WESTPAC Workshop

"Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems"

Phuket, Thailand, 19-21 January 2015

organized by

IOC Sub-Commission for the Western Pacific (WESTPAC)

In collaboration with

GOA-ON
Global Ocean Acidification Observing Network

KIOST
KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

19-21 January 2015
Phuket, Thailand

WESTPAC Workshop on "Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems"

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Table of Contents

Foreword

The ocean, our common heritage, is key to sustaining all humankind on the planet. It shapes Earth's climate and influences the distribution of ecosystems, biodiversity, and thus food availability. Humans, however, have put the ocean at risk of irreversible damage. Due to increasing levels of atmospheric CO_2, the ocean, which absorbs large amounts of it, is becoming more acidic at a rate not seen for the last 20 million years, with significant impacts on marine food chain, biodiversity, food security and livelihoods of coastal community.

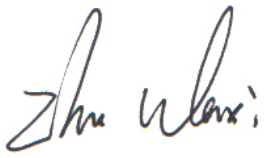
The Western Pacific and its adjacent regions, where we are living in, are among the richest and most productive in the world as a home to more than 600 coral species (more than 75% of all known coral species) and around 53% of the world's coral reefs. Most Southeast Asian coastal communities are socially and economically dependent upon coral reef ecosystems, and an estimated 70-90% of fish caught in Southeast Asia are dependent on coral reefs.

Despite the recognition that ocean acidification represents a major global threat to coral reefs and other calcifying marine organisms, the ecosystem responses to ocean acidification are poorly understood in the region and thus it is unlikely to enable resource and fisheries managers, and policy makers to develop effective long-term mitigation and adaptation strategies for the people of the region.

The IOC[1] Sub-Commission for the Western Pacific (WESTPAC), rooted in the most densely populated region with significant social and economic reliance on ocean and coasts, is mandated to promote international cooperation in marine research, observations, services, and capacity development, in order to assist its Member States in the region to build knowledge base and foster science-policy interface for the improvement of management, and sustainable development of their marine and coastal resources.

In this context, WESTPAC is well positioned to take initiative in the establishment of partnership with its member states and the development of national and regional capacity for the study and long-term monitoring of the impact of ocean acidification on ocean ecosystems, especially on coral reefs, in the region.

"A journey of a thousand miles begins with a single step", we sincerely expect you to join the effort towards the improvement in management practices and decision-making processes for sharing the wealth of the ocean to benefit all.



Wenxi Zhu
Head, IOC Regional Office for the Western Pacific (WESTPAC)

[1] Intergovernmental Oceanographic Commission of UNESCO

Program

WESTPAC Workshop on *"Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems"*

Phuket, Thailand, 19-21 January 2015

Provisional Programme

OBJECTIVES OF THE WORKSHOP

- Improve the understanding, and develop regional capability of research and long-term monitoring on ocean acidification in the Western Pacific and its adjacent regions;
- share existing and proposed ocean acidification monitoring and research approaches, methods, and techniques;
- establish an ocean acidification monitoring and research network among scientists, institutions, and agencies in the region;
- identify challenges, gaps and explore the possibility, building on existing coral reef monitoring initiatives, of a joint long-term monitoring program on the impacts of ocean acidification on coral reefs, and of joint research on ocean acidification and its related changes/processes in seawater chemistry in the region.

Sunday 18 January 2015

Arrival of participants and check in at the Sino House Phuket Hotel or Mei Zhou Phuket Hotel

Monday 19 January 2015

08:00 **Gathering at the lobby of the Sino House Phuket Hotel, and departure for the Cape Panwa Hotel**

08:45 – 09:00 **Registration**
Venue: Meeting Room "Tamarind", on the lobby floor of the Cape Panwa Hotel

09:00 – 09:40 **Opening and self introduction**
(*Facilitator: Mr Wenxi Zhu*)

- Welcome Remarks by Director of the Phuket Marine Biological Center (PMBC)
- Opening Remarks by Dr Somkiat Khokiattiwong, Chair of the IOC Sub-Commission for the Western Pacific (WESTPAC)
- Congratulatory Remarks by Dr Dwight Gledhill, Global Ocean Acidification Observing Network (GOA-ON), NOAA Ocean Acidification Program
- Participants' brief self introduction

09:40 – 10:50 **Session 1: Setting the scene**
(*Facilitator: Dr Suchana Chavanich*)

- Brief on the workshop objectives, layout and expected outputs and outcomes – *Mr Wenxi Zhu, UNESCO/IOC Regional Office for the Western Pacific (WESTPAC)*
- Overview on Ocean Acidification: what is OA and why do we care? – *Dr Adrienne Sutton, NOAA/UW Joint Institute for the Study of the Atmosphere and Ocean*
- Global Ocean Acidification Observing Network (GOA-ON) – *Dr Dwight Gledhill, NOAA Ocean Acidification Program*
- Need to intensify research and monitoring efforts in the Western Pacific and adjacent regions – *Dr Somkiat Khokiattiwong*

10:50 – 11:20 **Group Photo and Coffee Break**

11:20 – 12:30 **Session 2: Research and monitoring efforts on ocean acidification in the region** *(10-20 minutes each)*
(*Facilitator: Prof Dr Jamaluddin Jompa*)

- Ocean Acidification Threatens Marine Ecosystems and Livelihood Security in Bangladesh, *Prof M. Shahadat Hossain, University of Chittagong, Bangladesh*
- Coastal Zone Conservation and Management in Cambodia, *Dr Ratnak Ou, International Conventions and Biodiversity Department, Cambodia*
- Acidification Induced by the Individual Ocean Conditions, *Dr Qinsheng Wei, First Institute of Oceanography, China*
- Efforts and case studies of NMEMC in the research and monitoring of the ecological impacts of ocean acidification on coral reef ecosystems, *Dr Zhendong Zhang, National Marine Environmental Monitoring Center (NMEMC), China*

12:30 – 14:00 **Lunch**

14:00 – 15:40 **Continue Session 2: Research and monitoring efforts on ocean acidification in the region** *(10-20 minutes each)*
(*Facilitator: Dr Zulfigar Yasin*)

- Experimental Effects of Climate Change and Ocean Acidification on Coral Reefs: Synergic Impacts and Management Implication, *Prof Dr Jamaluddin Jompa, Hasanuddin University, Indonesia*
- Ocean Acidification in Indonesia: Present and Future, *Mr Suratno, Indonesian Institute of Sciences (LIPI), Indonesia*
- Projecting the Combined Effects of Rising Seawater Temperatures and Ocean Acidification on Coral Habitats around Japan under Multiple Climate Change Scenarios, *Dr Shintaro Takao, Hokkaido University, Japan*
- Variability of the Inorganic Carbon System in the Mid-East Coast of Korea, *Dr Geun-Ha Park, Korea Institute of Ocean Science &*

Technology (KIOST), Republic of Korea

- Transcriptional Changes in Coral Responding to the Marine Acidification and Rising Seawater Temperature, *Dr Seonock Woo, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea*
- Growth Rate Comparison of Pacific Oyster, Crassostrea Gigas, Reared in a high-CO_2 Environment, *Dr Jeong Hee Shim, National Fisheries Research and Development Institute, Republic of Korea*

15:40 – 16:00 **Coffee Break**

16:00 - 17:40 **Continue Session 2: Research and monitoring efforts on ocean acidification in the region** *(10-20 minutes each)*
(*Facilitator: Dr Jeong Hee Shim*)

- Diurnal Changes of pH and Alkalinity on the Coral Reefs of the Straits of Malacca, and the South China Sea, *Dr Zulfigar Yasin, Universiti Malaysia Terengganu, Malaysia*
- The Shell Characteristics of Bivalves at the Lowered pH Area Compared to a Normal Area, *Dr Aileen Tan Shau Hwai, Universiti Sains Malaysia, Malaysia*
- Impacts of Ocean Acidification on Marine Biodiversity: Gaps and Potential Research Collaboration, *Dr Emienour Muzalina Mustafa, University of Malaya, Malaysia*
- A Concerted Monitoring and Research Framework on Coral Reefs Conservation by Malaysian Universities, *Dr Hii Yii Siang, University Malaysia Terengganu*
- Status of Ocean Acidification Research in the Philippines, *Dr Maria Lourdes San Diego-McGlone, University of the Philippines*
- Coral Reef Monitoring in the Philippines, *Dr Hazel Arceo, University of the Philippines*

18:30 – 20:00 **Welcome Reception**
hosted by the IOC Sub-Commission for the Western Pacific (WESTPAC), *Venue: Tangke Seafood Restaurant*

Tuesday 20 January 2015

08:00 **Gathering at the lobby of the Sino House Phuket Hotel, and departure for the Cape Panwa Hotel**
Venue: Meeting Room "Tamarind", on the lobby floor of the Cape Panwa Hotel

08:45 - 10:45 **Continue Session 2: Research and monitoring efforts on ocean acidification in the region**
(*Facilitator: Dr Maria Lourdes San Diego-McGlone*)

- The Impact of pH on Development of Pocillopora damicornis larvae

in Thailand, *Dr Suchana Chavanich, Chulalongkorn University*

- Ocean Acidification Monitoring Program of the Department of Marine and Coastal Resources, *Dr Somkiat Khokiattiwong, Phuket Marine Biological Center, Thailand*
- Overview of NOAA Ocean Acidification Research and Monitoring Program, *Dr Dwight Gledhill, NOAA Ocean Acidification Program, USA*
- Overview of Academic Research and Monitoring on Ocean Acidification on Coral Reefs, *Dr Anne Cohen, Woods Hole Oceanographic Institution (WHOI), USA*
- Monitoring Activities of Coral Reefs in Vietnam, *Dr Van Long Nguyen, Institute of Oceanography, Vietnam*
- Trend of coastal water quality of Nha Trang bay, Viet Nam, *Ms Vinh Le Thi, Institute of Oceanography, Vietnam*

10:45 – 11:00 **Coffee Break**

11:00 – 12:30 **Session 3: Approaches and challenges**
(*Facilitator: Dr Somkiat Khokiattiwong)*

- Overview talk: Monitoring ecological impacts of ocean acidification on Indo-Pacific coral reefs and what are the possible components of an ocean acidification monitoring network based on existing resources – *Dr Rusty Brainard*
- Approaches/challenges to monitoring carbonate chemistry of coral reef ecosystems – *Dr Dwight Gledhill / Dr Adrienne Sutton*
- Integrating the use of ocean models into observing system design – *Dr Tom Oliver*
- Approaches/challenges to monitoring biological impacts of OA on coral reef ecosystems – *Dr Rusty Brainard*

12:30 – 14:00 **Lunch**

14:00 – 15:40 **Session 4: Brainstorming on the way forward, particularly bearing in mind the objective to develop a regional program to monitor the impacts of ocean acidification on coral reef ecosystems**
(*Facilitator: Dr Rusty Brainard, Dr Somkiat Khokiattiwong, Dr Suchana Chavanich and Mr Wenxi Zhu*)

The purpose of this session is to enable all experts to brainstorm any feasible ideas on future collaborative research and/or monitoring efforts on ocean acidification in the region.

