maritime boundaries between states, in most cases either it is not necessary to resolve or it is possible to circumvent the question of whether or not a particular island is a rock in the sense of Article 121 (3)[(8)]."

In fact, on 3 February 2009, the International Court of Justice (ICJ) – unanimously! – delivered its Judgment in the *Case Concerning Maritime Delimitation in the Black Sea* (Romania v. Ukraine), avoiding the question of whether or not Serpent's Island (Ukraine Territory) is a rock in the sense of Article 121 (3)[(9)]. As Elferink pointed out earlier: "for most, delimitations of maritime boundaries the clarification of Article 121 (3) is not a matter of great urgency[(10)]," and this is the case with the Black Sea Maritime Delimitation.

In this vein, Elferink also pointed out that: "it is likely that state practice will provide most incidents of relevance to Article 121 (3)[(11)]." For this reason, this paper is going to examine recent state practices.

II. Recent State Practices on Desert Islands in the post-UNCED Era

What approaches are taken to secure the status of "island" under Article 121 (3)? Although it is difficult to review all desert islands scattered around the world, I can point out the main trends as follows: (1) posting small military forces or meteorological observation station staff, etc. and (2) establishing marine protected areas around desert islands.

(1) Posting small military forces or meteorological observation station staff, etc.

As an example of the first category, France, which has the second largest EEZ in the world (10,084,201 sq km, equal to 8% of the total world's EEZ, excluding the EEZ around Antarctic territory), has most of its established EEZ around remote uninhabited islands, among others, on uninhabited small islands (except Saint-Paul Island) that belong to Terres australes et antarctiques françaises (TAAF), where small military or meteorological stations have been constructed, several personnel are stationed, but on which there are no residents or fisheries[(12)].

In Venezuela, Aves Island (Isla de Aves in Spanish) provides a good example. It is a sandy shoal (500 m x 150 m at maximum, and 50 m at minimum[(13)]) located 700 km north of the mainland in the Caribbean Sea[(14)]. The President at that time inaugurated a new research base on October 18, 1978[(15)]. This 18-meter high station with radar facilities is owned by the Coast Guard, and is manned by several military and research personnel.

The Venezuelan government concluded bi-lateral maritime boundary delimitation treaties regarding a 200-mile zone and Continental Shelf around Aves Island with the Netherlands (1978), the US (1980) and France (1983). Governments from countries like St. Kitts and Nevis protested the status of Aves Island in the sense of Article 121 (3) and at the request of Antigua and Barbuda, Saint Kitts and Nevis and Saint Vincent and the Grenadines, their protests have been circulated to the States that are Parties to the Convention(16).

(2) Establishing marine protected areas around desert islands

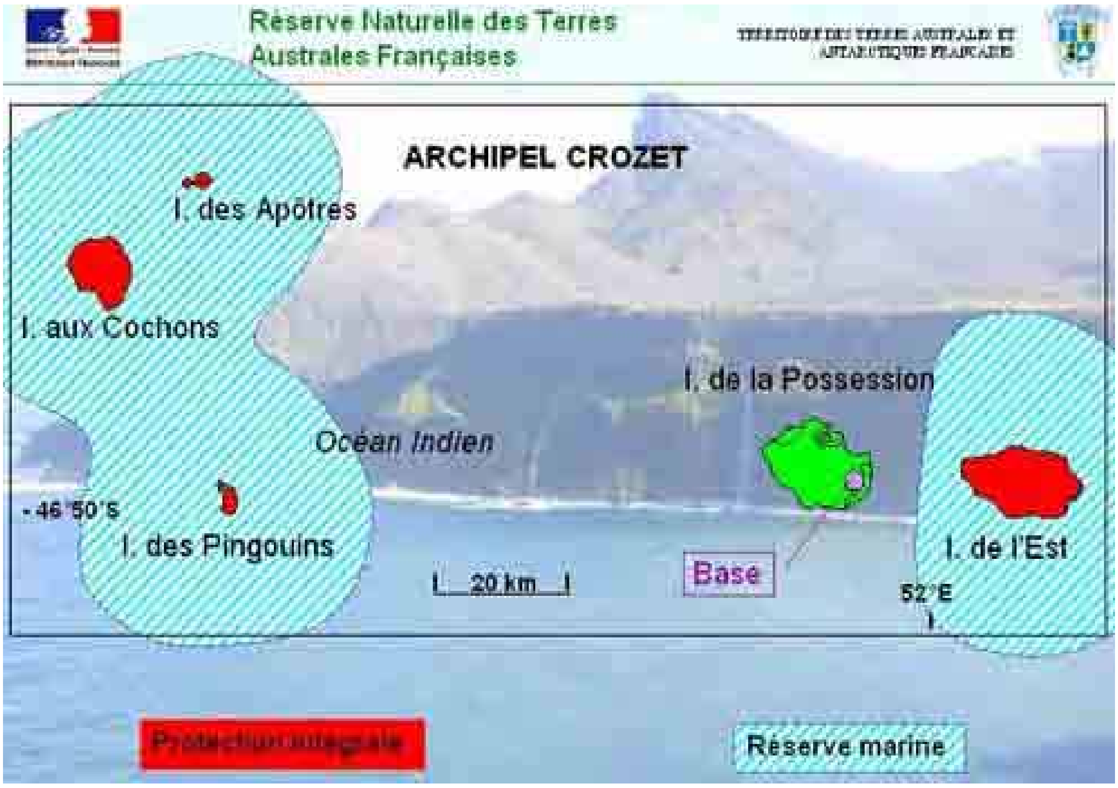
The second category of practices has become significant recently. Designated protected ocean areas are generally called a Marine Protected Area (MPA). MPAs are not mentioned in the UNCLOS, and these have developed independently of the Convention. Since the 1990s, however, MPAs have received strong support from the international community as a coastal and marine management tool with which to implement the Convention on Biological Diversity (CBD) as well as the UNCLOS and to strike a balance between development and environmental protection, in particular, ecosystem conservation.

Although the MPA concept is still in the process of formation(17), it is one of the symbols for the development of environmental protection in the post-UNCED Era. For example, the 2002 WSSD Plan of Implementation, promotes “the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012...” (Para. 32(c)) and CBD COP 7 (2004) set a target of establishing and maintaining ... by 2012 for marine areas of comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas (Decision VII 28). These are called the “*2012 Target*.”

Against this backdrop, there are many interesting practices around the world. For example, in TAAF nature reserves (Fig. 1) have been designated as such by a 2006 decree(18). The nature reserves generally extend for 12 nautical miles from the shore. The purposes of establishing nature reserves are to preserve ecological richness and historical and scientific value, and so on. In principle, access is prohibited. Commercial fishing is severely regulated or even prohibited. With regard to these protected areas, the Chief of the TAAF is in charge of management. A Management Plan is to be formulated and executed by the Chief in consultation with the Council of TAAF.

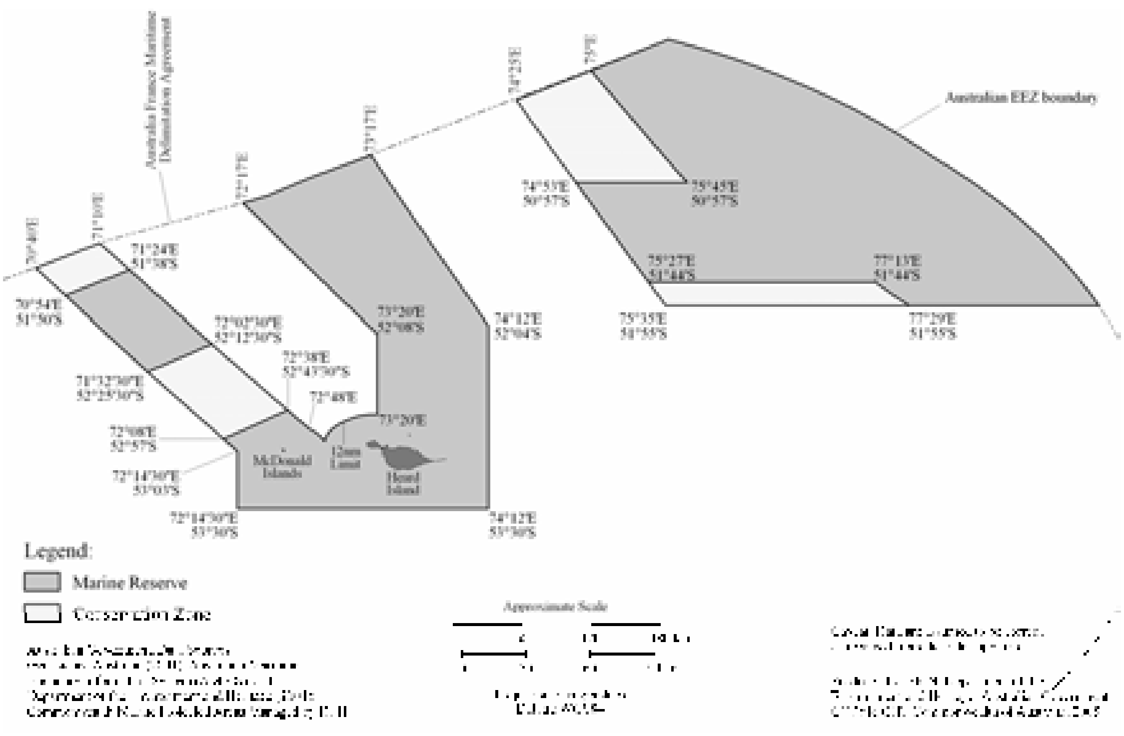
The official fact sheet emphasizes that the nature of small islands in the TAAF region is a “natural laboratory” and scientific research activities are promoted in these reserves(19). The French government is considering applying these kinds of nature reserves in Îles Éparses, another group of desert islands scattered in the Indian Ocean(20).

Australia too, has a huge EEZ, some of which has been claimed around uninhabited islands. Heard and McDonald Islands are large islands (Australia’s tallest peak, Mt. Big Ben, is located there, and the island has an area of 368 sq km) with tiny rocky elevations. Both of these islands are uninhabited because of their geographic and climatic characteristics. While terrestrial management of these Islands started in the 1950s(21), maritime management started in the 1970s. Fishing Zones that extend for 200 miles were claimed in 1979 and both islands and their territorial waters were listed as World Heritage sites in 1997. In 2002, a 200-mile marine reserve (The Heard Island and McDonald Islands (HIMI) Marine Reserve) was designated around both islands, under Section 344 of the 1999 *Environment Protection and Biodiversity Conservation* (EPBC) Act (Fig. 2).



(Fig.1) Map of Nature Reserve of TAAF (Crozet Archipelagos)

Source: http://www.taaf.fr/spip/spip.php?article115



(Fig.2) Map of the Heard Island and McDonald Islands (HIMI) Marine Reserve

Source: http://www.environment.gov.au/coasts/mpa/heard/maps/images/boundary-high.tif

Is Heard Island a "rock"? For at least one learned judge, yes. In a separate opinion attached to the Judgment of the International Tribunal of the Law of the Sea in *the Volga case* in 2002, Judge Vukas criticized the EEZ around Heard and McDonald Islands. The learned judge found that there could be no "coastal fishing communities", because "[t]here is no permanent habitation". Therefore, economic interests and concerns do not exist in respect of these islands.

Let us examine one more recent MPA practice around uninhabited islands. The US's practice presents an interesting case study. Although the US is not a member of the UNCLOS or CBD, in practice it takes these Conventions into account. Northwestern Hawaiian Islands (NWHIs) consist of 10 islands and atolls stretching over nearly 1,700 km, the distance from Chicago to Miami.

Among them, only Midway Island and Kure Atoll are inhabited by trained military personnel and the others are *de facto* uninhabited. Some insular formations are precipitous volcanic rocks, while others are atolls. Since 1983, 200-mile EEZs have been claimed around all NWHIs.

In 1988, US scholars, including Van Dyke of Hawaii University, examined NWHIs in terms of Article 121 (3) with the original criteria that insular formations having stable communities of permanent residents can claim EEZ status, and concluded that eight of the 10 islands are "rocks" under Article 121 (3), and recommended that EEZs not be created around them(22).

However, the US exercised another option: designating MPAs around the NWHIs instead of withdrawing EEZs. According to the White House, the NWHIs are home to more than 7,000 marine species, a quarter of which are found nowhere else on earth. To preserve such a vulnerable ecosystem, protected areas such as wildlife sanctuaries have been designated on land areas since the first half of the 20th century.

In 2000, President Bill Clinton designated the first ocean region, a Coral Reef Ecosystem Reserve of roughly 340,000 sq km in the NWHIs, as an MPA. The reserve extended from the seaward boundary of Hawaiian state waters to 50 nautical miles from the geographic center of the NWHIs.

Six years later, President George W. Bush designated a giant marine protected area around the NWHIs based on Session II of the Act of June 8, 1906 (the *Antiquities Act*(23)), then named the NWHI Marine National Monument, and recently renamed in the local language as the Papahānaumokuākea Marine National Monument. The seaward boundary of the reserve is 50 nautical miles from the geographic center of the NWHIs(24) and it is slightly larger than the previous Ecological Reserve. With an area of 362,000 sq km, the NWHI Marine National Monument was the largest MPA and no-take zone in the world (at that time(25)), surpassing Australia's largest MPA, the Great Barrier Reef Marine Park.

The Management Regulations of this Monument came into operation on August 25, 2006. The regulations are jointly implemented by the Secretary of the Interior, through the U.S. Fish and Wildlife Service (USFWS) and by the Secretary of Commerce, through the National Oceanic and Atmospheric Administration (NOAA).

Activities can be conducted with adequate safeguards for the resources and ecological integrity of the Monument. Access to the Monument is prohibited, in principle, and many activities are prohibited or regulated. For example there are prohibitions on: exploring for, developing, or producing oil, gas, or minerals within the Monument area; introducing or otherwise releasing an introduced species from within or into the Monument area; and anchoring on or having a vessel anchored on any living or dead coral with an anchor, anchor chain, or anchor rope. Commercial fishing for bottom fish or associated pelagic species will be prohibited in the Monument area after June 15, 2011.

These regulations shall be applied in accordance with international law. No restrictions shall apply to, or be enforced against, a person who is not a citizen, national, or resident alien of the United States (including foreign flag vessels) unless done in accordance with international law.

The "care" for NWHI is gathering momentum. In March 2008, the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) designated a maritime area around this Monument as a Particularly Sensitive Sea Area (PSSA)(26). Several Areas to be Avoided (ATBA) have been established and all ships solely in transit should avoid the areas. In these areas, recommended/mandatory ship reporting systems are applied, and certain classes of ships are required to participate in the US' ship reporting system (CORAL SHIPREP).

