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Climate Changes and Globalization
—Environment and People's Life in the Pacific Islands—
気候変化とグローバリゼーション
—南太平洋島嶼域における環境と人々の生活—

鹿児島大学多島圏研究センター
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気候変化とグローバリゼーション
－南太平洋島嶼域における環境と人々の生活－

Symposium on the Pacific Islands, Kagoshima University
Feb. 3, 2007, Inamori Hall
鹿児島大学多島域フォーラム・シンポジウム報告
2007年 2 月 3 日 稲盛会館

鹿児島大学多島圏研究センター
KAGOSHIMA UNIVERSITY RESEARCH CENTER
FOR THE PACIFIC ISLANDS

Welcome Address

YOSHIDA Hiroki
President, Kagoshima University

Welcome and thank you very much for your participation. It is my great pleasure to welcome you on behalf of Kagoshima University.

Kagoshima University is one of the largest universities in Japan, comprised of eight faculties, two on humanities and six on science, and nine graduate schools with approximately 10,000 undergraduate and 2,000 graduate students enrolled. Furthermore, 13 centers and museum on research and education such as the Research Center for the Pacific Islands are part of the university.

The Kagoshima University is located in Kagoshima prefecture, the southern most of the main islands, where the climate changes from subtropical to temperate. The prefecture stretches 600 km from latitude 27° north to latitude 31° north, and the islands strewn to Okinawa, Taiwan, the South East Asia and the Pacific Islands. The university has been maintaining research and education for the region including Kagoshima, South East Asia and the Pacific Islands. Newly established Sub-division of 'Shochu (local liquor made from sweet potatoes) Science and Technology' in the Faculty of Agriculture is in such line of studies and education of the university.

The Research Center for the Pacific Islands (former Research Center for the South Pacific) was established under these circumstances in 1981. Since then, its research activities have been focused on the region, from Kagoshima to the Pacific Islands with the focus on interdisciplinary and comprehensive studies. Studies on the Pacific Islands regions as well as ones on surrounding regions are very unique.

This symposium is trying to understand the phenomena of so called 'global warming' and 'globalization', and to suggest some solutions for them. There is a lot of news which might relate to the global warming; over production of winter vegetables, no snow on ski slopes, full-flowering cherry blossoms in January in Washington, etc. Warning signs clearly presents the global nature of climate changes. We need to look more seriously on the matter considering global-scale environmental problems.

I would like to conclude my welcome address by wishing for the fruitful discussions in the symposium and would like to encourage all the participants to deepen the understanding of the phenomena and to contribute by giving the solutions for them.

開会挨拶

本日はお忙しいところご来場ありがとうございました．本シンポジウムの開催に当たり，鹿児島大学を代表して，一言，歓迎のご挨拶を述べさせて頂きます．

鹿児島大学は，12,000人の学生が学び，文系２学部，理系６学部，文系・理系の９大学院，さらには，地域との関係が深く，また，学際的領域を対象とした多島圏研究センターなど13の学内共同研究施設や付属病院などからなる総合大学であります．

本学の位置する鹿児島県は，日本列島の最南端に位置し，温帯から亜熱帯まで南北600kmに及び，その南は，沖縄，台湾，やがては南太平洋へと続いております．このような地理的条件の下，鹿児島大学は，設立当初から，鹿児島県及びそれ以南の自然や文化を対象とする研究を多く行って参りました．最近設置された，産官学連携寄付口座の「焼酎学講座」は，鹿児島県の焼酎文化及びその技術の伝承等を願って設置されたものでありますが，研究としては同様な流れの中にあるということができます．

そのような背景の下，本センターの前身である南方海域研究センターも設立されました．この南方海域研究センターから，今回，本シンポジウムを主催している多島圏研究センターまで，組織の名称は変わりましたが，その研究は一貫して鹿児島県から南太平洋に広がる島嶼域を対象として，人文学，社会学，あるいは理学，農学，医学等，複数の学問領域に渡る，学際的，総合的研究であります．中でも，南太平洋島嶼域を対象とした研究の取り組みについては，その歴史・量とも，特筆すべきものがあります．

さて，本シンポジウムは，最近地球的規模で問題となっている温暖化などの気候変化とグローバリゼーションが，その南太平洋島嶼域の環境とそこに生きる人々へ与える影響を明らかにし，さらには，今後，我々が取りうる方策等についても提言を試みようというものであります．

今冬，我が国は暖冬だと言われております．過剰生産に陥ったキャベツやピーマン等の廃棄，あるいは，雪がなく，営業できないスキー場のニュースなど，温暖化と関係のあるニュースは枚挙にいとまがありません．海外においても，オーストリアではクリスマス前に氷のクリスマスツリーが溶けてしまったり，ニューヨークでは桜が開花するなど，温暖化による生態系の変化はますます顕著になりつつあります．

このような状況下での本シンポジウムの開催はまことに意義深いものがあります．本シンポジウムが，地球温暖化の問題への理解を一層深め，今後ますます大きな課題となると思われる地球環境の保全のために大きな貢献をすることを期待して，歓迎のご挨拶にしたいと思います．

鹿児島大学学長　吉　田　浩　己

Symposium Introduction

HIDAKA Tetsushi (Kagoshima University)

Global average temperature of the Earth's near-surface has risen about 0.5℃ in the past century and the phenomenon has accelerated during the past two decades. There is stronger evidence that most of the warming observed over the last half century is attributable to human activities. Since the Industrial Revolution, excessive usage of fossil fuels such as coal and petroleum, and deforestation of the Earth have caused the concentrations of heat trapping gases such as carbon dioxide (CO_2) and methane (CH_4) to increase significantly in the Earth's atmosphere. These gases prevent heat from escaping to outer space, just like the glass ceiling of a greenhouse. According to the model released yesterday (Feb. 2, 2007) by the Intergovernmental Panel on Climate Change (IPCC), the average temperature of the Earth's surface may increase from 1.8 to 4.0℃ in 100 years.

An increase of global temperature could in turn cause other unfavorable events for life on the Earth including sea level rise and changes of climate. These changes might induce extreme flood, drought and typhoons, which cause loss of lands, lower agricultural yields, extinctions of species and spread of diseases such as malaria and dengue fever. Some changes on the natural environment are already occurring. Observed changes include blooming earlier, glacier retreat, sea level rise, shortening freezing period of rivers and lakes and extreme weather events such as increased intensity and frequency of typhoons and tornados.

Although the Pacific island countries have almost nothing to do for causing the global warming, they are subjected at first and severely to the impacts by them. In addition, the economic globalization might exacerbate natural resource depletion and depreciate Pacific island environments.

Even though scientific uncertainties for the degree of climate change in future remain, people are trying to understand the phenomena and to find the ways to reduce future global warming, or at least to deal with expected changes.

In the symposium, we are focusing on people's life and environment from the view point of the climate changes and globalization.

The organizers of the symposium cordially welcome everyone to share the experiences and build up the network to understand the phenomena and propose solutions for them.

趣旨説明

多くの科学者が地球表面の温度が過去100年間で約0.5℃上昇していることを指摘しており，また，その上昇率は，ここ数十年間では過去に例がないほど急激なものとなっています．この温暖化現象の，少なくとも過去50年間における原因は人間によって引き起こされたというのが大多数の人々の共通の認識であります．

約200年前に産業革命が起こり，その後の人間の経済活動は大きく進展致しました．しかし，それは同時に，石油や石炭などの化石燃料の急激な消費を伴い，また，人口の増大や農地の拡大等に伴って森林の伐採等も進むことになりました．その結果，二酸化炭素やメタンなどの，いわゆる温室効果ガスの排出が増大し，結果的に地球の大気中でのそれらの濃度が増加することとなったわけです．これらのガスは，太陽から流入する可視光の日射エネルギーは透過させ，地球表面を暖めてくれるのですが，地球表面から放射される波長の長い赤外線は吸収しやすく，その結果，地球があたかも温室の中に入っているような効果をもたらすことから温室効果ガスと呼ばれるようになったわけです．京都議定書の基礎にもなった，温暖化などの問題に関して助言や評価を行っている機関に「気候変動に関する政府間パネル」，簡単には「IPCC」と呼ばれている機関がありますが，そこが昨日発表した予想モデルによると，今後，100年間で，地球表面の平均気温は1.8℃から4.0℃にまで上昇することが予想されています．

地球温暖化が進むと，北極や南極，あるいは氷河などの氷が溶けることに起因する海面上昇や気候の変化など，地球上の生命にとっても危機的な状況となることが予想されます．また，洪水や干魃，台風なども予想もしない頻度や強さで起きることとなるでしょう．その結果，海抜の低い土地は海中に沈むことになりますし，農作物の生産量の低下，色々な生物種の絶滅，マラリヤやデング熱など，現在熱帯地域に限られている病気の拡散等も起こることが予想されています．すでにいくつかの現象が起こり始めていることは皆さんもご存じのことと思います．すなわち，桜などがいつもより早く開花したり，アルプスやロッキー山脈の氷河が溶け出したり，海面が上昇して海岸線が後退したり，これまで凍っていた川や湖が凍らなかったり，また，台風の起きる頻度やその強さもここ近年増加しています．

太平洋の島々は，地球温暖化の原因にはほとんど無関係と言ってもいいのですが，しかし，地球温暖化の影響を最初に，また，深刻に受けることが予想されています．また，人々の経済活動が全地球的な規模に広がるにつれ，これまで伝統的な生活スタイルを保ってきたそれらの島々でも，いわゆるグローバリゼーションの影響を大きく受けるようになってきています．

科学的には，地球温暖化の原因やその影響などについてはまだ不確実な部分もありますが，将来の危機に備えるため，多くの人々がこの現象を理解しようと努めております．また，さらなる温暖化にブレーキをかけるべく，あるいは，少なくとも将来起きるであろう種々の問題を何とかしようとしています．

このシンポジウムでは，太平洋の島々を中心に，地球温暖化やグローバリゼーションにより引き起こされている問題の現状と課題を理解するとともに，それらの問題の解決に少しでも寄与することができればと願い，企画されました．皆様の積極的なご参加をお願いして，趣旨説明とさせて頂きます．

鹿児島大学　日　高　哲　志

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Addressing Climate Change and Sea Level Rise in the Pacific Islands

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Abstract

Climate change and sea level rise are no longer a future phenomenon; they are taking place now and require more concerted effort. The situation in the Pacific Islands is even more serious because even though these small islands have done little to cause the problem and can do little to address it, they will be the first victims. Furthermore, the options for these islands are restricted by their small sizes and lack of resources.

However, Pacific Islanders have extensive experience living in these small islands for generations and can offer worthwhile lessons on how to address climate change and sea level rise. In this paper, we examine some options for addressing the phenomenon in the Pacific Islands.

A strategy for addressing the challenges of living in a world affected by climate change and sea level rise will be unveiled. As always, innovation and good plans and strategies will influence in the ability of Pacific Islands to address this problem. Addressing climate change and sea level rise in the Pacific Islands, has to be appropriate for these islands, which means that the solution has to be found from within the small islands. Some areas where changes can be considered include appropriate coastal protection, adaptation in land use and living practices and new options such as aquaculture, sustainable living at community level and new crops and varieties.
Keywords: coastal protection, community, customary practices, good plans, innovation, land loss

要　旨

気候変化や海面上昇はもはや未来の出来事ではない．それらの現象は現実に起こりつつあり，その解決のためには人々のさらなる協力が必要とされている．太平洋の島々は，これら気候の変化や海面上昇の原因としてはほとんど無関係であるにもかかわらず，より深刻な影響を受けている．また，これらの現象に対する備えもほとんどないため，その最初の被害者となろうとしている．さらに言えば，これらの島々は小さく，また，資源もほとんどないため，その対策もほとんど限られている．

しかし，これら小さな島々に住む人々は，長い世代に渡って蓄積された豊富な経験を持っており，気候の変化や海面上昇などの問題の解決のための何らかの有効な答えを発見できると思われる．この講演では，これらの現象への備えとして，いくつかの解決策について検討したい．

まず，気候の変化や海面上昇が起こる世界で生き抜いていくための戦略について検討したい．革新的な方法や計画，戦略は，これらの現象に対処する人々の能力にも影響を与えると思われる．気候の変化や海面上昇に備えるための戦略は，これらの島々にとって適切なものでなければならず，すなわち，解決策はこれら小さな島々から生み出されてくるものでなければならない．具体的な方法としては，海岸線の防護や土地の利用法，生活様式，水産業などの改良，あるいはコミュニティレベルにおける持続的生活様式や新しい作物あるいは品種等の導入などが考えられる．

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Introduction

The Pacific Islands cover an area of about 30 million km^2 of the world's largest ocean. The islands are small but there is also great geographic, demographic and developmental diversity (SOUTH *et al*. 2004). Detailed descriptions of the islands are provided in Annex 1. Differences in climate, 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 also features of the region.

Although some of the larger island groups have significant mineral, forestry, fisheries and agricultural land resources, most Pacific Island states and territories and smaller outer islands and isolated rural communities do not. The options for economic development are thus extremely limited.

Climate change and sea level rise are now global phenomenon. The IPCC Third Assessment reports and the recently released Fourth Assessment reports outline what is to be expected by 2100 with the only uncertainty relating to the timing and magnitude of the changes; not its occurrence (IPCC 2007). In the Pacific Islands these events are already evident through coastal flooding, erosion, salt water intrusion into ground water sources and increased storm damages. In addition, the countries of the region are also under threat from their rapidly increasing population that needs settlements and the necessary facilities. These events make it critical that Pacific Islands devote more concerted effort to address these eventualities.

It is ironic that the Pacific Islands are required to commit resources they do not even have to address climate change and sea level rise because these small islands have done little to cause the problem and can do little to address it. However, unlike the industrialized countries that have response and adaptation options, these countries will be the worst victims. While the industrialized countries ponder over their loss of employment and of industries, Pacific Islands will be considering emigration and resettlement abroad in foreign land.

However, there is hope. 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 climate change and sea level rise issues (VEITAYAKI 2002). In this presentation, we examine some options for addressing the phenomenon in the Pacific Islands.

The region needs to pool its resources and expertise to map a regional strategy for addressing the challenges of living in a world affected by climate change and sea level rise. This will require innovations, good planning and the involvement of all stakeholders. Pacific Islands will need to forge partnerships and collaboration locally and internationally. Climate change and sea level rise responses and adaptations in the Pacific Islands have to be appropriate for these islands. There cannot be too much of the high-tech and costly solutions but those that are 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, sustainable living at community level and new crop varieties.

There are four other sections to the paper. The first is an overview of the Pacific Islands, which highlight some of the features of life that will be influential to the options and choices that are available. The second section examines some of the issues that are relevant to addressing climate change and sea level rise. The third section introduces the policies strategies and actions that Pacific Islands can adopt to address the problems of climate change and sea

level rise while there will be reflections on the future as the concluding remark.

Pacific Islands

The Pacific Islands are dominated by the ocean, which has social, spiritual, cultural and ever increasingly, economic significance (Fig. 1). Land accounts for only 2 percent of the region's total area of approximately 550,000 km^2. The largest of the islands is Papua New Guinea (PNG) with 84 percent of the region's land area. Seven islands have land areas of over 700 km^2 while four have less then 30 km^2 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 atoll countries and territories has meant that the focus in recent times is directed to the resources of the oceans to sustain livelihoods. This same focus has grown in importance over the years to the point where it has become necessary to put in place management structures to attempt to monitor and control the increasing demand placed on 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 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 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.

Important social and economic issues in the region include high population growth rates, 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 current situation in Solomon Islands, Fiji, French Polynesia and Tonga.

Loss of land is a major concern throughout the Pacific Islands. Even for the higher and larger island, the loss of land associated with any increase in sea level will be 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 burial grounds.

In Tuvalu, some of the graves have been washed away and there was one occasion when the coffin started to float to the surface due to high tide before it was buried. In some of the countries, cremation is now being done but the acceptance of this practice is not easy to promote

in some of the Pacific Islands. "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 territory and island for Pacific Islands are immense. The loss of territory and island will diminish areas under national jurisdiction and impact heavily, among other things, on economic and subsistence needs of island nations. The sale of licenses in the Kiribati EEZ was worth $A29.4 million some years ago and was one of the main source of foreign exchange (BOROVNIK 2006). In all Pacific Islands, local communities have traditional, cultural and spiritual attachments to the sea, particular species, reefs, islands and natural formations. This will make the disappearance of territory and island significant. It can also influence the demarcation of maritime boundaries.

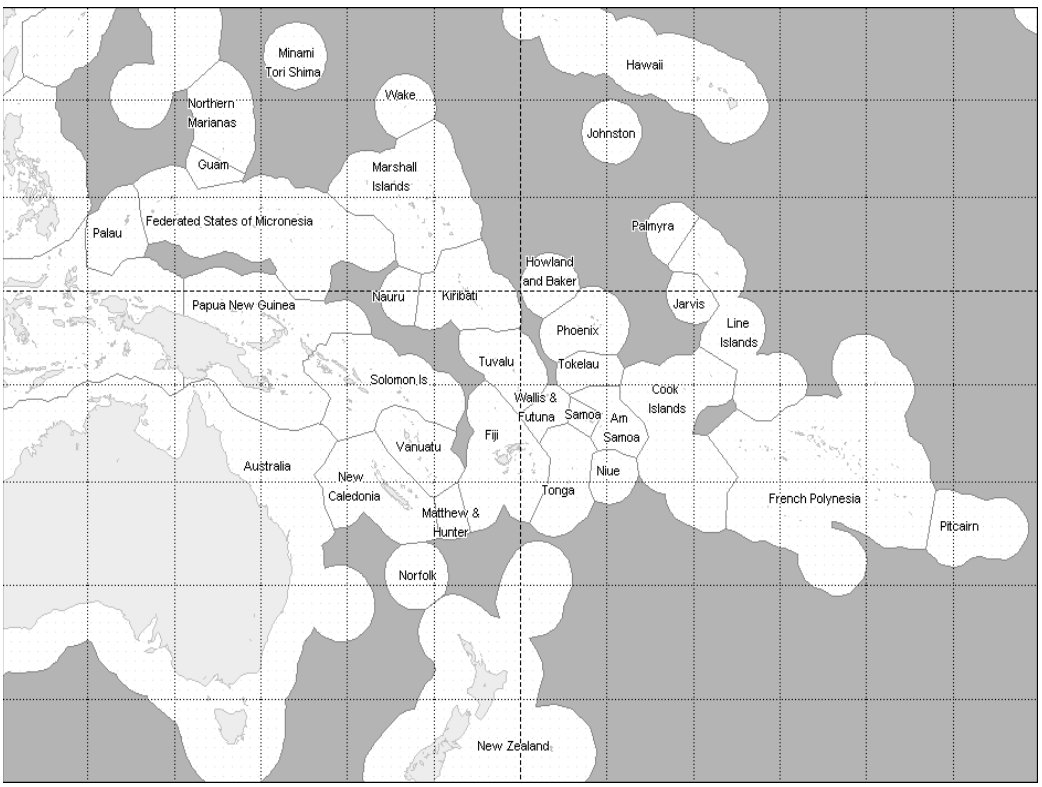

Fig. 1. Pacific Island showing their EEZ boundaries.

Issues Relating to Climate Change and Sea Level Rise Issues

Pacific Islands are highly vulnerable to climate and sea level changes and have a large natural resilience that is increasingly impaired by human pressures. Some of the issues relating to climate change and sea level rise that are considered critical in the Pacific Islands are examined to show the nature of these issues, the attempts undertaken within the region to address these and the challenges that have to be addressed and overcome to secure the lives of the people and communities in these islands. The examination should also highlight the policies,

strategies and actions that have to be undertaken to address the issues. The issues discussed here reiterate some of those that were raised by Seremaia TUQIRI (2001) as background to the Pacific Islands Regional Ocean Policy conference.

Climate change and sea level rise related issues are widespread in the region but are regarded differently by each state and territory, which have its own set of priorities, strategies, and responses to the different issues. The Pacific Islands are vulnerable to the effects of climate change and sea level rise but the atolls and coastal and low lying areas are most at risk. Many coral atolls do not rise over 5 m above sea level and could become 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 disaster management plan at the regional, national, district and local levels.

The impacts of climate change will affect all sectors of the economy in the Pacific Islands. It is 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 be affected. 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 organizations had demonstrated great commitment in undertaking proactive actions to address the effects of 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) have focused on policies and strategies for climate change and sea level rise and promoted integrated coastal management plans but these need to be implemented. The Pacific Islands Climate Change Assistance Program (PICCAP) assisted countries with their reporting obligations under the UNFCCC.

Any change in sea level is expected to affect the claims by coastal states that have declared extensions of their maritime zones. The extension of maritime boundaries is 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; some reference points for which are based on some very low islands and reefs. Some of the boundaries still need to be formalized. Furthermore, 45 common boundaries between Pacific Islands need to be finalized 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 conduct research and field surveys to prove that they have continental shelves. The maritime area claims can be altered greatly if the baselines are altered because of sea level changes.

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 while the rest are uninhabited. While some of other islands in the group were

inhabited in the past for at least two years, the main reason for the departure of the inhabitants is the unavailability of potable water.