15:40 – 16:00 **Coffee Break**

16:00 – 17:45 **Session 5: Breakout sessions**
(*Facilitator:*
Biological Group – Dr Rusty Brainard and Dr Suchana Chavanich; Physical/chemical Group - Dr Dwight Gledhill, Dr Adrienne Sutton, and Dr Somkiat Khokiattiwong)

The purpose of this session is to define the measurements of the monitoring program.

All participants will be divided into two groups, respectively on biological aspect and physical/chemical aspect. The two groups will focus on what measurements need to be accounted for in the program design, from a physical/chemical perspective, a biological perspective, and most importantly, from an integrated perspective.

To facilitate breakout discussions, the following list of questions was proposed as below. However, please be assured that any other questions raised from prior sessions could be added at any time.

1. What minimum physical, chemical and biological parameters should be measured? where? at what depths?
2. What is the desired spatial (where? what depths? how many?) and temporal resolution (frequency) of these measurements?
3. What (parameters) and where are the gaps in present observing systems? Where and what new measurements do we need?
4. Where could be suggested as pilot sites with interests received for the development of a monitoring program on the impacts of ocean acidification on coral reefs, and of joint research on ocean acidification and its related changes/process?

Wednesday 21 January 2015

08:00	**Gathering at the lobby of the Sino House Phuket Hotel, and departure for the Cape Panwa Hotel** *Venue: Meeting Room "Tamarind", on the lobby floor of the Cape Panwa Hotel*
08:45 - 10:40	**Continue Session 5: Breakout sessions**
10:40 – 11:00	**Coffee Break**
11:00 – 12:30	**Reports of Breakout Groups, followed by plenary discussions to synthesize chemical/physical and biological approaches into an integrated regional ocean acidification observing network.**
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Recommendations, conclusions, and next steps**

Abstracts & Speakers

(unedited)

Session 1: Setting the Scene

- **Speaker Information:**

Dr Adrienne J Sutton, Research Scientist, Carbon Program, Pacific Marine Environmental Laboratory, NOAA-UW Joint Institute for the Study of the Atmosphere and Ocean, USA

Dr. Adrienne Sutton is a Research Scientist with the NOAA Joint Institute for the Study of the Atmosphere and Ocean at the University of Washington and a lead PI in the Carbon Group at NOAA's Pacific Marine Environmental Laboratory (PMEL). Her research focuses on advancing our scientific understanding of the ocean carbon cycle and the impact of rising atmospheric carbon dioxide on marine ecosystems. In particular, she maintains mooring time series observations that document the natural variability of seawater chemistry and the evolving state of ocean acidification. She is interested in using interdisciplinary approaches to explore how physical and biological mechanisms, such as the El Nino/Southern Oscillation and coral reef metabolism, drive variations in ocean carbon chemistry across time and space. Adrienne also has an interest in science communication and policy, and regularly participates in venues that connect to both. After receiving her PhD from the University of Maryland in 2006, she worked at NOAA headquarters in Washington, D.C. engaging the U.S. Congress on issues concerning oceans and climate through 2008. She then moved on to a postdoctoral position with Drs. Jane Lubchenco and Bruce Menge at Oregon State University working on science policy issues before returning to ocean biogeochemical research with Drs. Richard Feely and Chris Sabine at PMEL.

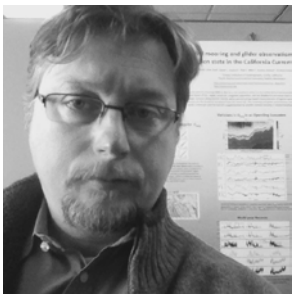
- **Presentation:**

Overview on ocean acidification: what is it and why do we care?

Fundamental changes in seawater chemistry are occurring throughout the world's oceans. Since the beginning of the industrial revolution, the release of carbon dioxide (CO_2) from humankind's industrial and agricultural activities has increased the amount of CO_2 in the atmosphere. The ocean absorbs about a quarter of the CO_2 we release into the atmosphere every year, so as atmospheric CO_2 levels increase, so do the levels in the ocean. Initially, many scientists focused on the benefits of the ocean removing this greenhouse gas from the atmosphere. However, decades of ocean observations now show that there is also a downside — the CO_2 absorbed by the ocean is changing the chemistry of the seawater, a process called ocean acidification. The aim of this overview talk is to briefly review our current knowledge on the extent and magnitude of ocean acidification, the impacts, and the broader socioeconomic implications of the changing chemistry of the oceans.

- **Speaker Information:**

Dr Dwight K. Gledhill, Deputy Director, NOAA Ocean Acidification Program, USA



Dr. Gledhill serves as the Deputy Director of the U.S. National Oceanic & Atmospheric Administration (NOAA) Ocean Acidification Program (OAP). Previously he was an associate scientist with the UM/RSMAS Cooperative Institute of Marine & Atmospheric Sciences (CIMAS) with NOAA's Atlantic Oceanographic & Meteorological Laboratory Ocean Chemistry Division where he advanced ocean acidification research primarily related to monitoring and understanding the process of ocean acidification within coral reef ecosystems. He was instrumental in establishing the NOAA Coral Reef Conservation Program (CRCP) Atlantic Ocean Acidification Test-beds (AOAT) in La Parguera, Puerto Rico and within the Florida Keys National Marine Sanctuary. He also has worked on the development of a satellite-based ocean acidification data synthesis product for the Greater Caribbean Region that scales up discrete ship-based observations of surface ocean carbonate chemistry. The model produces synoptic monthly fields of carbonate chemistry that can be used to track regional and seasonal dynamics in ocean acidification available from NOAA Coral Reef Watch. Gledhill has also been contributor to numerous NOAA and interagency strategic planning initiatives related to ocean acidification. Gledhill received his M.S. and Ph.D. from the Department of Oceanography at Texas A&M University in 2005 where he primarily investigated carbonate mineral kinetics in complex electrolyte solutions as well the sediment biogeochemistry associated with methane clathrates in the Northern Gulf of Mexico.

- **Presentation:**

The Global Ocean Acidification Observing Network

The Global Ocean Acidification Observing Network (GOA-ON) is a newly-established collaborative and international approach to document ocean acidification across a range of marine environments designed to improve understanding of the global impacts to marine ecosystems. The GOA-ON builds upon and extends an existing global oceanic carbon observatory network and promotes integration into existing marine ecosystem monitoring efforts. The monitoring strategy prescribed by the GOA-ON adopts monitoring metrics to track direct chemical changes, organism response, biodiversity impacts, dissolution/bioerosion, and community-scale feedbacks. The changing status of these metrics over time should aid in ascribing specific attribution to ocean acidification, though it is recognized that significant challenges remain in standardizing biological monitoring methodologies and interpreting long-term changes amidst multiple factors driving ecosystem change. By integrating ocean acidification monitoring within broader ecosystem monitoring efforts we can better capture measures of important co-variants which must be tracked to better facilitate interpretation of the time-series. This presentation will provide an overview of the GOA-ON with an emphasis on the strategy being employed for coral reef ecosystems.

THE U.S. NOAA Ocean Acidification Program (OAP)

The NOAA Ocean Acidification Program (OAP) was established under SEC. 12406. of the U.S. Federal Ocean Acidification and Monitoring Act (FOARAM, 2009) to oversee and coordinate research, monitoring, and other activities consistent with the Strategic Plan for Federal Research and Monitoring of Ocean Acidification developed by the Interagency

Working Group on Ocean Acidification (IWGOA). The program is to foster and direct (A) interdisciplinary research among the ocean and atmospheric sciences, and coordinated research and activities to improve understanding of ocean acidification; (B) the establishment of a long-term monitoring program of ocean acidification utilizing existing global and national ocean observing assets, and adding instrumentation and sampling stations as appropriate to the aims of the research program; (C) research to identify and develop adaptation strategies and techniques for effectively conserving marine ecosystems as they cope with increased ocean acidification; (D) educational opportunities that encourage an interdisciplinary and international approach to exploring the impacts of ocean acidification; (E) national public outreach activities to improve the understanding of current scientific knowledge of ocean acidification and its impacts on marine resources; and (F) coordination of ocean acidification monitoring and impacts research with other appropriate international ocean science bodies including the IAEA Ocean Acidification International Coordination Center (OA-ICC). As part of its responsibility, the OAP provides grants for critical research projects that explore the effects of ocean acidification on ecosystems and the socioeconomic impacts of increased ocean acidification that are relevant to the goals and priorities of the strategic research plan. This presentation will review the portfolio of ocean acidification monitoring and research being advanced by the OAP and briefly discuss the strategic priorities detailed within the IWG-OA Strategic Plan for Federal Research and Monitoring of Ocean Acidification.

- **Speaker Information:**

Dr. Somkiat Khokiattiwong, Chair of the IOC Sub-Commission for the Western Pacific (WESTPAC) and Head of Oceanography and Marine Environment, Phuket Marine Biological Center, Department of Marine and Coastal Resources, Thailand

Dr. Somkiat Khokiattiwong graduated and received his doctor degree from the University of Southern Denmark. He is the Head of Oceanography and Marine Environment, Phuket Marine Biological Center, Department of Marine and Coastal Resources, Thailand

He has been involving with many regional activities under intergovernmental agencies and international research project. He has involved with IOC activities since 2005 as delegation of Thailand to UNESCO-IOC and IOC-WESTPAC especially on Southeast Asian Ocean Global Observing System (SEAGOOS) as Coordinator, which is one of IOC-WESTPAC Programme. He was the member of IOGOOS since 2006 and become the officer since 2007 to present. He was invited to be member of Scientific Steering Committee of Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER), which is one of IOGOOS Programme, since 2007. Beside international experience, he also play many importance role as the lead of project and programme in Thailand which many of them could be able to contribute to international activities such as ocean-atmospheric study and operational oceanography and modeling. It was contributed to two projects of IOC-WESTPAC such as Monsoon Onset Monitoring and Social and Ecosystem Impacts (MOMSEI) and Ocean Forecast Monitoring (OFD). At the Ninth Intergovernmental Session of IOC Sub-Commission for the Western Pacific (WESTPAC-IX, Busan, 2012) he was elected by delegates at the Session to serve for one Session and one intersessional period until the closure of the 10th Intergovernmental Session of WESTPAC, May 2015.