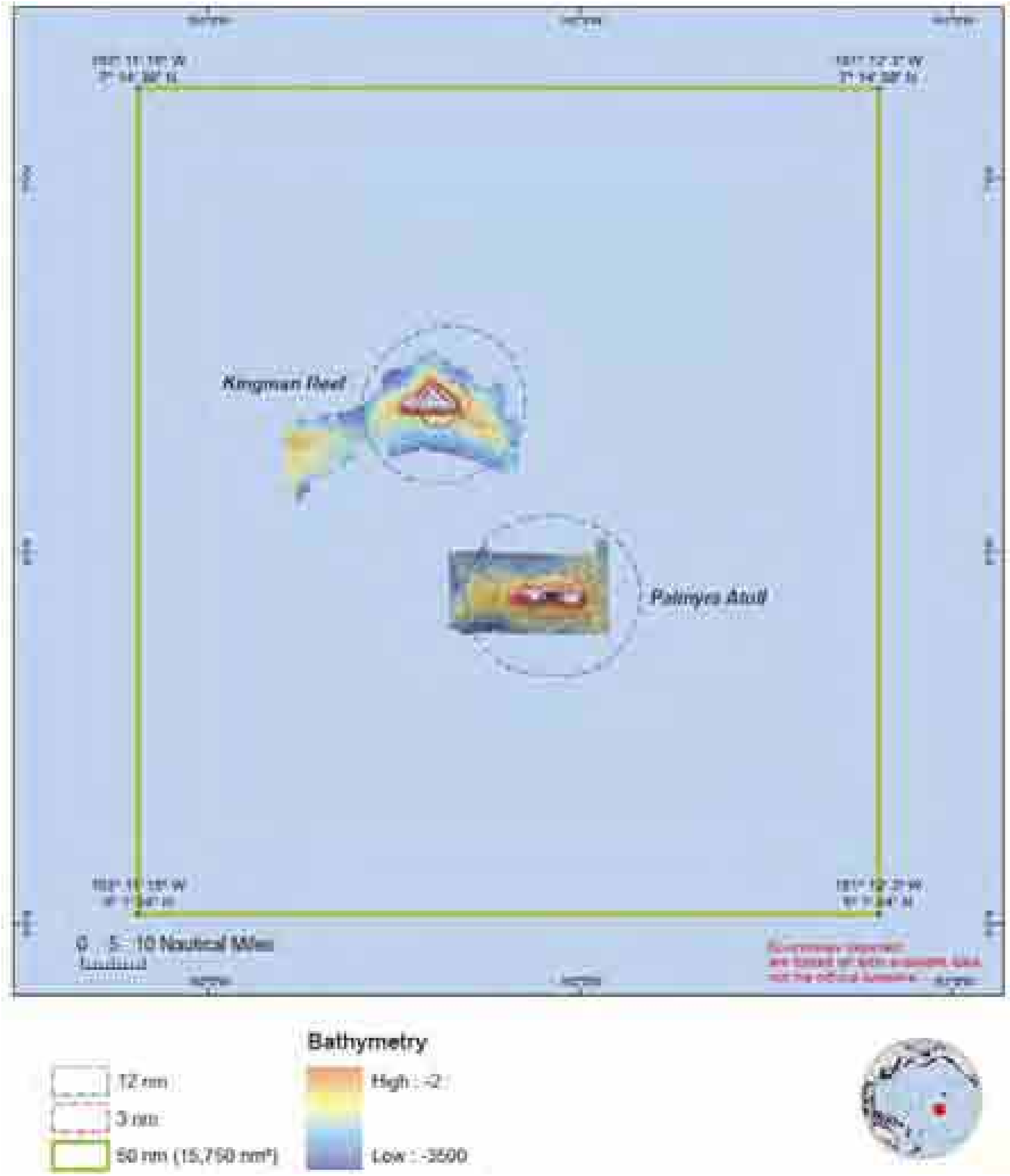
On 23 December 2008, NOAA, USFWS, and the state of Hawaii released the final *Papahānaumokuākea Marine National Monument Management Plan* and associated environmental assessments for the Monument(27). Thus, the Management Plan for remote uninhabited-island ecosystems is steadily being upgraded.

Furthermore, on January 6, 2009, the Papahānaumokuākea Marine National Monument was officially nominated to the UNESCO World Heritage List. It will be America's first marine site, and the world's first cultural seascape(28). Interestingly, the Heritage category is "Mixed" (Cultural and Natural), because in the Native Hawaiian cosmology and tradition, a portion of the islands is believed to lie within the place where life originates and to which it returns. A determination by UNESCO is scheduled to be made in July 2010.

At the same time as this nomination, the US government announced three new Marine National Monuments(29). They are the Marianas Trench Marine National Monument, the Pacific Remote Islands Marine National Monument and the Rose Atoll Marine National Monument. Combined, these designations represent the largest fully protected area in the world (195,274 sq miles), according to the press release.

Among others, the Pacific Remote Islands Marine National Monuments, which consist of the marine areas around seven uninhabited islands (Kingman Reef, Palmyra Atoll, Howland, Baker, Jarvis Islands, Johnston Atoll and Wake Island) (Fig. 3) are, the press release says, the home of many endemic species, including corals, fish, shellfish, marine mammals, seabirds, water birds, land birds, insects, and vegetation not found elsewhere, being an important part of the most widespread collection of marine- and terrestrial-life protected areas on the planet under a single country's jurisdiction and which are being administered as National Wildlife Refuges by the United States Fish and Wildlife Service of the Department of the Interior(30).The seaward boundary of the reserve is 50 nautical miles from the geographic center of the islands just the same with NWHIs(31).

All Federal land and interests in land within the boundaries of this monument are hereby withdrawn from all forms of entry, location, selection, sale, leasing, or other disposition under the public land laws to the extent that those laws apply.



(Fig. 3) Pacific Remote Islands Marine National Monuments (Kingman Reef and Palmyra Atoll)

Source: http://www.latimes.com/media/acrobat/2009-01/44374653.pdf

The Secretary of the Interior, in consultation with the Secretary of Commerce, shall bear responsibility for management of the monument, to 12 nautical miles from the mean low water lines of remote islands. The Secretary of Commerce, through the National Oceanic and Atmospheric Administration, and in consultation with the Secretary of the Interior, shall bear primary responsibility for management of the monument seaward of the area 12 nautical miles from the mean low water lines of remote islands, with respect to fishery-related activities regulated pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) and any other applicable legal authorities. The Secretaries of Commerce and the Interior shall not allow or permit any appropriation, damage, destruction of, or removal of any feature from, this monument, except as provided for by this proclamation and shall prohibit commercial fishing within the boundaries of the monument.

With regard to the regulation of scientific exploration and research, subject to such terms and conditions as the relevant Secretary deems necessary for the care and management of the objects of this monument, the Secretary of the Interior may permit scientific exploration and research within the monument, including incidental appropriation, damage, destruction of, or removal of features from this monument for scientific study, and the Secretary of Commerce may permit fishing within the monument area for scientific exploration and research purposes to the extent authorized by the Magnuson-Stevens Fishery Conservation and Management Act.

Thus, within the boundaries of the National Marine Monuments, developments are severely regulated while research and exploration are somewhat promoted. The Secretary of the Interior shall provide a process to ensure that recreational fishing shall be managed as a sustainable activity in certain areas of the monument, consistent with Executive Order 12962 of June 7, 1995, as amended, and other applicable laws.

The Secretaries of the Interior and Commerce shall, within two years of the date of this proclamation, prepare management plans within their respective authorities and promulgate implementing regulations that address any further specific actions necessary for the proper care and management of the objects identified in this proclamation at the islands, except the Johnston Atoll and Wake Island under the control of the Department of Defense.

The management plans and their implementing regulations shall impose no restrictions on innocent passage in the territorial sea or otherwise restrict navigation and over-flight and other internationally recognized lawful uses of the sea in the monument area and shall incorporate the provisions of this proclamation regarding Armed Forces actions and compliance with international law. This proclamation shall be applied in accordance with international law. No restrictions shall apply to, or be enforced against, a person who is not a citizen, national, or resident alien of the United States (including foreign flag vessels) unless this is done in accordance with international law.

III. Concluding Remarks - Beyond “island or rock”

Merely designating MPAs around uninhabited islands will not provide a legal basis for claiming an EEZ around them. What is the missing link between MPAs and Article 121 (3)? This is a previously-unexplored question.

Let us introduce one positive approach. American law clerk, Jonathan L. Hafetz quoted environmental economics research results to the effect that the optimal use of an island is to leave it undeveloped and that an MPA will yield economic benefits, not only from increased sustainable fishing yields, but also due to the preservation of biological diversity, which itself will lead to both new pharmaceuticals and to consumer products, such as cosmetics[(32)].

This suggests that MPAs can have an economic life of their own, within the meaning of Article

121 (3), when a State uses them to both protect the marine environment and to gain net economic benefit. In terms of this, uninhabited NWHIs could be classified as islands under Article 121 (3). NWHIs Monument covers not only the preservation of the ecosystem, but also considers the possibility of developing new, potentially useful compounds, in the ocean. The White House touches on this in its background on NWHIs, referring to the more-than 170 U.S. patents that US marine biotechnology research has produced since 1983(33). Research activities are firmly supported under the Regulations. One purpose of designating the Monument is to implicitly secure marine biodiversity in order to explore new marine genetic resources in the NWHIs.

This is an interesting environmental policy for desert islands, balancing ecosystem and biodiversity conservation and utilization of development in the post-UNCED era, and showing an interesting alternative way of resolving the stalemated “island or rock” dispute.

On the other hand, there has been strong objection to the claiming of EEZs around uninhabited islands. For example, as has been cited above, Van Dyke and co-authors oppose the extension of EEZs around the NWHIs. They acknowledge that the restrictions on extended maritime claims adjacent to uninhabitable insular possessions may seem injurious to United States’ economic interests in the short run, because the United States may be deprived of exclusive rights to some marine resources. However, they continue, the restrictions would ultimately benefit the United States because they would limit the tendency for ever-greater coastal state claims of exclusive jurisdiction, preserve more ocean space for unrestricted scientific research, and ensure that sufficient ocean space remains to promote the values underlying the concept of a common heritage. Furthermore, they conclude that if these long-term values are seen as important, then the United States might eventually set an appropriate example for other nations by limiting its own claims(34).

However, given that the existing regime governing marine environmental and development management of the high seas is immature, it seems more effective for sustainable development to bring ocean regions around uninhabited islands under the coastal states’ control, rather than leave them designated as being high seas. Provided MPAs are not nominal paper parks, but rather faithfully implement ecosystem management in accordance with the CBD, the UNCLOS, and post UNCED Development, it seems that designating MPAs around uninhabited islands follows the spirit of sustainable development embodied in the UNCLOS and CBD, and could bring a broader meaning to the term “economic life of their own”.

In other words, this environmental policy has the possibility of providing states that own desert islands an incentive to protect vulnerable ecosystems, or otherwise leave them untouched by only establishing a “paper EEZ”. Article 121 (3) should be interpreted as a catalyst for the sustainable development of desert islands and marine areas, not as a fuse to conflicts.

(1) E.D. Brown, "Rockall and the Limits of National Jurisdiction of the United Kingdom: Part I," 2 *Marine Policy* (1978), p. 206.

(2) Article 3 of the Law Regulating the Eighth Paragraph of Art. 27 of the Exclusive Economic Zone 1976, 15 *International Law Materials* (1976), pp. 382-3.

(3) W. van Overbeek, "Article 121(3) in Mexican State Practice in the Pacific," 4 *International Journal of Marine and Coastal Law* (1989), p. 262.

(4) Clive R. Symmons, "Ireland and the Rockall Dispute: An Analysis of recent developments," *IBRU Boundary and security Bulletin* (Spring, 1998), p.81 and accompanying footnote.

(5) Ibid., p. 83.

(6) Ibid..

(7) Barbara Kwiatkowska and Alfred H. A. Soons, "Entitlement to Maritime Areas of Rocks Which Cannot Sustain Human Habitation or Economic Life of Their Own," 21 *Netherlands Yearbook of International Law* (1990), p.176.

(8) Alex G. Oude Elferink, "Is it Either Necessary or Possible to Clarify the Provision on Rocks of Article 121(3) of the Law of the Sea Convention?" in M. A. Pratt and J.A. Brown (eds.), *Borderlands Under Stress*, Kluwer Law International (2000), pp. 397.

(9) Judgment of February 3, 2009, *Case Concerning Maritime Delimitation in the Black Sea* (Romania v. Ukraine), paras. 179-188. It is also interesting to see that the Court "considers it inappropriate to select any base points on Serpents' Island for the construction of a provisional equidistance line between the coasts of Romania and Ukraine." (para. 149)

(10) Elferink, *supra* note 8, pp. 397-8.

(11) Ibid., p. 398.

(12) Judge Vukas (Croatia) attached the Declaration to the Judgment of *The "Monte Confurco" Case* (Seychelles v. France), 18 December 2000, and said that "it is highly questionable whether the establishment of an exclusive economic zone off the shores of these 'uninhabitable and uninhabited' islands (according to Captain Yves-Joseph de Kerguelen-Trémarec) is in accordance with the reasons which motivated the Third United Nations Conference on the Law of the Sea to create that specific legal régime, and with the letter and spirit of the provisions on the exclusive economic zone, contained in the United Nations Convention on the Law of the Sea." As we will see below, he repeated his opinion in a Separate Opinion in *the "Volga" case* Judgment in 2002.

(13) Kaldone G. Nweihed, "EZ (Uneasy) Delimitation in the Semi-enclosed Caribbean Sea: Recent Agreements Between Venezuela and Her Neighbors," 8 *Ocean Development and International Law*, 1980, p. 21.

(14) Academia de Ciencias Físicas, Matemáticas y Naturales, *Resumen Ejecutivo*, at http://academiasnacionales.gov.ve/avespropuesta.htm

(15) Nweihed, *supra* note 13, p. 21.

(16) LOS/SP/1 dated 12 August 1997; LOS/SP/2 of 13 August 1997; and LOS/SP/3 of 9 September 1997.

(17) The most popular definition of an MPA: "Any area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." --*Resolution by 17th General Assembly of IUCN*, 17.38, 1994.

In 2008, a new IUCN definition of Protected Area (including MPA) was launched: "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." --*Guidelines for Applying Protected Area Management Categories* (IUCN, 2008).

(18) Dècret n.2006-1211 du 3 octobre 2006 portant création de la réserve naturelle des Terres australes françaises, 32 *Journal official des Terres australes et antarctiques françaises* (31 decembre 2006), pp.4-8.

(19) See Ministère de l'Ecologie et du Développement durable, *RAPPORT SUR LA RESERVE NATURELLE DES TERRES AUSTRALES FRANCAISES*, at http://www.ecologie.gouv.fr/IMG/pdf/PresentationTaaf-2.pdf

(20) For detail on the Îles Éparses, see Sarah Caceres, *Etude préalable pour le classement en Réserve Naturelle des Iles Eparses*, DESS Sciences et Gestion de l'Environment Tropical - DIREN Reunion - Laboratoire ECOMAR, especially pp. 13-5 and 22. By the law dated 21 February 2007, Îles Éparses constitute the fifth disrtict of the TAAF. See Ministère de l'Écologie, de l'Énergie, du Développement durable et de l'Aménagement du territoire, *Overseas France an outstanding natural heritage*, June 2008, at http://www.ecologie.gouv.fr/IMG/pdf/5%20-%20Brochureanglaisoutre-mer.pdf, p. 17.

(21) See *Heard Island and McDonald Islands Act* 1953, http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/0/5BA772342A829EFFCA256F71004F51A1/$file/HrdMcdIsl53.pdf

(22) Jon M. Van Dyke, Joseph R. Morgan and Jonathan Gurish, "The Exclusive Economic Zone of the Northwestern Hawaiian Islands: When Do Uninhabited Islands Generate an EEZ?" 25 *San Diego Law Review* (1988), pp. 466-482.

(23) 34 Stat. 225, 16 *U.S.C.* 431. Protected Areas based on the *Antiquities Act*, see e.g. Jeff Brax "Zoning the Oceans: Using the National Marine Sanctuaries Act and the Antiquities Act to Establish Marine Protection Areas and Marine Reserves in America," 29 *Ecology Law Quarterly* (2002), pp. 71-129.