The loss of island territory because of storm surges and sea-level rise is a real threat to claims and existing maritime jurisdiction of Pacific Island. 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 not adequately addressed in international law. Where territory 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 an island is severely impacted by climate change, there will be an inclination by Pacific Islands 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. Would this activity be 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 climate change and sea level rise 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, however, have little or no MSR capability and rely heavily on regional organizations such as the Pacific Islands Forum Fisheries Agency (FFA), South Pacific Applied Geoscience Commission (SOPAC), University of the South Pacific (USP), Pacific Regional Environment Program (SPREP) and Secretariat of the Pacific Community (SPC) and competent international research organizations. Marine scientific research can provide information vital for addressing the impacts of climate change and sea level rise.

SOPAC leads the delimitation of maritime boundaries 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 conducts applied research and training on mariculture, 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 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, Fiji, Kiribati, Marshall Islands, Tonga, Tuvalu, and Samoa. 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 program 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. About 41 percent of the reefs in the Pacific 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 suggests a 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 population for most Pacific Islands and coastal developments such as infrastructure, coastal settlements and coastal development contribute to serious coastal problems. With urban centers such as South Tarawa, Majuro, Funafuti, Nukualofa and Suva having very high populations for their sizes, the pressures on coastal environment and resources worsens. In fact, most of the ports in the Pacific Islands are badly polluted.

The use of pit latrines in some of the urban centers such as Funafuti and Tarawa will cause problems because eventually new pits will be required. Where land is limited, this may become a major constraint. 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 nature of the soil combined with a high water table 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 currently available (RESTURE 2006).

Training, education, and public awareness are cross cutting issues and are conducted at different levels by all of the regional organizations. The USP is responsible for formal training but applied research is also conducted by other technical regional organisation. 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 is shared to facilitate their use by others.

Response and Adaptations

Pacific Islands, with their financially weak economies and lack of resources, 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 utilize their traditional knowledge and customs to organize themselves and be prepared for the impacts of climate change and sea level rise. 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 an institution to coordinate the response and adaptation to climate change and sea level rise. The information should enable the individual countries to better understand how 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 centers.

Pacific Islands need to consider undertaking the following activities:

- gathering and improving information on the impacts of climate change and sea level rise on all human and natural systems in the islands
- building capacity in specific areas by collaborating with other organisations and institutions
- developing strategies for responses and adaptation using traditional and appropriate contemporary methods
- ratifying climate-related instruments and incorporating these into national legislation
- promoting awareness programs on useful lessons
- fostering collaborations with developed and industrialized countries
- improving early warning systems and back-up facilities to reduce vulnerability and improve response time
- encouraging appropriate reforms in the policies and measures to reduce greenhouse gas emissions
- promoting 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 can be implemented only in the larger islands. Moreover, 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 km^2. A third of the total land area is uninhabitable because it is used as the airfield or the excavated borrow pits that were used in the construction of the airport. Even with the land area of 2.79 km^2, the population of 4,900 (in 1996) on Funafuti results in a population density of 2,634/km^2. The density, which is higher than this amount if the uninhabitable area is taken into consideration 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/day or 730 t/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.

Tuvalu has secured an agreement with New Zealand (under the Pacific Access Category and the Temporary Labor Scheme) for the resettlement of 75 of her citizens to New Zealand each year. A similar application to Australia has been refused. In Tonga, PERMINOW (1993)

reported the internal movement of people into Kotu because of better opportunities compared to all its neighboring islands. Similar resettlement took place in Papua New Guinea (ALLEN *et al*. 1993). In both cases, there were some social and cultural relations that allowed for these resettlements. Resettlements will be the main option if life as currently undertaken is no longer possible in the islands and there need to be social and cultural arrangements made for this eventuality.

Accommodation is a where the alteration is made to the use of the area but the people continue their activities in the 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 (Fig. 1). Similarly, the Marine Studies Facilities at the USP is designed to allow water to flow underneath without causing too much problems (Fig. 2). Pacific Islands should encourage changes in the design of building, building standards and other measures to accommodate the expected changes. 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. People may consider riding bicycles and motor bikes instead of cars and trucks which would reduce the need for roads.

Fig. 1. (top left) House in flooded borrow in Funafuti.
Fig. 2. (top right) Building for change, Marine Studies Facilities, USP.
Fig. 3. (bottom left) Coastal protection built by Naovuka Villagers.
Fig. 4. (bottom right) Rehabilitated coastal habitats provide shelter in Nacavanadi Village.

Fig. 5. Rehabilitated mangroves in Malawai Village.

The production of new commodities such as the coconut furniture and products can provide excellent opportunities in the Pacific Islands. More attention should be devoted to new technology that will enhance the health of the environment. Compost toilets, smokeless stoves and fish aggregation devices are all examples of technology that can reduce human impact on the island environment. Other technologies such as the use of renewable energy and the management of waste can ensure the maintenance of the health of the environment that will in turn protect and provide for 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 the Pacific Islands, the absences of 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 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 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 the work of the local communities to manage their fisheries resources in the Solomon Islands, Vanuatu, Papua New Guinea, Cook Islands, Samoa and Fiji, the people have demonstrated their commitment to undertaking resource management activities when they are convinced that these actions are necessary. Villagers in Vanuaso Tikina in Fiji are already trying to address these issues as part of their resource management activities (Fig. 3, 4 and 5). The villagers are aware that there own survival is threatened if the resources that they depend on are under threat.

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 necessary to promote the need for adaptation to the impacts of climate change and sea level rise. With the increasing information and case studies becoming available, the lessons should be evident. These knowledge and practices should be publicised widely to all parts of the region. 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 Islands 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 seriously observe the implementation 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 local community actions.

Future

The Pacific Islands are now at the cross road. There homes are under threat from changes associated with climate change and sea level rise. 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 opportunity 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 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 and 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 international obligation. There are avenues to foster equitable collaboration with competent international organizations. The countries should design arrangements that will allow them to benefit from collaboration with developed countries partners.

The proposed research on Okinotorishima by Japan is relevant to Pacific Islands. If corals can be grown to enhance the 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 and likely 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 would require good research programs that many of the countries do not have. This has to be addressed because a lot more benefit will accrue from good research programs that are forward looking and innovative. Salt resistant crops, new uses of existing resources and new resources can all be obtained through good research and can be sources of new opportunities in Pacific Islands. It is also important to remember that international collaboration with local flavor will be the most appropriate option.

Development policies and adaptation approaches must emphasize proactive, anticipatory plans, projects and programs. The viability of long-term investments in infrastructure and development activities must focus on the sensitivity of projects to the effects of climate change and sea level rise. 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. Coastal protection needs to be thoroughly assessed for its possible adverse effects. In a number of cases such as with the construction of seawalls, the adaptive measures may have been more destructive because of effects on tempering of 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 and experimental work. Capacity building and institutional development should be ongoing with follow-up programs. 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.

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

Appendix I. Summary Data on Pacific Islands

American Samoa
Capital: Pagopago
Population: 57,790 (2006 est.)
Land area: 200 km^2
Max height (above sea-level): 966 m (Lata)
Rainfall:
EEZ: 390,000 km^2
Mean temperature: 30.9 ºC (87.7 ºF)
GDP per capita: US$ 5,800 (2005 est.)

Cook Islands
Capital: Rarotonga
Population: 21,390 (2006 est.)
Land area: 236.7 km^2
Max height above sea-level: 652 m (Te Manga)
EEZ: 1.8 million km^2
Rainfall: average of 2,040 mm per annum
Mean temperature: 24℃
GDP per capita: US$ 9,100 (2005 est.)

Federated States of Micronesia
Capital: Pohnpei
Population: 108,000 (2006 est.)
Land area: 702 km^2
Max height (above sea-level): 791 m (Dolohmwar)
EEZ: 2,978,000 km^2
Rainfall: Rainfall is high, varying from about 3,000 mm on drier islands to over 10,000 mm per annum in Pohnpei
Mean temperature: 27℃
GDP per capita: US$ 2,300 (2005 est.)

Fiji
Capital: Suva
Population: 905,950 (2006 est.)
Land area: 18,272 km^2
Max height above sea-level: 1,324 m (Tomani-ivi)
EEZ: 1.26 million km^2
Rainfall: Rainfall is highly variable and mainly orographic (influenced by the island topography and the prevailing south-east trades).
Mean temperature: 28℃
GDP per capita: US$ 6,100 (2006 est.)

French Polynesia
Capital: Papeete
Population: 274,580 (2006 est.)
Land area: 4,167 km^2
Max height above sea-level: 2,241 m (Mont Orohena)
EEZ:
Rainfall:
Mean temperature:
GDP per capita: US$ 17,500 (2003 est.)

Guam (USA)
Capital: Agana
Population: 171,020 (2006 est.)
Land area: 541 km^2
Max height (above sea-level): 406 m (Mt. Lamlam)
Rainfall: Annual rainfall varies from 2000 mm to 2500 mm
EEZ: 218,000 km^2
Mean temperature: 27ºC (81ºF)
GDP per capita: US$ 15,000 (2005 est.)

Kiribati
Capital: Tarawa
Population: 105,430 (2006 est.)
Land area: 811 km^2
Max height (above sea-level): 87 m (Banaba)
Rainfall:
EEZ: 3.6 million km^2
Mean temperature: 29℃
GDP per capita: US$ 2,700 (2004 est.)

Republic of Marshall Islands
Capital: Majuro
Population: 60,420 (2006 est.)
Land area: 181.3 km^2
Max height (above Sea-level): 10 m (Likiep)
EEZ: 2,131,000 km^2
Rainfall: Varies from north to south; Ujelang has an average of 2,030 mm per annum while Jaluit, further south, has twice that amount.
Mean temperature: 27℃
GDP per capita: US$ 2,900 (2005 est.)

Nauru
Capital: Yaren District
Population: 13,050 (2005 est.)
Land area: 21 km^2

Max height (above sea-level): 70 m (location along plateau ring)
Rainfall:
EEZ: 320,000 km^2
Mean temperature: 29ºC
GDP per capita: US$ 5,000 (2005 est.)

New Caledonia
Capital: Noumea
Population: 219,250 (2006 est.)
Land area: 18,576㎢
Max height (above sea-level): 1,628 m (Mt. Panie)
EEZ: 1,740,000㎢
Rainfall: Varies from 2,000 mm in the east to 1,000 mm in the west per annum
Mean temperature: 23℃
GDP per capita: US$ 15,000 (2003 est.)

Niue
Capital: Alofi
Population: 2,170 (2006 est.)
Land area: 259 km^2
Max height above sea-level: 68 m (near Mutalau settlement)
Climate: Tropical; modified by southeast trade winds
Rainfall: Average of 2,177 mm per annum
Mean temperature: 28.45℃
GDP per capita: US$ 5,800 (2003 est.)

Palau
Capital: Koror
Population: 20,580 (2006 est.)
Land Area: 488 km^2
Max height (above sea-level): 213.5 m (Mt. Ngerechelchuus)
Rainfall: Maritime tropical rainy climate
EEZ: 629,000 km^2
Mean temperature: 27 ºC (82º F)
GDP per capita: US$ 7,600 (2005 est.)

Papua New Guinea
Capital: Port Moresby
Population: 5,670,540 (2006 est.)
Land area: 462,243 km^2
Max height (above sea-level): 4,697 m (Mt. Wilhelm)
Rainfall: Mean annual rainfall of 2000 to 6000 millimeters
EEZ: 3,120,000 km^2
Mean temperature: 26℃

GDP per capita: US$ 2,700 (2006 est.)

Samoa
Capital: Apia
Population: 176,910 (2006 est.)
Land area: 2,935 km^2
Max height (above sea-level): 1,860 m (Mt. Silisili)
Rainfall: Average annual rainfall is about 3,000 mm
EEZ: 120,000 km^2
Mean temperature: 25℃
GDP per capita: US$ 2,100 (2005 est.)

Solomon Islands
Capital: Honiara
Population: 552,440 (2006 est.)
Land area: 28,785 km^2
Max height (above sea-level): 2,447 m (Mt. Makarakombou)
EEZ: 1,340,000 km^2
Rainfall: Varies from 3,000 - 5,000 mm per annum
Mean temperature: 26℃
GDP per capita: US$ 600 (2005 est.)

Tonga
Capital: Nuku'alofa
Population: 114,690 (2006 est.)
Land area: 718 km^2
Max height above sea-level: 1, 030 m (extinct volcano, Kao)
EEZ: 700,000 km^2
Rainfall: 1,775.5 mm
Mean temperature: 24.7℃
GDP per capita: US$ 2,200 (2005 est.)

Tuvalu
Capital: Funafuti
Population: 11,810 (2006 est.)
Land area: 26 km^2
Max height (above sea-level): Approximately 5 m
Rainfall:
EEZ: 1.3 million km^2
Mean temperature: 30 ºC
GDP per capita: US$ 1,600 (2002 est.)

Vanuatu
Capital: Port Vila
Population: 208,870 (2006 est.)

Land area: 12,190 km^2
Max height (above sea-level): 1,877 m (Mt. Tabwemasana)
Rainfall:
EEZ: 710,000 km^2
Mean temperature: 24℃
GDP per capita: US$ 2,900 (2003 est.)

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Tropical Cyclone Behavior in a Warmer World

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Abstract

The surfaces of most tropical oceans have warmed by 0.25 - 0.5 degrees Celsius during the past several decades. The Intergovernmental Panel on Climate Change (IPCC) considers that the likely primary cause of the rise in global mean surface temperature in the past 50 years is the increase in greenhouse gas concentrations. The global community of tropical cyclone researchers and forecasters as represented at the 6th International Workshop on Tropical Cyclones of the World Meteorological Organization recently released a statement on the links between climate change and tropical cyclones. During the past decade, there have been a number of high-impact tropical cyclone events around the globe. These include 10 landfalling tropical cyclones in Japan in 2004, five tropical cyclones affecting the Cook Islands in a five-week period in 2005, Cyclone Gafilo in Madagascar in 2004, Cyclone Larry in Australia in 2006, the first-ever documented hurricane in the South Atlantic Ocean in 2004, and the extremely active 2004 and 2005 North Atlantic tropical cyclone seasons - including the catastrophic socio-economic impact of Hurricane Katrina. The participants of the IWTC 6 worked out a comprehensive statement providing the latest guidance and consensus views of the tropical cyclone community on the effects of climate change on the behavior of tropical cyclones. Common questions asked by the media and the public (and addressed in the statement) include:

Will the basin and global numbers of tropical cyclones go up in a warmer world?
Will the intensity of tropical cyclones increase in a warmer world?
Will the formation regions of tropical cyclones expand in a warmer world?
Will tropical cyclones retain their destructive potential further into the midlatitudes in a warmer world? And,
Are we already seeing the effects of climate change in the behavior of tropical cyclones?

This talk will provide a detailed description of the observed behavior of tropical cyclones over the past 30 or 40 years, and will address the possible changes to tropical cyclone behavior that may occur in a warmer world. The consensus statements concerning tropical cyclones and climate change made by participants of the 6th International Workshop on Tropical Cyclones (IWTC-VI) are presented and critically analyzed in this talk from the perspective of an active participant in the drafting of those statements.
Keywords: climate change, cyclone behavior, global warming, IPCC,

要　旨

ここ数十年の間に，熱帯の多くの海の表面温度が0.25～0.5℃上昇した.「気候変動に関する政府間パネル（IPCC)」によると，過去50年間における地球表面の平均気温の上昇は，温室効果ガスの増加が最大の原因であるという．世界気象機関（WMO）が主催した第６回熱帯サイクロンワークショップ（IWTC６）では，気候の変化と熱帯サイクロンの関係に関する声明が発表されている．ここ10年間に多数の大型熱帯サイクロンが出現した．2004年，日本に10個の台風が上陸し，2005年，クック諸島は，５週間に５個の熱帯サイクロンに襲われた．その他，2004年にマダガスカルを襲ったサイクロン「ガフィーロ」や2006年にオーストラリアを襲った「ラリー」があり,2004年には南大西洋で初めてハリケーンが発生している.また,2004年と2005年は北大西洋で多くの熱帯ハリケーンが発生した年であり，ハリケーン「カトリーナ」が引き起こした人的経済的被害は甚大なものとなった．前述したIWTC６で発表された声明は，気候の変化が熱帯サイクロンに及ぼす影響に関する，最新の指標や考え方を含めた総合的なものである．声明では，その中で，新聞などのメディアや一般の人々からよく質問される以下の問題についても言及している．すなわち，

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温暖化すると，熱帯サイクロンに影響される地域や熱帯サイクロンの発生数は増加するのか？
温暖化すると，熱帯サイクロンの勢力は強くなるのか？
温暖化すると，熱帯サイクロンが発生する海域は増加するのか？
温暖化すると，熱帯サイクロンはその勢力をさらに高緯度の地域まで維持し続けるのか？
すでに気候の変化の影響は熱帯サイクロンの動きに現れているのか？

ここでは，過去30～40年に渡る熱帯サイクロンの動きについて詳述するとともに，温暖化した地球での熱帯サイクロンの動きについて論議する．また，気候の変化と熱帯サイクロンの動きとの関連についてのIWTC 6 の声明の中身について述べるとともに，声明で述べられている今後の見通しについても十分に検討したい．

Introduction

During the past several decades, the average temperature of the earth's atmosphere and oceans has warmed. The warming has not been steady, but has had some periods of rapid warming, with some periods of steady or cooling temperatures (Fig. 1). During the 1970's (one of the periods during which the global temperatures seemed to be falling), it was thought that the next ice age was imminent. Since then, however, the global temperatures have steadily warmed, and during the past several years many locations have set all-time highs for many temperature statistics. For example, December 2006 was the warmest December of record for most of the continental United States.

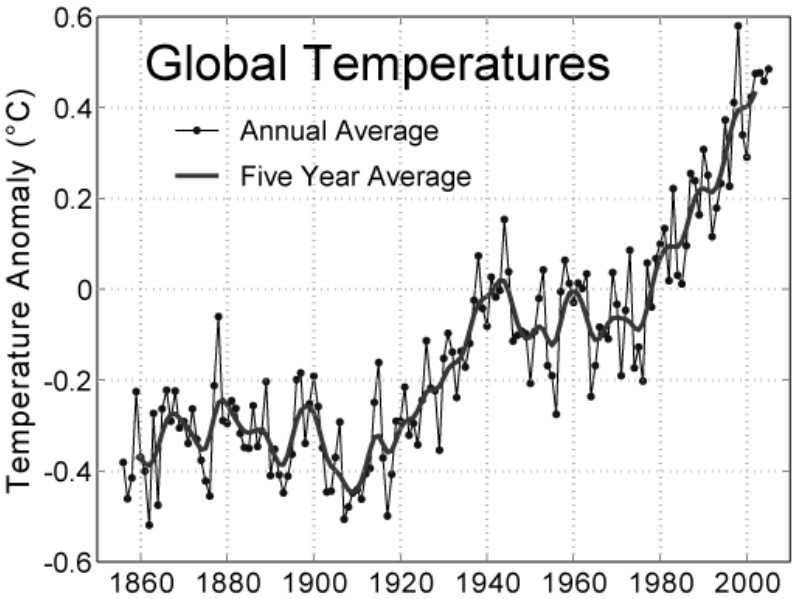

Fig. 1. Global average surface temperature for the past 150 years

The consensus concerning global warming has three tenets that are not widely disputed: 1. Global warming is happening; 2. It is (at least in part), caused by human use of fossil fuels; and, 3. It will continue for many decades. Three other tenets are less certain, but are widely accepted: 1. It poses grave dangers to humanity; 2. Reduction of human output of Carbon Dioxide will slow or even reverse the warming, and 2. The benefits from taking action to reduce CO_2 emissions will far exceed the costs. We do not know how much we must change our economic activity to produce a particular reduction of warming. And we do not know whether warming is necessarily dangerous.

Two of the most imminent plausible dangers of the climate in a warmer world are sea level rise and changes to the climate of tropical cyclones. These dangers are obviously more worrisome for low-lying tropical Pacific islands and atolls than in other areas of the world.

At the recent Sixth International Workshop on Tropical Cyclones (IWTC-6) held in San Jose, Costa Rica for two weeks in November 2006, a special group session was convened to generate a statement from the tropical cyclone community on the possible changes to tropical cyclone climate in a warmer world. Over the span of two full days, and many hours of behind-the-scenes work, the IWTC-6 participants produced a draft of its Statement on Tropical Cyclones and Climate Change. The summary statement (http://www.wmo.ch/web/arep/press_releases/2006/iwtc_summary.pdf) is one page and reflects a consensus among *all particpants* (125 people from 34 countries) at the IWTC-6.

The surfaces of most tropical oceans have warmed by 0.25 - 0.5 degree Celsius during the past several decades. The Intergovernmental Panel on Climate Change (IPCC) considers that the likely primary cause of the rise in global mean surface temperature in the past 50 years is the increase in greenhouse gas concentrations. The global community of tropical cyclone researchers and forecasters as represented at the 6th International Workshop on Tropical Cyclones of the World Meteorological Organization has released a statement on the links between anthropogenic (human-induced) climate change and tropical cyclones, including hurricanes and typhoons. This statement is in response to increased attention on tropical cyclones due to the following events:

a) There have been a number of recent high-impact tropical cyclone events around the globe. These include 10 landfalling tropical cyclones in Japan in 2004, five tropical cyclones affecting the Cook Islands in a five-week period in 2005, Cyclone Gafilo in Madagascar in 2004, Cyclone Larry in Australia in 2006, Typhoon Saomai in China in 2006, and the extremely active 2004 and 2005 Atlantic tropical cyclone seasons - including the catastrophic socio-economic impact of Hurricane Katrina.

b) Some recent scientific articles have reported a large increase in tropical cyclone energy, numbers, and wind-speeds in some regions during the last few decades in association with warmer sea surface temperatures. Other studies report that changes in observational techniques and instrumentation are responsible for these increases.