Presentation:

Need to Intensify Research and Monitoring Efforts on Ocean Acidification in WESTPAC and Adjacent Regions

One of the direct impact from increasing of green house gas, especially carbon dioxide gas, to the ocean is ocean acidification. IPCC report has shown that pH of sea surface water has been decreased by 0.1 since the beginning of industrial era which caused from rapidly increase of CO2. Ocean also play very important role to the sink of CO2 from the atmosphere. However ocean could also be the source of CO2 to the atmosphere due to the upwelling and other related processes. Ocean acidification and its impacts have been carrying out mostly in north Pacific and Atlantic Ocean including experimental on impact of ocean acidification on marine organisms. It indicates that increase acidity of ocean could be positive and negative impact to marine organisms. But it is higher negative than positive impacts. This could be influence to marine ecosystem. The projection of pH has show that pH of sea surface water will be approximately changed from 8.2 to 7.8 within next 100 years. Since the WESTPAC and adjacent region is one of the highest marine biodiversity and fishery productivity. The impact from OA will be one of a key issue to be concerned especially on the coral reef ecosystem beside other marine organisms. As the WESTPAC region has a high diversity and density of coral and its associated organisms. Under Archi Biodiversity Target of CBD also concern the impact of OA to global biodiversity. Recently, outcome from the International Marine Symposium of IOC-WESTPAC in Nha Trang, Vietnam showed that there were some experimental study on impact of OA on marine organisms and its influence to the fishery productivity including modeling. But it is still lack of understand the status and

situation of OA in the WESTPAC and adjacent region. This information could make more understand on the impact of OA to the marine ecosystem in this region including its future change. The results from the Symposium agree that the WESTPAC should establish the OA monitoring project and its network under the IOC-WESTPAC. This project and network will bring the scientists who are working on OA in the region to work together and setup the standard method for the monitoring system of seawater chemistry and ecosystem. Other related scientific research development could be further developed in the future. The implements of AO need contribution from member country especially to carry out the research in their waters and sharing information. The IOC-WESTPAC would like to thank to NOAA, USA, for their technical support through the experts.

Session 2: Research and monitoring efforts on ocean acidification in the region

- **Speaker Information:**

Prof M. Shahadat Hossain, Professor and Director, Institute of Marine Sciences & Fisheries, University of Chittagong, Bangladesh

Dr. M. Shahadat Hossain is a Professor at the Institute of Marine Sciences and Fisheries of the University of Chittagong, Bangladesh. He received MSc in Marine Science from the same institution in 1993 and then followed a second Masters in 'Integrated Tropical Coastal Zone Management' at the Asian Institute of Technology, Thailand in 2001. He was awarded PhD degree in 2008 for his research on 'Coastal Ecosystem Modeling'. Dr Hossain worked at Texas A&M University, USA on 'Climate Change Risk Modeling' in 2009-2010 as a Post-Doctoral Fellow. He has been involved in teaching and research in coastal zone management, climate change challenges, and ocean ecosystem modeling. Dr Hossain has authored more than 150 publications, including peer-reviewed journal articles, books, monographs, book chapters, refereed conference/seminar articles and supervised theses. He is the reviewer of academic journal from Elsevier, Blackwell, Springer, and so on. Dr Hossain rewarded funds from DFID, FAO, IMARES, BC, DANIDA, UGC and Bangladesh Government. He is attached with professional societies of coastal and ocean research, fisheries management and food production, climate change and environment, social welfare and youth development.

Presentation:

Ocean Acidification Threatens Marine Ecosystems and Livelihood Security in Bangladesh

M. Shahadat Hossain, S. M. Sharifuzzaman, Sayedur Rahman Chowdhury, Subrata sarker and Shah Nawaz Chowdhury
Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh

Rising atmospheric carbon dioxide (CO_2) will lead to lower oceanic pH and increase sea surface temperature (SST), both of which are unfavourable for the growth, survival and reproduction of marine calcifiers such as coral reefs, molluscs and other shelly organisms. In this study, time-series datasets on seawater pH and SST were analyzed to know the state of ocean acidification in the northern Bay of Bengal, Bangladesh. An average pH of 7.8, 7.6 and 7.3 in the years of 1970-1979, 1980-1989 and 1990-1999, respectively, clearly indicates a declining trend. Moreover, an average SST of 28.39^0C, 28.86^0C, 29.31^0C and 29.39^0C during the years 1970-1979, 1980-1989, 1990-1999 and 2000-2010, respectively, shows a rising trend. Therefore, ocean acidification coupled with elevated levels of SST may threaten 66 coral species and 317 marine molluscs biodiversity of Bangladesh by hampering the process of reef/shell formation, i.e. calcification. In consequence, numerous reef-based organisms and their habitats (i.e. spawning, feeding and nursery grounds) may shifts and thus affect species diversity, abundance and distribution. In particular, hundreds of reef fish species, many of which are commercially important, may face probable extinction, if reefs disappear. Aggregated effects can, in the long run, modify the ecosystem functioning and services, which will have significant implications for food security, nutrition and the livelihoods

of millions of coastal poor. However, impacts of ocean acidification on marine fauna and ecosystem processes are poorly understood, and virtually no science works have done in Bangladesh. Therefore, adequate research and continuous monitoring programme is required to determine the current and future costs of ocean acidification in Bangladesh. Development and implementation of specific national action plans and adaptation strategies to deal with ocean acidification is also a priority.

- **Speaker Information:**

Dr Ou Ratanak, Deputy Director of Biodiversity Office, General Department of Administration for Nature Conservation and Protection, Ministry of Environment, Cambodia

He has 14 year experiences with International Conventions and Biodiversity Department, Ministry of Environment on managing, planning and implementing of the environmental and agricultural sector development and management and played role as coordinator and trainer in the field of biodiversity research and monitoring, community based natural resources management and environmental management both for national and provincial level. This also coordinates and trained NGOs partners and local community for implementing and managing project's activities. At that time he also has been working very close with international NGOs and UN especially FAO and UNDP. He has gained Doctor Degree at Tokyo University of Agriculture in the middle of 2014 and graduated Master Decree on Agricultural and Resource Economics specialized in Environmental Economics from Japan and obtained a bachelor degree of Forest Science from Royal University of Agriculture since 1999. In addition to that, he has attended a number of international and national training courses related to forest and wildlife management, biodiversity conservation and environmental economics.

Presentation:

Coastal Zone Conservation and Management in Cambodia

The first protected area in Cambodia was Angkor Archaeological Park, declared in 1925, one of the first in south-east Asia. The Royal government of Cambodia has designated 23 Protected Areas (PA) by Royal decree in 1993. The total area of PA has covered approximately of 18% of total land area of the country. All those PAs have classifies into 4 IUCN categories namely National Park (7), Wildlife Sanctuary (10), Multiple-use Areas (3), and Protected Landscape (3). 6 protected areas are located in Coastal Area with the length of 435 km and cover of 4 provinces namely: Kampot, Kep, Preah Sihanouk and Koh Kong. Those PAs are administrated and managed by General Department of Administration for Nature Conservation and Protection (GDANCP) of the Ministry of Environment. Overall, about 88% of inhabitants rely on natural fishing and fish related activities for their livelihood and income generation. 10.5% of households count fishing or fishing related activities as their primary occupation while another 34.1% are engaged on a part-time basis. Thus, over one million people are either fully or partly dependent on fisheries resource harvesting and related activities for their income.

The country possesses 64 island; 10 species of sea grasses; 70 species of hard corals belonging to 33 genera and 11 families identified in Cambodia's marine waters; 30 species of mangroves and 435 fish species from 97 families. Mangroves are severely affected by wood harvesting for charcoal production and other uses, urbanization and other development work, and intensive shrimp aquaculture. Coral reefs and seagrass beds that are highly critical to marine productivity were also threatened by offshore oil and gas exploitation and the associated pollution. Many watersheds were degraded and coastal zones eroded or polluted by oil spills and from other human activities. The capacity of the Fisheries Administration, then Department of Fisheries, in preventing illegal fishing, and monitoring the marine and coastal resources was limited by lack of technical capacity, inadequate equipment and

budget constraints, some actions have not implemented yet especially the research and monitoring of Ocean Acidification (OA) and coral reef. These priority actions will be included in the National Biodiversity Strategic and Action Plan (NBSAP) updating.

Based on the NBSA updating, Cambodian Coastal Areas which at this moment is mostly focus on priority areas such as: observation and monitor of ocean acidification; vulnerability of Coastal Zone and marine sedimentary Environment; climate Change Adaptation and Impact Prediction in Coastal Areas; Marine Environment, Ecosystem, and Biodiversity Conservation; Coastal and Marine resources utilization and urbanization planning; Capacity building Integrated coastal management; Coastal tourism development and tourism resources management; Marine Policy and Law; Prevention and mitigation of coastal disasters; Solid waste management and marine pollution.