(24) The breadth of the Monument is "approximately 50 nautical miles from the islands". See Federal Register Vol. 71, No. 167 (August 29, 2006), 50 CFR Part 404, p. 51134. With regards to the breadth of the Monument, James L. Connaughton, who chairs the White House Council on Environmental Quality, said the administration had determined that going beyond 50 miles would not provide significant "scientific benefits for conservation" and that there was no scientific record demonstrating that the waters above the trench need to be protected. *Washington Post*, January 6, 2009, at http://www.washingtonpost.com/wp-dyn/content/article/2009/01/06/AR2009010602107.html

(25) As of January 2009, it seems that the largest MPA of the world is the Phoenix Islands Protected Area (PIPA), an area of 410,500 sq km. PIPA is established around the eight uninhabited islands (except one atoll, Kanton, is currently inhabited by an administrative population of less than 50 people). To establish and maintain this huge protected area, The Republic of Kiribati, in partnership with the New England Aquarium and Conservation International (CI), has committed to the protection of the Phoenix Islands and their surrounding waters. The Phoenix Islands Protected Area has also been nominated as a UNESCO World Heritage Site due to its unique biological, cultural and historical significance. See *Republic of Kiribati Phoenix Islands Protected Area* (fact sheet), at http://phoenixislands.org/pdf/pipa_fact_sheet.pdf

(26) IMO Res. MEPC.171 (57), *DESIGNATION OF THE PAPAHANAUMOKUAKEA MARINE NATIONAL*

MONUMENT AS A PARTICULARLY SENSITIVE SEA AREA, Adopted on 4 April 2008.

(27) *Papahānaumokuākea Marine National Monument Official site by* US NOAA, at http://hawaiireef.noaa.gov/management/mp.html.

(28) *FACT SHEET: Nomination of Papahānaumokuākea Marine National Monument to the UNESCO World Heritage List*, at http://hawaiireef.noaa.gov/management/FactSheet_WorldHeritage.pdf

(29) *Fact Sheet: Marine National Monuments*, Office of the Press Secretary, January 6, 2009, at http://www.fws.gov/pacific/news/2009/monuments/Factsheet.pdf

(30) *Establishment of the Pacific Remote Islands Marine National Monument A Proclamation by the President of the United States of America*, Office of the Press Secretary, January 6, 2009, at http://www.fws.gov/pacific/news/2009/monuments/pacificremoteislands.pdf

(31) See *supra* note 24, for the reason of the 50 miles.

(32) Jonathan L. Hafetz, "Fostering Protection of the Marine Environment and Economic Development: Article 121(3) of the Third Law of the Sea Convention," 15 *American University International Law Review* (2000), pp. 604-611.

(33) White House Office of Communications, *The Northwestern Hawaiian Islands Marine National Monument: A Commitment To Good Stewardship Of Our Natural Resources*, 15 June 2006.

(34) Van Dyke *et al*., *supra* note 22, p. 488.

Implementing Oceans Governance in the Pacific Islands Region
Regional Solutions to National Challenges

Quentin Hanich
Senior Fellow
Australian National Centre for Ocean Resources and Security (ANCORS)

Abstract
The Pacific islands region encompasses a unique grouping of some of the world's smallest countries surrounded by a vast maritime estate. The combined exclusive economic zones (EEZs) of the Pacific island States are home to the world's richest and largest tuna fisheries. The significance of these EEZs, and the rights and responsibilities attributed to coastal States by the Law of the Sea, assign a critical role to Pacific island States in the development and implementation of oceans governance throughout this region.

The Pacific island States have established a number of cooperative agreements and institutions to support the management and conservation of these tuna fisheries and are a critical membership bloc of the Western and Central Pacific Fisheries Commission (WCPFC). Despite these arrangements overfishing and overcapacity now threaten the long term sustainability of some of these tuna fisheries and significantly lower the benefits available to coastal and distant water fishing States.

These sustainability and economic concerns require national and regional policy and regulatory responses that are challenging to conceptualise, negotiate and implement. While regional arrangements are inherently necessary due to the migratory nature of tuna stocks, effective implementation primarily falls to the coastal and flag State governments. This requires effective institutions and governance at the national level and the political will to implement, at times, contentious and difficult decisions.

The sustainable management and profitable development of the region's tuna fisheries is the key ocean governance challenge for the Pacific islands region in the short and medium term. Resolving these challenges is fundamental to the long term future of the region and its ability to implement oceans governance across all resource and conservation concerns.

This paper identifies some key implementation challenges facing Pacific island States and proposes a comprehensive new sub-regional approach to cooperative management that will be ultimately required for the Pacific islands States to effectively implement their coastal State obligations and sustainably manage fishing for tuna within their EEZs.

Introduction
The Pacific Islands region encompasses a unique grouping of small island States that includes some of the world's smallest countries surrounded by a vast maritime estate. The combined exclusive economic zones (EEZs) of the Pacific island States cover roughly 30,569,000 km² of the Western and Central Pacific Ocean (WCPO) [1] and includes some of its most productive waters.[2] Yet the combined landmass of these island States is only 552,789 km², of which 84% is found in Papua New Guinea.[3]

Many of these States are in a precarious condition[4] with low economic growth, political instability and significant weaknesses in their institutions and governance. Economic activity in much of the region is dominated by governments, while foreign fishing access agreements and foreign aid comprise significant components of national budgets. While there are many shared concerns within the region (particularly over issues such as climate change and fisheries), there is also a significant cultural, economic and institutional diversity with large variances between island States in their levels of development, institutional capacity and effectiveness of governance.

Due in part to this paucity of land and wealth of ocean, the region is heavily dependent upon the oceanic and coastal fisheries of the WCPO. While coastal fisheries provide important sources of traditional food and income to artisanal communities, the oceanic tuna fisheries are the cornerstone upon which many Pacific island States depend for revenue and economic activity. Fortunately, the WCPO is home to the world's richest and largest tuna fishery with an estimated value of approximately AUD$3.4 Billion.[5]

However, overfishing and overcapacity now threaten the long term sustainability of some of these tuna fisheries and significantly lower the benefits available to coastal and distant water fishing States. These sustainability and economic concerns require national and regional policy and regulatory responses that are challenging to conceptualise, negotiate and implement. While regional arrangements are inherently necessary due to the migratory nature of tuna stocks, effective implementation primarily falls to the coastal and flag State governments. This requires effective institutions and governance at the national level and the political will to implement, at times, contentious and difficult decisions.

Given the high dependence of the region on fisheries resources for revenue and food security, it is vital that the Pacific islands States are able to effectively govern their oceanic resources and address increasingly urgent sustainability concerns. Any serious impediment to securing the long term sustainability and development of the

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[1] For the purposes of this paper, the WCPO is defined as those waters within the Area defined by the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. This stretches from Indonesia and the Philippines in the west to Hawaii, Kiribati and French Polynesia in the East.
[2] Gillett, R. (2005). Pacific Islands Region. Review of the State of World Marine Fishery Resources. Rome, Food and Agriculture Organisation. **No. 457:** 144-157.
[3] Ibid.
[4] Pacific Islands Forum Secretariat (2005). Enabling Environment - Good Governance and Security. Pacific Plan Regional Analysis Papers. Suva, Pacific Islands Forum Secretariat.
[5] Reid, C. (2007). Value of WCPO Tuna Fisheries. Honiara, Pacific Islands Forum Fisheries Agency.

tuna resources can be viewed as a direct threat to the economic viability and food security for particularly vulnerable Pacific Island States.

The sustainable management and profitable development of the region's tuna fisheries is the key ocean governance challenge for the Pacific islands region in the short and medium term. Additionally, resolving these governance and institutional challenges is fundamental to the long term future of the region as this will provide the necessary platform to implement ocean governance across all marine resource and conservation concerns: from today's priority of implementing sustainable management for the region's tuna fisheries, to potential future challenges relating to climate change mitigation and sea bed mining.

This paper identifies key implementation challenges facing Pacific island States and proposes a comprehensive new sub-regional approach to cooperative management that will significantly boost the capacity of Pacific islands States to effectively implement their coastal State obligations and sustainably manage their oceanic resources.

Challenges to Implementing Oceans Governance in the Pacific Islands Region

In 2007, the author and two colleagues undertook a study for the Pacific Islands Forum Fisheries agency (FFA) on the fisheries governance arrangements amongst the Pacific Island country members of the FFA.[6] The study identified a large number of governance and institutional challenges across the region that were considered significant either because of their substantial direct national impact on some Pacific island States, or their substantial indirect impact on all members through the challenges they pose to participation and implementation of regional agreements.

This paper briefly summarises the key challenges from the FFA study (further detail can be found in the original report) and then builds on the FFA study to propose a sub-regional response to some of governance and institutional challenges facing ocean governance within the Pacific islands region.[7]

Fisheries Management Institutions

Given the socio-economic importance of fisheries resources to Pacific island States, it is critically important that national fisheries institutions are capable of effectively managing, developing and conserving their fisheries resources and implementing their national goals and regional obligations. However, the FFA study found that the ability of many national fisheries institutions throughout the region at meeting these goals or implementing their regional obligations, is significantly limited due to a number of institutional or governance weaknesses. The study suggested that some Pacific island States simply lack the resources to manage their fisheries sustainably or effectively implement national and/or regional conservation and management measures. Some

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[6] Hanich, Quentin., Teo, Feleti. and Tsamenyi, Martin. (2008). Closing the Gaps: Building Capacity in Pacific Fisheries Governance and Institutions. Honiara. Pacific Islands Forum Fisheries Agency (FFA). The study was commissioned by the FFA in 2007 and is available at http://www.apo.org.au/linkboard/results.chtml?filename_num=209706

[7] It should be noted that the views expressed in this paper are entirely the responsibility of the author alone and are in no manner associated with the FFA or any other agency or individual associated with the study.

Pacific islands States continue to suffer from an inadequate legal framework despite ongoing attempts to update legislation.

Licensing
The ability of countries to profit from their fisheries resources and to implement effective management is dependent upon their ability to control fishing activities through licensing, and their ability to gain a reasonable return from each license. However, the study noted that some Pacific islands lack the capacity, procedures, transparency and accountability to adequately review, issue, monitor and enforce fishing licenses and conditions.

Verification of catch and effort data
Data reporting and collection throughout the Pacific island region has historically been poor and continues to be problematic. Challenges to data collection have been identified in various reports[8] and further elaborated in the FFA study. Furthermore, many Pacific island States lack processes to verify catch and effort data. The study noted that few Pacific island States had the analytical or monitoring capacity or the actual data to verify the accuracy or otherwise of catch data and confirm if there was widespread misreporting or laundering of catch taken from Pacific island EEZs and claimed as catch from the high seas. The study noted multiple examples where ad hoc cross-verifications of catch reports against export sheet data, VMS data or observer data detected discrepancies in either the catch log reports, or the other data source used to cross-check the catch log reports.

Vessel Monitoring Schemes (VMS) and Observer Schemes
Some Pacific island States suffered from poor operation and implementation of national observer and VMS programmes. The study suggested that observer programmes were undermined by a shortage of observers due to recruitment problems and lack of government support. The study suggested that VMS suffers from a lack of domestic monitoring and limited punitive actions taken against vessels who turn their VMS off. The study suggested that the real problem wasn't necessarily the VMS, but the lack of monitoring and enforcement.

Governance, Decision Making, Coordination and Communication
The poor performance of institutions in Pacific islands States has been identified as an important barrier to growth[9] and various studies have identified weaknesses in national governance as a key constraint undermining or stalling national and regional management and development of the region's fisheries.[10] The study suggested that

[8] Lewis, T. (2004). Special requirements of FFA member countries with respect to science and data capabilities: evaluation and proposal for funding. Forum Fisheries Agency. Honiara. And: SPC. 2003. Capacity of Pacific Island Countries and Territories to meet the likely data requirements of the Western and Central Pacific Fisheries Commission. Oceanic Fisheries Programme of the Secretariat of the Pacific Community. Tabled to Working Group II of the Preparatory Conference 5th Session. Rarotonga.
[9] AusAID. (2006). Pacific 2020. Challenges and Opportunities for Growth. Australian Agency for International Development (AusAID). Canberra.
[10] Clark, Les. (2006). Pacific 2020 Background Paper: Fisheries. Paper prepared for AusAID based on roundtable discussions in June 2005. Cartwright, I and Preston, G. (2006). A Capacity Building Strategy for the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. Forum Fisheries Agency. Honiara. Barclay, K and Cartwright, I. (2006). Capturing Wealth from Tuna: Key Issues for Pacific Island Countries. Gillett, Robert. (2003). Domestic Tuna Industry Development in the Pacific Islands. The Current Situation and Considerations for Future Development Assistance. FFA Report 03/01. Honiara.

weak governance was widely regarded as a critical obstacle to implementing strong fisheries management and profitable development. Some Pacific island States suffer from poor decision making process and systems and a lack of accountability and transparency in decision making. This is a key concern as policies or decisions that are known only to the specific administrators distort the governance process and undermine implementation.[11]

Strategic and analytical capacity
Some Pacific island States suffer from a lack of strategic analytical/planning capacity: The study suggested that some Pacific island States lack capacity in strategic analysis and strategy development, setting of national objectives and national planning. Without a clear analysis, understanding, vision and strategy – many Pacific island States find it difficult to effectively support their aspirations and work within regional fora to best advance their interests. Furthermore, the lack of a clear vision of national interest limits the ability of fisheries departments and stakeholders to prioritise and motivate communities and governments to implement actions.

Corruption
There is clearly a concern throughout the Pacific Islands region regarding the impact of corruption and associated weaknesses in governance on the ability of the region to effectively manage and develop its fisheries.[12] Corruption in the fisheries sector in the Pacific Islands region is believed to be widespread, but it is difficult to measure its extent or frequency due to the secretive and underhand nature of the activity.[13] However, it appears that corruption has stolen much needed funds that should have gone into national accounts and local communities, undermined negotiating positions by Pacific Island States, and weakened the ability of Pacific Island States to benefit from their fisheries resources. The study suggested that corruption was an ongoing concern for some Pacific island States, occurring at political and operational levels.

Participation and advocacy in regional fora and implementation of regional measures
Some Pacific island States have little capacity to analyse/determine national interest and participate in regional fisheries management deliberations: The study suggested that some Pacific island countries lacked the capacity to analyse and determine their national interest and develop strategies and positions at international meetings that best served their national interest. Similarly, the study suggested that some Pacific island States lacked the capacity and confidence to negotiate at international levels.

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[11] Mellor, Thuy and Jabes, Jak. 2004. Governance in the Pacific: Focus for Action 2005-2009. Asian Development Bank. Manila.

[12] AusAID. Valuing Pacific Fish: A Framework for fisheries-related development assistance in the Pacific. Canberra: Australian Agency for International Development (AusAID); 2007. Crocombe R. The South Pacific. Suva: Institute of Pacific Studies of the University of the South Pacific; 2001. Cover Report: Fighting Off Competition – Commercial Fishermen Band Together. Published in: Islands Business. Suva: October 2004. Accessed online March 2007 at: www.spc.int/mrd/pacifictuna /press/04-sep-IB.htm Hooper M. Coherence through Co-operation: The Challenge for Achievement of Policy Coherence for Fisheries Development in the Pacific. Published in: Fishing for Coherence, Proceedings of the Workshop on Policy Coherence for Development in Fisheries. Paris: Organisation for Economic Cooperation and Development (OECD); 2006. Saldanha C. Pacific 2020 Background Paper: Political Governance. Canberra. Australian Agency for International Development (AusAID). 2005.

[13] AusAID. (2007). Tackling Corruption for Growth and Development: A Policy for Australian Development Assistance on Anti-Corruption. Canberra: Australian Agency for International Development (AusAID).