The Ten Consensus Statements are as Follows:

Consensus Statements by International Workshop on Tropical Cyclones-VI (IWTC-VI) Participants

1. Though there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record to date, no firm conclusion can be

made on this point.

2. No individual tropical cyclone can be directly attributed to climate change.

3. The recent increase in societal impact from tropical cyclones has largely been caused by rising concentrations of population and infrastructure in coastal regions.

4. Tropical cyclone wind-speed monitoring has changed dramatically over the last few decades, leading to difficulties in determining accurate trends.

5. There is an observed multi-decadal variability of tropical cyclones in some regions whose causes, whether natural, anthropogenic or a combination, are currently being debated. This variability makes detecting any long-term trends in tropical cyclone activity difficult.

6. It is likely that some increase in tropical cyclone peak wind-speed and rainfall will occur if the climate continues to warm. Model studies and theory project a 3-5% increase in wind-speed per degree Celsius increase of tropical sea surface temperatures.

7. There is an inconsistency between the small changes in wind-speed projected by theory and modeling versus large changes reported by some observational studies.

8. Although recent climate model simulations project a decrease or no change in global tropical cyclone numbers in a warmer climate, there is low confidence in this projection. In addition, it is unknown how tropical cyclone tracks or areas of impact will change in the future.

9. Large regional variations exist in methods used to monitor tropical cyclones. Also, most regions have no measurements by instrumented aircraft. These significant limitations will continue to make detection of trends difficult.

10. If the projected rise in sea level due to global warming occurs, then the vulnerability to tropical cyclone storm surge flooding would increase.

For my talk at the Kagoshima Forum, I decided to focus on one particular item mentioned in the IWTC-6 Summary Statement: the 10 landfalling tropical cyclones in Japan during 2004 (Fig. 2) (http://agora.ex.nii.ac.jp/digital-typhoon/year/wnp/1992.html.en). Records dating back to the early 1950's of landfalling typhoons in Japan indicate that 10 in one year was the most (by far) in the record (Fig. 3).

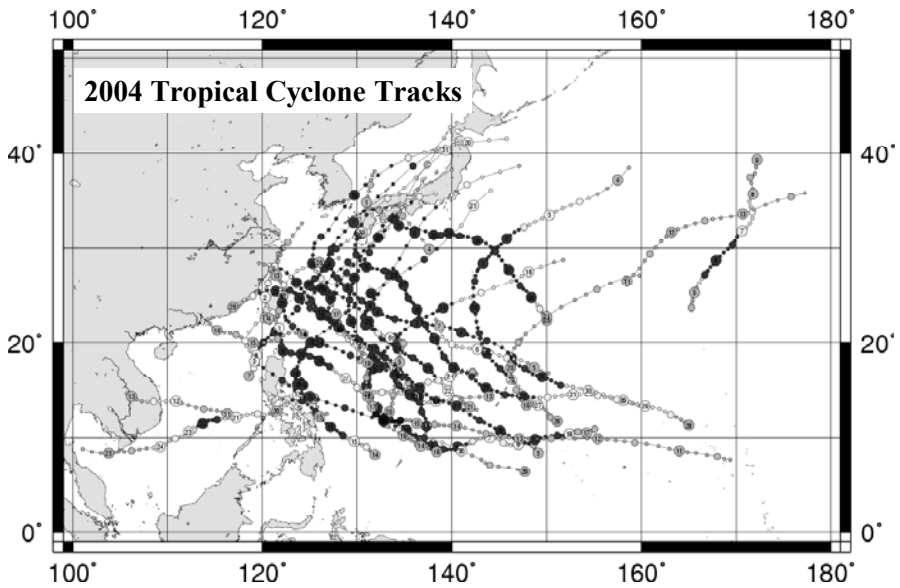

Fig. 2. Typhoon tracks of 2004 indicate a large number affecting Japan.

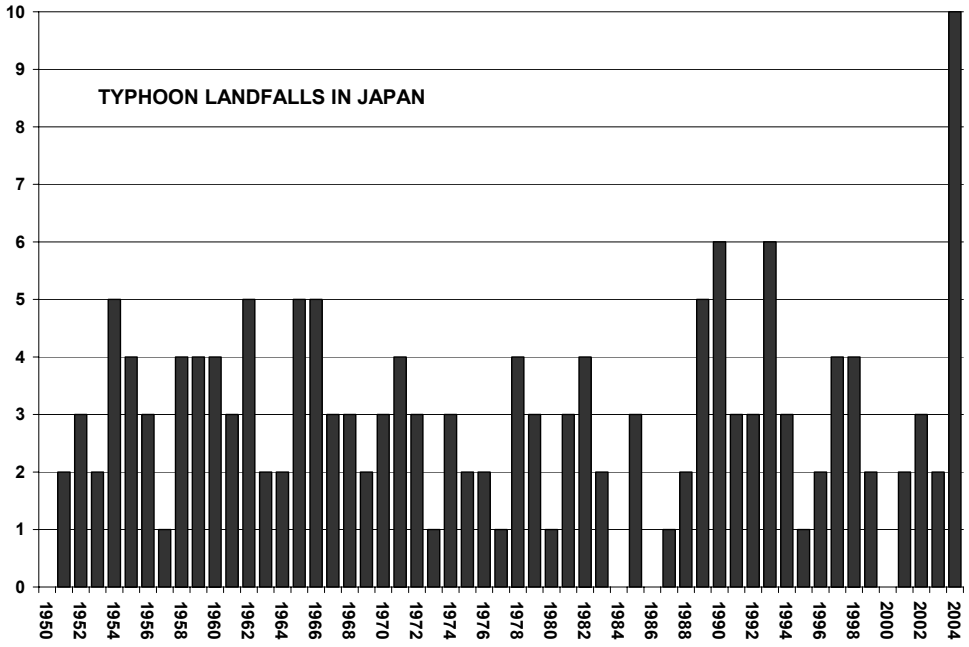

Fig. 3. The historical record of the annual number of landfalling typhoons in Japan.

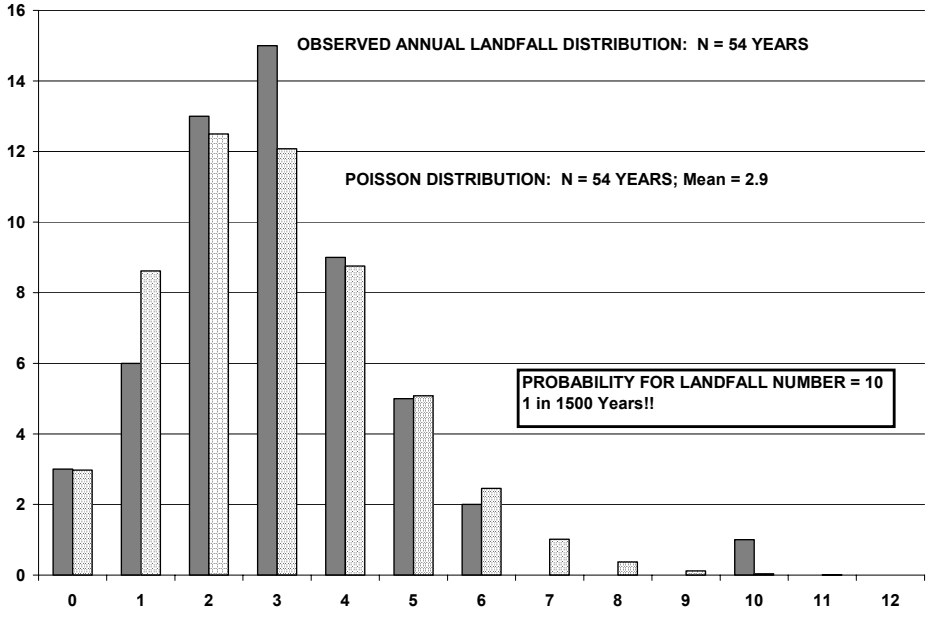

Fig. 4. The distribution of the annual number of landfalling typhoons in Japan during the period 1951 - 2004 (54 years). For example, in this time period there were 13 occurrences of two landfalling typhoons and 15 occurrences of three. Half-tone columns indicate the annual numbers given by a Poisson distribution with the same mean and same number of years as the actual data.

As one can readily see from Fig. 3, the ten Japan landfalling typhoons of 2004 was a remarkable event! There was concern by residents of Japan that this event was a product of climate change, and that it could portend an increase in the frequency of such occurrences in the future. Just how remarkable was this event? Can it be linked to climate change?

The occurrence of an extreme event naturally evokes the question of whether it is just a normal (but infrequent) part of the natural variability of a stable climate system, or whether it represents a jump from one state of the climate system into a different state with wholly new statistical parameters such as the mean of the time series and the year-to-year variability of the occurrences. In order to investigate this, the first thing one might wish to evaluate is the odds of the occurrence of the extreme event, given that the historical record is a snapshot of a stable climate system in which there are no systematic changes or trends underway. If one examines the Japan typhoon landfall record, it is quite clear that it is well represented by a statistical distribution know as the Poisson Distribution (Fig. 4).

The Poisson distribution arises in connection with Poisson processes. It applies to various phenomena of discrete nature (that is, those that may happen 0, 1, 2, 3, ... times during a given period of time or in a given area) whenever the probability of the phenomenon happening is constant in time or space. Examples of events that can be modeled as Poisson distributions include:

(1) The number of cars that pass through a certain point on a road
(2) The number of spelling mistakes one makes while typing a single page.
(3) The number of pine trees per unit area of mixed forest.
(4) The number of stars in a given volume of space.
(5) The number of light bulbs that burn out in a certain amount of time.

And, most certainly:
The annual number of landfalling typhoons in Japan.

In Fig. 4, a Poisson distribution with a mean occurrence rate of 2.9 per year (the same mean as the actual data) and for a sample size of 54 (the number of years of historical data) closely fits the actual data, with some departures that might be expected in a limited sample size. The Poisson model of the Japan typhoon landfalling data can be used to estimate the rarity of the occurrence of a high value, say ten, of the statistic (i.e., the annual number of landfalling typhoons in Japan). In a sample size of only 54 years one would expect 10 landfalling typhoons to occur only .034 times (i.e., far less than once). In order to raise this rate of occurrence to a numerical value of *one*, the sample size would have to be increased to approximately 1500 years. The 10 typhoons affecting Japan in 2004 was thus a rare event indeed, and would be expected to occur (on average) only once in 1500 years! This, of course, assumes that the background typhoon climate is stable.

It turns out that the annual number of typhoons that make landfall in Japan is strongly linked to the annual total number of tropical cyclones in the whole western North Pacific (Fig. 5a, and Fig. 5b). This is not trivial, since hurricane occurrences in other regions (e.g., the New England States of the U.S. Mainland) are not so strongly linked to basin-wide activity - other regional climate patterns such as the North Atlantic Oscillation (NAO) play a big role there by modulating the tracks of the Atlantic hurricanes independently of the basin activity (for example, Elsner, J.B. http://ams.confex.com/ams/pdfpapers/32845.pdf).

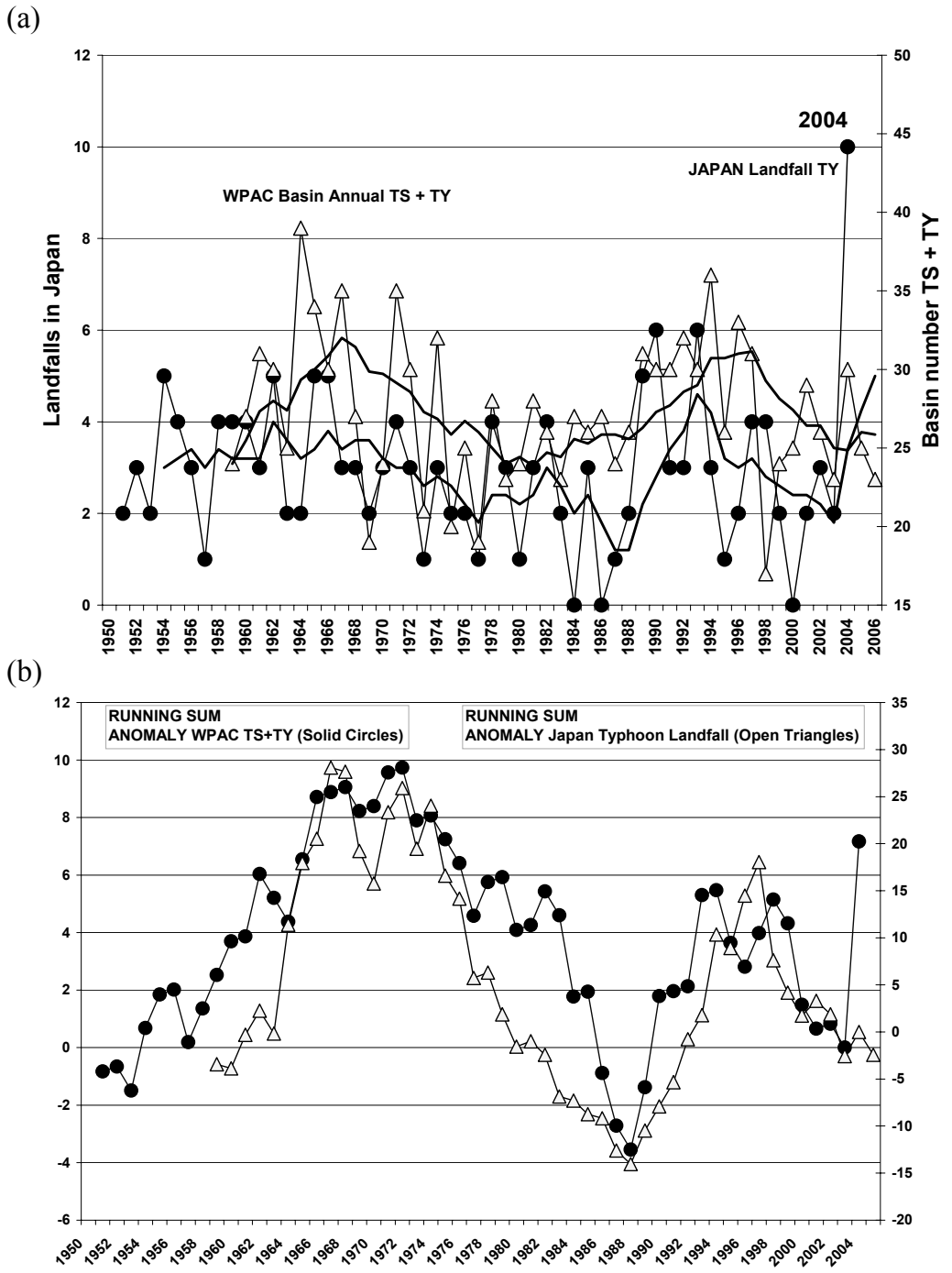

Fig. 5. (a) Time series of annual number of tropical storms and typhoons in the entire western North Pacific (solid circles) and the annual number of Japan landfalling typhoons. (b) Running sum of the anomalies of annual WNP TS + TY (solid circles) and the running sum of the anomalies of the annual number of Japan landfalling typhoons.

In recent General Circulation Models of the atmosphere run for a warmer world, the annual numbers of tropical cyclones in the models actually decreases in most basins. This was noted in the IWTC-6 report (summary point 8). Given this, one might then predict that in a warmer world with fewer TCs in the whole basin, Japan might have a slightly reduced, or at least unchanged number of landfalling tropical cyclones. However, even if the whole basin saw a slight reduction in the annual numbers of tropical cyclones, it is not known whether there will be any processes operating to change the regional distribution of the cyclones within the basin or to change the track patterns so as to offset or even negate the consequences of a reduction in number.

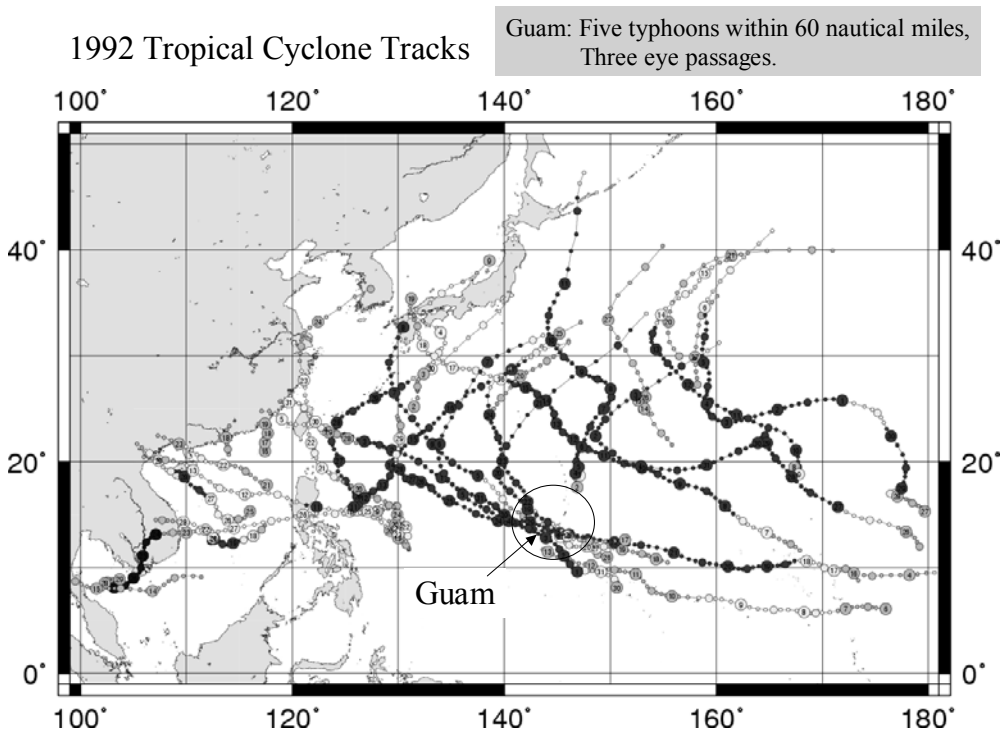

Fig. 6. The tropical cyclone tracks of 1992 showing a clustering of tracks near Guam. Guam experienced typhoon conditions five times in 1992 including three directs hits (eye passages over the island).

During 1992, the island of Guam (13.5°N ; 145°E) was impacted by five typhoons. Three of these typhoons were direct eye passages over the island (Fig. 6). There was then concern on Guam that some change in the climate system was acting to produce this unusual event; especially since Guam had experienced the effects of major typhoons in both 1990 and 1991 as well. As with the landfalling typhoons in Japan, the number of typhoons that hit Guam is a good example of an event that can be modeled as a Poisson process. In so doing, one finds that three typhoon eye passages over Guam in one year might happen an average of once every 700 years! This is certainly very rare, but it is actually not quite as rare as 10 landfalling typhoons in Japan, which has a rate of occurrence of about one time in 1500 years. It is always tempting to interpret a very unusual event as something caused by a shift in the climate. To those on Guam

who thought in 1992 that something strange was happening to the climate system, one only needed to point out that the neighboring island of Saipan only 150 km away had not had a direct strike by a major typhoon since 1986! To those in Japan who felt that the record number of typhoon landfalls in 2004 was a sign of a shift in the climate system that would bring such occurrences more frequently, one could point out to them that statistical analysis indicates that an almost impossible increase in the basin-wide number of tropical cyclones would be needed to bring about a large change in the number of them that hit Japan.

Summary of Important Findings

At the recent Sixth International Workshop on Tropical Cyclones (IWTC-6) held in San Jose, Costa Rica for two weeks in November 2006, a special group session was convened to generate a statement from the tropical cyclone community on the possible changes to tropical cyclone climate in a warmer world. The ten summary points of this statement are included in the text of this manuscript.

During 2004, there were ten landfalling typhoons in Japan. This was a record number, far exceeding anything that had occurred during the previous 53 years. A statistical analysis indicates that this event was indeed rare, with a recurrence interval of approximately 1500 years! The occurrence of such an extreme event is probably not an indication of a shift in the climate system that would result in a noticeable increase in the annual average number of typhoons making landfall in Japan or a more frequent occurrence of an extreme number of them, say 10, in one year. The 100-year extreme event, or the 500-year event, or the 1000-year, or the 1500-year event has to occur sooner or later. That the 1500-year event would occur in any 54-year segment of the time series has a probability of about 3 or 4% - not really all that improbable after all. One has a far smaller chance of winning a major lottery anytime in 54 years!

The annual number of landfalling typhoons in Japan is closely linked to the annual number of tropical cyclones in the whole western North Pacific basin. There are approximately 30 tropical cyclones per year in this basin. There is no evidence that this number will change substantially so as to strongly influence the number of typhoons that hit Japan (or any other location in the western North Pacific).