- **Speaker Information:**

Dr Qinsheng Wei, Assistant Researcher, First Institute of Oceanography, State Oceanic Administration

Since entering into FIO (First Institute of Oceanography, State Oceanic Administration) to work in 2007, Dr Qinsheng Wei has been engaged in research on chemical oceanography/marine biogeochemistry/chemical hydrology. Now, he is hosting one project of the National Natural Science Foundation of China named "Oxygen consumption and organic carbon mineralization in the hypoxic zone off the Changjiang estuary" and one Young Marine Sciences Fund Project of State Oceanic Administration named "Sedimentary record research of intensifying eutrophication in Jiaozhou Bay, China". Meanwhile, he has also participated in a series of research projects, including UNDP/GEF project "Reduce Yellow Sea Large Marine Ecosystem Pressure", and the National Key Basic Research and Development Program (973 project) "Evolution Mechanism of Algal Blooms Disaster and ecological safety in China's Coastal Sea", and so on. Furthermore, he has finished the analysis on the long-term variations of pH in the Yellow Sea and on the acidification in summer bottom oxygen-depleted waters off the Changjiang Estuary, and the related papers are also being prepared. Through those research experience, he has made some progress in regional chemical oceanography, biogeochemical processes and chemical hydrology in the Yellow Sea and off the Changjiang Estuary, obtaining some understanding and new perception on mass transportation, nutrient cycling, coastal hypoxia and acidification. In recent years, he has participated in four cruises conducted in the Eastern Indian Ocean, including two cruises supported by the "Monsoon Onset Monitoring and Its Social and Ecosytem Impacts (MOMSEI)" project. He is more and more interested in the research in the tropical oceans, especially in the coupling research of chemical oceanography and physical conditions, and in the ecological impacts (e.g. hypoxia and acidification) of climate change and growing human footprint in those areas. Particularly, he has attended several related academic conferences/workshops and given a oral presentation on a typical research issue in each meeting, including "The 6th China-Thailand Joint Workshop on Ocean Sciences and Technology Collaboration (Jul 2014, Qingdao, China)", "The 7th China-Indonesia Joint workshop on Marine Science and Environmental protection cooperation (Dec 2013, Guangzhou, China)", "The 2nd Planing Workshop on Eastern Indian Ocean Upwelling Research Initiative (Nov 2013, Qingdao, China)", and "The 5th Korea-China Joint Workshop on Yellow Sea Cold Water Mass Ecosystem (Dec 2013, Qingdao, China)". More importantly, he also has rich bio-geochemical investigation experience (almost 3 months on board in recent three years).

Presentation:

Acidification Induced by the Individual Ocean Conditions

Ocean acidification, resulting from dissolution of atmospheric anthropogenic CO_2, has been representing an emerging global threat to the marine ecosystems. In this presentation, we explored the acidification in two ocean systems including large river (Changjiang River) estuary and subtropical upwelling (the upwelling off the coast of Vietnam in the South China Sea) area. Since the 1980s, anthropogenic activities have caused excess nutrient enrichment and subsequent severe environmental problems such as harmful algae blooms (HAB) and hypoxia at the bottom off the Changjiang River estuary. In May and August of 2011, dissolved oxygen (DO) and pH off the Changjiang River estuary were surveyed. The result showed that the bottom hypoxia and acidification occurred off the estuary from the

spring to summer, and the extensive area of low pH coincided with the hypoxic zone. The seasonal bottom hypoxic phenomenon was proposed to be the result of coastal eutrophication and the subsequent algal blooms and/or red tides. Furthermore, the analysis of data collected off the Changjiang River estuary revealed a significant positive correlation between bottom water pH value and DO concentration, which also linked the acidification to oxygen consumption via local organic matter remineralization. Upwelling is one of the most important physical processes in marine systems. By transporting deep water with a high concentration of nutrients to the euphotic zone for a potential phytoplankton bloom, the upwelling significantly modulates the local biogeochemistry and biological productivity. In the survey conducted in June of 2009 in the western South China Sea, cross-shelf transects revealed the upwelling off the coast of Vietnam. This upwelling provided waters with low background level of pH value and high background level of dissolved inorganic carbon (DIC). Additionally, the nutrients brought by the upwelling could also promote the reproduction of phytoplankton in the upper layer waters, which would thereby form buffering capacity to the further decreasing of pH value. Those signals of acidification in river estuary and open upwelling systems suggest that the intense acidification may be closely related to the typical/special ocean conditions. Results from these studies provide insight on the mechanisms responsible for acidification in different sea areas, which is essential for understanding and predicting acidification.

- **Speaker Information:**

Dr Zhendong Zhang, Associate Researcher, National Marine Environmental Monitoring Center, China

Zhendong Zhang obtained B.Sc. in Aquaculture from the Ocean University of China in 2000 and Ph.D. degree in Marine Biology from the Institute of Oceanology, Chinese Academy of Sciences in 2005. As an associate researcher of the National Marine Environmental Monitoring Center of SOA, he has engaged in the study of marine biodiversity monitoring and climate change for 8 years, in particular ecological effect of ocean acidification on coral reef ecosystem and some key sensitive marine organisms, such as effects on photosynthesis and calcification rates of coralline algae (*Corallina pilulifer*) and effects on metabolism and acute toxicity of sea cucumber (*Stichopus japonicus*), etc.

He has conducted ecological monitoring and evaluation of coastal ecological monitoring and control zones since 2007, mainly focus on tropical marine ecosystems, such as coral reefs and mangroves. Some important environmental data and evaluation results of ecological he alth status and effect of ocean acidification on coral reef ecosystem of Sanya and the Xisha Islands have been obtained. Some crucial monitoring results and research experiences in analyzing and evaluating the impact and response of ocean acidification on sensitive marine organisms have been acquired as well during my study process.

Presentation:

Efforts and case studies of NMEMC in the research and monitoring of the ecological impacts of ocean acidification on coral reef ecosystems

The ocean has absorbed about one third of the anthropogenic carbon dioxide emissions and which is altering the seawater chemistry condition. Concerns about increasing ocean acidification have focused on the potential negative effects on coral reef ecosystem and other calcifying marine organisms. I have conducted related monitoring, assessment and research work of ecological health and effect of ocean acidification on coral reef ecosystem and sensitive marine organisms.

According to the monitoring results of Xisha Islands (Paracel islands) monitoring and control zone during 2005 to 2009, the acidity of seawater is relatively low. The average pH value were 7.98, 8.10, 8.00 and 8.00 in 2005, 2006, 2007 and 2009, respectively. Among all the 74 bottom monitoring stations, 19 stations of pH value were lower than 8, accounting for 25.68% ; There 29 stations with a pH value were between 8 and 8.1, accounting for 39.19% ; 11 stations of pH value are between 8.1 and 8.2, accounting for 14.86% ; 15 stations of pH value are higher than 8.2, accounting for 20.27%. Acidic seawater could decrease calcification rate of reef-building coral, slow down the growth of coral reefs and make skeleton become too brittle to withstand disastrous whether such as typhoon. This may be one of the important reasons causing the Paracel Islands coral reef degradation. Monitoring data of some key biological indicators that indicating the health status of coarl reef ecosystem such as coral coverage, recruitment rate of stony coral and density of coral reef fish showed obvious decrease.

Furhtermore, some experimental studies have been conducted to research and analyse the

impact of OA on biological process of some sensitive organisms.

Finally, a brief introduction of National Marine Environmental Monitoring Center and its scientific reasearch and investigation upon OA will be given.

- **Speaker Information:**

Prof Dr Jamaluddin Jompa, Dean, Faculty of Marine Science and Fisheries, Hasanuddin University

Prof. Jamaluddin Jompa, was borne on 8th March 1967 in Takalar, South Sulawesi, Indonesia. He got his PhD at James Cook University, Australia in 2001. He also graduated from McMaster University, Canada for his master degree in 1996. He is a senior lecturer and currently serves as Dean of Faculty of Marine Sciences and Fisheries. From 2004-2013, he served as director of Research and Development Center for Marine, Coasts, and Small Islands, Hasanuddin University. His researches have expanded from Aquaculture to Marine Biology, Marine Ecology, coral reef biology, reef bio-prospecting, and more recently on Coral Reef Ecology and Coastal Management. His current research projects are coral reef health and marine protected area. He has published about 70 journals/books; the majority of them are international publications.

In 2007 Jamal was seconded to the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia to assist in managing and directing the national Coral Reef Rehabilitation and Management Program Phase II (COREMAP-II). This was one of the largest coral reef management projects in the world in terms of area, finance, and project length. Jamal served as Executive Secretary of this very challenging project (in addition to his ongoing duties at UnHas) and successfully brought the project to a successful completion in December 2011.

Presentation:

Experimental Effects of Climate Change and Ocean Acidification on Coral Reefs: Synergic Impacts and Management Implication

The effects of climate change on coral reefs especially to the stony corals have been well known, especially due to increase sea surface temperature. Corals in general get bleach and potentially die when their ambient temperature increase by >2-3^{o}C from the average. Since the global warming is attributed to the increase CO_2 in the atmosphere (mainly due to excessive use of fossil fuel), it is inevitably that they also cause ocean acidification. This study aimed to demonstrate the experimental effects of the increased temperature and CO_2 concentration on growth and zooxanthella density of *Acropora Formosa.* We experimentally manipulated three levels of temperatures (30, 32, and 34 ^{o}C) and three levels of CO_2 concentration (385, 750, and 1000 ppm). The results indicated that both temperature and CO_2 have significant impacts on coral conditions. With the clear trends of elevated CO_2 on the atmosphere and SST, the fate of hard coral and coral reefs is gloomy. Therefore, we need to make sure to improve the strategic management to avoid further faster coral reef degradation.

- **Speaker Information:**

Mr Suratno, Indonesian Institute of Sciences (LIPI), Indonesia

Suratno is a junior researcher at Research Center for Oceanography, Indonesian institute of Sciences, Indonesia. He received master degree from Gadjah Mada University focus on Environmental Chemistry (phosphate removal from seawater using modified natural zeolite /master degree thesis). He starts working in RCO at 2008 to present in Ecotoxicology Laboratory, Pollution and Bioremediation Research Groups. He has been involved in research that correlated to respond of marine organisms (phytoplankton, fish larvae, echinoderms, shrimp and amphipod) to chemicals toxicant.

Presentation:

Ocean Acidification in Indonesia: Present and Future

Ocean acidification may be defined as the change in ocean chemistry driven by the ocean uptake of chemicals input to the atmosphere, including carbon, nitrogen and sulfur compounds. Evidence suggests that these changes will have significant consequences for marine organisms, particularly those that build skeletons, shells and tests of biogenic calcium carbonate. Indonesia is known as one of the world's mega-biodiversity countries, particularly in marine organisms but there were lack of information about biological and ecosystem responses to increasing ocean acidification in Indonesia. Mesocosm and in situ experiments may simulate and /or provide more natural conditions than single-species lab experiments. It has thus far used abrupt changes in seawater chemistry which do not allow for potential acclimation or adaptation by marine organisms. In situ experiments also need specific criteria. Monitoring the impacts of ocean acidification on coral reef ecosystems needs a lot of consideration such as minor physical disturbance, minimum influence from the land and time period.