Two Principles for Capacity Building in Pacific islands Fisheries Institutions
In responding to the challenges summarised above, two principles should be kept in mind when developing capacity building solutions in the Pacific islands region. First, responses should be developed within the national context of each Pacific island State. Regional projects that operate in a centralised 'top down' manner or attempt to impose a unitary analysis or solution are likely to fail due to the breadth of difference between each Pacific island State. Given that many of the challenges facing Pacific island fisheries agencies are 'whole-of-government', they are unlikely to be fixed by aid programs that specifically target one institution across the whole region. Pacific leaders have recognised the importance of addressing weak governance and implementing good governance across the whole-of-government and this has been prioritised as a central pillar of the Pacific Plan.[14]

Second, it is vital that the needs and goals of the Pacific islands States drive national and regional programmes and capacity building projects. They must be owned by the Pacific island States in order to be effective.[15] This principle was endorsed by the PIC/Partners meeting in July 2007 in the Pacific Aid Effectiveness Principles.[16] The principle of 'ownership' and engagement is twofold and requires that donors and regional agencies work to the needs and requirements of Pacific island States, while the States themselves comprehensively engage and lead their development.

A Sub-Regional Solution to National Challenges
The success or failure of regional cooperative agreements depends upon the effective participation of members and their ability to implement decisions within the national context. The inability of some members to effectively participate and buy in to regional decisions undermines the ability of the entire region to sustainably manage and benefit from ocean resources.

Collective regional strategies require the informed will of all parties involved. This requires that all Pacific island States have the national capacity and confidence to determine and pursue their own national interest, within their vision of a collective strategy. The compromises and balancing required in any collective strategy require members to make these compromises in the full knowledge of their strategic context. Otherwise, nice words and silences simply provide a treaty-thin veneer with little real substance underneath.

A capacity building and engagement strategy is required that works in-country within particularly vulnerable Pacific island States and builds the capacity of governments to prepare for, negotiate, and implement international fisheries instruments and conservation measures. Such a programme should be truly nationally focused. Additionally, the program should work behind the scenes, and not 'sit-at-the-table'.

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[14] ForumSEC (2006). *The Pacific Plan for Strengthening Regional Co-operation and Integration.* Endorsed by the Pacific Islands Forum in October 2005 and revised in October 2006. Suva.

[15] The United Nations Development Program suggests that "Capacity development efforts must be led and grounded in endogenous efforts if they are to be meaningful and sustainable." UNDP. (2007). Supporting Capacity Development: the UNDP Approach. United Nations Development Programme. New York.

[16] Pacific Islands Forum Secretariat. (2007). Pacific island countries and donor partners endorse aid principles. Press statement (76/07). 18th July 2007
http://www.forumsec.org/pages.cfm/2007/pic-donor-partners-endorse-aid-principles.html

This paper proposes a sub-regional strategy that would build ocean governance capacity in the short to medium term and address long term implementation challenges through the establishment of a collective authority. The strategy would work towards the national priorities of a small like-minded sub-region of the Pacific islands region, while supporting regional outcomes. One or both of two sub-regions could be considered for such a strategy. Each sub-region includes three or four small island States with similar concerns, challenges and opportunities. The suggested purse seine sub-region includes: Tuvalu, Kiribati and Nauru. The suggested long line sub-region includes Samoa, Cook Islands, Tonga and Niue.

The sub-regional strategy could be undertaken in two stages. The first stage would focus on capacity building and improving whole-of-government processes relevant to fisheries management. The second stage would build on this through the establishment of a sub-regional collective management authority which would stabilise the first stage capacity building gains and address ongoing demographic and economic challenges to the ongoing operation of governance institutions in these small island States.

First Stage: Develop a sub-regional in-country capacity building strategy that emplaces experienced desk officers into the fisheries departments of each sub-regional country for 1 to 3 years. These desk officers would be responsible for supporting the ongoing development of strategic and analytical capacity within each country and would assist each country with a number of analytical, strategic and administrative tasks. In supporting these tasks, the desk officers would be required to particularly focus on mentoring and building the capacity of local staff to perform such tasks in future. Tasks to be undertaken could include:

- facilitate strategic reviews of fisheries management and development challenges and opportunities within the sub-regional, regional and international context. These reviews would identify national, sub-regional, regional and global concerns as they impact on the national interest of the specific country in question;

- support the development of economic and scientific expertise to analyse the strategic opportunities and ramifications of international instruments, and potential conservation measures to support the pursuit of national interest;

- facilitate whole-of-government engagement in fisheries management in order to ensure adequate resourcing and support for due process, strong regulatory schemes and sustainable management practices;

- support analysis of regional fora papers and briefs in order to inform whole-of-government policy discussions and preparation of delegation briefs;

- develop a national strategy for national engagement in regional fora and facilitate the development of whole-of-government coordination processes that lead towards cabinet endorsed national positions and written delegation briefs/mandates. Strategies and processes should identify objectives and propose specific work (nationally and regionally) to pursue these objectives. Given the regional dynamics and national limitations, it is likely that national interest analysis and strategy development will generally identify regional and sub-regional co-operative strategies as the best mechanisms for pursuing national interest. Nevertheless, for the program to build the trust and commitment necessary to ensure its success, the program should support the pursuit of national interest above regional objectives (as is the case with any strong member of the FFA);

- support the development of negotiation and advocacy tactics and skills that improve the ability and influence of delegations within regional fora to progress national objectives;

- support the preparation of post meeting reports to minister/cabinet and relevant government agencies that: summarise meeting; analyse outcomes; identify obligations requiring national action or implementation; assess performance of delegation against national brief and national strategy; identify unresolved matters that are likely to carry-over to future meetings;

Second stage: Develop a sub-regional fisheries management collective authority. Considering the demographic reality of small Pacific island developing States, it is difficult to envisage how some of the institutional capacity challenges can be addressed at the national level, particularly in regard to some of the small island developing States with very limited populations. Regardless of the level of training or operational budgets, some Pacific island States will always have very limited opportunities to adequately staff and support their fisheries management institutions due to their very limited population base. In some cases the management costs, in terms of staff and budget, are simply too large to be met by the limited population.

In these cases, serious consideration should be given to the development of a sub-regional collective fisheries management institution that manages fish stocks across three or four EEZs. For example, a sub-regional group of neighbouring countries may negotiate an agreement to establish a fisheries management authority that replaces their individual national fisheries institutions. This collective authority would be granted a clear mandate to govern the collective fisheries within their waters and would operate to a set of specific objectives. Countries would retain their sovereign rights over all fisheries within their EEZs, but would grant the sub-regional authority the mandate to administer and manage on their behalf.

A collective sub-regional model such as this could significantly reduce the management burden on each country while substantially increasing the management resources available. Furthermore, such a model could create co-operative development opportunities and give these countries a competitive edge by establishing a one-stop licensing process for vessels which could allow them to fish across multiple EEZs.

A collective authority would provide the necessary organisation size to allow recruitment strategies to be developed that could build regional ‘pools’ of talented individuals. The collective size of the management authority would better support individual career development and address high staff turnover concerns found in smaller government institutions that have few career advancement opportunities. Similarly, many Pacific island States individually are too small to fulfil all their ongoing needs for specialists given the lack of career opportunities. A regional recruitment strategy could increase the size of the available pool of skilled individuals from national populations to regional populations by further enabling and encouraging recruitment across the region, rather than just from within domestic populations.

Conclusion

Ocean governance is inherently a complicated and multi-agency challenge to governments worldwide due to the variety of ocean uses and the inter-connected nature of the marine environment. While tuna fisheries are the most pressing ocean governance challenge for the short and medium term, other marine management and conservation issues will become increasingly important in the medium to long term, particularly climate change mitigation technologies and seabed mining. Resolving these current and future challenges requires a strong institutional and governance capability.

Given the high dependence of the Pacific islands region on their marine environment, it is vital that Pacific islands States are able to effectively govern their oceanic resources and address sustainability concerns. The sub-regional approach proposed in this paper will significantly boost the capacity of Pacific islands States to effectively implement their coastal State obligations and sustainably manage their oceanic resources.

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Coming Deep-sea Mining and the Environmental Aspects

Tetsuo YAMAZAKI
Osaka Prefecture University
1-1 Gakuen-cho, Naka-ku, Sakai, Osaka 599-8531, Japan
yamazaki@marine.osakafu-u.ac.jp

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STRATEGIC VISIONS IN METAL MARKET

Copper is one of the most popular metals in human history and in modern life. In industrialized countries such as US, EU countries and Japan, new demands of copper of 8-10 kg/person/year are necessary in addition to the recycled ones. These are steady statistic records as shown in Fig.1. Annual world copper production which almost equals to the demand is the third largest among metals, as shown in Table 1, and is about half the production of aluminum. Copper's abundance in earth's crust, however, is three orders less than that of aluminum. The imbalance between production and abundance is the most significant among the metals. Because of the higher consumption compared with the abundance, copper is fundamentally the most vulnerable to a shortage. On the other hand, as shown in Fig. 1, the demand in China is expected to increase rapidly, because of the economic growth and the population. Another potentially large demand is also expected in India near future.

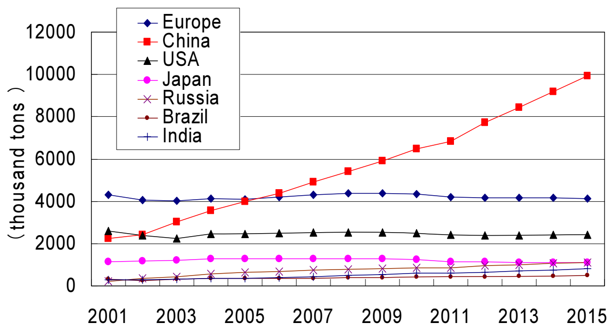

Fig. 1 World copper demand: static records until 2005 and projected after 2006

Source: K. Sawada, "World Supplies and Demands of Non-ferrous Metals in 2005 and the Prospects in 2006 in Case of Copper," PowerPoint Presentation File, 12th Conference for Research Activities Related to Non-ferrous Metals, Japan Oil, Gas and Metals National Corporation, 2006

Table 1 Productions and abundances in earth's crust of metals

Metal or product	World production in 2006 [metric ton]	Abundance in earth's crust [ppm in weight]
Platinum	518	0.01
Mercury	1,480	0.08
Gold	2,460	0.004
Silver	20,200	0.07
Cobalt	67,500	25
Molybdenum	185,000	1.5
Tin	366,000	2
Magnesium	584,000	23,300
Nickel	1,580,000	75
Lead	3,470,000	12.5
Zinc	10,000,000	70
Copper	15,100,000	55
Manganese ore	33,400,000	950
Alminium	33,700,000	82,300
Steel	123,000,000	56,300

Source of production data: http://minerals.usgs.gov/minerals/pubs/commodity/statistical_summary/myb1-2006-stati.pdf
Source of abundance data: Geological handbook, Heibon-sha, Tokyo, Japan Note: Manganese ore contains about 40% manganese.

Primary production industries, such as agriculture and mining, become the most important in economic activities, after current economic crisis, people will realize. Investment money will come back to agriculture and mining industries, soon. Demands of food, energy, and resources in accordance with economic growths in developing countries, none can stop. Under the situation, deep-sea mineral resources are the only sufficient sources for the metal demands.

ECONOMIC CHANCE OF DEEP-SEA MINING

In Pacific, manganese nodules on the deep-sea floors, as well as cobalt-rich manganese crusts (CMC) on the seamounts, have received attention since the 1960s as future resources for copper, nickel, cobalt, and manganese, due to their vast distribution and relatively higher metal concentrations. The outlines of these three deep-sea minerals are introduced in Fig. 2. International consortia conducted research and development of manganese nodules for 20 years (Welling 1981; Kaufman et al. 1985; Bath 1989), as have continued government agencies of several nations for 30 years (Herrouin et al. 1989; Yang and Wang 1997; Yamada and Yamazaki 1998; Hong and Kim 1999; Muthunayagam and Das 1999). These efforts have improved the technical and economic feasibility of mining manganese nodules. Conceptual outline of manganese nodule mining system is shown in Fig. 3.

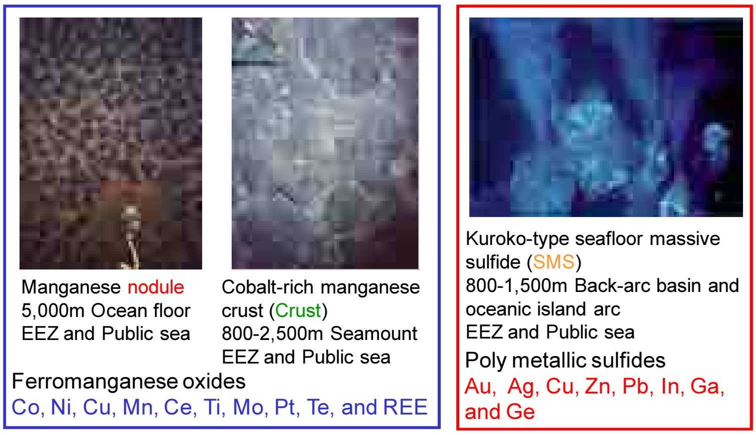

Fig. 2 Outlines of deep-sea mineral resources

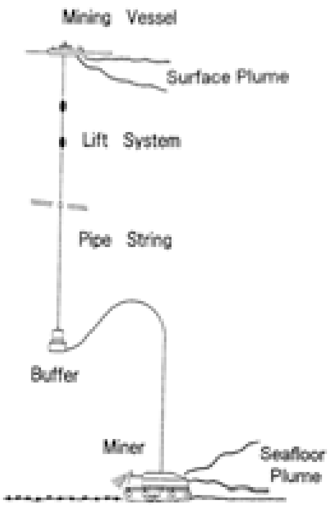

Fig. 3 Conceptual image of manganese nodule mining system and sources of environmental impacts

In Feb. 2008, ISA Workshop on Polymetallic Nodule Mining Technology - Current Status and Challenges Ahead was held in Chennai, India. An updated manganese nodule mining venture model was discussed and created with many experts in mining technology, metallurgical processing, and economy. Based on the model, the economic feasibility was re-evaluated with some technical options. The calculated results have been introduced to public through ISA website (http://www.isa.org.jm/files/documents/). The results are 14.9-37.8% in Internal Rate of Return.

For the feasibility of mining CMC, only the technical aspect has been discussed in a few reports on the basis of some selective technological efforts. Insufficient geological and geophysical information available for the economic evaluation was the reason. A preliminary model to examine the economic potentials of mining CMC was developed by the author, and some preliminary results were reported. However the results were not good at the mining venture under current situation (Yamazaki et al., 2002; Yamazaki, 2007). On the other hand, recently as future sources for rare earth elements (REE) in addition to Co and rare metals, the potential has been re-evaluated as shown in Fig. 4.