Point 8 of the summary points of the IWTC-6 statement on tropical cyclones and climate change indicates that there are some indications that the annual totals of tropical cyclones in most basins may decrease slightly in a warmer world. This cannot, however, be interpreted to indicate this decrease tropical cyclone activity would occur in all parts of any particular basin. Other factors governing regional differences and track distribution within each basin would have to be considered. Mostly these are poorly understood.

In typhoon-prone regions of the world, one must always be prepared for a devastating strike. It is tempting to think that one must wait 100 years for an event with a recurrence interval of 100 years to take place. This is not how it works. The 100-year event has a roughly equal (albeit low) chance of occurring in any particular year. Similarly, the idea that one is "due" for an extreme event because of a past lack of it, or that one may "rest easy" for a while after the occurrence of it are equally false notions.

Point 6 of the summary points of the IWTC-6 statement on tropical cyclones and climate change indicates that model studies and theory project a 3-5% increase in tropical cyclone wind-speed per degree Celsius increase of tropical sea surface temperatures. This is cause for concern.

Adequate preparation for today's distribution of tropical cyclones, however, should guarantee resiliency against any changes brought about by global climate change.

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Climate Changes and Globalization －Environment and People's Life in the Pacific Islands－

Small Island Sustainability Risks in Chuuk Atoll
－Climate Change and Globalization－

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Abstract

Pacific Atolls are under the threat of environmental changes -globalization and climate change. After Micronesia concluded the Compact of Free Association with the United States in the 1970s, cash transactions accelerated and the consumption economic society, which is separated from the production structure, expanded. This consumption economic society gradually came to stay, laying out a critical situation for maintaining the community life economy. Rice, wheat, imported processed meat and canned fish, which spread into people's lives a long time ago, still rock the foundations of their economic structures for life. In addition, they are in the crucible of competition in the globalizing economy. In this area, where cheaper goods are imported and high value-added products are not made, the separated structure between production and consumption is accelerating. The local economy is inclined toward a MIRAB (Migration, Remittance income, foreign Aid, Bureaucracy) economic structure, but it is becoming even more critical as the Compact Fund is reduced.

Even if their future vision should be on the conquering Insularity Economic Problem under Island Complex, global economic competitions present them super hard challenges. (1) 'Conquering the problem of Distances': hardships caused by the big ocean which occupies one third of the earth, and by high fuel cost, Information links by satellite or line should be revolution. However digital divide and high cost requirement problem occur to the islanders from now on. Someone may insist bioengineered products are the best methods for bridging the gap! However they can produce in other competitive place near market. (2) 'Conquering the problem of Smallness': their competitive commercial products are limited. 'Small is beautiful' and 'Slow Life' strategy need well trained high touch services and promotion of original culture. However these not always lead to high value adding economy, directly. (3) 'Conquering the problem of Marine': their hardness to prevent natural hazard is increasing. Endogenous marine industry is not strong enough to the world market. Charges for fishing in other piscatorial for EEZ are exogenous developmental method. Marine tourism needs harmony with local fishing and nature reservation, and they have to pay respect for vernacular culture. They have to establish local and global (GLOCAL in Japanese English) rule. However these paths are on the way of Industrial and Post-Industrial Civilization.

They and we have to prepare and add alternative path to the next civilization: Life-nomic Civilization. The development path to promote 'Life economy (by Hazel Henderson)' is the royal road based on traditional and subsistence economy for the Pacific Islander and us. Subsistence economy for everyday life and sustainability is substance for their future. This is the crisis for their future and society; recognition and awareness of these issues have to be revealed and be discussed each other beyond generation. However dominant structures of cash economy prevent their Turn Pike Path. We have to establish Fair Trade Structure with Pacific Islanders beyond low cost competition in the World Market.

Climate change is advancing more and more the collapse of subsistence/production foundations. The rise in ocean levels caused by global warming, understood only as an average sea level, is only one of these problems. As real problems, the killing of creatures on the shore and at the surface of the sea by El Nino which causes coral destruction damage, 'sea burning' by both continuous drought damage caused by high temperatures and temporary drops in the sea levels. Land damage from salt water by La Nina which causes temporary sea level rises, powerful typhoon increases with serious damage by rainstorms and flood-tides, ocean sand movement and lost in deep sea by seaside infrastructure by urbanization. The thinning of fresh water lens by rising sea levels cause not only vegetation decline, but also cause the catastrophic risk of human living sustainability through trotting step destruction of ecology. These problems of huge risks give them social unrest, and anthropological spoil from other Advanced Industrial and Civilized Society. Anthropological climate change require us new Global Wisdom.

To check the situation, we investigated the actual situation of small islands in the Chuuk Atoll area. The outline of the results shows individual and concrete examples of these issues mentioned above. Life changes towards a United States lifestyle strongly influence not only a filtering into the culture base but also a consumption economy structure. The need for cash transaction and the lack of business chances advances immigration to

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Hawaii, Guam, and the continental United States. They have to get over the collapse of production foundations and have to establish new paradigm and method toward sustainability.

International economic change is realized as the sensitive adjustment reaction to a lifestyle of importation. For example, in the case of a jump in oil prices, we can consider control of fishing and some drifting with high-risk without enough fuel. Extremely low-cost imported rice is sold as Guam-rice, and it cause change in family budget aspects, and production structure aspects, and health keeping aspects. They want to buy rice if money. Their nutrition had been well kept under the control of life culture of potato stomach and full body consumption, however now their imported food with high calories and partial body consumption lead them health keeping problem. Can we see any future plan under such changes? The only prospect is that a sense of impending crises exists in this generation. We have to show alternative methods and future passes which are appropriate to meet Pacific islanders' benefits to the next generations, and to avoid such big risk matters.

Our scholarly interests are as follows:

1) Can we propose, define, establish standards and take measures regarding the crisis critical point of sustainability for each scholarly area? And can we put these in a general order? For reference, Professor Lino Briguglio in Malta has ever proposed Vulnerability, but we can not know the measures by only extrinsic guidelines. We have to establish integrated intra island sustainability model of small island base and islander's life level, cooperated with integrated observation challenges by GEO（Group on Earth Observations）SS (System of Systems). It must be suitable to realize sound development and future plan for inhabitants of islands themselves. The problem is examining '5 Ware-5 Hierarchy, 3 Life Mode and Social Risk Management Procedure' and 'whether it can be countermeasure against Globalization + Climate Change or not'.

2) Keeping the balance of 'not traditional recurrent but future-oriented Life Economy', which is 'the first layer Ecology Economy, the second layer Inter-personal Activity Economy, the third layer Market/Government Economy', we can establish the global model through Pacific small islands, especially isolated islands? Of course, we check the proposal of the model and its concrete contents.

3) On consumer education and environmental education, for man-made factor regarding 'Sea level rise crisis' and 'Global abnormal weather', we have to introduce anthropological climate change and spoil risk. Then how does our understanding 'Island Area in Tropical Pacific/Polar Region' bring its force into play? We need to consider whether and how it can be the third pillar for the problem; the first pillar should be scientific technique －monitoring, prediction and simulation－, the second pillar is international regulation method by United Nations/International cooperation.

4) In addition to that, as national policy vision for Islands Area, can 'Re-consideration of post-MIRAB strategy' is sufficient condition of 'Traditional + Modernization + Globalization + Sustainability + Collaboration +Empowerment'? It must include concrete contents.

5) Especially, 'the scenario for sea level +88 cm rise at the end of 21 century' leaves problems unsettling those measures. We need to discuss study problem and forecast regarding those anxiety/measure social model. The key is social decision-making. We consider wisdom/concept/ method to add traditional Pacific Way.

要　旨

太平洋環礁域は環境変動の嵐にさらされている。グローバリゼーションと気候変動である。ミクロネシア地域は1970年代の米国との自由連合協定以降，現金経済化が加速化して，生産構造と分離した消費先行経済社会が展開して，その定着化が地域生活経済の持続可能性に危機的な影響を及ぼしている。米食・小麦食・輸入肉食・同加工品・缶詰魚食の浸透は，それより長い歴史性を持ちつつ，生存経済構造を根底から揺るがし続けている。これにグローバリゼーションの「競争」化が厳しい試練を突きつけている。より廉価に輸入され，高付加価値産品を持たないこの地域の，生産・消費分離構造はますます加速化されていく。地域経済はMIRAB（移民・送金収入・援助・官僚経済）構造に走りつつ久しいが，その中で人の移動は加速化し，現金経済・消費先行型経済は益々進んでおり，その資金源であった連合協定資金の減額化の中で，展望を持ちがたい危機を迎えている。

展望を得るとしたら，隔絶・環海・狭小性の是正である。時代は変わりつつある。地球の１/３をしめる大海原の「距離の暴虐」克服には情報化と高速移動手段の発達，「Small is beautiful」「Slow Life」の見直し，個性ある文化振興，海洋性の発揚・再生，

情報化リンク・EEZ入漁料・観光振興・バイオ産品開発等が，彼らの希望であり，未来である。しかし，それへの橋渡しは「持続可能性」の尺度での十分条件的基盤充実を前提にしなければならない。「生存経済ベースの生命系経済」振興以外にあり得ない。それへの危機意識・問題意識も「対策」として結実していない。

その生存・生産基盤崩壊はさらに気候変動で促進化されつつある。地球温暖化の海水面上昇問題（その平均値認識的無理解）だけではない。現実問題としての，エルニーニョ（高温干害の持続・海水面の著しい一時的低下の重なった珊瑚壊滅被害・海焼け）による陸上･海面生物破壊，ラニーニァ（海水面の著しい一時的上昇）による塩害被害，強力台風の増大，その暴風雨・高潮の重なりによる被害の甚大化，都市化・構造部・高潮による海砂移動と減少（外洋深海構造），高潮頻度の増大と水位上昇による淡水レンズ希薄化，による植生衰退の趨勢展望がもたらす社会不安・生存条件不安である。

これらの実態について，チューク環礁縁辺部小島嶼と中央部小島嶼の実態調査を行った。その概要は，まさに上記内容の個別的具体事例群であった。米国型ライフスタイルの変化は，文化基盤に浸透するのみではなく消費先行型の経済構造にも強い影響を及ぼしている。ビジネス機会の欠如での，現金経済獲得機会は，ハワイ・グアム・米国本土への移民を促進している。生産基盤崩壊は，人口圧を下げる対応で乗り切るしかない。また国際経済の変動は，移入価格への敏感な「生活行動調整反応」としても具現化する。例えば石油価格高騰は，出漁範囲調整・リスク高い移動での漂流頻発などである。極端にやすい輸入米はグアム米（再梱包）として売られ，「芋腹の生活文化」での健全性保持を，健康面（部分食・肥満）・家計面・生産構造（基盤）面で崩壊に導き続けている。この変化の持続の上にどのような未来設計があり得るのか。現世代に危機感が存在していることが唯一の展望であった。

学問的に関心が在るのは，①持続可能性の危機の臨海点（critical point）を，学問的に（それぞれの分野で）提示（定義・基準・対策）できるかどうか，またその総合的整理は可能かどうか（以前マルタのリノ教授 Lino Briguglio**が**Economic Vulnerability を示したが，外形的な指標だけでは対策が見えてこない。GEO（Group on Earth Observations）による統合観察を巡る試みに呼応しつつ，ミクロ次元・生活次元からの島嶼内統合的研究が必要である。諸島民自身の健全な発展とその未来構想に耐えられるものでなければならない。５Ware－５Hierarchy，３Life ModelとSocial Risk Management Procedureでの検討がそのGlobalization ＋ Climate Changeへの対抗力たり得るかの検討が課題である→②がさらにそのDevelopment Passの検証），②伝統回帰ではなく，未来志向的に「生命系の経済（第１層エコ経済，第２層対人的活動経済，第３層市場・政府経済）」の間のバランスで，太平洋小島嶼，特に離島が世界モデルを構築できるか。（モデルとその具体内容の提示可能性チェックをしてみる。）③消費者教育・環境教育的に「海進危機」「地球異常気象」の人為原因に対して，どう熱帯太平洋・極地海岸島嶼域「理解」が，力を発揮できるかに関して，国際政治的（国連・国際連携等）・科学技術的（モニタリングと予測・シュミレーション）に加えた第３の柱であり得る可能性についても，考えてみる必要がある。％ルール的移転と対策，原因物質削減，観測とエビデンス報道などの具体策に対して，教育の果たしうる役割の対比論である。④それらの上での島嶼域の国策的ビジョンとしての，脱MIRAB戦略の練り直しは，Traditional ＋ Modernization ＋ Globalization ＋ Sustainability ＋ Collaboration ＋ Empowermentで十分条件であり得るのかどうか。その内容に盛り込むべきもの具体的内容である。⑤特に，**21**世紀末の**＋88cm**海進シナリオは，これら対応・対策に耐えられない問題を残している。それら不安と対策の社会モデルに関する研究上の課題と見通しまで，論じておく必要がある。その鍵は，社会的意志決定である。従来のパシフィックウエーに加えるべき知・理念・手法を考える。

1. Environmental Change in the Pacific Islands

(1) Globalization and new Paradigm of the Pacific Way

When we consider **Environmental Change** in the Pacific Islands, now and in the future, two huge impacts to the Life-Style Changes of Islanders are indispensable: one is **Globalization** and other is **Climate Change**. Globalization is not only the problem of urbanization and modernization trends, but also the conflicts between urbanization vs. country or village life, modernization vs. traditional, monetary vs. subsistence, exogenous vs. endogenous, Papalagi (Euro/American) vs. Tuiavii (Pacific), Continental vs. Oceanic Island, and competitive vs. co-existence way of life for the Pacific Islanders. Pacific islanders' Life-Style Changes are confronted too much matters, so they need big challenges; digital divide strategy for informational revolution, monetary and consumer education for too much dependence on consumption, job opportunity and empowerment for income generation, local and vernacular culture promotion to meet with global cultural flux, local and traditional wisdom reservation like food knowledge and custom to meet with imported food flux, reproduction skill renaissance against exploitation by overuse by commercial activities, establishment of u-turn circumstances for after higher education by immigration, community promotion against de-population and urbanization problems.

A New Paradigm of the Pacific Way is needed by Pacific Islanders to meet the storm of globalization. This way is not to go back to the old days but towards a system that is the best for the next and future generation. The system should be based on their essential way of life and spirits more than exchange, competitiveness and overuse; that is share with, reciprocity, redistribution, consensus (long discussion), peace and order under authority, reproductiveness, sustainability, new identity, and endogenous decision making procedure.

(2) Climate Changes in the Pacific Island and Islanders' Life

Climate Changes in the Pacific Island are not only global warming, but also abnormal weather, El Nino, La Nina and so on. Climate change is advancing more and this is enhancing the collapse of subsistence/production foundations. The rise in ocean levels caused by global warming, understood only as an average sea level, is only one of these problems. Real problems are more severe.

If IPCC prediction of sea level rising by 88cm rise at the end of 21st Century is true, how will the islanders on atolls survive! Adding one century after, they shall lose almost all of their mother land into the sea. Like Fig. 1 shows, even a 20cm rise of sea level will destroy the ecological base of freshwater.

The changes include the killing of creatures on the shore and at the surface of the sea by El Nino, which causes coral destruction damage, "sea burning" by both continuous drought damage caused by high temperatures and temporary drops in the sea levels.

The thinning of fresh water lens by rising sea levels causes vegetation decline against ecological and sustainable development. Land damage from salt water by La Nina, which causes temporary sea level raises, with low pressure, shall occur at most level of sea level rise. Increase of powerful typhoons, which may be lowest level of pressure, with serious damages by rainstorms and flood-tides, are much risky than before the sea level rise. Sea level rise is risky on coastal management and with tsunami, shall cause destructive damages. We can see recent upgrading risky phenomena by El Nino and La Nina which occur at most levels of both directions in Fig. 2. by M. Lander.

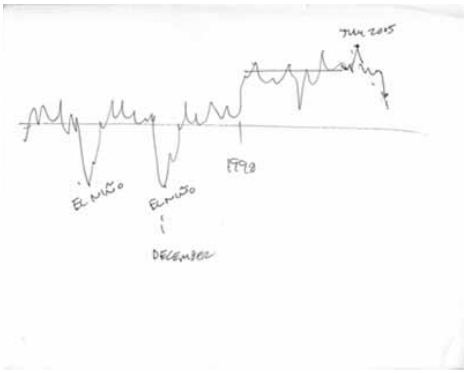


Fig. 1. (left). Sea level rise crisis by 20cm even
Fig. 2. (right). El Nino and La Nina Effect of the at most level of the sea. Hand writing by M. Lander Sep.2006 in UOG. Vertical=At most see levels, Horizon=years

In some places, like Majuro (see, the last our occasional paper), the damage is not only by climate change but also artificial seaside infrastructure constructions and dirty water by urbanization, ocean sand productivity and movement and lost occurred. This is also risky situation to protect beaches. These problems of many huge risks give the people social unrest, and anthropological spoil feeling from other Advanced Industrial and Civilized Society. Anthological climate change requires us to have new **Global Wisdom**.

How can they and we prepare against these risks? We need comprehensive methods for every risk management. The islanders can also contribute to the global activities, after all they are the first victims. They have to prevent their multiple risks, first!! Risk management methods are effective, however here we have cut to mention in detail by the limit of papers for print.

The author can use comprehensive human －environmental 5 ware model. For example for endurance system against salty water sacrifice, fresh water reservation and disaster prevention; we can consider in detail, hard-ware: ex. civil engineering, soft-ware; ex. safety net, ecological-ware; ex. salt endurance species, human-ware; ex. empowerment and spiritual-ware; ex. culture promotion on risk management by community. Each specialist can do support in detail and in concrete on this 5 wares or comprehensive managerial unit. These combinations are required on every small island in every atoll in the world.

2. Background and restriction of sustainability risks in FSM

Pacific Atolls are under the threat of environmental changes －globalization and climate change. After Micronesia concluded the Compact of Free Association with the United States in the 1970s, cash transactions were accelerated and the consumption economic society, which is separated from the production structure, was expanded. This consumption economic society gradually became established, laying out a critical situation for maintaining the community life economy. Rice, wheat, imported processed meat and canned fish, which spread into people's lives a long time ago, still are rocking the foundations of their economic structures for life. In addition, they are in crucible because of the competition, surplus production, mono-culture

products, and cash economic circulation/cash valued standard on globalization. In this area where cheaper goods are imported and high value-added products are not made, the separation in structures between production and consumption is accelerating. The local economy is inclined towards a MIRAB economic structure (Migration, Remittance income, foreign Aid, Bureaucracy). Besides population movement is accelerated and also cash economy/consumption driven economy structure is accelerated more and more. In addition, reducing fund from the Compact of Free Association which is main fund source makes hopeless crisis.

3. Toward post MIRAB economy and new civilization

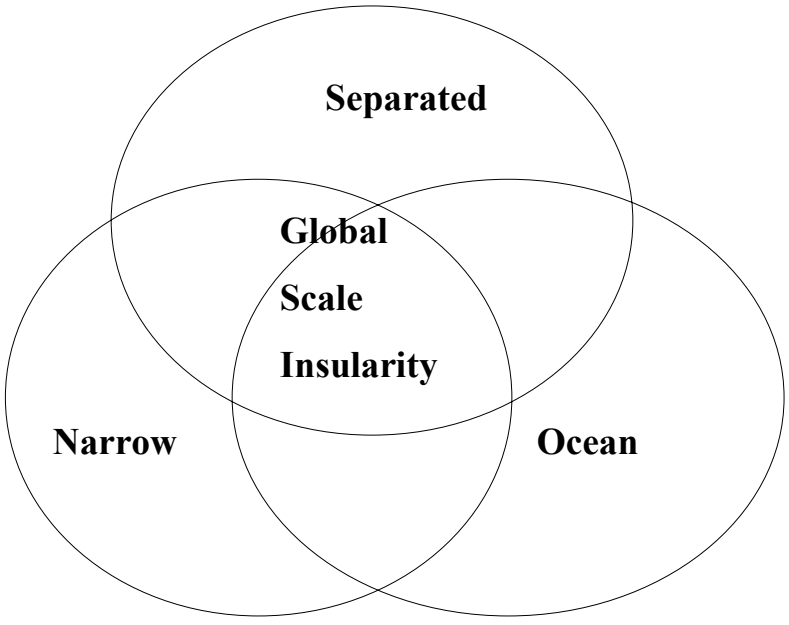


Fig. 3. Insularity Structure in Central Position of the Pacific Ocean

If their future vision should be on conquering Insularity Economic Problem under Island Complex, global economic competitions will undergo immensely hard challenges. "Conquering the problem of Distances": hardships caused by the vast ocean surface, which occupies one third of the earth, and by high fuel cost, Information links by satellite or line should be evolutional. However, digital divide and high cost requirement problems are faced by the islanders from now on. Someone may insist that bioengineered products are the best methods for bridging the gap!! Bioengineered products should be left to other competitive markets in their best competitive circumstances. "Conquering the problem of Smallness" : their competitive commercial products are limited, and scale merit shall be grate handicap for them. Alternatives are required. "Small is beautiful" and "Slow Life" strategies need well trained quality touch services and promotion of the original culture. However these do not always lead to direct high value additive economy. "Conquering the problem of Marine": it is becoming ever so difficult to prevent natural hazards. Endogenous marine industry is not competitive enough to the world market. Charges for fishing in other piscatorial for EEZ are exogenous developmental method. Marine tourism needs

harmony with local fishing and nature reservation, and they have to pay respect for vernacular culture. They have to establish local and global rule (GLOCAL in Japanese English). However, these paths are still on the way to Industrial and Post-Industrial Civilization.