- **Speaker Information:**

Dr Shintaro Takao, Postdoctoral Fellow, Hokkaido University, Japan

Shintaro Takao is a postdoctoral fellow at Hokkaido University (Japan) where he achieved his PhD in Environmental Science in 2013. His research interests include biogeochemical studies focusing on phytoplankton, community composition, and associated carbon fluxes. For this purpose, he has combined several approaches based on remote and in-situ measurements and laboratory experiments. These include primarily HPLC (High performance liquid chromatography) biomarker pigments, remote sensing of ocean color, and seawater carbon chemistry. His dissertation research focused on biogeochemical roles of phytoplankton functional types in the Southern Ocean carbon cycle. His primary research interest at present is to investigate effects of warming seawater and/or ocean acidification on distributional shifts/expansions for marine species, including phytoplankton, seaweeds, and corals, in the seas around Japan using outputs from future climate models.

Presentation:

Projecting the Combined Effects of Rising Seawater Temperatures and Ocean Acidification on Coral Habitats around Japan under Multiple Climate Change Scenarios

Using estimations from four coupled global carbon cycle-climate models combined with in-situ observations, we evaluated the effects of warming seawater and ocean acidification on potential habitats for tropical/subtropical and temperate coral communities in the seas around Japan. The suitable habitat for the coral communities is classified on the basis of the currently observed regional ranges for temperature and aragonite saturation state (Ω_{arag}). Our results suggested that continued warming may drive a northward shift in coral habitats with large differences depending on the climate scenario. For the highest emission scenario, coral habitats are projected to suffer coral bleaching and low Ω_{arag}, which could not support sufficiently high calcification rates. As a result, the suitable habitat for tropical/subtropical coral communities around Japan may be reduced by half by the 2020s to 2030s, and is projected to disappear by the 2030s to 2040s. Previously suitable habitat for the temperate communities is also projected to become untenable by the 2070s, although they are thought to have the higher tolerance for low Ω_{arag}. For the lowest emission scenario, most existing tropical/subtropical communities would be affected by severe bleaching. However, temperate communities would not be impacted by both bleaching and low Ω_{arag} by the 2090s. Our projections cloud serve as a baseline for assessing the future evolution of coral habitats, although we need to consider the potential adaptation of the coral communities, which would permit them to colonize habitats that are outside their current range.

- **Speaker Information:**

Dr Geun-Ha Park, Senior Research Scientist, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea

Dr Geun-Ha Park has focused her research efforts on three components of ocean carbon cycle research. First is a CO_2 uptake into the ocean's interior. She quantified the total amount of anthropogenic CO_2 penetrated into the interior of the East/Japan Sea and figured out its temporal variability with the recent warming trend. It was also shown how the oceanic CO_2 uptake has affected on the carbonate chemistry in the East/Japan Sea. Secondly, she has tried to determine the global sea-air CO_2 flux and its interannual variability more accurately with in situ dataset and remotely sensed products. She is one of the main contributors to the 2013 IPCC (Intergovernmental Panel on Climate Change) assessment on trends and variability in ocean uptake, by leading the global ocean component of the international RECCAP (Regional Carbon Cycle Assessment Project). Finally, she interprets the surface water CO_2 levels in context of ocean acidification and provides projections of regional differences. She estimated a multiannual trend of surface CO_2 using high-quality underway data of partial pressure of CO_2 (pCO_2) collected in the western tropical North Atlantic and found that the sea surface CO_2 has increased at a slower rate than atmospheric CO_2 for the recent period. This indicates that the CO_2 uptake to the ocean has been strengthened and the ocean acidification in this area has been accelerated. It also denotes that the status and progress of ocean acidification can differ regionally along with changes in CO_2 uptake rate.

She has been conducting ocean acidification monitoring in the eastern coast of Korea, especially in the area where the wind-driven coastal upwelling occurs since 2013. She is examining the seasonal and interannual changes in concentrations of inorganic carbon parameters (total dissolved inorganic carbon, total alkalinity, and pH) and saturation state of seawater with respect to aragonite and calcite and the effect of coastal upwelling on these changes. Dr Park plans to extend the monitoring capabilities by having an autonomous buoy and using an underway pCO_2 system onboard research vessel.

Presentation:

Variability of the inorganic carbon system in the mid-east coast of Korea

One of the ocean areas vulnerable to ocean acidification (OA) is coastal region which is frequently exposed to wind-driven upwelling. Thus we investigated temporal changes in the seawater carbonate system and the effect of upwelling on OA in Hupo, a central part of the east coast of South Korea. The estimated mean net sea-air CO_2 flux was -1.99 ± 1.18 mol C m^{-2} yr^{-1}, indicating that this region was a sink for atmospheric CO_2. Our monthly data revealed that temporal changes in surface CO_2 concentrations and $CaCO_3$ saturation states (Ω) were mainly governed by physical and biological processes. In particular, the wind-driven upwelling observed in July 2013 brought waters with high nutrients/CO_2 and low pH/Ω to the surface and thus enhanced biological production in surface waters. OA in this coastal ecosystem is expected to be exacerbated by anthropogenic CO_2 uptake and upwelling.

- **Speaker Information:**

Dr Seonock Woo, Senior Research Scientist, Korea Institute of Ocean Science & Technology (KIOST), Republic of Korea

PI of EcoToxico Genomics Laboratory, Korea Institute of Ocean Science and Technology, Rep. of Korea. Worked in Dept. of Nutritional Sciences and Toxicology, UC Berkeley, CA, USA. Awarded Science Ambassador (Korea Science Foundation) and working as Editorial board, Molecular and Cellular Toxicology.

Research focuses on the identification of biomarkers for environmental risk assessment for various environmental stresses like as climate change and ocean acidification. Major interests are the marine environment and marine organisms in relation to molecular level stress responses and various environmental stresses. These projects are all characterized by the application of classical and modern molecular methods including genomics, proteomics and field research to obtain more insight in environmental risk assessment method.

Recent researches purpose the rapid and inexpensive detection of pathogens in coral species using PCR-based assays and identifying pathogenic agents responsible for various outbreaks of coral disease, and the physiological aspect and transcriptional responses of the soft coral (*Scleronephthya gracillimum*) in Korea against combination of heat and carbon dioxide (CO_2) with or without.

Presentation:

Transcriptional Changes in Coral Responding to the Marine Acidification and Rising Seawater Temperature

Rising at atmospheric CO_2 concentrations are placing spatially divergent stresses on the world's tropical coral reefs through increasing ocean surface temperatures and ocean acidification. The carbon dioxide among the atmosphere is dissolved in the sea water, increase the concentration of the hydrogen ion. The concentration of the carbon dioxide maintained 260 ppm before industrial revolution. The biological and physiological processes of many organisms will be challenged by increasingly acidic conditions and temperatures.

In preliminary experiments, we carried out temperature and pH stress experiment independently in each experiment. In this research, we studied the physiological aspect, and transcriptional responses of the soft coral (*Scleronephthya gracillimum*) in Korea against combination of heat and carbon dioxide (CO_2) with or without. We collected corals from Jeju, Korea. The pH stress (pH 7.0, pH 7.5), heat stress (28 ^{0}C) and pH, heat stress (28 ^{0}C + pH 7.0, 28 ^{0}C + pH 7.5) exposure for 24 hr induces morphological changes. For the microarray experiment we exposed corals to a various pH stress (pH 7.0, pH 7.5), heat stress (28 ^{0}C) and pH, heat stress (28 ^{0}C + pH 7.0, 28 ^{0}C + pH 7.5). As the results, we found the shared genes in corals responding to various stresses. Eight common genes expressions were induced and 9 common genes were reduced over 2 fold by 28 ^{0}C, pH 7.0, pH 7.5, 28 ^{0}C + pH 7.0 and 28 ^{0}C + pH 7.5. These genes had the significant change of the expression more in temperature + pH stress. These isolated gene candidates were differentially expressed and the results suggested they could be used as molecular biomarkers for the identification of environmental stressors.

- **Speaker Information:**

Dr Jeong Hee Shim, National Fisheries Research and Development Institute, Republic of Korea

Dr Jeong Hee Shim is a research scientist of Marine Environment Research Division at National Fisheries Research and Development Institute (NFRDI) since 2009. Before joining NFRDI, she worked at Seoul National University and KORDI (now KIOST) as a postdoctoral position.

Her research interests include biogeochemical cycles of elements in coastal and aquaculture environments, particularly carbon & nutrients budgets/fluxes between environmental interfaces and recently, evaluation of ocean acidification to fisheries. She also conducted a project on ocean acidification, titled "Studies on effects of ocean acidification to early-development of marine fishes and seashells" during 2011-2013 and will present some results of the project at the WESTPAC workshop.

Presentation:

Growth Rate Comparison of Pacific Oyster, *Crassostrea gigas,* reared in a high-CO_2 Environment

JeongHee **Shim**[1], Hakbin Hwang[2] and Jung-no Kwon[1]
[1]National Fisheries Research & Development Institute, Busan, R Korea. E-mail: jshim@korea.kr
[2]Seodaemun Museum of Natural History, Seoul, R Korea

To discover effects of ocean acidification on marine invertebrates, we compared growth of Pacific oyster *Crassostrea gigas* reared in different pH conditions. We set up artificial mesocosm facilities that were made with frames and polypropylene film at the most important oyster spawning area of Korea on Nulcha Island, located at Nakdong River estuary, from April to May 2013 (about 50 days). During this mesocosm experiment, mean pH_{NBS} values (±SD) of controlled environments (M1, M2) were 7.71±0.28 and 7.72±0.28, respectively, while that of reference was 8.20±0.12. Juvenile oysters, with mean (±SD) shell length and weight of 29.21±6.30 mm and 4.08±2.36 g (n=90), respectively, were detached from shells of scallop (a device for settling spat), and exposed to three mesocosm treatments. The mean growth rates of oyster weight and shell length were significantly different (ANOVA, p=0.01). The weight and length growth rate of reference (19.5±17.6 mg day^{-1} and 0.143±0.121 mm day^{-1}) were higher than those of low pH controlled (M1: 13.5±14.3 mg day^{-1} and 0.100±0.076 mm day^{-1}, M2: 14.9±14.6 mg day^{-1} and 0.124±0.133 mm day^{-1}). These results indicate that ocean acidification can seriously affect shell and weight growth of juvenile oysters.