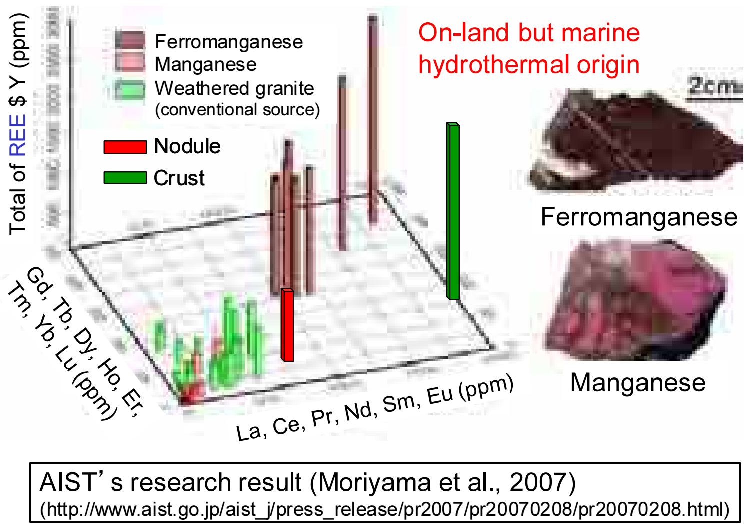

Fig. 4 Suggested potential of ferromanganese as REE sources

Nodule and crust data source: Hein, J. (2004). Proc. Minerals other than polymetallic nodules of the International Seabed Area, ISA, pp. 118-272

Kuroko-type seafloor massive sulfides (SMS) in the western Pacific have received much attention as resources for gold, silver, copper, zinc, and lead. Since the end of the 1980s, SMS have been found in the back-arc basin and on oceanic island-arc areas. The typical representatives found are in the Okinawa Trough and on the Izu-Ogasawara Arc near Japan (Halbach et al, 1989; Iizasa et al. 1999), in the Lau Basin and the North Fiji Basin near Fiji (Fouquet et al., 1991; Bendel et al, 1993), and in the East Manus Basin near Papua New Guinea (Kia and Lasark, 1999). A preliminary model to evaluate the economic potentials of mining SMS was developed by the author on the basis of geological and geophysical information in the Japan's EEZ, and some preliminary results were reported (Yamazaki et al, 2003; Yamazaki 2007). The higher gold, silver, and copper contents have increased the possibility of profitable mining under the recently increased metal prices, and a few private venture companies have kept interests and survey licenses for the mining (http://www.nautilusminerals.com; http://www.neptuneminerals.com). A pioneer mining project organized by one of the companies is under progress and the commercial mining is scheduled to start in a few years (http://www.nautilusminerals.com). Strategic national R&D projects for mining SMS have been launched in both Korea and Japan in 2008.

Currently the author have updated the economic feasibility model of mining SMS and re-evaluated the economy applying economic factors in 2006 and 2007. A material flow assumed in the model is introduced in Fig.5. There the ore dressing location has been shifted from on-board to on-shore. Depending on this relocation, the operation and capital costs listed in Table 2 and 3 for the transportation increased very much compared with the previous researches (Yamazaki et al, 2003; Yamazaki 2007). The capital cost of mining system has been updated referring with the ISA's model for manganese nodules. The drastic increase from the previous researches (Yamazaki et al, 2003; Yamazaki 2007) is the result of this updating.

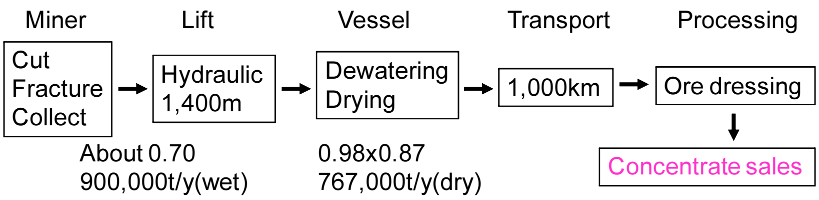

Fig 5 Material flow in model for mining SMS

Table 2 Operation cost of mining SMS

Subsystem	Kuroko-type seafloor massive sulfides with production scale 900,000t/y	
	with economic factors in 2006	with economic factors in 2007
Mining system	90	100
Transportation	37	41
Mineral processing	11	12
Metallurgical proc.	-	-
Total	**138M$**	**152M$**

Table 3 Capital cost of mining SMS

Subsystem	Kuroko-type seafloor massive sulfides with production scale 900,000t/y	
	Capital costs	
Mining system	324	
Transportation	115	
Mineral processing	38	
Metallurgical proc.	-	
Sub-total	**477M$**	
	with economic factors in 2006	with economic factors in 2007
Continuing expenses	98	99
Working capital	104	114
Total investment	**202M$**	**213M$**

Table 4 Results of economic evaluation

Case		Kuroko-type seafloor massive sulfides with production scale 900,000t/y		
		Payback periods (year)	NPV($)	IRR (%)
Metal prices in 2006	High grade	2.2	2,091M	98
	Low grade	8.2	217M	11
Metal prices in 2007	High grade	2.1	2,237M	103
	Low grade	7.7	264M	13

Low grade: Example average metal contents of mined Kuroko ore delivered from underground pit to flotation mineral processing plant

Cu:1.66%, Zn:10.5%, Pb:2.45%, Au:1.4ppm, Ag:113ppm

High grade: Example average metal contents of SMS core sample recovered by Benthic Multi-coring System

Cu:6.67%, Zn:14.95%, Pb:0.78%, Au:6.38ppm, Ag:392ppm

The difficulty in economic evaluation of mining SMS is the selection of metal contents in mined ore. No one can expect from the data of sulfide samples and the recovered cores. Here in the re-evaluation, average metal contents of mined Kuroko ore delivered from underground pit to processing plant are used as a low grade case. Then the ones of SMS core recovered by Benthic Multi-coring System are used as a high grade case. The values are introduced under Table 4. The economies calculated are summarized in Table 4. Even in the low grade case, still reasonable Internal Rate of Return (IRR) value is obtained. Actually in between the high and low grades, a commercial operation of mining SMS will start. The results show a highly attractive feature in mining SMS.

ENVIRONMENTAL ASSESSMENTS FOR DEEP-SEA MINING AND SOME ISSUES

Owing to growing concern for the environmental impacts of deep-sea mining, multi-disciplinary environmental studies (oceanography, geology, geochemistry, ecology and geotechnical engineering) for manganese nodules have been progressive in many countries (Ozturgut et al.. 1978; Ozturgut et al.. 1980; Burns et al. 1980; Thiel et al. 1995; Zielke et al., 1995; Schriever, 1995; Schriever et al., 1997; Bluhm, 1999). Three major sources of in-situ environmental impacts are expected during the mining manganese nodules. They are direct miner tracking on seafloor, a seafloor plume created by discharged sediments from the miner, and a surface plume created by discharged sediments and water from the mining vessel as shown in Fig. 3. Among the three, the impacts concerned with the miner tracking and the seafloor plume have been well examined (Trueblood et al., 1997; Kotlinski and Tkatchenko, 1997; Desa, 1997; Yamazaki and Kajitani, 1999; Sharma et al. 2003; Radziejewska 2003; Ohkubo and Yamazaki, 2003).

The mining system proposed for mining SMS is a similar one like manganese nodules in Fig. 3 except the miner and the discharge point of lifted sediments and water. The miner is necessary to add cutting and crushing functions for the SMS ore body. The lifted sediment and water are planned to return to the bottom via pipeline and those discharged near the seafloor (http://www.nautilusminerals.com). Both the direct destruction of the ecosystem occurred on and in the SMS ore body to be extracted and recovered, and the blanketing of the ecosystem in the surrounding area of the SMS ore body with the resedimentation of fine particles separated from the SMS ore, are the expected environmental impacts caused by the SMS mining on the seafloor.

A unique large biomass ecosystem has been found around active hydrothermal vents (http://www.whoi.edu/oceanus/viewArticle.do?id=2420). They are bacteria mat (*Beggiatoa)*, shell fishes (*Calyptogena*, *Bathymodiolus* etc.), tubeworms (*Riftia pachyptila*), amphipods, copepods, snails, shrimps, crabs, sea urchins, sponges, star fishes, corals, and fishes. All SMS in the western Pacific mentioned above are accompanied with many active hydrothermal vents. The primary productions in the ecosystem are sulfur oxidation using hydrogen sulfide supplied from the venting water and immobilization. The filamentous, colorless sulfur oxidizing bacteria *Beggiatoa* spp. often grows abundantly on top of sulfide-rich sediments. They are found around hydrothermal vents throughout the world's oceans, and may form mats on marine sediments ranging in size from a few millimeters to several meters (Fenchel and Bernard 1995). *Calyptogena* spp., which harbors sulfur oxidizing bacteria in their gills, is thought to be sustained by chemosynthetic energy sources under immobilization. *Bathymodiolus*, and tubeworms (*Riftia pachyptila*), have the same functions like *Calyptogena*. They are either found adjacent to hydrothermal vents and *Beggiatoa* fields.

The other animals found around active hydrothermal vents, such as amphipods, copepods, snails, shrimps, crabs, sea urchins, sponges, star fishes, corals, and fishes, are the secondary species categorized as the chemosynthesis-affected ecosystem on the organic carbonate creation with the chemosynthetic members (http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/chemosynthesis.html). The food web structure around hydrothermal vent is illustrated in Fig. 6 and is compared with the one in normal benthos. Because of additional primary production from the chemosynthesis, the biomass around the hydrothermal vent is quite richer than the one in normal benthos.

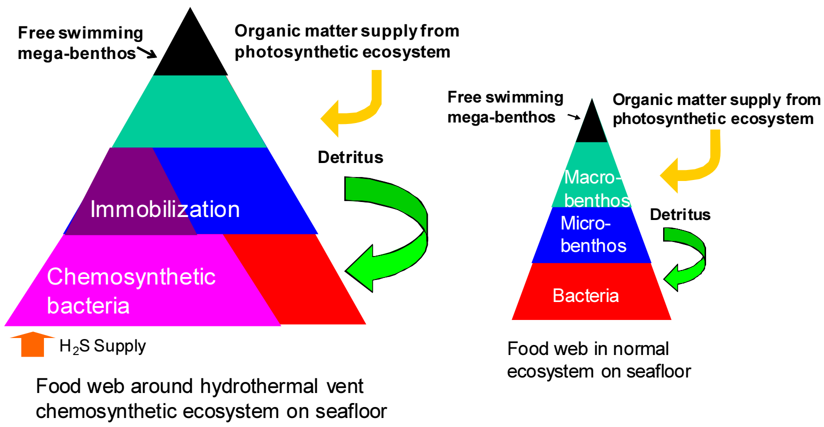

Fig. 6 Comparison of food web structures around hydrothermal vent and in normal benthos

Not only the active hydrothermal vents, but also the sites, where small chemosynthetic communities are present, are recognized as dangerous zones for the seafloor miner. The vents and the sites have active hydrothermal flux routes through fissures, and/or faults and high temperature water may be increased and/or induced with the mining activity. The miner's robotic control mechanism and sensors are too weak against the high temperatures though it is 40 - 50 ºC (104 - 122ºF). Thus, no direct destruction of chemosynthetic community is expected. However, the direct destruction of the chemosynthesis-affected ecosystem and the blanketing of the chemosynthetic community, the chemosynthesis-affected ecosystem, and the normal ecosystem are expected. The schematic distribution relationship among the attractive mining target, the active hydrothermal vents, the chemosynthetic community on the active hydrothermal vents, the chemosynthesis-affected ecosystem in the transition zone, and the normal ecosystem far away from the active hydrothermal vents are introduced in Fig 7.

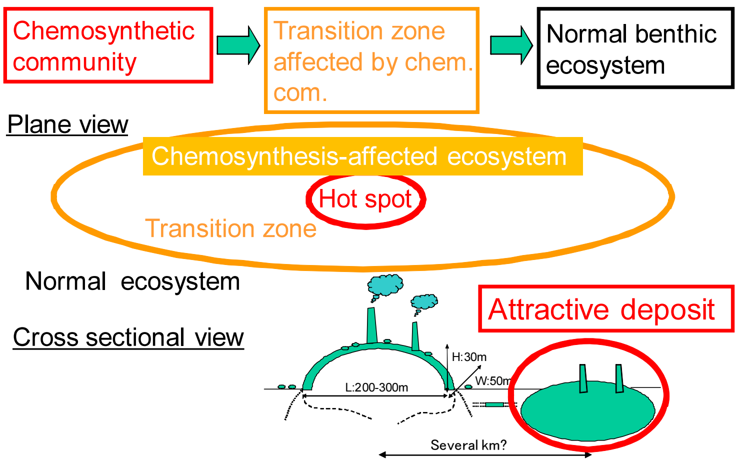

Fig. 7 Schematic distribution relationship around attractive mining target and active hydrothermal vents

Because the chemosynthetic communities around hydrothermal vents are unique and different from the normal ecosystem, the quantitative distribution and abundance data are necessary for baseline analysis. The data on the chemosynthesis-affected ecosystem are necessary, too. However, at present only many scientific and biological studies, such as the chemosynthesis mechanism and DNA analyses, are available in the literature. Therefore, a baseline survey from the chemosynthetic community on the active hydrothermal vent near the target mining site, through the chemosynthesis-affected ecosystem in the transition zone to the normal ecosystem far away from the mining site, are required.

In addition, as learned from some previous research mentioned above, the impacts concerned with the direct destruction by miner and the blanketing in the surrounding area must be examined through an artificial impact experiment and the post experiment monitoring. On the basis of the understanding of the baseline conditions, a numerical ecosystem model around hydrothermal vents should be developed that includes the chemosynthetic community, the chemosynthesis-affected ecosystem, and the normal ecosystem. By applying the experiment and the monitoring data, the model will be improved to simulate the mining impacts and the recovery process. Thereafter, the model is used as an effective tool for expecting scale-upped mining impacts and for assessing environmental impacts with proposed deep-sea mining.

STRATEGIC VISION FOR PACIFIC

Very many and wide applications of survey, mining, and environmental technologies concerned with the mining SMS are expected in offshore and ocean development fields as shown in Fig. 8. A quick proceed of mining SMS is a kind of entrance into technical advantages in offshore and ocean industries. The technical advantages are also effective for cooperation with Pacific countries in survey, mining, and environmental assessment for mining SMS, manganese nodules, and cobalt-rich manganese crusts.

Japan conducted a cooperative survey program for deep-sea mineral resources with SOPAC countries from 1985 to 2005 (http://www.jogmec.go.jp/mric_web/koenkai/060124/briefing_060124_okamoto.pdf). Now is the timing to re-start the same type cooperation, the author believes.

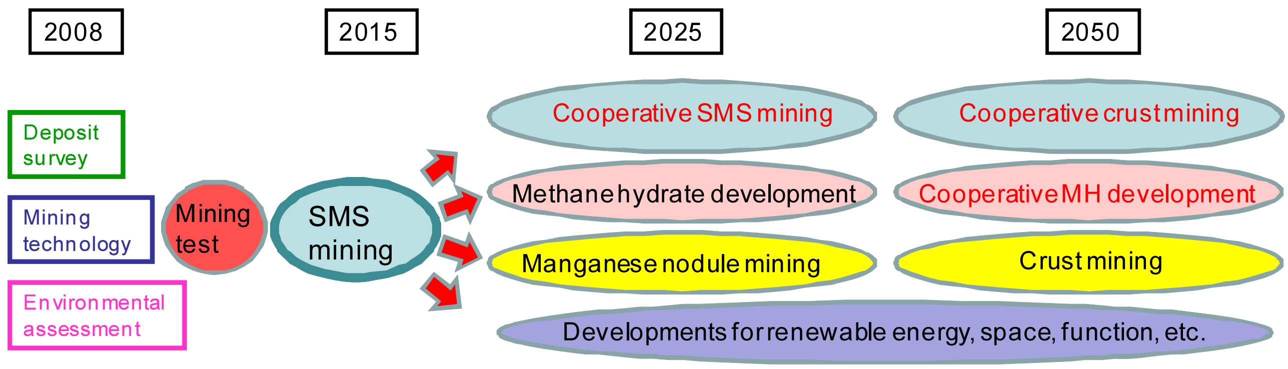

Fig. 8 Expected application of survey, mining, and environmental technologies for SMS in offshore and ocean development field

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The Need for a Comprehensive Study on the Problems of Islands and Management of their Surrounding Waters

Hiroshi Terashima

Executive Director
Ocean Policy Research Foundation

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International Symposium on Islands and Oceans

1. Creation of a new legal order on the oceans in the latter half of 20th century

The ocean covers 70% of the earth's surface and is the birthplace of life on Earth. Mankind has benefited greatly from the ocean's bounty, enabling our survival and the development of our societies. However, the ocean is a very different space from our terrestrial environment: it's filled with water and so under great pressure at depths, making the penetration of light and radio waves extremely difficult. Mankind would perish in an ocean environment, and even our activities there are often thwarted. Until recently, and aside from a narrow coastal zone, the ocean was an international space belonging to no state. All people had free use of that space, whose resources were open to all.