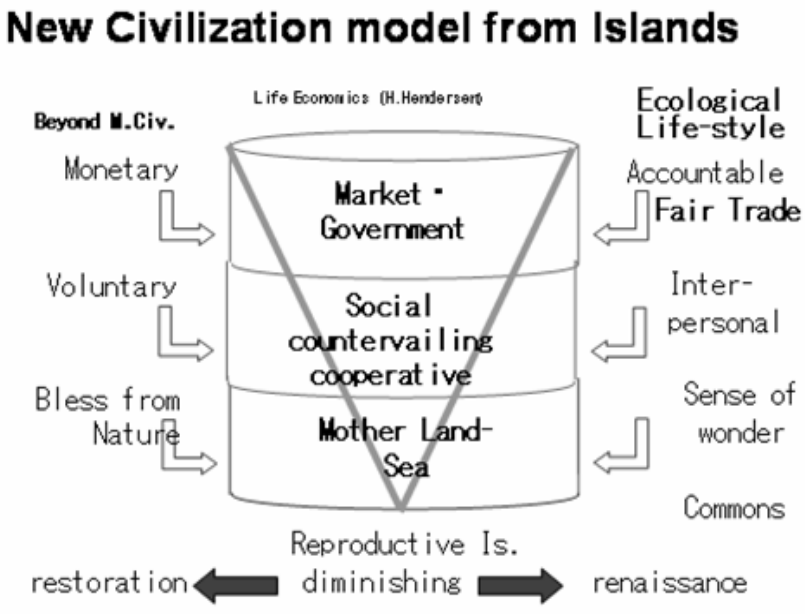


Fig. 4. Alternative Model for the Next Civilization: Life-nomic Civ.

The locals and us professionals have to prepare and add alternative paths to the next civilization: Life-nomic Civilization. Life Economy, which is the first class layer is Ecology Economy, the second class layer is Inter-personal Activity Economy, the third class Market/Government Economy, can we establish the global model through Pacific small islands, especially the isolated islands?

The developmental path to promote "Life-nomic" economy is the royal road based on a subsistence economy for the Pacific Islander and us. Subsistence economy for every day life and sustainability are key concepts for their future, not only from traditional path. However their recognition and initiative movement is not enough established, even their sustainability conditions are confronted to many risks by globalization and climate change. This is the crisis for their future; recognition and awareness of these issues are measurably noted. However dominant structures of cash economy prevent their Turn Pike Path. We have to establish Fair Trade Structure with Pacific Islanders beyond low cost competition in the World Market.

NPO establishments in the second class layer shall be co-governance revolution. Mutual help system in traditional rule shall more effectively work with inner-networking and inter-networking, sometimes with global link.

Volunteer guide and activities shall be changed to the professional work by valuably respect fee. Local knowledge and traditional training system shall be paid by eco-money or community-money (reciprocity cycle) with many thanks.

Re-evaluation and planning by ecological productivity measure beyond monetary and short

term measure is the best effective global sustainability path rather than local benefit. This may be **the best policy for global warming** by the Pacific Islanders. Kyoto protocol and carbon tax strategy shall be supportive of this way beyond and within global market. Figure 5 shows these productivity indexes. We need add more indexes and measures for assessments in concrete in each Pacific Island. Eco-tourism is not almighty, however if we can make better arrangement, mutual understanding shall be enforced.

TABLE 9.2

Primary Productivity Rates in the Ocean
(after Sumich 1988 and Barnes and Hughes 1982)

Location	Average productivity (gC/m²/yr.)*
Open ocean (tropical)	40
Open ocean (temperate)	120
Continental shelf	200
Upwelling zones	300
Seagrasses (temperate)	600
Mangroves	800
Coral reefs	1000
Kelp beds	1000
Seagrasses (tropical)	1500

*average figures from various studies; much higher maxima frequently occur.

Fig. 5. Primary Productivity in the Ocean source. (Moshe Rapaport ed. 'The Pacific Islands 1999, p.111'

Multiple use strategy and technology is another alternative for bio-zero emission. Not only utilized their resources, make less import and some case can make export with advanced technology (sometimes by university and academic contribution) or marketing; like one village one product movement.

4. Small islands researches in Chuuk Atoll on Environmental Change

(1) Outline of the researches by RCPI

Researches were conducted on those devastating conditions in Chuuk atoll area by RCPI (Kagoshima University Research Center for the Pacific Islands) using scientific research expenses, some are subsidized by research foundation of JSPS (Japan Society for the Promotion of Science) by the title; on Environmental changes in atoll area: internationally cooperative research to create the stronghold of monitoring center and functions in Chuuk Atoll in FSM. We crossed to the atoll 4 times in 3 groups in almost last year. In the duration of the stay, we were able to make Academic Exchange Agreements with Guam University. The research was conducted by the following groups. First group: Nov.2005, Terada R. (Ueno= Korea Ocean Research Center), January 2006, Nagashima S., Hidaka T. (Ueno, Tonowas, Etten, Uman, Piis); Second group: September 2006, Tajima Y., Noda S., Tominaga S., Nagashima S., Kuwahara S. and Kawai K. (Ueno, Tonowas, Etten, Piis, Romonum, Tol, Fanapages), Third group: November 2006, Onjyo M., Tsuda K., Kawai K. and Nishimura A. (Ueno, Tonowas, Romonum, Fanapages). (Boldface was the focal research destination.) Their specialties are anthropology, geography, humanities, human life and environment (nissology), mosquitoes and medicine, fruit sciences, soil, potatoes, insects, marine animals, sea glass.

(This thesis is neither the official report nor the summary from the team, but the private opinion and responsibility in author's field and specialty on nissology.)

1. January 2006

2. September 2006

3. November 2006

Research teams of Research Center for the Pacific Islands

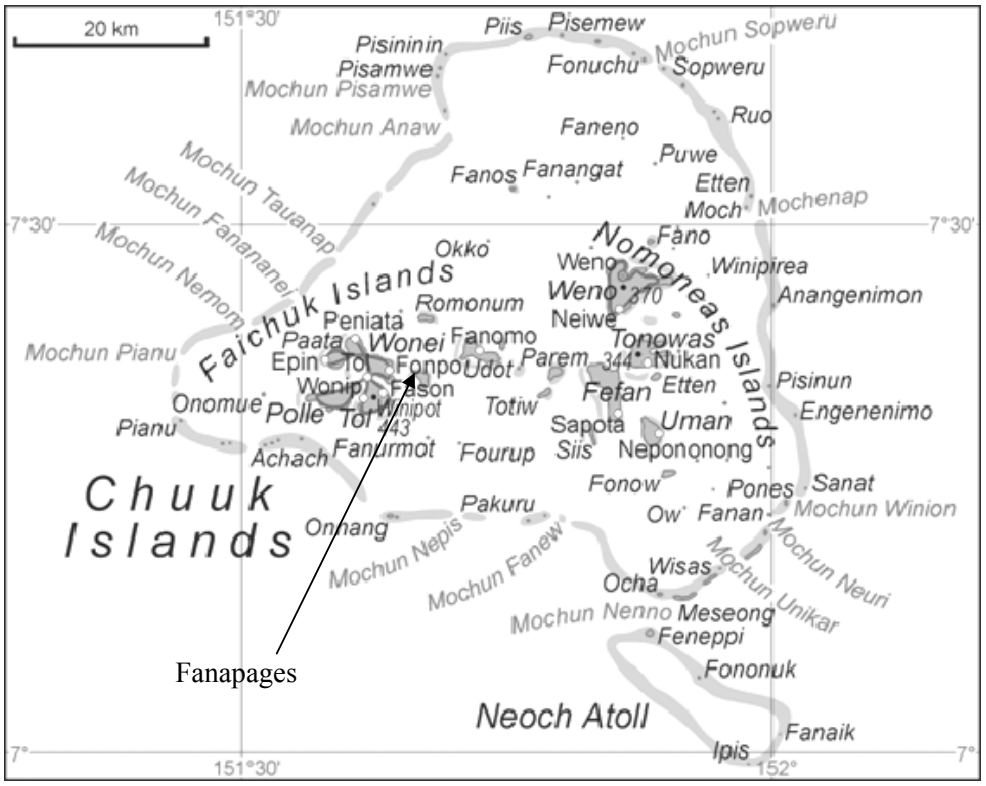
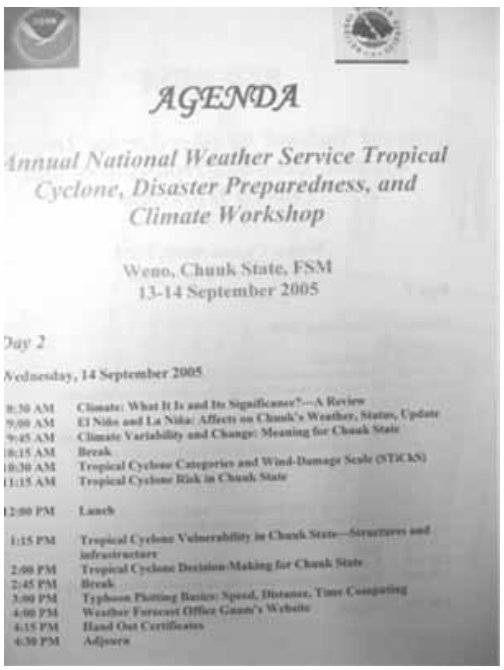


Fig. 6. Map of our research area.



AGENDA

Annual National Weather Service Tropical Cyclone, Disaster Preparedness, and Climate Workshop

Weno, Chuuk State, FSM
13-14 September 2005

Day 2

Wednesday, 14 September 2005

8:30 AM	Climate: What It Is and Its Significance?—A Review
9:00 AM	El Niño and La Niña: Affects on Chuuk's Weather, Status, Update
9:45 AM	Climate Variability and Change: Meaning for Chuuk State
10:15 AM	Break
10:30 AM	Tropical Cyclone Categories and Wind-Damage Scale (STICKS)
11:15 AM	Tropical Cyclone Risk in Chuuk State
12:00 PM	Lunch
1:15 PM	Tropical Cyclone Vulnerability in Chuuk State—Structures and infrastructure
2:00 PM	Tropical Cyclone Decision-Making for Chuuk State
2:45 PM	Break
3:00 PM	Typhoon Plotting Basics: Speed, Distance, Time Computing
4:00 PM	Weather Forecast Office Guam's Website
4:15 PM	Hand Out Certificates
4:30 PM	Adjourn

(2) Method and procedure

Our research of the first was preliminary one to see the outlook of the environmental changes and feasibility check of research; however we could check many evidences on our main theme. We were happy to know that important workshops have done with the staff from University of Guam (Fig. 7). At the Mortlock Development Commission, they have kept a copy of power point as if precious treasure; because they have heavy disasters attack zone and islands. During the second time, we prepared interview sheet on our main theme.

Fig. 7. Workshop by UOG.

What kind of food do you eat for everyday meal? Weight of Local-food vs Imported-food.	
Anxiety level to Socio-Economic Change and Climate Change I What is the Main(no need single answer) and Second Anxiety on Socio-Economic Change? To each Main(Strong), Second(Some), No-problem	
1 Exodus of younger generation	
2 Income Structure or Stability	
3 Cultural Restoration	
4 Local Identity	
5 Sustainable Life	
6 Other (in detail or HOPE)	
II Anxiety level to Climate Change and How and When you feel anxiety To each M(Strong), S(Some), No-problem If possible in detail, please	
1 High Tide	
2 Hurricanes or Strong Wind	
3 El Nino and/or La Ninja/ Too Hot and Cold	
4 Droughts and/or Heavy Rain especially what	
5 Sustainable Agriculture and Fishery	
6 Health and Care	
7 Other (in detail or HOPE)	

CPI Interview Format No.

Village Location		Electricity/ Cooking Fuel	
Name		Age/ Gender Last Education	
Duration in Moen		Duration in Other Chuuk	Where,
Duration out Chuuk	Where	←Aim And Activities	
Occupation (Family Income activities%)	Farming % Fishery % Remittance % from who Others % in Detail		
Community Role or Status			
Member of Household(Family)[Gender, Age, Relationship] live here			
Member of Household(Family)[Gender, Age, Relationship] living in other places			
What kind of crops do you grow?			

Fig. 8. Interview sheet.

(3) Briefing the impression and comments on the circumstances.

Investigations took place to study the actual situation of small islands in the Chuuk atoll area on environmental dynamic changes. The outline of the results shows individual and concrete examples of the issues mentioned above. Life changes towards United States lifestyle strongly influence not only a filtering into the culture base but also a consumption economy structure. The need for cash transaction and the lack of business chances advances immigration to Hawaii, Guam, and the United States mainland. They have to get over the collapse of production foundations and have to start establishing new paradigm and method toward sustainability.

International economic change is known as the sensitive adjustment reaction to a lifestyle of importation. For example, in the case of a jump in oil prices, they cannot go fishing faraway and some drifting occurs with high-risk. Extremely low-cost imported rice is sold as Guam-rice, and it causes the health keeping based on the life culture of potato stomach consumption to lead to a collapse in health aspects, family budget aspects, and production structure aspects. Can we see any future plan under such changes? The only prospect is that a sense of impending crises exists in this generation. We have to show alternative methods and future passes to the next generations, which are appropriate to meet pacific islanders' benefits and to avoid such big risks.

Reports and concerns about the abnormal sea level seem a bit exaggerated, but it seems adequate if we were to think about the seriousness of the problem. The problematic impact of the climate change to the societies affects not only Tuvalu, which was of concern at the Pacific Islands Forum in February 2005 by RCPI, but also the islands in the Pacific region, especially the low island and the overall atoll area. Our researches confirm our concerns. In addition to that, globalization which is one of the factors of climate change brings serious problems.

Sonsorol Atoll in Mortlock located outside Chuuk Atoll is known to be low islands and be hit by typhoons frequently and has had major damages by tsunami in the past. We scheduled to conduct preparatory research of the area, but due to restricted time and troubles with oil supplies, the trip could not be confirmed. We waited for information the resumption for half a year, however there was only disappointment. This region remains to be a crucial area for research.

Investigation at Chuuk Atoll by members of Research Center for the Pacific Islands, Kagoshima University.

Salty water anxiety by big typhoon and sea level rise (Piis).

We have to make briefing to know well circumstances beyond research sheet on current conditions and outlines of the researched area. Low island, Piis, (originally North Island in Japanese) located on the periphery of the atoll was a farming island during the war and there were no soldiers. There are 30 soldiers at Pisemuu Island (originally New Island) across from North Pass. There are 939 official residents (in fact 500 without emigrants). Population comparison between two villages is 6:4, but continual cooperation in region integrates two villages into one village and now there is only one head mayor in the island. From junior high school, they have to go to Ueno (originally, Spring Island, which is the Main Island), but in the outskirts of the city centre, there are residential areas for Piis. In the central a little hilly island, Romonum (previously known as Sunday Island), with 711 official residents, had anti-aircraft gun and the land caved in by bombing. In the island of Fanapages (previously known as Tuesday Island), with 606 official residents, immediately after the election our research group went to investigate this island. An island called Tor (previously known as Wednesday Island) has no roadway or cars and where the army opened the canal, but was full of life economy. As former Japanese professional baseball pitcher and the head chief, Aizawa Susumu (eternal title) had died; our purpose was to visit his grave. He was in a good shape at the beginning of the year and we had spoken for an hour. On the main island, Moen, he was doing business with Susumumaru and other liners. Being quite an intellect, in 1984 he had spoken about the frequent eruptions of cholera epidemics. As a measure of forbidding aquatic toilets, they had to form a system where chiefs from other islands took turns to be the watch, because the chief treated the locals with a kindness like a father. Due to this new system, they were able to at once thoroughly solve the problem. His nephew is the vice ambassador to Japan and the director of tourism bureau. Currently with $300,000 his youngest nephew is constructing communication tower for education and preservation of health. He is the technician for the 20 different sites under construction in centre of the outer islands. Like those examples, some Japanese related people are in the core of the society in Chuuk, and international cooperation with Japan is becoming more important.

(4) Small Islands Environmental Change and Social Unrest

As the team, we are conducting interdisciplinary and comprehensive researches. The key purpose of research, 'Environment changes of small islands in Atoll' will be outlined. The biggest concept of each climate changes is narrowed down to increase in intense typhoons and damages caused by El Nino. Especially the high temperature, coral reef extinction, and shortage of rain during the 8 months beginning from September 1998 were detrimental. Social changes are also rapid and are serious matters.

1) El Nino

Overlaps of coral destruction, high temperature, damages of evaporated plans are caused by continual high temperature and dropping of sea level. There are strong anxieties towards this. The high temperature climate during the 8 months since September 1998 had made even the natives, who are used to heat, dull. Coral reefs of outer island Piis, surrounded by shallow sea of Inou (coral reef forming the outer wall), and received destructive damages. Coral reefs are kept at high temperature, and dramatic decrease in the water level has caused coral reefs inside the shallow lagoon area a devastating damage, and it has still not recovered from these damages. The ones currently growing are fractions after damage. For a full recovery, it is estimated to take

a few years, and it may be likely to have another outburst of devastations. Seriousness of the evaporation and destruction of plants and water scarcity were narrowly secured by drinking water supplied by ship from main island Ueno where there are highlands. Measures against damages in areas where problems mentioned above cannot be solved like Sonsorol and other atolls lead to problems with international human rights (BHN=Basic Human Needs). Maintaining records of the devastations of the outer islands will be part of their safety net. It is necessary to find procedures to carry out investigations with the cooperation of the locals.

Taro patch destruction: Seven household units = 15 x 800 feet (Romonum).

Sea level rise anxiety and evidence of beach sacrifice.

2) Tidal wave and La Nina

Flood tide damages leave behind a very unpleasant aftermath in the coastal area. For example, the occurrence of flood tide and low atmospheric pressure such as SetoUchi islands (inland see in Japan) at BisanSeto area in 2003, were independent from typhoons. There are new records of the damages by abnormal water level in Kumamoto (neighbor prefecture of Kagoshima). Of course the typhoons are results of incredibly low atmospheric pressure, so the water level rises at once. Even to the present day since the mid-July 1996, their lives are affected. The occurrences of high flood tides are seen when La Nina was affecting the Micronesia and equatorial regions (Mark Lander, Guan University). The 15x800 feet taro farm used by 7 families in Romonum in the islands inside the lagoon was lost 10 years ago, and it still has not recovered.

Recoveries were seen in places where the water falls down directly from the spring water of the hills and the rain. There are many abandoned land in the outer island, Piis.

We have done present land surveys, but we have to conduct comparison investigations regarding diagrams of current and past land usage and do research on the soil quality of abandoned land. Of course, on this land, it is strongly relevant that originally bread-fruit was the staple diet but recently there have been shifts to rice and other products. Piis relies heavily on living substantial economy more than Romonum, so possibility of continuation of farming is becoming anxiety factors.

3) Increase in frequency of severe rain

Frequent occurrence of landslides and silt layer being washed away in higher island type are causing environmental damage. The topsoil of coral reef area is thinning, and washing away of this valuable topsoil (equivalent to damages cause by red soil washed away in Okinawa) is bound to cause environmental pollution.

4) Escalation of frequent eruptions of large scale typhoons

Increase in extreme damages and anxieties are severely affected in low islands around atoll region. There are times of frequent attacks, and they say that there are the most intense problems. The strength of the typhoons are higher than average. Highest speed can be over 200km/h (many occurrences of similar typhoons are also found in the Caribbean; in the Commonwealth of Dominica and Grenada, I have heard stories of the damages at churches; they are as serious as Katrina). Especially in the outer atoll Sonsorol, the effects of tsunami, which was enormous enough to engulf the islands, caused anxieties to the point of trauma. Being a site for tsunami damages, it is necessary to gather information of their instructions, measures, and traditions, and to check for room for improvements in their forecast system (system support after wireless maintenance). Piis is acknowledged as a site to have immense direct image. A medium-sized boat, which seemed like a Japanese aid, lay shipwrecked on the port.

5) Sustainability fishing, agriculture and total life

These damages and anxieties are linked to the collapse of existing base for agriculture and fishery. Sustainable living economics or village economics are already under threat of collapse due to shifts in socioeconomics. In Romonum there was a tradition of making the broiled and mush bread-fruit to a sticky paste and preserving that in soil (bread-fruit are seasonal). The domestic food supply in the small island is nearing 90%.However potential need for rice, wheat,

noodles, canned goods, and other imported food stuff is strong enough. If they can keep electricity and use refrigerator well, frozen meat and meal should be flood, if money. It seems like cash can resolve some problems, and to the road of destructing of sustainability and health.

Typhoon attack

Severe rain attack

Hygiene Sanitation Health Emergency

Throughout Micronesia, especially in the Pacific, lies a common problem: the cash flow and consumption driven lifestyle after concluding the Compact of Free Association. The remarkable gap between the production structure and this problem has been indicated since 1982 after requests for research, but disappointingly not only are the problems not resolved but it is causing the sustainable living economics itself as the social base to be abandoned and collapse. The problem can affect even on the island of Piis, 'if we have money, primal usage should be on rice and tinned fish'. Changes in people's taste in likes and dislikes of food and changes in socioeconomic circumstances facilitate the worsening of the situation. Crisis of decreasing taro potato farms and growing "sea burning" and breach of coral are spurring on for a malignant cycle.