- **Speaker Information:**

Dr Zulfigar Yasin, Director, School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, Malaysia

Prof. Zulfigar is currently the director of the Institute of Oceanography and Environment (INOS) in Universiti Malaysia Terengganu. He obtained his PhD in Marine Biology in 1988 from the Salford University, UK. His field of research includes marine ecology, biodiversity, conservation and coral reef studies research on invertebrates, environmental studies (remote sensing & environmental impact assessments). His current research is on the ecological effects of ocean acidification on coral reef and benthic ecosystems in the Straits of Malacca and at a hydrothermal vent in Pulau Weh, Indonesia. Some of these addresses issues at various scales, which includes the study on coral skeletal growth; coral and benthic community structure along the pH gradient; and diurnal changes of the seawater carbonate chemistry at selected locations in the Straits of Malacca and South China Sea.

Presentation:

Diurnal changes of pH and alkalinity on the coral reefs of the Straits of Malacca, and the South China Sea

Zulfigar Yasin[1, 2], Nithiyaa Nilamani[1], Norhanis Razalli[1], Zulfikar[3] and Aileen Tan Shau Hwai[1]

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The ocean absorbs approximately one third of the anthropogenic carbon dioxide (CO_2) emitted to the atmosphere. The amount of absorbed CO_2 is massive that it is significantly changing the chemistry of the ocean. The raising of dissolved CO_2 concentration and lowering of pH will likely affect many marine organisms and alter the ecosystem community structure. Coral reefs are believed to be particularly vulnerable to ocean acidification as the reef framework is composed of calcium carbonate. Knowledge on the diurnal fluctuation in seawater pH and total alkalinity (A_T) provides information on the range of natural variability that coral reef organisms are exposed to. Thus, this study shows an internal short-term variation in pH and total alkalinity at coral reef environment. We documented 3-day diurnal variability in pH and A_T on a shallow water coral reef at three different islands at the Straits of Malacca and the South China Sea during the wet season. Loggers were deployed near the coral reef area for continuous data logging and water samples were collected every 3 hours for analysis. pH and A_T showed distinct diurnal fluctuation throughout the observation period at all three locations. It is suggested that the diurnal variability can occur as a result of biological processes, such as respiration and photosynthesis. Average value of pH and A_T were 8.13 and 2140.77 µmol kg^{-1} for Pulau Payar, 7.92 and 2160.45 µmol kg^{-1} for Pulau Gaya, 8.01 and 2161.78 µmol kg^{-1} for Pulau Bidong. Although the pH is higher, but Pulau Payar is more susceptible to ocean acidification to other sites in this study due to its low A_T value.

- **Speaker Information:**

Dr Aileen Tan Shau Hwai, Senior Lecturer, School of Biological Sciences, Universiti Sains Malaysia, Malaysia

Assoc. Prof. Dr Aileen received her PhD from Universiti Sains Malaysia (USM) in 2001 and has been lecturing in School of Biological Sciences, USM for almost 14 years. Her research focuses mainly in the field of marine science, aquaculture and environmental studies which covers the field of coral reefs, benthic biology, conservation and marine environmental management. She has published 7 books, 60 articles in national and international journals and about 200 papers have been presented in conferences worldwide. She is also a reviewer and editor for local and international journals.

She is very active in academic societies nationally and internationally. She is the panelist for Environmental Impact Assessment on Marine Ecology with the Ministry of of Natural Resources, Malaysia. She is the Deputy National Coordinator of Malaysia in Western Pacific NaGISA and she is a permanent Council Member for SCESAP- Society for Coastal Ecosystems Studies – Asia Pacific.

She has been elected as the President for Unitas Malacologica from 2013 till 2016 and will be hosting the international conference in Penang in 2016.

Presentation:

The Shell Characteristics of Bivalves at the Lowered pH Area Compared to a Normal Area

Aileen Tan Shau Hwai[1], Mohammad Reza Mirzaei[1], Teh Chiew Peng[1], Nithiyaa Nilamani[1], Norhanis Razalli[1], Zulfikar[3], Nadras Othman[4] and Zulfigar Yasin[1, 2]

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[4]School of Materials and Mineral Resources Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia

Ocean acidification is the decrease in carbonate ion concentration and pH of the seawater as a response to rising atmospheric ρCO_2, which expected to have a negative effect on the reef-building corals and calcifying marine organisms. Thus, a study on the shell characteristics of bivalves collected from the areas with different pH environment namely three sites in Pulau Weh, Indonesia (adjacent to a volcanic vent): jetty, hotspring station and bubble station. These stations are located along a pH gradient. The control site was in Penang, Malaysia (control site). In this study, the pH at the sites at Pulau Weh ranged from 7.14-8.08 while 8.30-8.45 in Penang. The bivalve shells were collected from the rocks around the study areas. The shell characteristics of the bivalves from different locations were studied using X-ray diffraction, X-ray Fluorescene and Scanning Electron Microscopy. Results showed that the degree of crystallinity decreased in shells exposed to lower pH environment. The microstructure of the shells changed from large irregular shapes to flat as the pH in the

environment decreased. The findings from this study describe the changes in the shell characteristics of bivalves with respect to the changing of the pH of seawater along a gradient.

- **Speaker Information:**

Dr Emienour Muzalina Mustafa, PostDoctoral Research Fellow, Institute of Ocean and Earth Sciences, University of Malaya, Malaysia

Dr. Emienour Muzalina Mustafa is PostDoctoral Research Fellow at Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia. She received a B.Sc in Biochemistry in 2000, Master of Technology (Environmental Management) in the waste bioremediation using algae in 2003 and a Ph. D. in Genetic ecotoxicology of algae in 2013 from University of Malaya, Kuala Lumpur, Malaysia. She is biochemist who does research in a broad range of issues relating to stress physiological processes of aquatic organism especially micro and macro-algae. Her research fields are assessment of growth, biochemical composition, DNA damage and oxidative stress enzymes activities in the micro and macro–algae under stress conditions (chemical contaminants such as metals, pesticides, textile dye, moderately elevated temperature, UV, dehydration, high irradiance and high salinity); Biodiversity of micro-algae and macro-algae (including fresh and marine algae, toxic and harmful algae) based on molecular and taxonomic identification; Using macro and micro-algae for wastewater treatment (landfill leachate, palm oil mill effluent, chicken dung) and renewable energy (biofuel).

Presentation:

Impacts of Ocean Acidification on Marine Biodiversity: Gaps and Potential Research Collaboration

Emienour Muzalina Mustafa, Choon Weng Lee & Siew-Moi Phang
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Ocean acidification is a global environmental problem that will have significant impacts on the coastal and marine environment and the coastal communities. The effects of ocean acidification on marine species and ecosystems are variable and complex, impacting developmental and adult phases differently across species depending on genetics, pre-adaptive mechanisms, and synergistic environmental factors. The marine species most vulnerable to ocean acidification are the corals, shellfish, marine phytoplankton (coccolithophorids), which will have impaired abilities to form calcified structures due to the increased acidity of the seawater. Malaysia is situated in the west Pacific region (including the Coral Triangle) which has the highest coral diversity (500 species in Malaysia). Massive coral bleaching has been reported for 11 islands in Malaysia (Langkawi, Payar, Pangkor, Perhentian, Redang, Bidong, Tenggol, Tioman, Tinggi, Sibu, Aur & Dayang Isalnds). Preliminary observations point to pollution as the main cause, with no scientific evidence relating bleaching to increased temperature or acidification in these Malaysian waters, as yet. Of Malaysia's marine bioresources, the endangered species include the large marine animals like the dugongs, dolphins, whales and turtles. Little is known about the effect of ocean acidification on these species. The marine phytoplankton together with the other marine plants, are responsible for carbon drawdown from the atmosphere through photosynthesis. Ocean acidification may reduce their populations resulting in reduced efficiency of the ocean as a carbon sink, as well as reduced food for the marine species especially the fisheries species. Abundant gaps exist in the understanding of the response of the marine biota and

ecosystem to ocean acidification. The following include areas to focus research collaborative efforts in the South China Sea region: i) identification and mapping of coastal areas vulnerable to ocean acidification; ii) impacts on marine biodiversity & ecosystems (rich biodiversity; incomplete inventory; many more new species to be discovered); impacts on fisheries; iii) impacts on coral reefs; iv) impacts on endangered marine animals; v) impact on the security of the coastal and maritime communities; how will their livelihoods be impacted by reduced productivities of fisheries, etc.

- **Speaker Information:**

Dr Hii Yii Siang, Associate Professor, School of Fisheries Science and Aquaculture, University Malaysia Terengganu

Dr Hii graduated with Ph.D. degree from University Putra Malaysia in 2004 and become lecturer at University Malaysia Terengganu since 2004. He is Interested in the pollution studies on the resilience of coral reefs ecosystem.

Currently he is leading four research projects and supervise 6 post-graduated and students. He is also a member of Panel of reviewer for the Malaysian government for research funds in the marine science cluster. His team published more than 47 scientific articles and invented 3 patent pending invention.

Presentation:

A Concerted Monitoring and Research Framework on Coral Reefs Conservation by Malaysian Universities

The challenges of conserving and restoration of corals reefs ecosystem are not only limited to the ground efforts, it required comprehensive understanding and knowledge on the biotic-abiotic as well as biotic-biotic interaction in the unique ecosystem. Without patching the knowledge gaps in the ecosystem, it is unlikely for the managers to stike a balance between conservation and utilization of the resource. Studies on the coral reefs ecosystem is just another uphill challenge, the magnitude of complicated interaction among the components in the coral reefs presented a great challenges to the researchers. In many case, contradict findings were published and reported by different groups of researchers in coral reefs research. Working in a silo is counter productive and does not contribute to the big picture. The number of researchers in coral reefs study from the Malaysian Universities are relatively small. In the Malaysian scenario, a concerted monitoring and research framework on coral reefs conservation is crucial. Under the High Institution Centre of Excellence under the Ministry of Education, the Coral reef conservation and restoration framework was molded and move forwards. Under the current framework, there are four stake holders identified under the framework; University Researchers, Government Administrators, Non-governmental organization and the community. The framework attempt to outline the communication node on the function of each stake holder. There are two immediate actions needed to enhance the efforts. Connecting the framework to international platform, as well as engagement of the community. The community engagement appears to be the weakest link that withdraw the sustainability of the coral reefs conservation and restoration in Malaysia.