However, in the 20th century, especially the latter half, as the world's human population increased and limits began to be seen to the resources necessary to maintain life and economic activities, all countries began to take a new interest in the resources to be found in the ocean.

After the end of World War 2, many countries began to assert exclusive rights to wider ocean areas off their coasts and the resources to be found therein. At the same time, there was an increase in pollution derived from human activities on land and on and below the ocean's surface. As the effects on human life and the earth's ecosystems became more obvious, protection and conservation of the marine environment began to be called for. Supporting these calls were advances in scientific knowledge about the ocean and the development of new marine technologies.

As a result, countries from around the world participated for ten years in deliberations that resulted in the adoption of the United Nations Convention on the Law of the Sea in 1982 and its coming into effect in 1994. The Convention's basic stance is expressed in its preamble, where it states, "the problems of ocean space are closely interrelated and need to be considered as a whole." By setting out provisions for almost all aspects of ocean law, it created a new legal order aiming at the comprehensive management of the ocean.

2. UNCLOS and the management of large areas of ocean space by Coastal States

One of the most important features of UNCLOS was that it entrusted the management of large areas of ocean space to Coastal States. Until that time, ocean space was divided by custom into the three nautical mile rule for narrow territorial waters, beyond which the principle of "freedom of the seas" held sway. However, as UNCLOS set territorial sea limits at 12 nautical miles and established the EEZ and continental shelf regimes, extending up to 200nm from shore, 40% of ocean space came under the jurisdiction of one State or another. Beyond that, in areas falling under no State's jurisdiction, the sea bed and below was designated "the Area," and the Common Heritage of Mankind regime was established to share the sea bed and the minerals therein. In other words, UNCLOS changed the old dual partition of the "narrow territorial seas" and "broad high seas", divided ocean space into a variety of areas of differing legal character, and established regimes for the seabed, continental shelf, and the Area.

As UNCLOS responded to the claims of Coastal states for rights over ocean space and minerals off their shores by establishing the EEZ and continental shelf regimes, there is a strong tendency to regard those ocean spaces as solely areas in which Coastal States can exercise their rights over minerals, etc. However, UNCLOS at the same time included provisions assigning obligations and responsibilities to Coastal States to preserve living natural resources and protect and conserve the marine environment in their ocean areas. Furthermore, UNCLOS regulates States' activities on the high seas regarding the preservation of living natural resources and the protection and conservation of the marine environment. In other words, reflecting the highly unified nature of ocean space, UNCLOS casts a wide management net aimed at Ocean Governance.

Therefore, from its premise that "the problems of ocean space are closely interrelated and need to be considered as a whole," UNCLOS calls on all States to participate in ocean management initiatives, based on the Convention, at the global, regional, and state levels.

Today, the belief in the need for comprehensive management of the ocean is widely held among ocean stakeholders. However, almost no work has been done internationally to formulate how we should proceed with the comprehensive management of development, use, and conservation of vast ocean areas, and even initiatives by individual countries on this issue have made little progress. It is no exaggeration to say that research by academics and other researchers is just now getting under way.

For comprehensive management of the ocean, we should get down to the problem of delimiting the ocean areas for which each country is to assume responsibility, a precondition for the management of ocean space. Difficulties are especially likely in the delimitation of overlapping exclusive economic zones and continental shelves between states with opposite or adjacent coasts, or if the "rock" problem of UNCLOS Article 121.3 arises. We should note that Islands have shouldered the more important role in the Ocean Governance under the UNCLOS regime.

Given the increased importance of islands due to UNCLOS, to address the issue of "Development, Use, Conservation, and Management of Islands and their Surrounding Waters" has become one of the important issues not only to those countries whose territory comprise islands in the ocean, but also to the whole world as it is crucial in the promotion of comprehensive management and sustainable development of the ocean. We must therefore begin by discussing what methods we should employ.

3. UNCLOS, Article 121: Regime of Islands and its Problem

As mentioned above, UNCLOS set the limits for territorial waters at 12 nautical miles. It also established the EEZ and continental shelf regimes for the areas up to 200 nm from the coastline, thereby greatly increasing the areas under Coastal States' jurisdiction.

There was much discussion during the drafting process of UNCLOS over whether small islands should be accorded territorial waters, adjacent sea areas, exclusive economic zones, and continental shelves on the same conditions as other land areas. In the end, they were indeed treated the same as other land areas, with the exception of Article 121.3, though the problems inherent in the Article were left unresolved.

The Article 121.3 of UNCLOS states that "Rocks which cannot sustain human habitation or economic life of their own shall have no exclusive economic zone or continental shelf".

As discussion on Article 121.3 was not exhausted before its acceptance, there remain some variance on the Convention's interpretation and application. One example stems from the lack of a definition for the term 'rock' in the Convention. With the relationship between the term 'island' in Article 121.1 and 'rock' in Article 121.3 thus left unclear, consensus on the interpretation of the article among States and legal scholars is not always realized.

There is also the following problem of interpretation and application. It is generally understood that "rocks which can sustain human habitation or economic life of their own" is set as the condition for designation of an island without actually requiring such habitation or economic life in practice, but only requiring the possibility of them. If such is the case, as science and technology advances, the possibility of habitation or economic life will change from time to time, leading to the lack of clarity in the requirements to be met.

This leads to situations in which doubts are raised among scholars and the States involved concerning the validity of the small islands used as baselines by Coastal States to determine their EEZs and continental shelves.

As countries move forward with initiatives to manage their ocean areas, there is a potential danger of this becoming a significant international problem. It is therefore advisable that we clarify and reevaluate our thinking about islands and the management of their surrounding waters.

4. UNCLOS, Article 56: Rights, Jurisdiction and Duties of the Coastal States in the exclusive economic zone

In considering the management of waters surrounding islands, there is another problem I would like to bring up. UNCLOS established the special legal system of the Exclusive Economic Zone, whereby Coastal States are given jurisdictional rights over the ocean areas adjacent to their territorial waters up to 200nm from the baseline used to determine the width of those territorial waters. The rights, jurisdiction, and duties of the Coastal States in their EEZs are as follows:

UNCLOS　Article56

1. In the exclusive economic zone, the coastal states has:

(a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the water superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;

(b) Jurisdiction as provided for in the relevant provisions of this convention with regard to:

(ⅰ) the establishment and use of artificial islands, installations and structures;

(ⅱ) marine scientific research;

(ⅲ) the protection and preservation of the marine environment;

(c) other rights and duties provided for in this Convention.

The title given to this Article is “Rights, Jurisdiction and Duties of the Coastal States in the exclusive economic zone.” However, while sovereign rights are explicitly granted for the purpose of “exploring and exploiting, conserving and managing the natural resources,” and “other activities for the economic exploitation and exploration of the zone,” and jurisdictional rights are made clear regarding the “establishment and use of artificial islands, installations and structures,” “marine scientific research,” and “the protection and preservation of the marine environment," the regulation regarding Coastal States' duties stops at "other rights and duties provided for in this Convention."

I believe it is due to this imbalance in the regulatory approach that discussions on the EEZ regime have tended to focus primarily on the rights of the Coastal States, rather than taking the Ocean Governance perspective, which would put more emphasis on their responsibilities and roles in managing their coastal waters.

Among the main responsibilities of Coastal States are the conservation of living resources and the protection and conservation of the marine environment. While the Convention does accord sovereign rights to the Coastal States, the conservation and management of natural resources actually implies great responsibilities. The object of the jurisdictional rights in Article 56, "the protection and preservation of the marine environment," is also stated in Section 12 to be a duty of States.

In recent years, under the FAO and regional fishery organizations' frameworks, progress has been made in the conservation and sustainable management of living resources. Also, among initiatives for the protection and conservation of the marine environment, there has been a shift from the initiatives that emphasized marine pollution responses at the time the Convention was drafted, to those aimed at conservation of marine biodiversity, ecosystem-based management, and marine spacial management. In consideration of these circumstances, I believe there is a need to comprehensively reexamine the rights and duties of Coastal States regarding the management of their EEZs, actual management practices, and the role they should play.

5. Management of EEZs and the role of small islands

This kind of reexamination would no doubt have a large effect on the responses to be given to the question of small islands and whether they should have EEZs and continental shelves. The reason why is that in recent years, as I mentioned earlier, there has been a shift among initiatives for the protection and conservation of the marine environment towards marine biodiversity, and many discussions have been held on how best to promote ecosystem-based management and marine spacial management. Small islands are more closely interrelated with their surrounding ocean areas than are other land areas, thus the management of ocean areas is of great importance to them, and, in fact, mid-ocean islands especially have a large role to play as hubs in the survey, development, use, conservation, and management of their surrounding waters. I therefore think there is a need to examine this problem by asking how islands, their inhabitants, or users, are interacting with the surrounding ocean areas and what is the most appropriate role for them to play.

I hereby raise the question of islands, especially small, mid-ocean islands, and the management of their surrounding ocean areas and would like to propose that we more fully examine the problem mentioned above from many different perspectives.

Island Conservation and Revival Initiatives
Comment by Dr. Makoto Omori, Akajima Marine Science Laboratory

Coral reefs in the world have continued to deteriorate after the climate change bleaching in 1998 and human pressures. Comparing with the Indian Ocean who had damaged by tsunami and the Caribbean who had seriously deteriorated by more bleaching and hurricanes, however, conditions of coral reefs and coral reefs in the Pacific are still generally in good condition, excepting for densely populated islands.

According to "Status of Coral Reefs of the World 2008" (Wilkinson, 2008), degradation of coral reefs near major centers of population continues with losses of coral cover, fish populations and probably biodiversity. It is estimated that the world has effectively lost 19% of the original area of coral reefs; 15% are seriously threatened with loss within the next 10-20 years; and 20% are under threat of loss in 20-40 years.

The majority of Pacific reefs of island nations have been under traditional stewardship and the reefs served as important sources of food for subsistence fishers. However, traditional utilization and management of reefs are declining in many of the islands, following the breakdown of traditional lifestyles and social systems. Moreover, recent development of tourist industries has led to problems of over-exploitation and pollution at many regions. It is afraid that climate change alone may trigger a global coral die-off by 2100 (Hoegh-Guldberg et al. 2007). But local environmental problems such as eutrophication, pollution, and reclamation are killing of more coral reefs now.

Japan is one of a few developed nations who are blessing with coral reefs. We should be able to play a larger role for conservation and restoration of coral reefs on behalf of developing countries in the tropic that cannot afford to conduct basic research on coral reefs. Driven by such aspiration, we founded Akajima Marine Science Laboratory (AMSL) in 1988 on Akajima Island, Okinawa, Japan.

When we moved to Akajima Island which was surrounded beautiful coral reefs, many local habitants including fishermen thought that corals are kind of stone. In order to enlighten environmental protection of the island, we have commenced education about the sea and coral reefs for school children and island community. We continued publication of local newsletter describing the laboratory's activities. In the 1990s, a scuba diving boom began, and thousands of people of all ages from Japan and abroad have visited Akajima Island. Accordingly, many tourist homes and diving shops have opened. Population of Akajima Island has increased from 214 in 1985 to 348 in 2000 (Number of school child in primary school: 11 in 1985 and 26 in 2000). After twenty years environmental education and public enlightenment, all islanders now thank to blessing of coral reefs. School children write composition about spawning of corals, and local divers, besides assisting the coral transplantation activity of AMSL, are continuing extermination of crown-of-thorns starfish in their important diving area.

In light of the current state, AMSL have developed coral culture technique that use sexual propagation of corals from eggs to small juvenile colonies. And, we have ways of transplanting such colonies onto seabed in degraded reefs. Following the success of coral culture at AMSL, Fishery Agency of Japan established coral culture center at Akajima. Using the same culture technique that we have developed at AMSL, they produced juvenile coral colonies from eggs in aquaria and transplanted in April 2008, about 63000 colonies at Okinotorishima, Japan's southernmost island in the Pacific.

I believe that health of marine ecosystem cannot be kept easily by message from policy makers but is maintained by spontaneous movement of various stakeholders in the local area. Poor understanding of situation and phenomena of environment hinder progress of counter measure for the issues. What we have learned from our activity is that in order to permeate thought to protect coral reefs among islanders, it takes a long time steady effort to show our achievements of science and technology, and to keep companionship between scientists who are willing to conserve coral reef ecosystem and local community who is willing to receive sustainable services of coral reefs.

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How should the economic value of an island be evaluated?

Tomohiko Fukushima
UT Ocean Alliance, University of Tokyo

Abstract

The economic value of an island means the economy of the island itself and the economy of surrounding exclusive economic zone (EEZ). If it is a remote island such as Okinotorishima, weight of the EEZ relatively rises so you can say the economic value of an island and the EEZ are almost same. It goes without saying that the economic value of the EEZ depends on "the existence of resources", it is also influenced by “will to develop” or “the degree of the technical achievement”. In another words, the economic value of the EEZ changes depending on social conditions and technical level. Given to those backgrounds, the present author tried to estimate a quantity of mineral resources in the sea floor as a case study in the previous stage to measure the economic value of an island. Estimation has done for the EEZ of Okinotorishima, where there are few cases of scientific researches and most results are not made public, and it indicated that the inferred resources of copper was 44,000t, nickel was 210,000t and cobalt was 260,000t. When they convert it into an annual consumption, quantity of copper did not reach the annual consumption of our country, that of nickel was equivalent to a year, and cobalt was twenty years of the consumption. Although those estimations shows that this place may not be suitable for development of mineral resources, if rare earth or other rare metals included in ores are taken as a by-product, extra value will be born. In order to estimate the economic value of islands, information about the social science such as a law, economy and the politics are also necessary, because natural resources are the things which human society uses.

1. Introduction

Since UNCLOS took into effect, more than 40 percent of sea area has been under the jurisdiction of coastal state. So the importance of the island came to be emphasized. Japan is in the same situation. As you know, Japan is an island state formed of Hokkaido, Honshu, Shikoku, Kyushu and 6848 of small Islands. There is an exclusive economic zone (EEZ) of 400,000 square km, and more than 60 percent of the EEZ is based on islands except Hokkaido, Honshu, Shikoku and Kyushu. The fact demonstrates the importance of islands.

The economic value of an island is various. There are a lot of agricultural crops or residence spaces of human beings at the land area. In the same way, there are mineral resources or fishery resources in surrounding EEZ. If it is a remote island, weight of the EEZ relatively rises so you can say the economic value of an island and the EEZ are almost same. While the economic value of the EEZ changes depending on social conditions and achievement levels of ocean technology. For example, when our country ratified the UNCLOS, the economic value of the EEZ was able to be replaced with the value as the fishery ground i.e. technologies were not enough to develop for other resources. However, in the present day, such a substitution is impossible because various resources potential are getting to be recognized. Considering such a fact, evaluation of island value might be very difficult. In this case there are two choices. One is to give up an evaluation of islands value, the other is to evaluate it in a feasible range and update it as needed. The present author chose the latter, and tried to estimate a quantity of mineral resources in the sea floor as a case study in the previous stage to measure the economic value of Okinotorishima.