6) Population problems

Issue of population outflow is not a matter here, but problem of overpopulation is serious because of its effects on the future production base. Especially on small islands there is a limit to the expansion of resources found on land. On Romonum where the cash economics is in its primary progressive stage, there was a strong awareness of the worrying consciousness. There are times when commercial activities overtake the regional resource recycling cycle. Depending on the management of the situation, this may be destructive (for example from over-deforestation and mono-culturalization like seen in a part of islands in South East Asia). It is vital for the small scale island model to maintain the compound multiple production structure. Along with resolving issues of primary industrial production technology, there are callings for cooperating with the main island on reorganization of diversification of production system within the region and developments of skill-oriented education like technical college.

7) Island identity and globalization

Transfiguration of lifestyle is becoming a problem. It is certain that they have solid island identity; love and pride. However, over-penetration of consumption driven society and individualistic United States culture and lifestyle is a worrying matter when it comes to the future of the islands. Prevalence of videos is accelerating, and storm of information from televisions and internet is approaching the islands. As part of United States' aid, there are now new 50 Personal Computers mounted with Windows XP in Micronesia College.

8) Water circulation

Water circulation is related to the decisive difference between life structure/ production structure of the small-hill islands and the small-low islands. The richness of the power of collecting rain on the hill islands can be seen on laundries even when they use running water. The dirtiness of the well used for laundries and shower in the low islands is abysmal. Severely prodigious contamination was shown when bacterial examination was carried out; to the point the whole test paper changed its color! To note, waterworks in Japan has the standards of zero expectancy.

Spread of those basic health information, on the other hand, thinization of fresh water lens with drought and sea-level rising, increase of fresh water demand according to lifestyle, reservation of city water that is indispensable to existence/ crops/ economic activity, this adjustment of quality and quantity of tri-lemma is a big urgent problem.

Sustainability

Human Life and Environment

Ecology

Sustainability

Income Structure

Urbanization

Modernization

Tourism ⇔ Culture ⇔ Identity

1980's skull diving vs. remembering tour by survivors

Best interest for the next generation and islanders

Overpopulation anxiety than depopulation

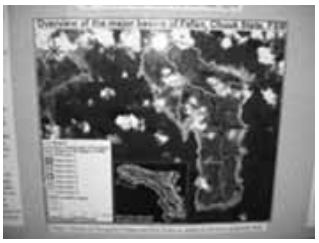
Quality of fresh water

Basic human needs

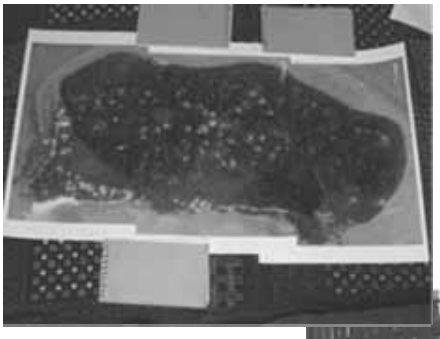
Globalization

Electricity

How to meet industrial society



Informative society in the main island



Informative society in the small island

Non refrigerator
Cf. Imported meal

Food and nutrition

Health and subsistence affluence

High potential of desire

Traditional lunch

Commercial
Use ⇔
Goods ⇔
Activities
Sustainble
life, technology
system

Sustainable
fishing and
agriculture

Power generation; Cost vs. usage

Fuel cost attacks from global market price.

Fishery and transportation

Transportation not only cost but safety

9) Problems with medical care and health

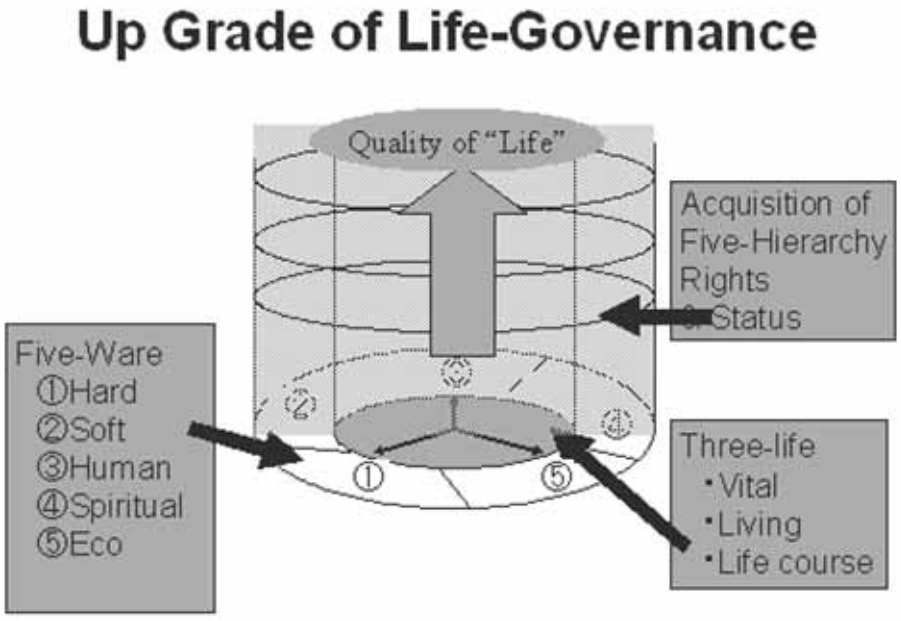
In both these islands there are no medical doctors, and quick to note this is a very troubling matter. Although there is a native nurse in her 30s, there is a limit of what she can do during emergencies (in terms of technology, prescription, information, and transferring). Especially dealing with situations in the remote islands and outer islands, there will be predicaments due to traveling time, expenses, high waves, storms, and the like. We should consider "multi-usage of information technology through communication towers that are currently being built in the outer islands" to put to practical use in the inner atoll, so that this can culminate to function as a whole island system. We can expect an outstanding result from optimum experiments. We should consider the public heath nurse system and medical care assistance system that has been successfully installed in Okinawa to aid expansion in the atoll area. At Kagoshima University International Island Medicine's seminars, with the cooperation of Research Centre for the Pacific Islands, we receive medical doctors from islands in the South East Asia and the Pacific Islands, and with JICA and prefecture government, they undergo medical training in remote islands.

10) International value fluctuations

The rising price of oil is especially problematic in both the areas. Remotely situated Piis not only can be sustained existence cash economy foundation but also gas price for transportation to and from the island costs $50. In our second visit, we encountered boat that was out of gas and were waiting for aid for two hours. The seven passengers probably expected gas shortage when they boarded the ship. Danger seems to be inescapable. Piscatorial radius and opportunities are under constraint. Also, ice making facilities provided as a Japanese aid is not under operation due to fuel problems. Popularization of household electronics was at one point seen constantly (about 30%), but fuel problems decreased the usage of these goods to 10%. It is hard to say that it is consistent. A fraction of solar battery was seen on the Romonum Island. One of the places is International Net Religious Facility. Another for a long term use is the one gained from piscatorial resource project by an ex-civil servant. He said that it is vital for radios and the like. Accepting core figure in Romonum, a protestant pastor, owns a power plant, and with wireless ham he was communicating and was regulating connections with central cities.

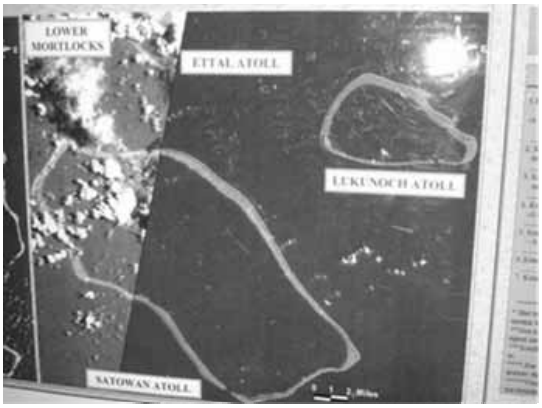
5. Problems and prospects on environment change in the Pacific

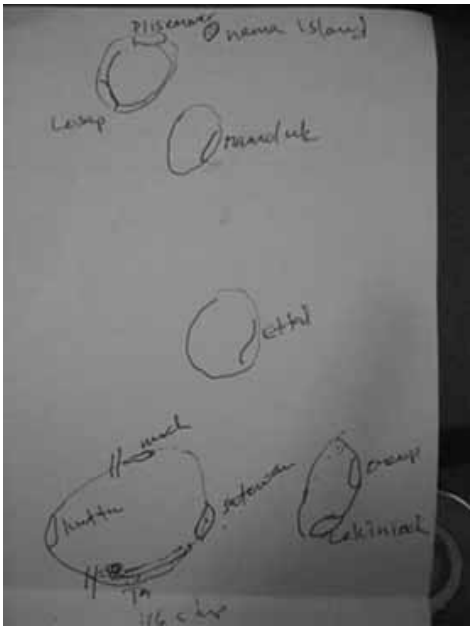
The development of globalization/information network at capital cities of Pacific islands is remarkable. The author have often visited since the trusteeship Government was retained 26 years ago, and its change are remarkable speedy in the world. Universally, detail researches of individual circumstances are indispensable for concern of local identity and useful method of local measures. In Pacific islands, especially isolated islands, there were many problems on social change and consumption economy, when author start to study in the field in Micronesia. Each level of trade frequency, information network, cash economy, electrification was different. But now the double-punch of climate change and globalization, or the storm of comprehensive and dynamic environmental change, may increase all at once and steadily. To follow these phenomena, those comprehensive and multi-disciplinary methods are needed by professional researches on the islands. Especially in the isolated islands, these environmental dynamic changes may work destructive to keep the community base. Then we have to respect raison d'etre of vernacular system, and endogenous process which may be different from our modernization, even if outlook and technology might be the same.



Outer remote island disaster society
(Culture/ ecology/ life style/ globalization)

Jet fuel problem for supply

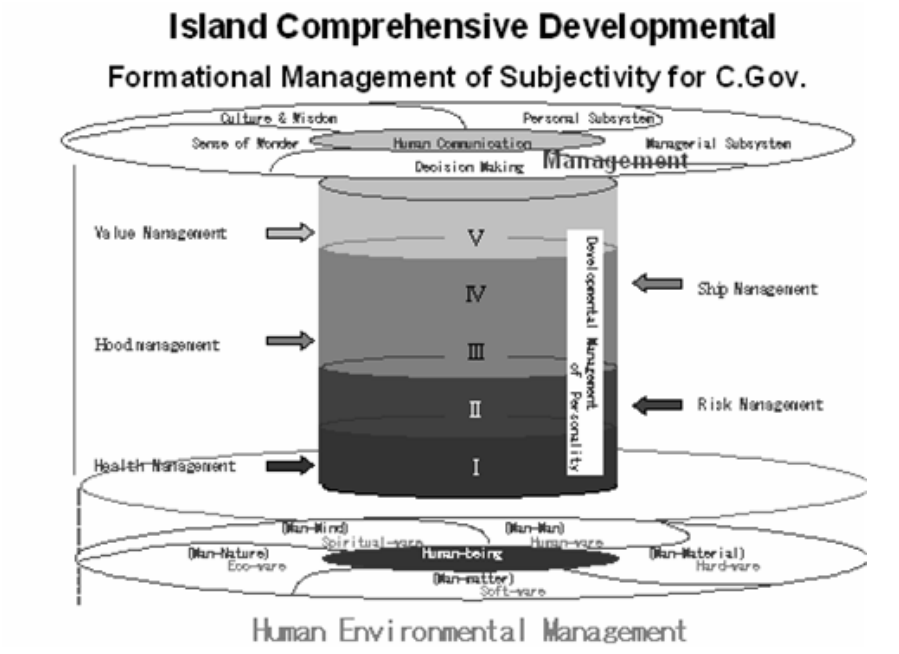




Climate change

Typhoon and tsunami

International collaboration



Endogenous process with counter part

Historical burden and mutual respects

With best friendship

Small is beautiful.

Our academic interests on environmental dynamic changes are as follows:

(1) Can we propose, define, establish standards and take measures regarding the crisis critical point of sustainability for each scholarly area? Can we put these in the order of importance? For reference, Professor Lino Briguglio in Malta has proposed Vulnerability, but we can not know the measures by only extrinsic guidelines. It must stand up healthy development and future plan for islanders themselves. The data of Pacific islands is restricted originally and is large-scale except statistic relatives of time lag. Therefore we need to consider the phenomenon understanding depended on data can be highly outdated and limited partly. The problem is examining '5 Ware-5 Hierarchy, 3 Life Mode and Social Risk Management Procedure" and "whether it can countermeasure against Globalization + Climate Change or not'.

(2) Keeping the balance of "not traditionally recurrent but future-oriented Life Economy, which is the first class Ecology Economy, the second class Inter-personal Activity Economy, the third class Market/Government Economy," can we establish the global model through Pacific small islands, especially the isolated islands? Of course, we may check the proposal of the model and its concrete contents.

(3) On consumer education and environmental education, for human-derived factors regarding "Sea level rise crisis" and "Global abnormal weather," how does our understanding of 'Island Area in Tropical Pacific/Polar Region' bring its force into play? We need to consider whether or not educational method can be the third pillar; first is the political and second is the academic method.

(4) GEOSS; Global Earth Observation System of Systems is now active working to get global data from satellite and combine with the local date. Japan is working as the leader in Asian Pacific regions. We need to combine our community base study in the small islands in the Pacific with these global units.

How we can make approach with appropriate method? Not only get information, but we may make combine micro and local phenomena as the concrete and representative data in fact, which is not as a case study. We may act for the checking function to the scientific techniques - monitoring, prediction and simulation by comprehensive method, social unset and ecological restorations.

(5) In addition to that, as national policy vision for Islands Area, can "Re-consideration of post-MIRAB strategy"are sufficient conditions of 'Traditional + Modernization + Globalization + Sustainability + Collaboration +Empowerment'? It must include concrete contents.

(6) Especially, 'the scenario for sea level +88cm rise at the end of 21 century' leaves problems unsettling these measures. We need to discuss study problem and forecast regarding those current anxiety-provoking social model. The key is social decision-making. We have to consider wisdom/concept/ method to add to the traditional Pacific Way. Regarding those problems now is the time to have cooperative research with the next generation of native islanders. On and How, we need discussion together, like let's start with what's close at hand, zero emission, enhancing biological productivity, biomass energy and soft energy, resource management, environmental management and sustainability.

This time, we did out research only the small and little isolated islands, with pre-research measure and research measure, because of budget limitation. But we got the fixed interdisciplinary result. We expect more details to be gathered special knowledge and result from each field. For more detail researches of human and social phenomenon, especially, for researches of whole life, we need repeat visit, diversified observation, hearing and collecting data. Detail researches and diversified observation with enough time at local are most important. Particularly, at Pacific islands (especially, isolated islands), statistics and literature materials are limited. It is indispensable for high quality of result that the past researches, some materials and human network in Guam University, South Pacific University and Hawaii University are combined. It is a significant international contribution that we establish the maintaining research base in close cooperation with local collage, local government, local research organization (Korea Ocean Research Center located at Chuuk, KORDI). But we see, at library in Chuuk branch school, Micronesia collage, even science books were not put in order enough. This time, we could have a simple discussion with collage staff, but, regarding outer atoll and isolated research, with consideration of interdisciplinary and time-limitation, establishing the sustainable research system with locals and the repeatable collaboration are requested especially.

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Climate Changes and Globalization －Environment and People's Life in the Pacific Islands－

Seeking Safety from the Storm: The Impact of Climate Change on Inter-Island Relations and Human Migration in Micronesia

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Abstract

Pacific Islanders are well aware of the intimate relationship between climate change and people's life within island environments. For many Micronesian islanders, especially those living on coral atolls only one or two meters above sea level, cultural adaptations to climate changes such as droughts, typhoons, and changes in sea level have been necessary for survival from the earliest times of settlement, over a thousand years ago. One important strategy for cultural adaptation to climate change in Micronesia has involved the ability of small island communities to draw together through larger inter-island relationships of mutual assistance. Because low coral islands are especially vulnerable to these sudden or gradual changes in climate, throughout Micronesia low island communities have developed inter-island networks among themselves, and special political linkages to neighboring high volcanic islands that are less vulnerable and can provide emergency refuge and assistance after devastating storms or floods on the small coral islands.

Within Micronesia, Yap and the Outer Islands have developed the most extensive network of inter-island relations between a high island complex and a group of far-flung low coral islands. Lying along the track of the most frequent and destructive typhoons of the western Pacific, the Yap Outer Islands have always been the most vulnerable islands in Micronesia to storm damage and to the impact of climate change. Centuries ago the "Yapese Empire" developed, linking all the Outer Islands under the authority of one high-ranking group of villages on the main high island complex of Yap. Traditionally the Outer Islanders have paid tribute to their Yapese chiefs, and relied upon the Yapese for protection and assistance after storms.

In very recent years a unique new phenomenon has been occurring, as Outer Islanders, using their traditional linkages to Yapese chiefs, are establishing stable migrant settlements in various parts of Yap. Within the past five years, three major new settlements have taken shape, with Outer Islanders constructing homes and planting gardens in Yap. Many factors are contributing to this new migration movement, which is part of a globalizating and urbanizing trend throughout the Pacific. One factor is certainly islanders' concerns about the impact of climate change on their low coral atoll home islands. Although climate change is not yet well understood in the general population of Islanders, educated community leaders are aware of the longterm threat of climate change, and such leaders have played a significant role in spearheading efforts to secure land in Yap for the growing number of Outer Island migrants.

要　旨

太平洋の島々に住む人々は，気候の変化と人々の生活が密接に関係していることを良く知っている．多くのミクロネシアの人々，特に海抜１，２ｍしかない環礁に住む人々は，干ばつ，台風，海面の変化といったことに数千年前の定着当初からそれらの状況に適応しようと努めてきた．また，それら気候の変化に適応するために，それぞれの小さな島々の共同体が相互に助け合うための大きな共同体を構成するという文化的な戦略もある．海抜の低い珊瑚礁の島々は，突然，あるいは次第に変化する気候には特に脆弱であり，共同体同士が助け合うというネットワークを作ってきたのである．特に，海抜の高い火山島からなる島々はそれらの危険に対して海抜の低い島々ほどには大きな影響を受けない．そこで,海抜の高い島々がその周囲の海抜の低い島々と政治的にも結びつき，台風や洪水時の避難先として，また援助の手を差し伸べるという役割を果たしてきたの

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である．

ミクロネシアで見てみると，ヤップとその外側の島々が，海抜の高い島とその周囲に広がる珊瑚礁の低海抜の島々とで構成される大規模なネットワークを構成している．西太平洋における台風の通り道にあるため，ヤップの低海抜の島々はミクロネシア内では台風や気候の変化に最も弱い島々である．数百年前，ヤップは，「ヤップ帝国」として，その主島の村の支配層がその周囲の島々を支配下に治めるという形態を取っていた．周囲の島々に住む人々は，主島の酋長達に貢ぎ物を納め，台風時にはその援助を受けるという関係を保ってきたのである．

ごく近年になって，その関係に新しい出来事が認められるようになった．すなわち，周囲の島々の人々は，酋長達との伝統的な関係を利用して，ヤップに移り住むようになったのである．過去５年間で，３ヶ所に新しい移住地が形成された．人々はそこに住宅を建設し，庭を作っているのである．これには多くの要因が関わっていると思われるが，一つは太平洋全域に認められるグローバリゼーションや都市化といった傾向である．もちろん，彼らが元々住んでいた環礁の島々は，海抜が低く，気候の変化の影響をもろに受けるということが最大の原因であることはいうまでもない．気候の変化という問題について，太平洋の島々に住む人々すべてが理解しているとは言えないが，教育を受けている共同体のリーダー達はこれによる長期的な被害についても認識しており，周囲の島々からの移住者のために大きな努力を払っているのである．

During the past decade, Yap State Outer Islanders have been establishing permanent settlements on the main island of Yap. In one sense this is a new and unique phenomenon: Outer Islanders have never before built permanent homes and cultivated perennial gardens in Yap. Yet in another sense this movement is part of an age-old pattern of Outer Islanders in Yap -and atoll dwellers in other parts of Micronesia as well-relying on their high island neighbors for assistance in times of need.

In this talk I want to focus on this process of Outer Islanders seeking safety through inter-island relationships among themselves, and especially through social and political ties with higher and larger neighboring islands. I also want to point out that climate change and globalization are intensifying this process of islanders seeking safety through expanding their social and political relationships.

Global warming and associated sea level rise will impact Micronesian islands differently. The main difference is that the high mountainous islands such as Yap or Guam provide much greater protection and more secure resources than the low coral atolls. The high islands provide more protection from destructive winds and devastating floods. The high islands also hold much greater groundwater capacity, and they are much less likely to suffer from drought or saltwater damage to interior gardens. Throughout Micronesia, high islands offer greater sustainability than the low coral atolls that are vulnerable to typhoon destruction and flooding from high waves. This contrast is especially evident in Yap State, which lies along the main path of frequent typhoon movements in the western Pacific Ocean. Typhoons in the western Pacific typically form as low pressure areas around Pohnpei or Chuuk states. The typhoons intensify as they move west towards Yap. Yap State, the westernmost of the four FSM states, usually suffers the greatest impact of the storms. The islands of Yap State lie mainly along an east-west belt, and typhoons have been known to travel down the chain of islands, causing destruction and damage

to each island community in their path.