- **Speaker Information:**

Dr Maria Lourdes San Diego-McGlone, Professor, The Marine Science Institute, University of the Philippines, Philippines

Dr. Maria Lourdes San Diego-McGlone is a Professor of the UP Marine Science Institute. Her research interests include nutrient biogeochemistry of coastal systems, estuarine chemistry, sediment-water interaction, and marine pollution. Her current research involvement includes harmful algal bloom mitigation, coastal ecosystem response to anthropogenic stressors, and ocean acidification. She has been interested in issues such as fish kills and the environmental consequences of mariculture and aquaculture activities. From her research works she has published over 60 papers in international and local journals. Dr. San Diego-McGlone has also been involved in various environmental impact assessments, resource and ecological assessments, and was a resource person and regional mentor for an international initiative to examine land-ocean interaction in the coastal zone. She has a PhD in Chemical Oceanography from Old Dominion University in Norfolk, Virginia, USA.

Presentation:

Status of Ocean Acidification Research in the Philippines

Ocean acidification research in the Philippines is relatively new. Initial efforts include c ollaborative work with NOAA to deploy instrumentation to establish baseline observation s, and individual studies by foreign research partners and student theses to examine c arbonate chemistry. Current research on ocean acidification centers on studies of cora l resilience to enhance coral restoration efforts. It is important to identify resilient coral species through field surveys and experimental characterization of physiological limits u nder varying scenarios of environmental stress due to temperature, pH, and nutrients. Several target sites (5) were established around the country with documented massive bleaching events, and these are to be monitored over time. A list of 17 coral species representing different growth forms and families were selected as candidates to be scr eened for resilience to the environmental stressors. Related to this are graduate stude nt research to determine the growth, net calcification, photosynthetic response, respiration, and zooxanthellae density of *Porites* sp*., Acropora* sp*.,* and *Heliopora* sp. to decreased pH levels. There is also student research to study the spatio-temporal variability of carbonate parameters in coastal waters affected by mariculture activities. Initial studies have been conducted to assess the role of seagrasses to relieve corals from ocean acidification.

Facilities to do ocean acidification work in the Philippines is housed at the Bolinao Marine Laboratory (BML) in Bolinao, Pangasinan located northwest of Luzon. BML is the marine station of the Marine Science Institute, University of the Philippines.

- **Speaker Information:**

Dr Hazel Arceo, Assistant Professor, Marine Science Institute, University of the Philippines, Philippines

Dr. Hazel O. Arceo, an Assistant Professor at the U.P. Marine Science Institute, has worked in both the pure and applied aspects of coral reef research for almost two decades. Her research areas have focused on coral reef ecology, coral bleaching, reef fish recruitment and ecological effects of marine protected areas (MPAs). Meanwhile, she has also worked on science-based applications to improve coastal resource management and biodiversity conservation. Her current research involvement includes determining resilient coral species from natural populations for application in reef restoration, fishing-induced changes in fish life history traits, reef fish biodiversity patterns in the Philippines, and reef fisheries. She is also increasingly interested in studying climate change impacts on the biology and ecology of reef fishes. Dr. Arceo has served as a resource person in various consultations for the development of local and national coral reef management policies, and is a regional coordinator for the Philippine MPA Support Network. She completed her D.Sc. degree at the University of Nice – Sophia Antipolis in France.

Presentation:

Coral Reef Monitoring in the Philippines

The Philippines was one of the first countries to undertake a systematic inventory of its coral reefs in the 1970's. Technical capabilities to carry out scientific reef assessment were enhanced starting in the mid- 1980's through an ASEAN-Australian coastal resources project. Monitoring (or repeated assessments) was initially conducted in a few sites, particularly to determine the effects of two marine protected areas (MPAs) in Central Philippines, but has since been done in many other MPAs in the country over the years. Starting in the early 1990's, the realization that the capacity to monitor reefs need not be limited to the academe and government agencies became apparent, and community-based or participatory reef monitoring methods were developed. Non-specialist monitoring programs, such as Reef Check, also gained mainstream application although the country continued to contribute to the Global Coral Reef Monitoring Network which largely employs the ASEAN-Australia methodologies. Meanwhile, the national level inventory conducted in the 1970's was never repeated because subsequent projects focused only in particular sections of the country. Repeated assessments of a similar scale would have been useful to establish patterns over time with more precision and to adapt management policies to the changing needs of coral reefs. In 2014, a national program for the nationwide assessment of coral reefs was initiated to determine the state of coral reef environments in the Philippines and to present possible projections of their future state based on their vulnerability and resilience to human and climate-related threats. The program also aims to lay the groundwork towards the development of a more systematically designed national coral reef monitoring program by establishing monitoring (or sentinel) sites in appropriate locations. A crucial component of the monitoring program is regular feedback of information to facilitate timely management responses and actions.

- **Speaker Information:**

Dr Suchana Chavanich, Associate Professor, Department of Marine Science, Faculty of Science, Chulalongkorn University, Thailand

Dr Suchana is currently working as associate professor at the Department of Marine Science, Faculty of Science, Chulalongkorn University. Her current research works include coral reef biology and ecology and the impact of climate change on coral reefs. She also has an interest on the impact of ocean acidification, and has been conducting research related to the ocean acidification since 2014.

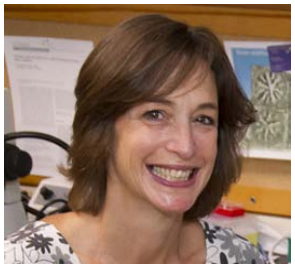
Presentation:

The Impact of pH on Development of Pocillopora damicornis larvae in Thailand

The purposes of this talk are to show the distribution of dissolved inorganic carbon, total alkalinity, and partial pressure of CO_2 in a coastal reef of Samea San Island, Chonburi Province in the upper Gulf of Thailand and to investigate the potential influence of pCO_2 on coral larvae. The carbon cycling in reefs can be driven by biological activities such as photosynthesis and respiration. Total alkalinity (TA) and dissolved inorganic carbon (DIC) are two important parameters in the oceanic carbon cycle. The monitoring has been started since December 2013. Seawater samples are collected, preserved by adding HgCl 1 ml, and stored for later analysis. In this study, we also investigated the influence of pCO_2 on the larval development of the coral, *Pocillopora damicornis*)Linnaeus, 1758). Treatments with different pCO_2 levels were conducted. The results show that pCO_2 can have a potential effect on the survival and development of coral larvae. More details of the results will be discussed.

- **Speaker Information:**

Dr Anne Cohen, Coral Reef Ocean Acidification Expert, Woods Hole Oceanographic Institution (WHOI), USA



Anne Cohen is a Tenured Associate Scientist at the Woods Hole Oceanographic Institution and faculty in the MIT-WHOI Joint Program in Oceanography. She combines laboratory manipulation experiments with field based research and monitoring to understand and project the impacts of climate change on tropical coral reefs. Author of more than 60 scientific papers and reports, Dr. Cohen has served as expert witness to the US House of Representatives Resources Subcommittee on Fisheries Conservation, Wildlife and Oceans during the Oversight Hearing on the Coral Reef Conservation Act. She also served on the science steering committee for the Intergovernmental Panel on Climate Change (IPCC) working group on Impacts of Ocean Acidification on Marine Ecosystems, and the Center for Ocean Solutions Working Group on Corals and Climate Change, which produced the *Consensus Statement on Climate Change and Coral Reefs.* Dr. Cohen's work has been featured in National Geographic, Discovery Channel US and Canada, Public Radio International's The World, the BBC and WGBH NOVA. She oversees ongoing research programs on coral reef ecosystems in the tropical Pacific and Atlantic oceans, and in partnership with NOAA's Coral Reef Ecosystem Division, The Nature Conservancy, Conservation International and the Palau International Coral Reef Center.

Presentation:

Overview of Academic Research and Monitoring on Ocean Acidification on Coral Reefs

Ocean acidification (OA) poses a significant threat to marine ecosystems worldwide. Recognizing that effects of OA will likely affect the development of management strategies for sustaining ocean resources, the US academic community is charged with developing a fundamental understanding of the nature, extent and impact of OA on present and future oceanic environments, informed – where possible - by past events and responses. The 5-year NSF-supported OA program significantly enhanced our understanding of OA impacts on coral reef ecosystems by promoting an interdisciplinary approach that focused questions in four main areas: 1) understanding and characterizing *in situ* reef carbonate chemistry conditions and the drivers of variability on diurnal through inter-annual timescales, 2) understanding and monitoring the future course of OA on coral reef ecosystems and how it might vary on regional and local scales, and through its interaction with other oceanographic and climate changes currently underway, 3) understanding and monitoring the impact of OA on reef biota and the reef structure in so far as its ability to support and sustain a diversity of life both above and within its sediments, and 4) identifying factors that might enable reef communities to either persist or adapt to, future OA. I will use examples from current projects to illustrate some of the main findings under this program, and specifically those most pertinent to the development of a regional research and monitoring OA network in the Western Pacific and its adjacent regions.

- **Speaker Information:**

Dr Van Long Nguyen, Head of Department of Marine Living Resources, Institute of Oceanography, Vietnam

Dr Van Long Nguyen has been working at the Institute of Oceanography since 1993 with major research activities focusing on assessments and monitoring of biodiversity and associated resources of marine ecosystems (coral reefs and seagrass beds) that formed baselines for planning and management of marine resources at different areas in Vietnam, especially for several MPAs in the southern part of Vietnam. In the period of 2005-2008, he was pointed as National Focal Point of Coral Reef Component of the UNEP/GEF/SCS project entitled "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand" and has been selected as Co-National Coordinator of Coral Reefs of Vietnam in the framework of Global Coral Reef Monitoring Network (GCRMN) since 2010. During the last ten years, he had been invited as lecturers or trainers for several training courses of monitoring of coral reefs (mainly biophysical indicators) for several MPAs in Vietnam (Cu Lao Cham, Nha Trang, Nui Chua, Phu Quoc). With more than 22 years of experience, he published 38 articles and 2 books with main description of species composition, distribution and structure of reef fish communities, status and monitoring of coral reefs and associated resources in national and international journals, of which there were 8 publications described the results of monitoring of coral reefs at specific MPAs (Cu Lao Cham, Van Phong bay, Nha Trang bay, Nui Chua, Hon Cau, Con Dao and Phu Quoc) and in the whole coastal waters of Vietnam. Recently, he has been taking part in responsibility for development and management of monitoring systems and databases of coral reefs at the Institute of Oceanography.