Okinotorishima is Japanese territory located in the western Pacific (20°25'N, 136°05'E). There are two small islands, called Higashi-kojima and Kita-kojima, at a top of a sea-mount. Officially, Okinotorishima means both islands, however in this report entire area of the table reef is called Okinotorishima. Though both islands are very small, our country is able to declare EEZ of four hundred thousand of square kilometer (400,000km^2). Besides, a quantity of sea water in this area is calculated for about two millions cubic kilometer (2,000,000 km^3) (Matsuzawa, 2005).Furthermore, if a continuous geological structure from the island to seafloor up to 350 nautical miles would be verified, our country could exercise over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources. These matters are very important for our country. However attentions should be attracted also the usage of the EEZ. In this context, in this study, quantities of deep sea mineral resources in the EEZ of Okinotorishima are estimated.

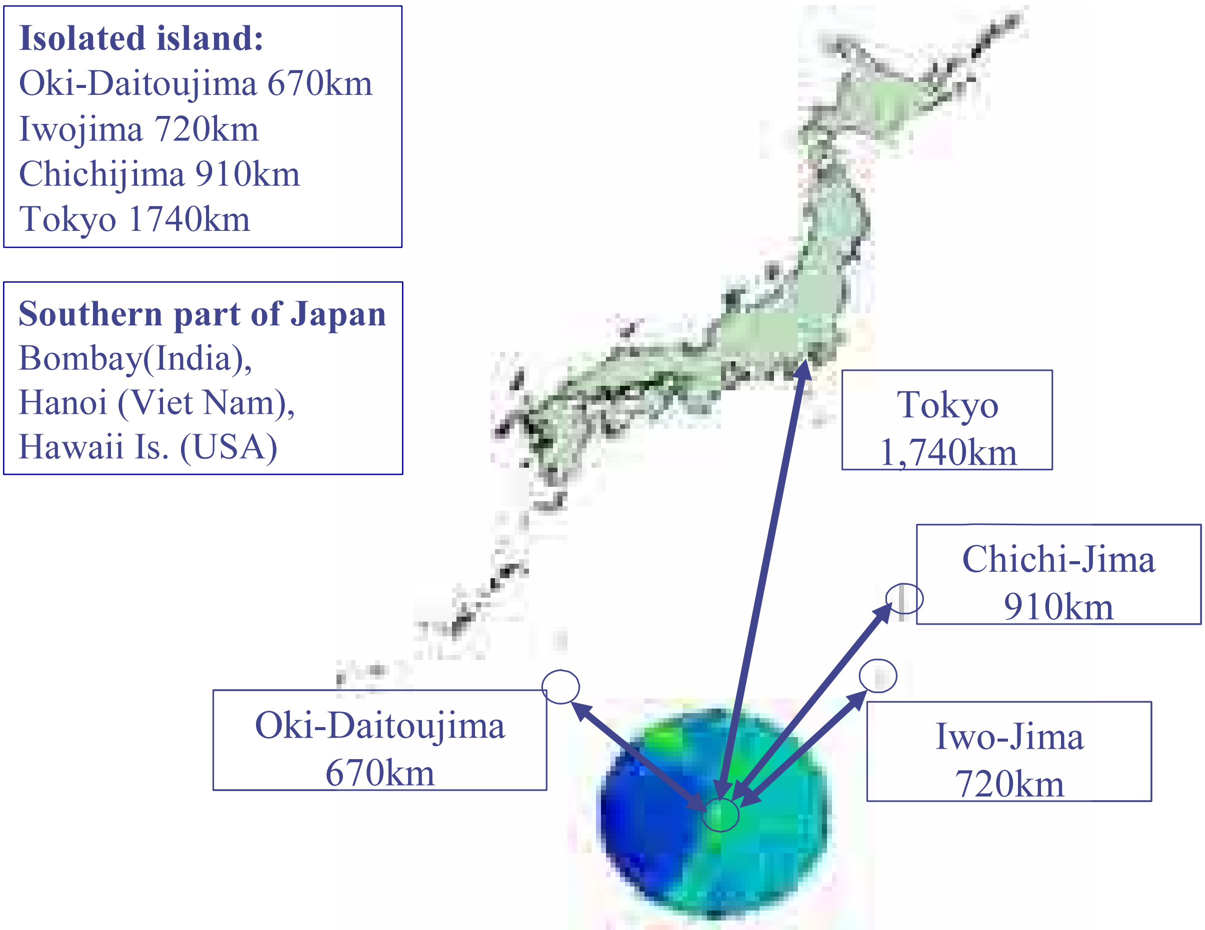


Fig.1 EEZ in the areas of Okinotorishima

Table1. Areas and volumes of EEZ in each country

	AREA		VOLUME	
ranking	Country	$10^6 Km^2$	Country	$10^6 Km^3$
1	USA	10.70	USA	33.8
2	Russia	8.03	Australia	18.2
3	Australia	7.87	Kiribati	16.4
4	Indonesia	6.08	Japan	15.8
5	Canada	5.80	Indonesia	12.7
6	Japan	4.46	Chile	12.5

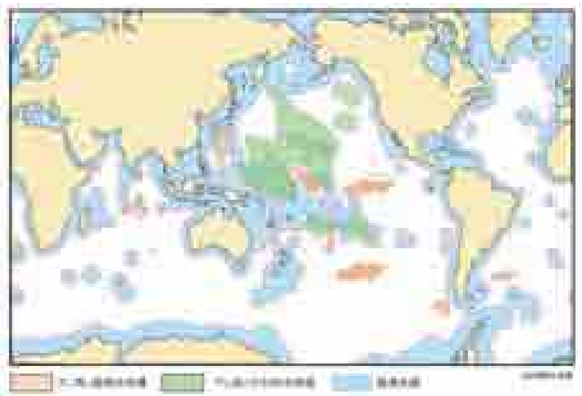
Table 1 Areas and volumes of EEZ in each country

After Matsuzawa (2006)

2. Methods

Target of evaluation

In general, ocean mineral resources are divided into three types i.e. manganese nodules (MN), cobalt rich crust (CRC) and seafloor massive sulfide (SMS). Different distributions are observed among the tree resources. In the EEZ around the Okinotorishima, CRC is the most appropriate target ore among the three.



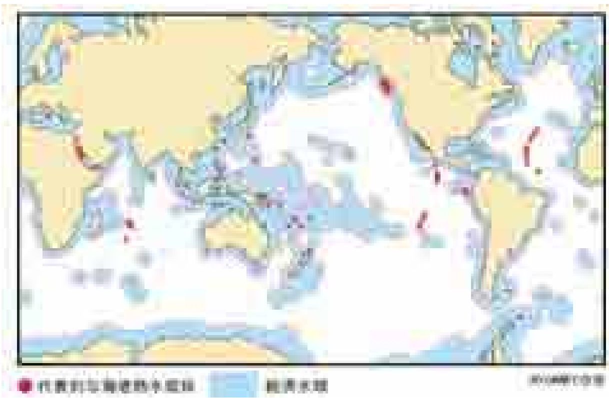


Fig 2 Distributions of manganese nodules(MN) and manganese crust (CRC)（left）
Fig.3 Distribution of seafloor massive sulfide（SMS）（right）after Hishida(2006)

Data source of topography and mineral resources

Topographic data-sets as followed are obtained from Marine Information Research Center (MIRC) and National Geographic Data Center (NGDC: USA).

JTOPO30: 30- Second Gridded topographic Data (provided by the MIRC)

JTOPO1: 1- Minute Gridded topographic Data (provided by the MIRC)

* MIRC: Marine Information Research Center of The Japan Hydrographic Association

ETOPO 5: Earth Topography on a 5-minute grid 2-Minute Gridded Global Relief Data (provided by the National Geographic Data Center)

Data-sets of ocean mineral resources in the areas of Okinotorishima are provided with the Geological Survey of Japan (present name: the National Institute of Advanced Industrial Science and technology); the Geological Study in the areas of the western Pacific area by the Geographic Survey of Japan.

Calculations

The inferred resources of CRC depend on the geographical features, especially the angle of seamounts slope. The calculation is conducted by original equation that is found from the Okamoto in 2003 and Kanda in 2006 as followed; basically the estimations were used the relationship between areas of respective seamounts slope and the inferred resources.

Precedent studies and the present study

Marshall Islands（Okamoto, 2003）

Inferred Resource on a SMT

＝ IR on the summit ＋ IR on Upper part of Slope ＋ IR Middle Part of Slope

IF in each part = A (G) × （R / S） × CT × SG (2) × G

A (G): area (km^2), R / S: Exposed area / Area covered by sediment

CT: Thickness of Crust, SG: Specific Gravity, G: Grade

Izu-Ogasawara Ridge and Kyusyu-Palau Ridge (Kanda, 2006)

Inferred Resource in the Target area = A(>15) × CT × SG (2) × G

A (>15): Slope area beyond 15 degree (km^2)

CT: Thickness of Crust, SG: Specific Gravity, G: Grade

Okinotorishima EEZ (The Present Study)

Inferred Resource in the Okinotorishima EEZ = Σ IR at SMT

IR at SMT = IR in the areas of respective slope (0-5, 5-10, 10-15, 15-20, 20-25 degree)

IR in the areas of respective slope = A(d) × （R / S） × CT × SG (2) × G

A (d): Slope area of certain slope (km^2)

CT: Thickness of Crust, SG: Specific Gravity, G: Grade

3. Results and Discussions

Geological feature in general

In this area, there are 22 sea mountains along the Kyushu-Palau ridge and the Okidaito ridge. There is the Philippine basin in the west side of the Kyushu-Palau ridge, and the Okinotorishima basin in the east side. While there is the Mangetsu basin in the vicinity where two ridges intersect. Besides, there is the Iwo-jima trough in the north-east side and, the Okidaito trough is in the north-west side.

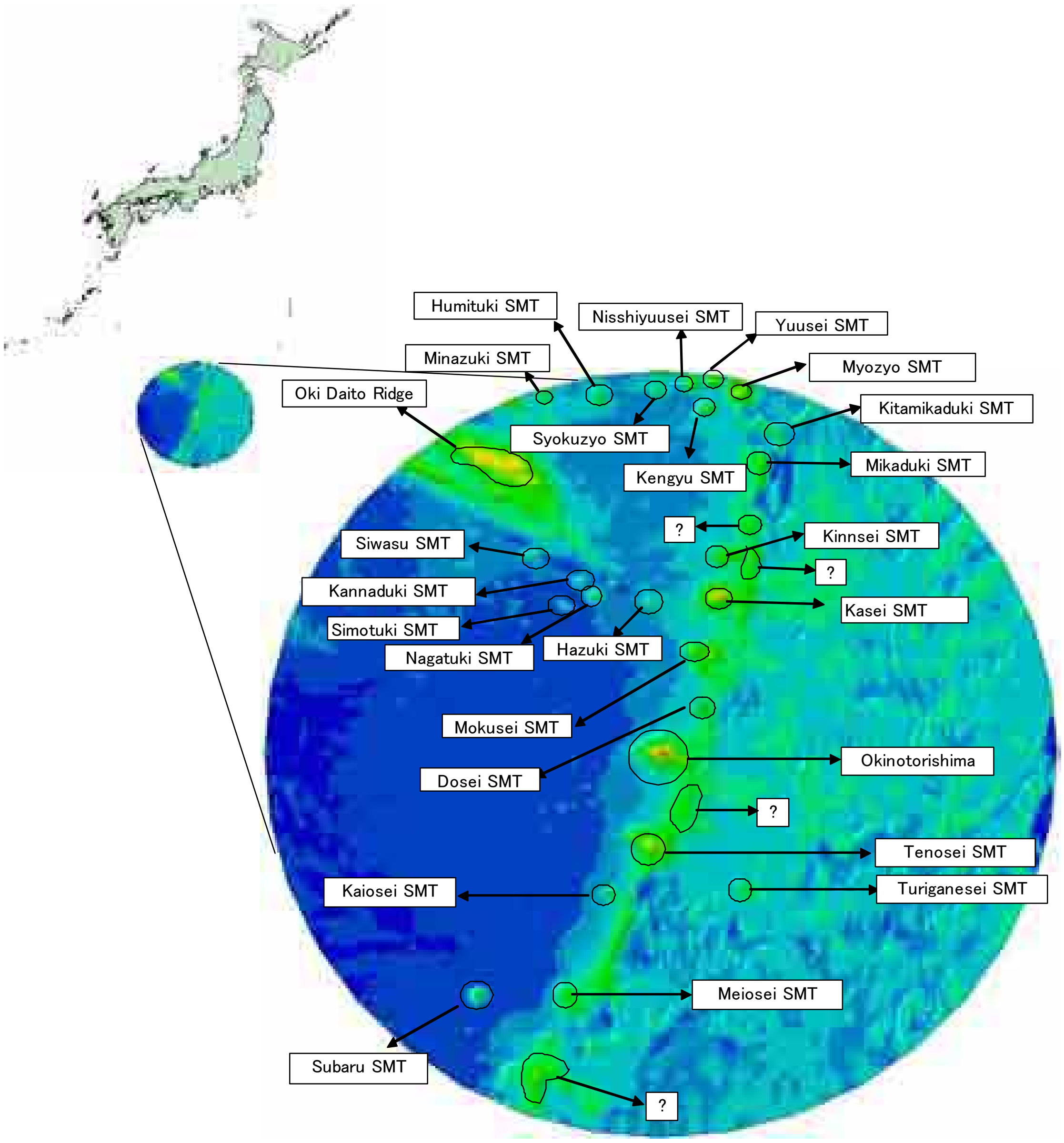


Fig. 4 Geological feature in the area of Okinotorishima

Area (km^2) respective slope

There is only 25,298km^2 in a part that is shallower than 4,000m in EEZ of the Okinotorishima (Fig.4). This area corresponds to 6% of the whole. In the EEZ, there is no slope of 25 degrees or more, and the majority is slope of 0-5 or 5-10 degrees.

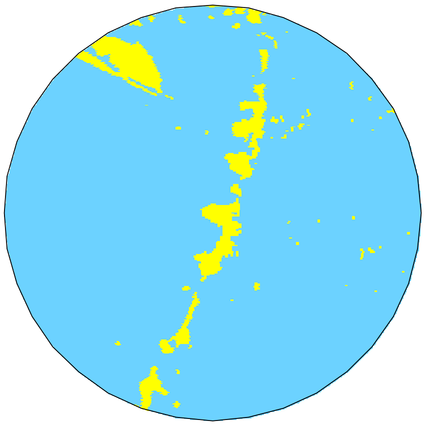


Fig. 4 Geological feature in the area of Okinotorishima. Area(yellow) shallower than 4,000m (25,298 km2)

Three representative seamounts, the Myozyo SMT, the Okinotorishima SMT and the Tenosei SMT, were selected and shown the geological features of them were shown in Table 2 and Fig. 5, 6 and 7.

Myozyo SMT: This sea mount is located in the north end of the EEZ. The slope of 10-15 degrees is the widest, and it is steepest one among three mountains.

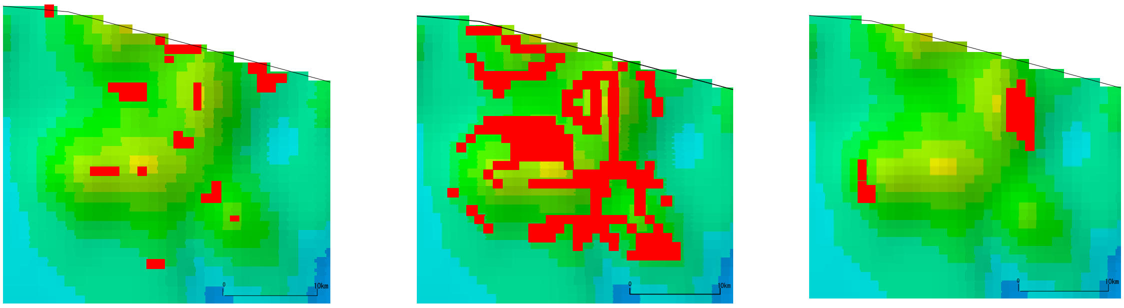
Okinotorishima SMT: This seamount is located in the central part of the EEZ. Although the steeper slopes are observed in the top part, the slope of 5-10 degrees is the widest.