The Outer Islanders of Yap have learned how to survive climate changes in the past, and they have learned how to adapt to recurrent climate extremes such as droughts, typhoons, and flooding. One important strategy for cultural adaptation has involved developing and maintaining social and political connections between the more vulnerable coral atolls and the neighboring high islands. These relationships probably go back to the earliest settlement, perhaps two thousand years ago, according to archaeological studies.

In Yap and the Outer Islands, these relationships became institutionalized over time into the *sawei* system-the so-called Yapese empire. This system evidently developed over five hundred years ago. It involved formal relations of tribute and aid between Gagil, a traditional center of chiefly power in northern Yap, and all the outer islands stretching a thousand kilometers between Yap and Chuuk. Every few years a fleet of outer island canoes carrying chiefs' representatives would sail to Yap, bringing tribute and trade items to the Yapese chiefs in Gagil. In turn, the Outer Island communities could count on assistance from the Yapese in times of need. Throughout Micronesia, similar relationships developed, although less formalized than the Yapese Empire. The low coral islanders of Yap are master seafarers and navigators, and they maintained social and political ties with kinsmen, chiefs, and trade partners on neighboring and distant high islands.

During colonial times over the past two centuries, these systems of social and political ties intensified. Permanent or semi-permanent resettlement communities of coral islanders grew up in the colonial administrative centers on the main high islands. In most cases, the creation of these resettlement communities was the direct result of natural disasters such as typhoons and droughts.

For example, two hundred years ago a devastating typhoon struck the Yap Outer Islands. Afterwards a small group of survivors from Lamotrek and Satawal sailed all the way to Guam, following traditional sailing routes. They asked the Spanish governor of Guam for permission to settle in Saipan. This is the origin of the current Carolinian population on Saipan. A similar example is found on Pohnpei. One hundred years ago, a few dozen islanders from Kapingamarangi, a low coral atoll 800 kilometers south of Pohnpei, fled a deadly drought on their home island, and settled in the port town of Kolonia on the high island of Pohnpei, which was then under German colonial rule.

During the same period, there were other similar examples on Pohnpei of islanders from low coral atolls in the Mortlock Islands in Chuuk, or from the small atolls of Pingelap and Mokil east of Pohnpei, who formed resettlement communities in Pohnpei after destructive storms or droughts in their home islands. During the German period in Palau, a similar settlement developed after a group of coral islanders from Tobi and Sonsorol, small coral atolls southwest of Palau, left their home islands after a destructive typhoon and came to the high island of Palau. They sought assistance from chiefs in Palau and they were given permission to live along the mudflats on Arakabesang Island near the main town and political center of Koror.

In all these cases, Outer Islanders seeking assistance on the high islands of Guam, Pohnpei, or Palau had to rely on political ties to local chiefs or to colonial rulers, in order to gain rights to land where they could resettle. Throughout Micronesia, islanders who live on the high mountainous islands have held greater political status and have presumed a sort of cultural superiority over their low island neighbors. This is especially true in Yap, where a traditional caste-like system put Outer Islanders at a particular disadvantage on Yap. Traditionally, Outer

Islanders were not allowed to own land on Yap, and when visiting Yap they were expected to behave with extreme deference towards the Yapese, almost like a servant class paying respect to a landlord class. Because of this cultural subordination, Outer Islanders had especial difficulty gaining permission to live in Yap. It was not until early in the American administration, during the 1950s, that Outer Islanders acquired a place to live in Yap. The Catholic Church purchased a small piece of muddy land beside the water, close to the main town of Colonia. This place was known as "Madrich" and it was designed to give Outer Islanders a temporary place to stay when they came to Yap to use the hospital or other government services. Over the years the population of Madrich outgrew the size of the land, and the area had to be expanded by extending landfill into the water. The reclaimed land belonged to Yapese who had traditional rights to the shoreline, and when these landowners demanded payment, the Yap State Legislature got involved and assumed the annual expense of leasing the land for the use of the Outer Islanders.

Since the mid-1970s, the process of economic globalization has led to growing numbers of Outer Islanders settling in Yap. The main force has been education: as the first generation of college-educated Outer Islanders returned home, many found jobs in government offices or private companies in Colonia, the main town of Yap. In the 1970s and 1980s, the Outer Islanders in Yap lived mostly in the crowded and muddy Madrich settlement. A few Outer Islander families occupied government houses in and around Colonia.

The threat of global climate change and sea level rise has prompted new efforts at strengthening and securing Outer Islander connections to neighboring high islands in Micronesia. These efforts have been spearheaded by the Outer Islander leaders, who are much more aware and concerned, than is the general population, about the potential for global climate change and sea level rise to render the Outer Islands unsafe or even uninhabitable. In Yap, Outer Islanders have pursued at least five separate efforts with increasing urgency in recent years. The goal of the Outer Islanders has been to either purchase land outright in the Yap main islands, or to acquire land through traditional means. Let me briefly describe these various efforts. Each effort has a complex history, but they all demonstrate the dependence of the Outer Islanders on political connections to the high islands, and the important role that the Outer Islander leaders have played in securing safe settlement areas in Yap.

The first effort began in the late 1980s. Outer Islanders acquired a piece of land called Dabwech in central Yap, in Tomil municipality. This land was leased from its original Yapese landowners, with the Yap State Legislature paying the cost of the lease, and the Outer Island Council of traditional Chiefs giving customary valuables like woven cloth lavalava and coconut fiber rope to the Yapese local chiefs and landowners. The Outer Island Council of Chiefs also assumed authority over the land. Today there are about a hundred Outer Islanders living at Dabwech, mostly from Woleai and Eauripik atolls. They are living in concrete homes reinforced for typhoon protection, and they are planting coconuts, bananas, taro and other food crops on their land.

A second effort began in the mid 1990s by a few key leaders from Fais Island. The Fais people acquired a large parcel of land called Ruu' in northern Yap, in high-ranking Gagil municipality. This effort is the most interesting from a traditional political perspective, because it's the only Outer Islander settlement in the chiefly municipality of Gagil. All the negotiations were done through traditional channels of communication with chiefs. Up now there has been no formal transfer of title or ownership, nothing is in writing, and no money has changed hands.

According to Yapese legend, Ruu' was the site of a very bloody war centuries ago, and afterwards the site was abandoned and allow to remain unused. Today about 75 Fais Islanders are living in Ruu', mostly in wood and tin-roofed houses, and they have planted extensive gardens of sweet potato and taro and other food crops.

A third effort is quite recent. Beginning only about four years ago, Outer Islanders began settling in a place called Gargey, which like Dabwech is in Tomil municipality in central Yap, although Gargey is not as far from Colonia town as Dabwech. Gargey was originally envisioned as a place where all the Outer Islanders on Yap could settle. One island leader from Woleai was the main proponent for this effort. He was an educated man and a former high official in the Yap State government, and he was aware of the growing threat that climate change and sea level rise held for the Outer Islands. The general community, however, resisted the idea and preferred to remain in their familiar settlement in Madrich. After Typhoon Sudal hit Yap in 2003 and destroyed most of the homes in Madrich, many families began moving up to Gargey. There has been a number of land disputes over the Gargey land, illustrating how difficult it is for Outer Islanders to acquire land in Yap. When discussions about Outer Islanders settling in Gargey first began, several Outer Island communities tried to put together the purchase price, over $200,000. When they failed to collect enough money, they appealed to the Yap State Legislature and the FSM national government. The FSM government passed an unprecedented bill authorizing purchase of the land as a grant to Yap State, for exclusive use by the Yap State Outer Islanders.

The last two efforts involve recent purchases within the past year or two by the Satawal Island community and the Faraulep Island community to buy land in Rull municipality in central Yap, close to Colonia. These settlements are still under construction.

All these five efforts in Yap illustrate the escalating demands from Outer Islander communities coping with concern over climate change and increasing pressure of economic globalization. These efforts in Yap State also have national implications in the Federated States of Micronesia. Now that the Congress of Micronesia has acted on behalf of the Yap Outer Islanders by appropriating money for a land grant for them in Yap main island, other resettled coral islander communities in the FSM are voicing demands for similar land grants. The Mortlockese and the Kapingans, who have occupied resettlement sites on the high island of Pohnpei since the early 1900s, also have sought national congress support to secure more land for themselves in their high island state center.

At higher levels of political relations, the Micronesian governments nationally have been pursuing a continuing association with the United States that will allow free emigration of Micronesian citizens to the United States and its territories. The immigration privilege was built into the 1986 Compact of Free Association between Micronesia and the US. Micronesian political leaders envisioned emigration to the United States as a sort of "safety valve" to relieve the pressure of population growth within the small islands, and to enable their citizens to get education and training in the U.S. Today, with increasing concern over global warming and sea level change, the open emigration privilege carries increased importance for many Micronesians moving out to Guam, Hawaii, or the US mainland.

Internationally also, Micronesia has taken steps to make its concerns known. The Federated States of Micronesia participated in the first international Earth Summit in 1992 in Rio, and the Micronesian delegation was the one to introduce at that conference the concept of "environmental refugees." The Micronesian island nations continue to take an active role in regional and international organizations like the Association of Small Island States and the

South Pacific Regional Environmental Program that look at these issues of climate changes and environmental damage. Thus concerns over climate change are evident at many levels in the Pacific Islands, from local island political relations, to national policy, to international diplomacy. The recent efforts of Yap Outer Islanders to secure land in Yap are one piece of a much larger pattern. As Pacific Islanders' awareness and concerns over global climate change grows, there will be increasing efforts to seek safety on higher ground, and to strengthen political connections with outside sources of assistance.

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Climate Changes and Globalization －Environment and People's Life in the Pacific Islands－

The Korea-South Pacific Ocean Research Center and its Effect on the Local Community

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Abstract

The Korea-South Pacific Ocean Research Center (KSORC) was established on 30 May 2000 on a small island located within the Chuuk Lagoon of the Federated States of Micronesia according to a Memorandum of Understanding signed between the Chuuk State government and the Korea Ocean Research and Development Institute (KORDI). Establishing a research station in an unfamiliar research territory of a tropical region, in which KORDI had to begin under very difficult economic and institutional circumstances, was a great challenge. However, with full support from the Chuuk State government and the local community, and with great enthusiasm and sacrifices from several KORDI researchers, KSORC currently has 20 local employees involved in various research and maintenance activities. Locally, both the government and the general public expect to gain economic assistance, as well as scientific knowledge, from KSORC activities. KSORC is responding to such expectations by conducting ocean research projects that may help the local economy, such as the development of full life-cycle black pearl production and other bio-resources development projects. Also, to respond to immediate concerns of island nations, oceanographic studies and a monitoring system have been initiated as KSORC's first and foremost objective since its establishment to understand the process of tropical ecosystems and provide essential scientific knowledge and baseline data needed to understand regional effects of climate change. Such continuous monitoring of ecosystems, as well as biodiversity surveys and coral monitoring, will eventually help to better understand the changes observed in Korean waters. Although the monitoring and periodic oceanographic process studies are still conducted on a small and infrequent scale due to funding issues, we are optimistic regarding the development of more active future global change studies on topics such as ocean acidification, sea level rise, coral monitoring, nitrogen cycling and primary production, mangrove and seagrass ecosystem processes, remote sensing, and tropical ecosystem studies.
Key words: Chuuk, climate change, economic effect, monitoring, regional cooperation

要　旨

韓国南太平洋海洋研究センター（KSORC）は，ミクロネシア連邦チューク州と韓国海洋開発研究所（KORDI）の合意により，2000年５月30日にミクロネシア連邦チューク環礁に設立された研究センターである。熱帯域における調査は，これまでKORDIが実施してきた研究領域とは大きく異なるものであり，また，予算的及び組織的にも困難なものがあり，この研究所の設立は我々自身にとっても大きな試練であった。しかし，チューク州政府及び地域社会の多大な協力と研究者自身の努力により，KSORCでは，現在，20名の地域住民が研究活動その他の仕事に従事するまでに至っている。地域住民や州政府は，KSORCの活動が，科学的な情報の発信だけでなく，経済的分野にまで波及することを期待しており，KSORCとしても，養殖真珠の母貝であるクロチョウガイの全生活史の解明やその他の海洋資源の開発などのプロジェクトにより地域社会の期待に応えてい

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る。また，太平洋島嶼国の重要な関心事であり，同時にKOSORC設立時の主要課題でもあった，基礎的なデータを得るための海洋学研究とそれに伴うモニタリング調査も実施しているが，これは，基本的な科学的知識の獲得や，気候変動の地域的な影響を理解するためにも重要なものである。このような長期的なモニタリング調査は，生物多様性調査やサンゴ礁の調査と同様，韓国近海の海洋の理解にも役立つと考えられる。このような海洋研究やモニタリング調査を，大規模に，また，恒常的に行うことは予算的にも困難な面もあるが，KOSORCは気候変動に関連する多くの分野，例えば，二酸化炭素が海水に過剰に溶け込むことに起因する海水の酸化，海面上昇，サンゴ礁のモニタリング調査，窒素の循環，海洋における新規の，あるいは第一次的な生産，マングローブと海藻の生態的環境，リモートセンシング，熱帯生態系についての研究等，種々の研究を発展させていく予定である。

Introduction

The Korea Ocean Research and Development Institute (KORDI), an independent, government-affiliated research institute, is the largest comprehensive ocean research institute in Korea that studies basic and applied ocean sciences, remote sensing, the Law of the Sea, integrated coastal management policy, ship and submersible engineering, ocean energy development, dike construction engineering, and many other topics. KORDI is considered a government-affiliated institute because about 33% of its operating budget is provided by the central government. The remainder of the budget is obtained through very competitive funding processes from various government agencies and private sectors.

With the globalization of ocean research, we now recognize that oceans are a connected system in which events in one location affect those in other areas. Global issues such as climate change affect ocean environments on a global scale and threaten the survival of many nations, particularly island nations in the tropics. The reported evidence is overwhelming for on-going climate change and its effect on ocean environments (DICKSON *et al*. 2002, HALL and STOUFFER 2001, HSIEH *et al*. 2005, LEVITUS *et al*. 2000, 2005). Reports of changes in what was once assumed to be a steady and unchangeable ocean environment are rapidly transforming scientists' perspectives on oceans and their ecosystem thresholds. Such an onslaught of information does not give scientists or policy makers enough time to contemplate and digest the data and demands urgent responses and actions to deal with the changing conditions.

Given the urgent need to obtain important scientific data on the Pacific Ocean, which directly influences Korean waters, KORDI needed a research station located in a climate-sensitive tropical Pacific region, from where KORDI scientists could readily obtain the information required to evaluate and understand ocean processes that may effect the Korean maritime environment, especially during the current 'rapid' climate change. However, establishing an outpost research station was difficult for an institute like KORDI, which has no surplus budget to support such an establishment. This difficulty was compounded by the unfortunate timing of a national economic crisis in the late 1990s, at which time the entire nation's financial situation was under the auspices of the International Monetary Fund. However, with a strong belief that such a tropical research outpost in the Pacific region is essential to accomplish KORDI's mission of understanding ocean processes to serve national interests and public well being, KORDI pushed forward with the establishment of a research outpost in the Pacific.

After a 2-year feasibility study and survey of numerous islands in the Pacific, a letter was sent on 28 December 1998 to inform the Chuuk State government, Federated States of Micronesia (FSM), of KORDI's decision to establish the Korea-South Pacific Ocean Research Center (KSORC; Fig. 1a, b) in Chuuk. The great potential of this state, the sincere willingness of the Chuuk State government to support KSORC, its distance from Korea, its strategic location in the ocean current, the large lagoon environment containing a relatively healthy coral system, and the relatively undamaged mangrove and seagrass beds provided important reasons for establishing KSORC on Weno Island within the Chuuk Lagoon (Fig. 2).

Fig. 1. Korea-South Pacific Ocean Research Center, Weno Island, Chuuk State, Federated States of Micronesia (left). Aerial view of the Korea-South Pacific Ocean Research Center (right).

Fig. 3. Crew exchange on KORDI's R/V *Onnuri*, which uses Chuuk Harbor as its port-of-call, before embarking on a KORDI Pacific climate study in September 2006.

Role of KSORC in Chuuk and the Pacific Island Region

With KORDI's research vessel *Onnuri* (Fig. 3) docked at Chuuk Harbor, nearly 60 employees of KORDI, government officials from FSM, including the Vice President, Chuuk State government officials, local government officials, and many local citizens gathered on 30 May 2000 to celebrate the opening of KSORC in the town of Sapuk, Weno Island, and to witness the first step in the common pursuit of oceanographic research by opening KSORC.

As a long-term goal, KSORC is expected to function as a gateway for promoting ocean research and related marine industries to enhance the prosperity and welfare of South Pacific island nations and Korea by studying the potential of marine resources and regional tropical ecosystems, including biodiversity. It is hoped that the success of KSORC will further the success of Chuuk and the greater South Pacific region. It is also hoped that KSORC will become the basis for fostering and encouraging bi- and multilateral exchanges of economic, cultural, and scientific experiences and knowledge for solid and mutually beneficial relationships, and that it will become a motivational hub for closer cooperation between Korea and the South Pacific region.

It is the specific intent of KSORC to pursue the establishment of cooperative efforts to explore and advance ocean science and technology. As a short-term goal, KSORC was established to mutually improve and develop ocean science and technology capabilities of Chuuk and FSM through a strong collaborative relationship between Chuuk and KSORC, and in the near future, with other South Pacific island nations. KSORC aims at generating and pursuing prosperity through research conducted on the potential marine resources of the region and research conducted to understand and protect the ocean environment to which these resources belong. Moreover, KSORC promotes and encourages bilateral exchanges of political, economic, cultural, and other social bonds, as well as stimulating and solidifying an enduring relationship with Pacific island neighbors for mutual benefits. KSORC also focuses on the interaction between ocean systems and coastal communities of mutual scientific and technological interest in the region. It is hoped that all of these activities will be carried out in cooperation with regional and international organizations.

By cooperating with regional organizations in any way possible, KSORC, which is very strategically located within the Chuuk Lagoon, strives to achieve the following: identify scientific and technical issues and problems of the region; develop and implement appropriate ocean research and development projects to find solutions or alternatives to those issues that may help local and regional communities; develop regional resources and find their potential application in industry or other useful fields to contribute to local and possibly regional economies; and provide logistical support and central facilities for related local and regional research and development projects within the capability of the center.

Climate Change, Chuuk, and KSORC

As an ocean science outpost, the principle underlying the establishment of KSORC from the very beginning was to obtain scientific data that may help to better understand and provide answers to questions that may arise concerning climate change affecting the Korean maritime region and local island nations from a global perspective. Thus, KSORC's earliest tasks and research projects focused on understanding the uncharted territory for most of KORDI scientists

of different tropical ecosystems and their processes, including climate-sensitive coral ecosystems, mangroves, and seagrass beds, in addition to identifying the best-suited potential and feasible resource development projects for local communities to help create sustainable economic development.

Chuuk State has seen increases in severe storms and typhoons, an average 3-cm rise in sea levels in FSM since 2000, increases in salt-water intrusion into the groundwater supply, changes in ocean currents, and a noticeable effect of decadal climate variations such as El Nino (OSIENA 2006). These environmental and oceanographic forces are probably changing the vital lagoon ecosystem of Chuuk, reflecting changing ocean eco-environments of the region, which inevitably affect the waters surrounding the Korean peninsula.

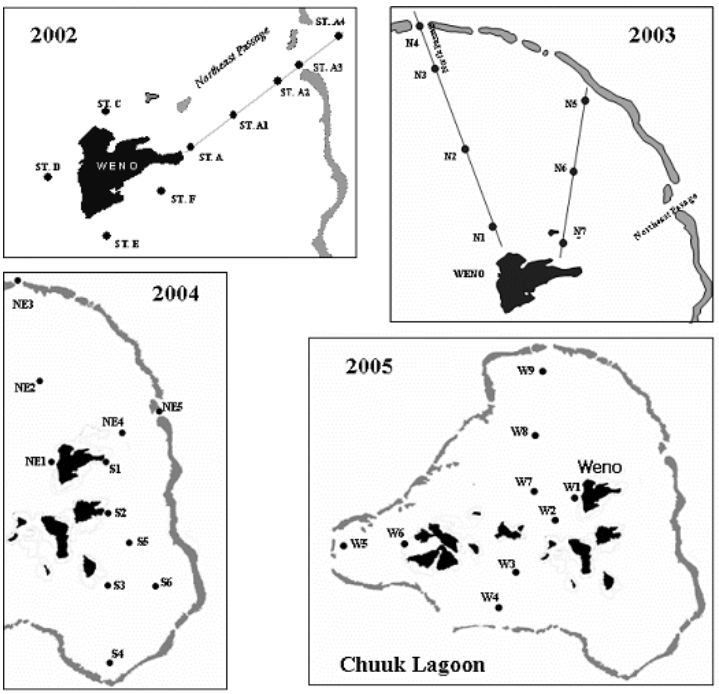

Fig. 4. An example of sampling stations (2002-2005) for basic eco-environmental surveys of the Chuuk Lagoon.

