

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

Charity M. LEE^{1,*}, Jae Hoon NOH², Moon Sang KWON³ and Heung Sik PARK⁴

^{1,2,4} *Korea Ocean Research and Development Institute
1270 Sa2dong Sangnokgu Ansan Kyunggido, 426-744, Republic of Korea*

¹ *Policy Research Division*

² *Marine Environmental Research Department*

⁴ *Marine Resources Research Department*

³ *Korea Institute of Marine Science and Technology Promotion
275-6 Yangjae2dong, 4th Floor, #B Samho Building, Seocho, Seoul.137-941,
Republic of Korea*

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答えてい

* : Corresponding author, E-mail: cmlee@kordi.re.kr Fax: 82-031-400-6505

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、種々の研究を進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.

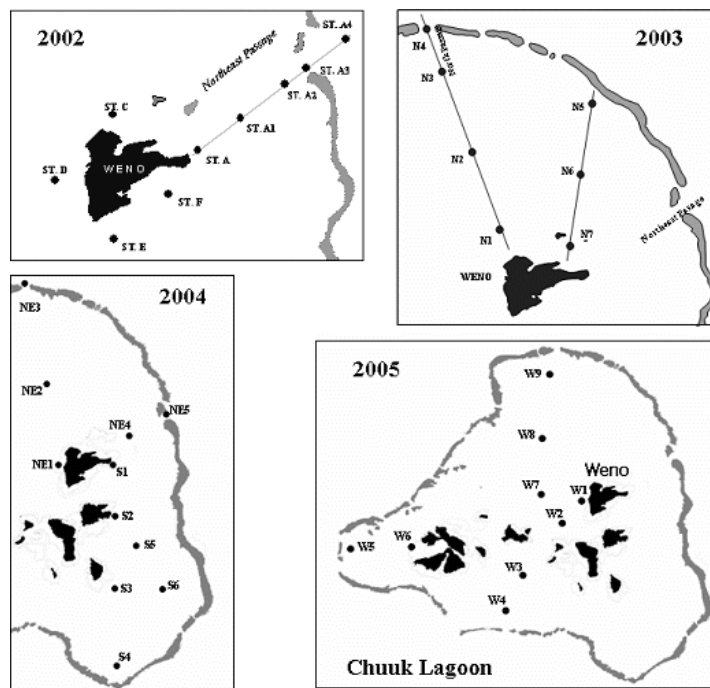


Fig. 4. An example of sampling stations (2002-2005) for basic eco-environmental surveys of the Chuuk Lagoon.

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 chemiluminescence 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).