Tenosei SMT: This sea mount is located in the south of Okinotorishima SMT. The slope of 0-5 degrees is the widest, and the inclination is the most gradual among three sea mountains.

Table 2 Area respective slope in the EEZ of Okinotorishima and certain SMT

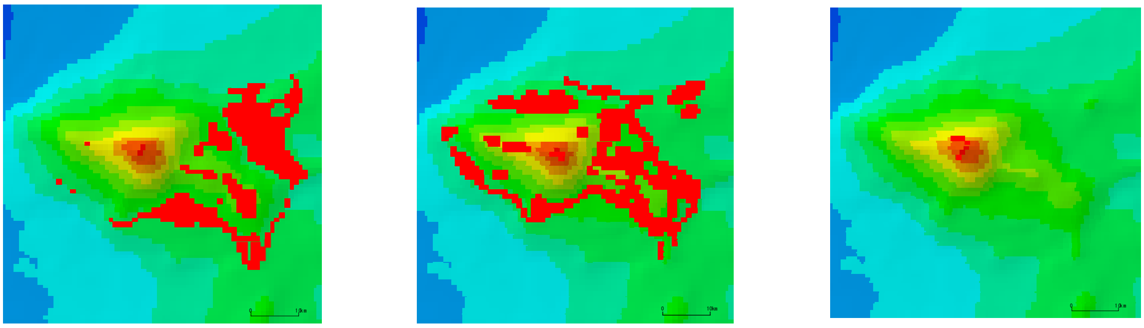
	degree (area ＞ 4,000m)						
Area	0-5°	5-10°	10-15°	15-20°	20-25°	25°-	total
Okinotorishima EEZ	10,921	9,342	3,527	1,399	109	0	25,298
	43 %	37 %	14 %	6 %	0.4 %	0 %	
Myozyo SMT	37	137	196	136	25	0	531
	7 %	26 %	37 %	26 %	4.7 %	0 %	
Okinotorishima SMT	394	521	391	177	5	0	1,488
	26 %	35 %	26 %	12 %	0.3 %	0 %	
Tenosei SMT	589	493	225	111	7	0	1,425
	41 %	35 %	16 %	8 %	0.5 %	0 %	

(km^2)



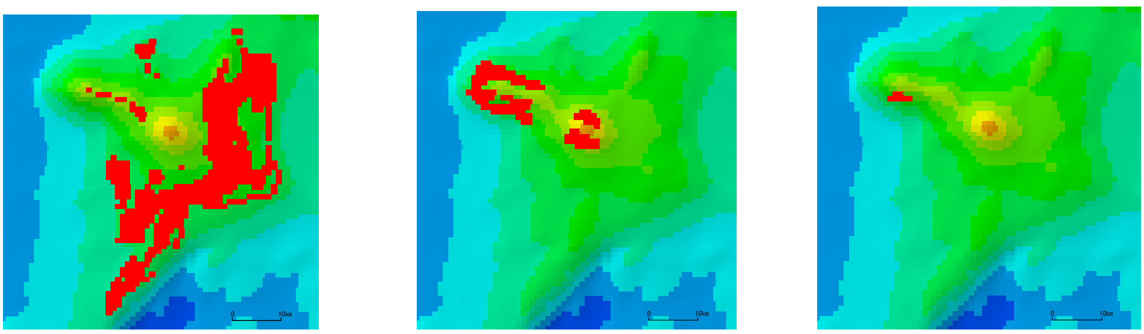
0°<,<5°(37 km^2)　10°<,<15°（196 km^2）　20°<,<25°（25 km^2）

Fig.5 Myozyo SMT



5°<,<10°(521 km^2)　10°<,<15°（391 km^2）　20°<,<25°（5 km^2）

Fig.6 Okinotorishima SMT



5°<,<10°(589 km^2)　15°<,<20°（111km^2）　20°<,<25°（5 km^2）

Fig.7 Tenosei SMT

Inferred resources

Inferred resources of Cu, Ni and Co in the three sea mounts are estimated. Although the thickness of crust is the order of Okinotorishima SMT, Myozyo SMT and Tenosei SMT, the grade of Cu, Ni and Co do not have a large difference among those seamounts. Then the highest values of Cu, Ni and Co are observed in the Okinotorishima SMT.

Total amount of copper was estimated for 44,000t, nickel 210,000t and cobalt 260,000t respectively in the EEZ. When they convert it into an annual consumption, quantity of copper did not reach the annual consumption of our country, that of nickel was equivalent to a year, and cobalt was twenty years of the consumption.

Table 3 Inferred resources and year's consumption in Japan

SMT	Area(km^2)	Cu (t)	Ni (t)	Co (t)
Myozyo SMT	531	3,806	23,886	21,519
Okinotorishima SMT	1,488	15,410	63,560	90,470
Tenosei SMT	1,425	6,880	16,063	22,259
Mokusei SMT	262	4,818	26,044	22,716
Kasei SMT	936	5,354	37,477	42,903
Kinsei SMT	240	2,075	17,191	35,568
Mikaduki SMT	481	5,741	29,661	25,533
Total	5,363	44,084	213,883	260,968

Table 4 Inferred resources and year's consumption in Japan

SMT	Area(km^2)	Cu (t)	Ni (t)	Co (t)
Consumption per year (2005)		1,218,780	173,600	12,600
Myozyo SMT	531	0.00 yrs.	0.14 yrs.	1.71 yrs.
Okinotorishima SMT	1,488	0.01 yrs.	0.37 yrs.	7.18 yrs.
Tenosei SMT	1,425	0.01 yrs.	0.09 yrs.	1.77 yrs.
Mokusei SMT	262	0.00 yrs.	0.15 yrs.	1.80 yrs.
Kasei SMT	936	0.00 yrs.	0.22 yrs.	3.41 yrs.
Kinsei SMT	240	0.00 yrs.	0.10 yrs.	2.82 yrs.
Mikaduki SMT	481	0.00 yrs.	0.17 yrs.	2.03 yrs.
year's consumption in Japan		0.04 yrs.	1.23 yrs.	20.71 yrs.

4. Conclusion

Although those estimations show that this place may not be suitable for development of mineral resources, if rare earth or other rare metals included in ores are taken as a by-product, extra value will be born. Besides, another data set will be obtained in future, different estimation might be shown. That say, too scarce data set prevent EZ and island with a feasible range and update it as needed. By doing this, we can drawn a ground design about the future of EEZ and islands with community of the social science such as a law, economy and the politics.

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Notes on Contributors and Participants

Hiroshi Terashima

Mr. Hiroshi Terashima, Executive Director of the Ocean Policy Research Foundation, specializes in marine policy and ocean governance at both national and international levels. He is also Visiting Professor at Yokohama City University and has been engaged in developing various proposals related to Japanese ocean policy, including the Ocean Policy Research Foundation's *A Proposal for 21st Century Ocean Policy* (2005, OPRF) and the Study Group on the Basic Law on the Oceans' *Outline for an Ocean Policy – Towards the establishment of a new ocean state* (2006, OPRF), which paved the way to the enactment of the Basic Act on Ocean Policy of Japan.

Makoto Omori

Dr. Makoto Omori is Professor Emeritus of Tokyo University of Marine Science and Technology and is currently Director of Akajima Marine Science Laboratory, Okinawa, Japan. Professor Omori's area of specialization is Biological Oceanography, Planktology, Coral Reef Ecology. He has written more than 190 relevant scientific papers and reports and is the author of twelve books including *Methods in Marine Zooplankton Ecology* (1984, Wiley-Interscience), and *Manual for Restoration and Remediation of Coral Reefs* (2004, Ministry of the Environment Japan).

Yasuhiko Kagami

Associate Professor Yasuhiko Kagami teaches at Tottori University of Environmental Studies, Japan. He specializes in maritime law and ocean governance and his current research interests lie in the field of Marine Spatial Planning, Marine Protected Areas, Integrated Coastal Zone Management. Kagami is also a member of the IUCN Commission on Environmental Law.

Hajime Kayanne

Dr. Hajime Kayanne is Professor at the University of Tokyo, Japan. He is an expert in the study of Earth System Science (coral reef, coast, carbon cycle, global change, paleoenvironment), and his current research interests are Coral reefs and coastal processes and Paleoceanography. Professor Kayanne has extensive field research experiences in the Pacific region and has published numerous articles on coral process and the history of sea level changes.

Tadao Kuribayashi

Dr. Kuribayashi is Professor Emeritus of Keio University, Tokyo and he is currently a Special Advisor at the Ocean Policy Research Foundation. Professor Kuribayashi specializes in contemporary international law and the law of the sea. He is also the chair of the Councilors' Meeting for the Japanese Integrated Ocean Policy organized by the Japanese Cabinet secretariat. He is the author of *Gendai kokusai hou (contemporary international law)* (1999, Keio University Press), and *Chuukai kokurennkaiyouhou jouyaku (commentary on United Nation's Convention of the Law of the Sea)* (1994, Yuhikaku).

Moritaka Hayashi

Dr. Moritaka Hayashi, currently a Special Fellow at the Ocean Policy Research Foundation, is Professor Emeritus of Waseda University, Tokyo, having taught at its School of Law from 1999 to 2008. Prior to joining Waseda, he worked for the United Nations system for more than two decades, with his last posts including Director of the Division for Ocean Affairs and the Law of the Sea of the Office of Legal Affairs, New York, and Assistant Director-General of the Food and Agriculture Organization of the UN (FAO), Rome, in charge of its Fisheries Department.

Tomohiko Fukushima

Dr. Tomohiko Fukushima is Project Associate Professor of UT Ocean Alliance, the University of Tokyo. His research interests are biological oceanographic process, deep-sea mineral resources and ocean policy. Professor Fukushima has written scientific papers, including *Examination for Environmental Assessment Methods of Deep Sea Development* (2005, Ocean Policy Studies).

Kazuhiko Fujita

Dr. Kazuhiko Fujita is an assistant professor at the Department of Physics and Earth Sciences, University of the Ryukyus. He is a marine micropaleontologist, particulary studying the ecology/paleoecology of reef-dwelling foraminifers (unicellular calcifying microorganisms).Lately he has been studying the distribution and sediment production of foraminifers on reef flats of some Pacific atolls, to understand the interaction between the production of reef calcifying organisms (foraminifers) and the atoll-island formation in the past, present and future.

Tesuo Yamazaki

Dr. Tetsuo Yamazaki is the Professor of Osaka Prefecture Univ., Japan. He has been studying survey and mining technologies for deep-sea resources, the environmental impact evaluation techniques, and the economic feasibilities. His focuses on manganese nodules in the Clarion-Clipperton Fracture Zones, the Kuroko-type seafloor massive sulfides in the Okinawa Trough and the Izu-Ogasawara Oceanic Island Arc, cobalt-rich manganese crusts in the north-west Pacific, and methane hydrates in the Nankai Trough. He continuously proposes strategic R&Ds of these resources.

Toshio Yamagata

Dr. Toshio Yamagata is Professor of Earth and Planetary Science in the Graduate School of Science at The University of Tokyo. His main interests are Climate Dynamics, Physical Oceanography, Geophysical Fluid Dynamics. Professor Yamagata has written numerous scientific articles and books on ocean-atmosphere system. He has been awarded various national and international scientific prizes, including The Sverdrup Gold Medal Prize of American Meteorological Society and Medal with Purple Ribbon from the Emperor of Japan.

Quentin Hanich

Mr. Quentin Hanich is a Senior Fellow at ANCORS. He is specialized in oceans governance; international fisheries; Antarctic and marine conservation; international environment and fisheries fora; and strategy development. Mr. Hanich co-ordinates much of ANCORS' commercial research on international fisheries and oceans governance for Australian and regional agencies, particularly in regard to the negotiation and implementation of international fisheries and marine conservation treaties.

Paul Kench

Associate Professor Paul Kench is a coastal geomorphologist at the University of Auckland, New Zealand. He has specific research and teaching interests in coastal, coral reef and reef island geomorphology. In particular, he has investigated the process controls on reef island development and change in the Maldives, Kiribati, Fiji, Great Barrier Reef and Tuvalu. Results of his work are used to examine the future trajectories of reef islands with the spectre of climatic change.

Richard Kenchington

Professor Richard Kenchington is a Visiting Professorial Fellow of the Australian National Centre for Ocean Resources and Security of the University of Wollongong, Australia. A marine ecologist, he studied crown of thorns starfish and later was a foundation member of the staff of the Great Barrier Reef Marine Park Authority (GBRMPA) in 1978. He was Director of planning until 1990 during the declaration and initial planning of the Marine Park. He retired in 1999 as Executive Director of the Authority. Between 1990 and 1992 he was Secretary of the Coastal Zone Inquiry of the Resource Assessment Commission. From 2003 to 2007 he was a member of the Advisory Committee for the Pew Fellows Program in Marine Conservation.

Rosemary Rayfuse

Dr. Rosemary Rayfuse is Professor at the faculty of law, University of New South Wales. Her research interests are Public International Law generally including, law of the sea, international fisheries law, international wildlife law, international environmental law, international humanitarian law, and use of force. Professor Rayfuse is a member of the IUCN Committee on Environmental Law and Co-Chair of its Working Group on High Seas Governance. She is the author of *Non-Flag State Enforcement in High Seas Fisheries*, in Publications on Ocean Developments (2004, Leiden: Martinus Nijhoff Publishers).

Clive Schofield

Dr. Clive Schofield is a QEII Research Fellow at ANCORS. He is a political geographer specialising in international boundaries and particularly maritime boundary delimitation. The central theme of his research can be summarised as the examination of the intersection of geographical/technical, legal and political disciplines in the law of the sea with particular reference to maritime boundary delimitation. Prior to this appointment he was Director of Research at the International Boundaries Research Unit (IBRU), University of Durham, UK.

Martin Tsamenyi

Dr. Martin Tsamenyi is Professor of Law and Director of the Australian National Centre for Ocean Resources and Security (ANCORS) at the University of Wollongong, Australia. His areas of specialization include fisheries law; fisheries monitoring, control and surveillance; shipping law; marine environmental law and ocean policy. Professor Tsamenyi has written extensively on these subjects and has undertaken consultancy and advisory work for several governments and international organizations.

Joeli Veitayaki

Dr. Joeli Veitayaki is the Head of the University of the South Pacific's School of Marine Studies and Director of the International Ocean Institute-Pacific Islands. He is from Fiji and his research interests are in human ecology. Together with other practitioners from Fiji, Professor Veitayaki has been working toward the effective management of marine resources among Pacific communities. Veitayaki has published widely in the areas of customary marine tenure, capacity building, marine resources management and regional cooperation.

Arthur WEBB

Dr. Arthur Webb is the Manager of the Ocean & Islands Programme and Coastal Processes Adviser at the Pacific Islands Applied Geoscience Commission (SOPAC). Since the early 1990's. Webb has been predominantly involved in coastal processes, analysis and research in sub tropical east Australia and the South Pacific. His main areas of responsibility within SOPAC has been the assessment and analysis of shoreline erosion, marine water quality issues, assessment of the impacts of dredging and a diverse range of other coastal resource use problems throughout the region.

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〒105-0001 東京都港区虎ノ門1-15-16　海洋船舶ビル
TEL 03-3502-1828　FAX 03-3502-2033
http://www.sof.or.jp　E-mail：info@sof.or.jp

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