Table 1. Various environmental parameters surveyed in the ecosystem and climate change studies.

Survey items	Variables	Tools/methods	Notes
Physical parameters	Temperature, salinity, depth, chlorophyll, fluorescence, transparency, PAR	CTD with attached extra sensors	CTD between 2002 and 2005 Additional parameters since 2006
Chemistry	Nutrients (NOx, P, Si, ammonia) Chlorophyll-a	Automatic nutrient analyzer, HPLC, spectrofluorometer	Since 2002

Chemistry : DMS	Water, atmosphere	Gas chromatography (Donam Instruments) with sulfur chemiluminesence detector (SCD, Sievers Inc.)	Since 2006 with coccolithophore diversity, taxonomy, morphology, distribution and abundance
Chemistry : pollution	POP (persistent organic pollutants : PCBs, DDT), and EDCs (endocrine-disrupting chemicals such as alkyphenols and sterols-nonylphenol, bisphenol A) in sediment, water, and air	GC-mass spectrometry (Agilent, USA),High-volume air sampler (Kimoto, Japan)	Forced air sampling to begin in 2007
Geology	High-resolution bathymetry	Multi-beam echosounder (SEA Submatrix, UK) and positioning system (DGPS, Ashtec, USA) with ship speeds of 5 knots	Since 2002
Geochemistry	Sediment/coral metal concentrations	Sedigraph 5100, ICP and/or AAA, CHNS analyzer	Since 2006
Biological parameters	Phytoplankton (including pigments, picoplankton, coccolithophores)	Niskin bottles, nets, corers/mesh, HPLC, flow cytometry, microscopy, scanning electron microscopy	Including biodiversity of phytoplankton, including coccolithophores
	Primary production	C-14 method, liquid scintillation counter	Since 2002
	Zooplankton	Net, light microscopy, photographs	Including biodiversity of zooplankton
	Bacteria/bacterial production	Flow cytometry, microscopy, 3H, liquid scintillation counter	Including genetic diversity of bacteria
	Meiobenthos	PVC corers/various mesh, light microscopy, photographs	Including biodiversity of meiobenthos
	Macrobenthos	Photographs, image recordings, field observations	Biodiversity of macrobenthos, including corals
Other	Tide measurements	Tide and wave gauge	Since 2001
	Alternative energy	Wind, solar, tidal/current	Solar power in a pilot stage, continuous monitoring (ADCP) for potential tidal/current power
	Ocean acidity and pH, pCO_2, sea level monitoring, new production and nitrogen fixation, coral study, DO, remote sensing/satellite, etc.	Various instruments/equipment	From 2007 on

Since its establishment in 2000, KSORC has conducted basic oceanographic surveys in Chuuk Lagoon to help understand the tropical Pacific lagoon ecosystem and to begin accumulating long-term data to detect changes that may be occurring in the area (Fig. 4). Specific studies are also being conducted in mangrove forests and seagrass ecosystems (Fig. 5), which are important parts of tropical island ecosystems. In addition to basic parameters, new survey parameters are being added with passing time because the environmental research budget has been increased since 2006 (Table 1).

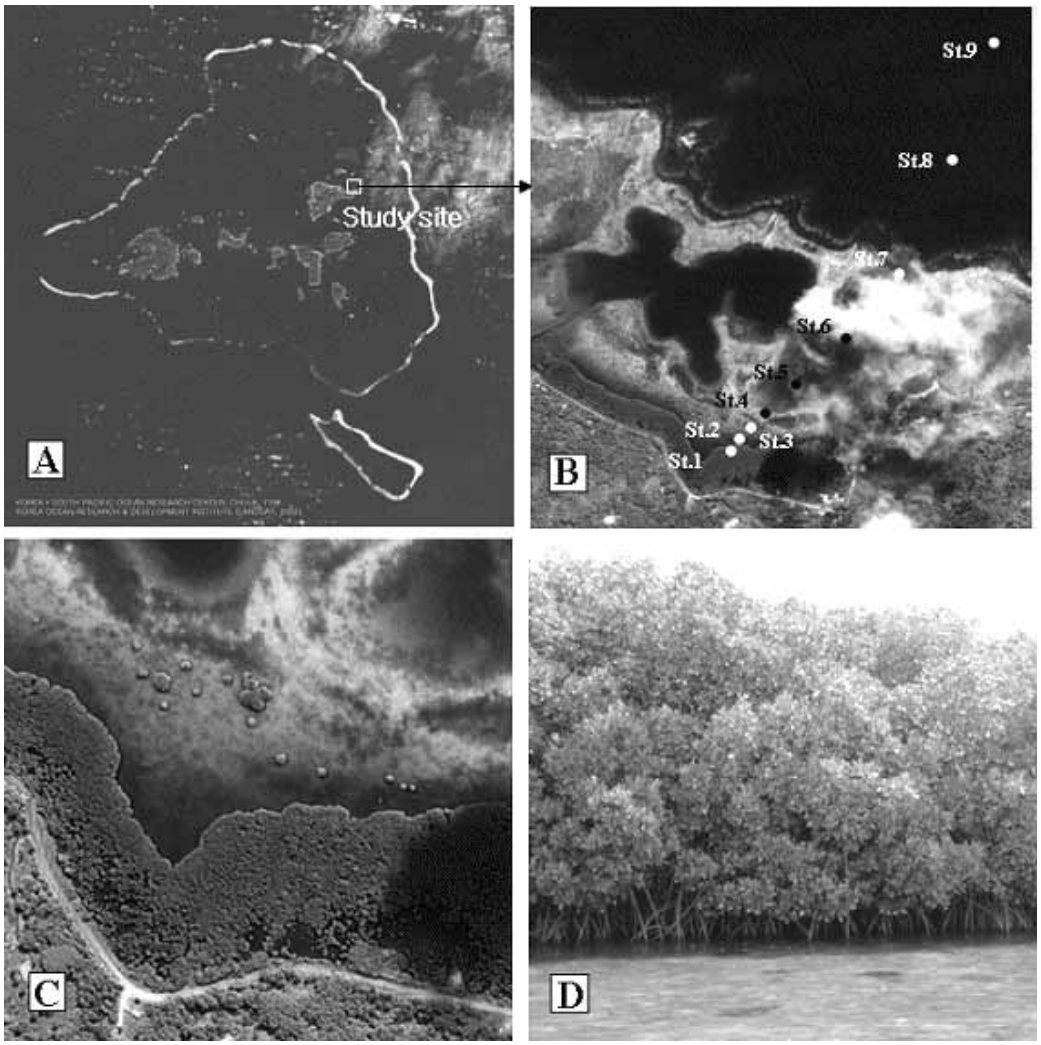

Fig. 5. (A) Landsat image of Chuuk Lagoon showing volcanic islands and barrier reefs surrounding the islands. (B) Sampling stations in the mangrove forests and adjacent waters. (C) Mangrove forests located in the low intertidal zone and near a local road. (D) Close-up of mangrove forest in a sampling area.

Fig. 6 (left). Local assistants trained in CTD operation. CTD with attached PAR sensor, fluorometer, and beam transmission recorder is manually deployed and retrieved.
Fig. 7 (right). A local assistant trained in water sampling using a Niskin bottle is helping the visiting scientists. The Niskin bottle is manually deployed and retrieved.

Fig. 8 (Right). Locals trained in zooplankton netting, phytoplankton netting, and Secchi disk operation. These are manually deployed and retrieved.

Currently, in cooperation with the Marine Resources Department of Chuuk, KSORC has established a long-term monitoring station within the lagoon, where locally trained individuals under the supervision of resident KORDI scientists conduct weekly surveys of Conductivity-Temperature-Depth (CTD) (Fig. 6), photosynthetically active radiation (PAR), transmission, chlorophyll fluorescence, and water sampling (Fig. 7) for chlorophyll a, phytoplankton pigments, nutrients, and picoplankton, as well as bi-weekly netting for phytoplankton and zooplankton samples (Fig. 8). KSORC has maintained a tide and wave gauge continuously on and off for 6 years. In 2006, a temperature logger was also deployed to measure water temperature every 15 min, and a photometer was set up to measure solar radiation. In 2007, the tropical eco-environment team is planning to deploy a continuous temperature-salinity recorder, a custom-made high-resolution

real-time pressure gauge to monitor sea level changes, and an active air sample collector.

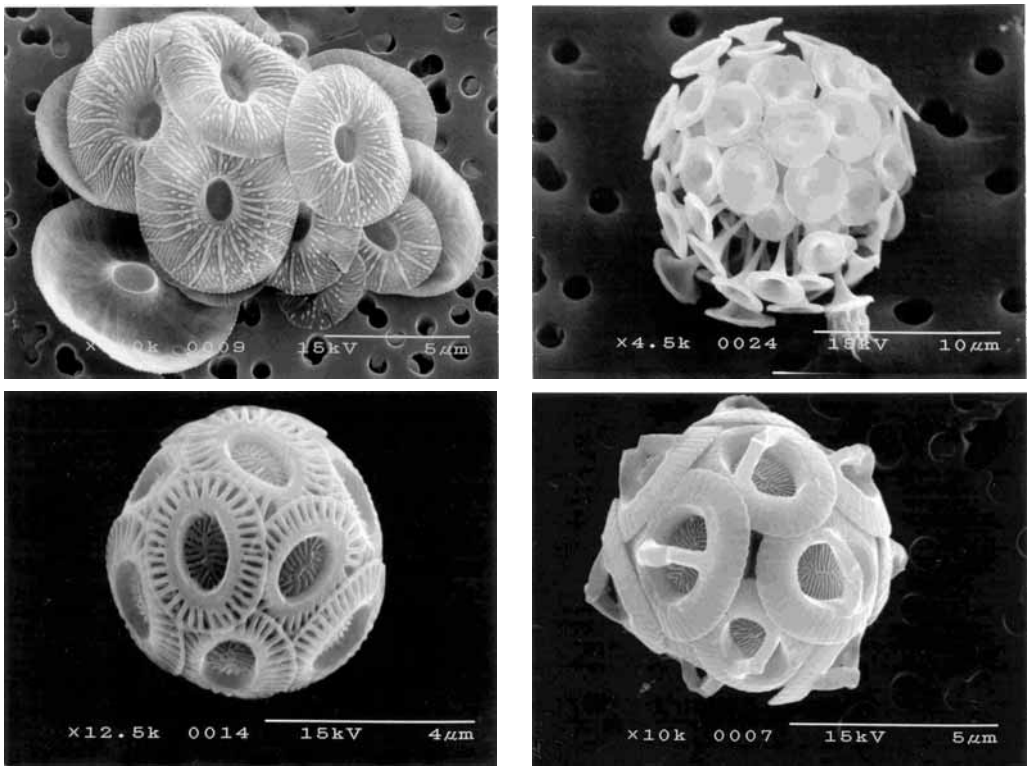

Fig. 9. Examples of coccolithophores isolated from the Chuuk Lagoon (top left, *Umbellosphaera tenuis*, top right, *Discosphaera tubifera*, bottom left, *Emiliania huxleyi*, bottom right, *Gephyrocapsa oceanica*).

Fig. 10 (Right). DMS air sampler attached atop the R/V *Lagoon Pride*.

In addition to the aforementioned monitoring activities, annual field studies are being conducted to help understand detailed ecosystem processes and to study biodiversity in relation to climate change. For example, as a part of an eco-environmental baseline study of the Chuuk Lagoon, coccolithophore studies have been ongoing since 2002 (Fig. 9). This phytoplankton group is one of the major producers of dimethylsulfide (DMS), which is only produced by marine ecosystems; oxidation products of DMS affect the number and size of tropospheric cloud condensation nuclei, with possible consequences for cloud albedo and

heat balance, which in turn may affect the global climate (TOOLE and SIEGEL 2004). Coccolithophores, one of the most productive calcifying phytoplankton groups, are also sensitive to changes in oceanic acidification and are therefore often being used as indicators of the acidifying ocean (KLEYPAS *et al*. 2006, LANGER *et al*. 2006). In relation to the ongoing studies of coccolithophore taxonomy, distribution, abundance, morphology, and diversity study, the eco-environment team included DMS among its study variables in 2006 (Table 1, Fig. 10) as an important part of climate change study.

In addition to comprehensive monitoring surveys and field studies of the Chuuk Lagoon, a continuous high-resolution bathymetric survey of the lagoon is underway (Fig. 11) using a multi-beam echosounder system attached to R/V *Lagoon Pride* (Fig. 12) as part of an eco-environmental study to help with habitat identification and coral monitoring, geo-environmental changes as well as re-calibrating the lagoon navigational chart.

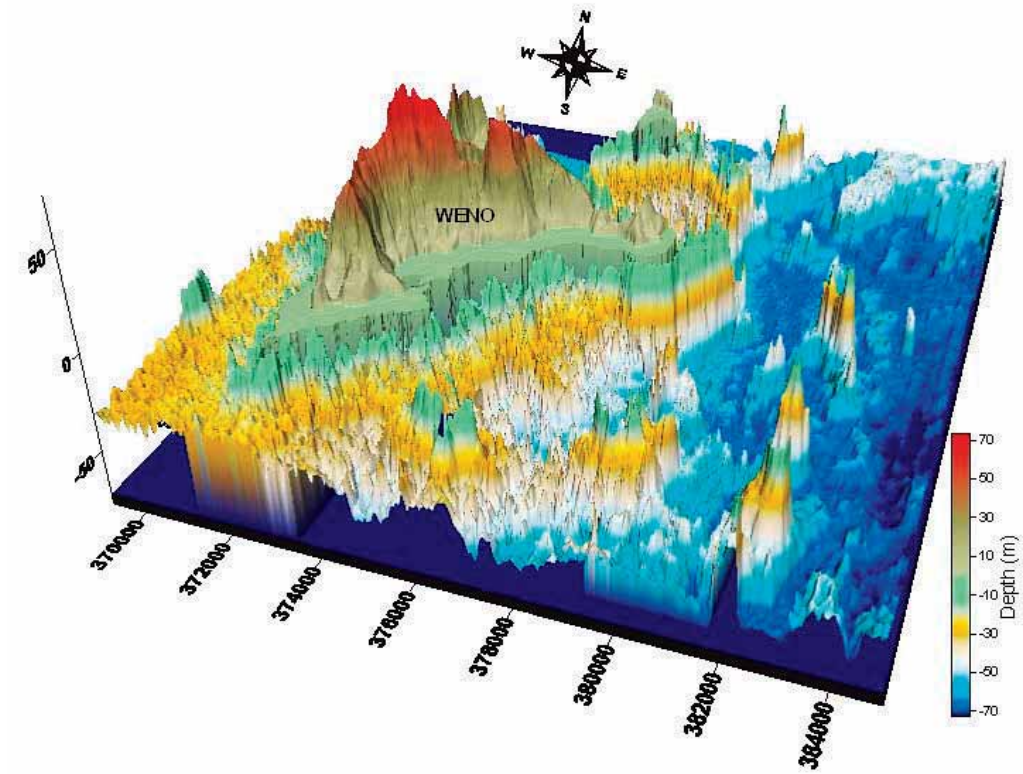

Fig. 11. Complicated bathymetry around Weno Island (inset, ICONOS image) obtained through high-resolution multi-beam 12-channel echosound mapping. Weno Island in the bathymetric map is scaled differently to show the details of the coral-bound bathymetry of the Chuuk Lagoon.

Fig. 12 (left). KSORC's 5-ton R/V *Lagoon Pride*, which is used to study the Chuuk Lagoon.
Fig. 13 (right). The first Seminar on KSORC Research Activities, held in May 2006 at KSORC.

Fig. 14 (left). Chiefs of local tribes and local governmental representatives attended the first KSORC activities report.
Fig. 15 (right). The governor and other local government officials actively participated in the First International South Pacific Islands Regional Investigation on Tropical Marine Systems (SPIRITS) workshop held in Seoul, Korea, in November 2006.

These activities are all being carried out in close cooperation with Chuuk State and local tribes because Chuuk has a traditional custom whereby all land, water, and islands of the Chuuk Lagoon are community owned. Through continuous communication with the local community, maintaining a good relationship with local tribes, and a consistent effort to build the center as a trustworthy entity, KSORC is hopeful that our research activities will grow and thrive over time. We do not conduct our activities alone, nor can we conduct them alone. The success of obtaining essential scientific data and information is achieved with help from the local government, local community, local people, and the center abiding by local customs. For example, one method of communicating our activities and building a good relationship with the local community is through meetings such as the KSORC Activity Report Seminar held in early 2006 (Fig. 13), at which guests included chiefs of local tribes, in addition to government

representatives (Fig. 14), and by inviting local representatives to international meetings such as the First International South Pacific Islands Regional Investigation on Tropical Marine Systems (SPIRITS) workshop held in November 2006 in Seoul, Korea (Fig. 15). To maintain the smooth operation of KSORC and carry out successful research activities, respecting local customs and developing local public relations are major components of KSORC's operation. We believe that such important experiences will help KSORC form a strong relationship with other Pacific island nations in the near future.

Discussion and Conclusions

The monitoring and research activities of KSORC are beginning to have an impact on the local community. However, the center is still in its infancy. Using science-based data and information collected through research activities, KSORC must actively inform local authorities and local communities about the importance of such activities. The KSORC Activity Report Seminar was an informative meeting to alert the local community about what exactly KSORC is doing and how these activities may affect the local community over the long term. For example, the local community was excited that its mangrove ecosystems have higher biodiversity than reported in Australian mangrove areas. Now, with weekly and biweekly monitoring and other ecosystem research activities, it is expected that the next meeting will be even more informative.

The center also would like to focus our effort on local students. A branch of the College of Micronesia (COM) is located in the downtown area of Weno Island where most students are studying to become teachers. With the help of KORDI researchers, KSORC would like to set up a marine environmental science program through the Chuuk branch of COM, where KSORC can provide local students with hands-on experience in marine environmental science and even help them carry out small projects. Because KSORC has aquarium facilities for ornamental fisheries hatchery projects, it will be also a good educational facility for younger people to visit and learn about the living systems of their marine environment. With a large cafeteria which can be converted into a seminar room, an imaging-system attached to a microscope, and other resident laboratory equipment and instruments, KSORC can provide in situ experience of actual marine science to various levels of students and instill the importance of protecting their environment and participating in continuous long-term monitoring of the ecosystem to understand how climate change may affect the Chuuk Lagoon, a vital ecosystem that provides everything the locals need, but is sensitive to their activities.

In addition to ecosystem studies for climate change and understanding tropical ecosystem processes, several resource development studies are also being conducted; these will eventually be transferred to the local community to help local community with their effort in sustainable economic development. By working together with local authorities, local experts, and local manpower from the very beginning of these projects, KSORC is helping to nurture the capacity of local human resources to carry out the projects once techniques and knowledge from these projects have been transferred to the local community in the future.

Conducting these activities in Chuuk requires strong local support because, as mentioned before, Chuuk has a very strong traditional value of tribe-owned properties, including the lagoon water itself. This is a blessing and a curse for the Chuuk ecosystem. The lagoon system has been preserved in a relatively healthy state because of tribe ownership values. However, it has been a curse because there are increases in coastal development projects, e.g., large-area dredging and

large-scale coral and coral sand mining, which are used by locals for buildings, and other coastal constructions which may result in coastal erosion and environmental damage.

The difficulty in conducting research activities in locally owned waters without prior permission is not allowed, and such situation provides a challenge for researchers. KSORC hopes that such challenges may turn into opportunities to forge stronger relationships with local communities. KSORC is not an isolated or excluded research station; rather, it is becoming an integral part of the community, sharing both good and bad times. For example, KSORC actively participates in local weddings, funerals, graduations, church construction, and other events. KSORC welcomes student visitors for marine education-related diving activities using our fully equipped diving shop. KSORC hopes that the center will not only provide essential science-based data for climate change and sustainable resource development contributing to the local economy in some way, but also hopes to contribute to increasing the local awareness of the importance of their ocean environment, provide much needed work opportunities through better training, provide vital information for integrated coastal management systems and marine protected areas, and help to predict and prepare for changes resulting from global climate change.

We have just begun, and much work remains to be done. Climate change and global warming are threatening the very vitality of the Chuuk Lagoon ecosystem. The lagoon eco-environment must be monitored to assess the following: ocean acidification and changing temperature; planktonic and bio-feedback systems, which are the base of this ecosystem; sea level rise and coastal erosion and their effects on mangrove ecosystems; coral monitoring for bleaching and disease epidemics; nitrogen cycling and new production for changes affecting the productivity of the lagoon, mangrove, and seagrass bed ecosystem cycles and processes; and air and coastal pollution to manage a healthier lagoon environment. The data and knowledge gained and the resulting understanding of the lagoon system will eventually help to explain what is happening to the Korean marine environment, which will benefit both local and regional ocean communities.

It is hoped that with our increased budget, KSORC can now begin to build a practical cooperative relationship with regional and global organizations in relation to eco-environmental studies in good faith. KSORC hopes and continually endeavors to become one of major contributors to cooperative research programs and activities for the benefit of island nations, our neighbors in the Pacific, and Korea. After years of hard work, exciting years are ahead for KSORC, and encouragement and advice are always welcome (KSORC homepage: http://www.ksorc.org/).

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