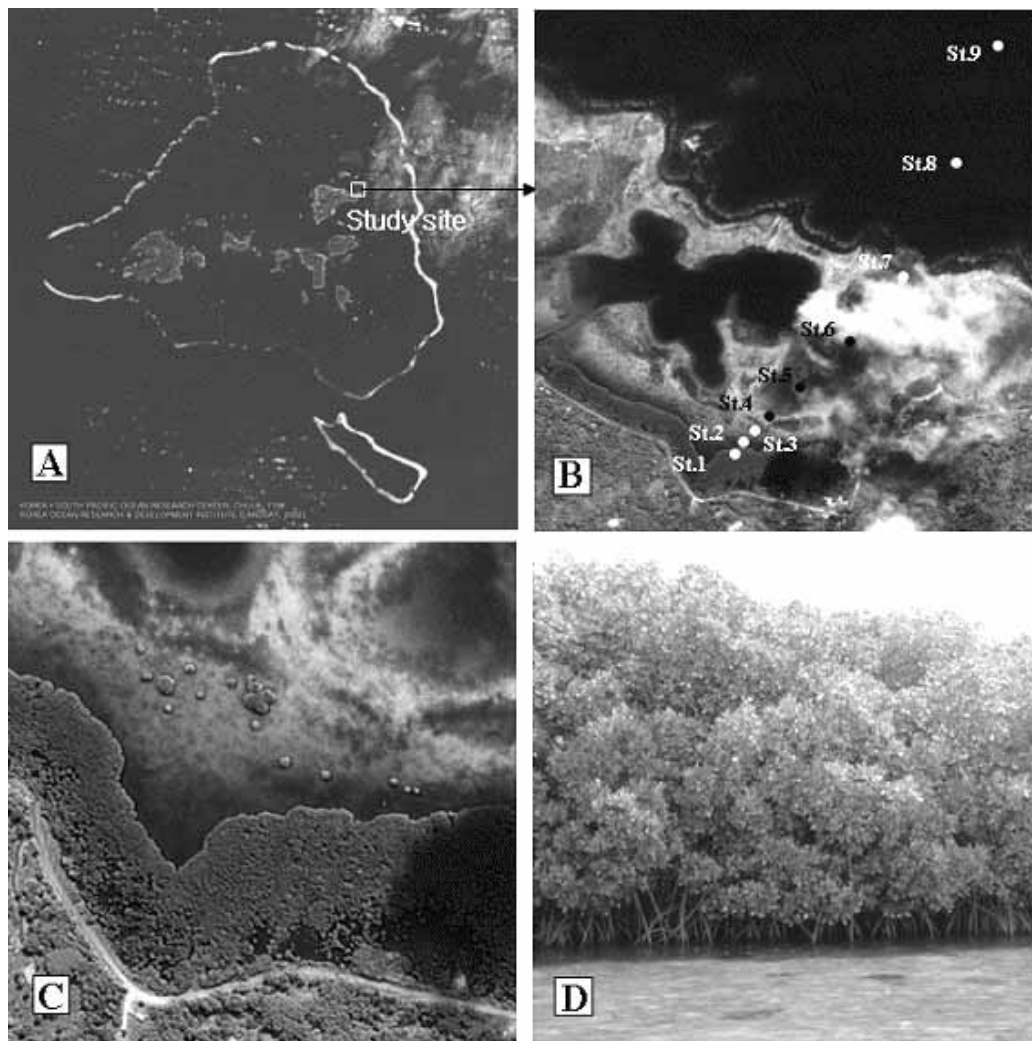


Fig. 5. (A) Landsat image of Chuuk Lagoon showing volcanic islands and barrier reefs surrounding the islands. (B) Sampling stations in the mangrove forests and adjacent waters. (C) Mangrove forests located in the low intertidal zone and near a local road. (D) Close-up of mangrove forest in a sampling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

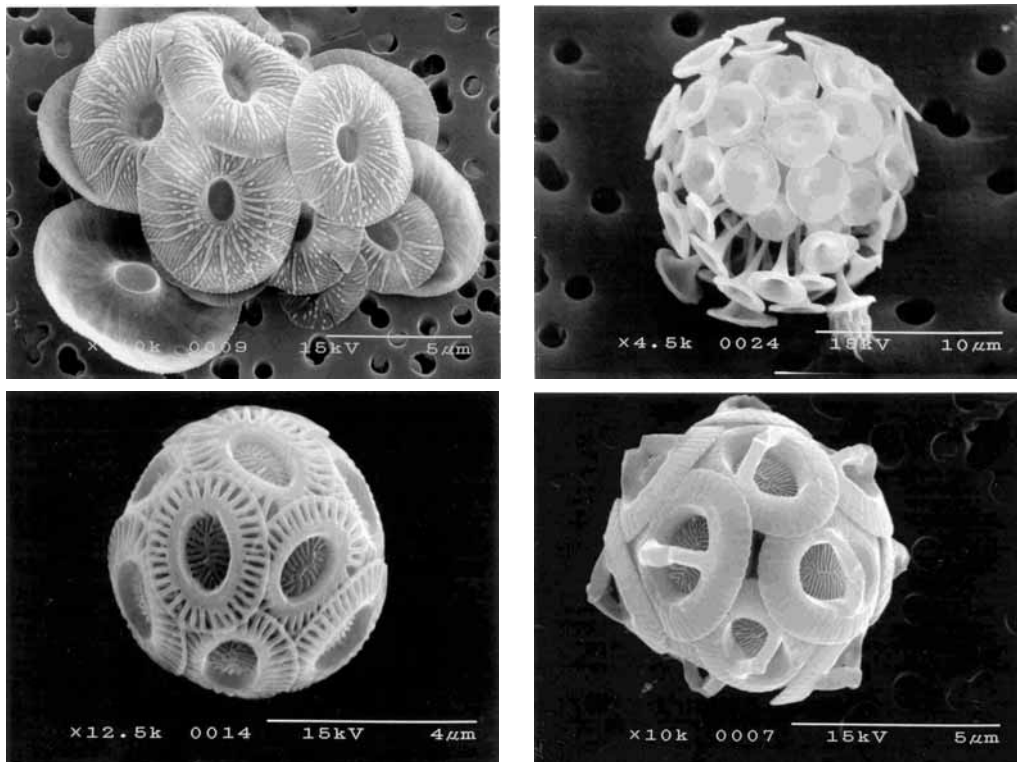


Fig. 9. Examples of coccolithophores isolated from the Chuuk Lagoon (top left, *Umbellosphaera tenuis*, top right, *Discosphaera tubifera*, bottom left, *Emiliana huxleyi*, bottom right, *Gephyrocapsa oceanica*).

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.

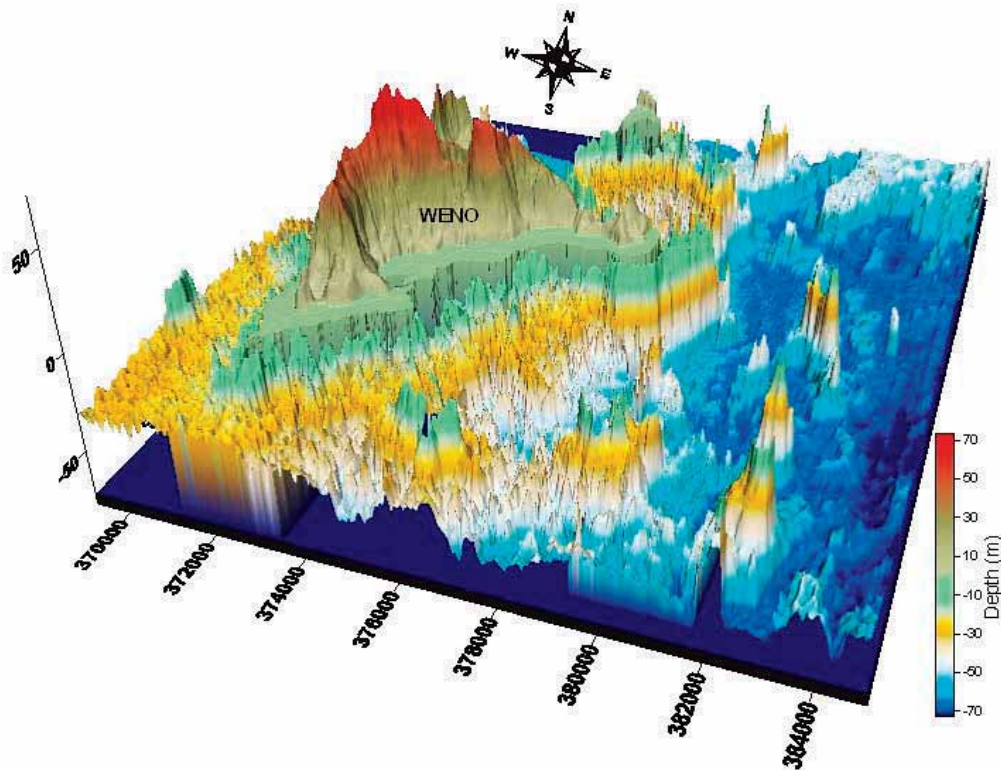


Fig. 11. Complicated bathymetry around Weno Island (inset, ICONOS image) obtained through high-resolution multi-beam 12-channel echosound mapping. Weno Island in the bathymetric map is scaled differently to show the details of the coral-bound bathymetry of the Chuuk Lagoon.



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 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/>).

Acknowledgments

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