Presentation:

Monitoring activities of coral reefs in Vietnam

Monitoring activities of coral reefs in Vietnam has been conducted since 1998. Although there have been officially no monitoring programme of coral reefs established in Vietnam to present, but the number of sites permanently established and monitored at 7 key areas gradually increased from 8 sites in 1998 to 11 sites in 2000, 53 sites in 2006 and dereased to 33 sites in 2012 under support from several provincial, national and international projects. Parameters monitored were mainly focused on biophysical parameters (benthic cover, indicators of fishes and macro-invertebrates, and physical impacts to coral reefs). Overall status of coral reef benthos surveyed at 89 sites from 10 key areas in the coastal waters of Vietnam during 2010-2011 showed a low overall average value of live coral cover. There were no reefs in excellent condition (> 75% cover) found, only 2.2% of reefs in good condition (range 51-75 % cover), 34.4% reefs in fair condition (26-50% cover) and 63.5% of reefs in poor condition (< 25% cover). Comparison with data monitored between periods of time from 1994 to 2012 indicate that overall mean cover of hard corals in Vietnam notably declined from 34.6% in 1994 to 25.6% in 2006 and 21.1% in 2012. Among them, reefs that are improving between time 1994 and 2012 averaged 10.8% whereas reefs that are declined and remained unchanged occupied with 55.4% and 30.0% respectively. In general, the overall interval decline in hard coral cover during the last 16 years averaged at 13.0% with a higher decline found in the period of 1994-2000 (16.3%) compared to that in the period of

2000-2006 (3.2%) and 2006-2012 (4.5%). During the last several years, coral reefs in many areas of Vietnam have suffered more severe impacts from coral bleaching, coral damage from natural events (storms, etc), damaging fishing methods and coastal development damage (ports, airports, dredging, etc) than that from sediments & nutrients from land-based, anchor, trawler & others kind of damage (divers, trampling, etc) and outbreaking or invasive organisms (COTS, *Drupella, Diadema*, etc).

- **Speaker Information:**

Ms Vinh Le Thi, Head of Department of Hydro-Geochemistry, Institute of Oceanography, Vietnam

Ms Vinh Le Thi is a researcher at the department of Hydro - Geochemistry, Institute of Oceanography, Nha Trang, Viet Nam since 1984. Her research has been involved with aspects of environmental quality, related to basic parameters (pH, temperature, salinity, turbidity, DO), organic matter (BOD_5, COD, N and P), nutrients (ammonia, nitrite, nitrate, phosphate, silicate), heavy metals (Zn, Cu, Pb, Cd, Fe) hydrocarbon etc in water and sediment in bays, lagoons, estuaries and coastal area of Viet Nam and hydrogeochemical processes in estuaries and coastal water environment and pollutant sources and environment impact assessment of human on marine ecosystems such as coral reefs. She is also advisor for some undergraduate students. With 30 years of experience, she published 45 articles with main description of water-sediment quality in the coastal areas of Viet Nam such as Thi Nai lagoon, DeGi lagoon, Nai lagoon, Van Phong bay, Nha Trang bay, Phu Quoc Island, Mekong estuaries. Recently, she has been taking part in responsibility for development and management of monitoring systems and databases of water and sediment quality at the Institute of Oceanography.

Presentation:

Trend of coastal water quality of Nha Trang bay, Viet Nam

Nha Trang Bay is famous not only because of its beauty but also of the biodiversity values, especially coral reefs. Water quality monitoring in the whole bay was carried out from 2007 to 2014. The results of the surveys in the dry (from April to June) and rainy season (October to November showed that the value of the common parameters (pH: 6.65-8.29; TSS: 1.0 - 86.9 mg/l; DO: 4.60-7.96 mg/l; BOD_5: 0.10-5.01mg/l), nutrient concentrations ($NH_{3,4}$: 0-108 µgN/l; NO_2: 0-21.2 µgN/l; NO_3: 23-86 µgN/l and PO_4: 3.3-34.6 µgP/l; SiO_3: 69-3665 µgSi/l), heavy metals (Fe: 34-2624 µg/l, Zn: 4.9-24.9 µg/l, Cu: 0.6-5.2 µg/l and Pb: 0.3-4.4µg/l), hydrocarbon (233-808 µg/l) quite changed in space (nutrient concentrations and Fe were often higher and pH were lower in mouths) and period (the values of DO, BOD_5, SiO_3, NO_2 and Fe were higher in the rainy season while the values of pH and ammonia were lower). From 2007 to 2014, water quality did not change clearly although there were the obvious trend of decreasing in TSS and hydrocarbon and increasing in BOD_5 and Cu in both seasons. According to criteria for Aquatic Life Protection, in generally, coastal water quality at entire bay was quite good although there were some partial contamination of some parameters at few moments.

Related to water quality at the coral reef, the results of surveys in August 2010 and 2013 showed that water quality did not change clearly (temperature: 26.1-30^oC; pH: 7.98-8.20; TSS: 6.2 - 32.0 mg/l; DO: 6.00 to 7.08 mg/l, $NH_{3,4}$: 0 - 18.4 µgN/l; NO_3: 29-35 µgN/l and hydrocarbon: 267-563 µg/l. According to criteria for Coral Reef Conservation, water quality was pretty good.

- **Speaker Information:**

Dr Russell 'Rusty' E. Brainard, Chief, Coral Reef Ecosystem Division, Pacific Islands Fisheries Science Center, National Oceanic and Atmospheric Administration, USA

Dr Brainard is a supervisory oceanographer and founding Chief of NOAA's Coral Reef Ecosystem Division (CRED), an interdisciplinary, ecosystem-based research program that conducts integrated ecosystem observations, long-term monitoring, and applied research of coral reefs to support ecosystem-based management and conservation. CRED monitors the distribution, abundance, diversity, and condition of fish, corals, other invertebrates, algae, and microbes in the context of their diverse benthic habitats, human pressures, and changing ocean conditions, including ocean acidification (OA) and warming.

Dr Brainard has served as NOAA's technical lead for the Coral Triangle Initiative's Ecosystem Approach to Fisheries Management theme providing technical assistance and capacity building to address threats to coastal and marine resources, including efforts to establish a regional network to monitor the ecological impacts of OA on coral reefs as part of the Global OA Observing Network. Rusty led an assessment of the status of and risk of extinction to 82 species of corals that informed NOAA's decision to list 20 coral species as threatened under the Endangered Species Act. Rusty serves on the Ocean Carbon and Biogeochemistry – OA subcommittee, whose mission is to study OA effects on marine ecosystems and biogeochemistry. Rusty served as co-PI of the Coral Reefs project of the International Census of Marine Life, where his team developed tools to systematically monitor biodiversity.

Dr Brainard has served NOAA in various capacities since 1981, the first 21 years as a NOAA commissioned officer where he spent 8 years at sea, including 3 ½ years as captain. He was station chief of NOAA's Geophysical Monitoring for Climatic Change South Pole Observatory, where he monitored atmospheric processes including climate. Rusty examined oceanographic processes influencing marine ecosystems along the eastern Pacific and central Pacific seamounts. He examined role of variability of internal waves and mixing along the equator on modulating ENSO.

Dr Brainard completed a BS in Marine Science from Texas A&M University in 1981, and MS in Oceanography in 1986 and PhD in Physical Oceanography in 1994 from the Naval Postgraduate School. Rusty serves as adjunct graduate faculty at the University of Hawaii and committee member for graduate students at University of California Santa Cruz, Woods Hole Oceanographic Institution, and Wageningen University. Rusty as co-authored 91 scientific papers on various aspects of oceanography, marine ecosytems, fisheries, biodiversity, and climate change and ocean acidification.

Presentation:

Long-term Monitoring of Ecological Impacts of Ocean Acidification on Coral Reefs

Ocean acidification has been predicted to have significant impacts on coral reefs and the associated ecosystem services they provide to human societies over this century. To inform, validate, and improve laboratory studies and modeling predictions of future conditions and impacts, NOAA's Coral Reef Conservation Program and Ocean Acidification Program have initiated collaborative and integrated efforts to monitor the ecological impacts of ocean acidification on coral reef ecosystems of the United States at part of the National Coral Reef

Monitoring Program (NCRMP). This presentation will focus on implementation of NCRMP across the vast and remote regions of the U.S. Pacific Islands as part of NOAA's Pacific Reef Assessment and Monitoring Program (Pacific RAMP), which conducts triennial coral reef ecosystem surveys of the Hawaiian Archipelago in the North Pacific, American Samoa in the South Pacific, the Mariana Archipelago in the Western Pacific, and the Pacific Remote Islands Marine National Monument in the Central Pacific. In addition, NOAA has assisted partners in establishing similar observations at a few sites in the Philippines, Timor Leste, and Papua New Guinea. As part of these efforts, NOAA and our collaborators are assessing spatial patterns and monitoring long-term temporal trends of seawater carbonate chemistry, benthic community structure and biodiversity, and calcification and bioerosion rates of corals and calcareous algae spanning gradients of biogeography, oceanography, and anthropogenic stressors across the central and western Pacific. For the coral reef ecosystems surveyed, surface and near-bottom water samples and limited moored instrument arrays characterize carbonate chemistry, biological surveys provide composition and abundance of key benthic functional groups, autonomous reef monitoring structures (ARMS) provide indices of cryptobiota diversity, calcification accretion units (CAUs) provide estimates of net accretion of calcium carbonate, bioerosion monitoring units (BMUs) provide estimates of bioerosion, and coral cores provide calcification and extension rates of key massive reef-building corals. Collectively, these observations of the ecological responses to ocean acidification of coral reef ecosystems in their natural environment are essential to support resource managers and policymakers in their efforts to implement effective management and conservation strategies. These efforts are also part of the Global Ocean Acidification Observing Network (GOA-ON).

Concept Paper

Towards the Development of a Regional Program to Monitor the Impacts of Ocean Acidification on Coral Reef Ecosystems

(v.4, 8 October 2014)

Concept Paper
Towards the Development of a Regional Program to Monitor the Impacts of Ocean Acidification on Coral Reef Ecosystems

(v.4, 8 October 2014)

Justification

The ocean has absorbed about one third of the anthropogenic carbon dioxide (CO_2) emissions since the industrial revolution, greatly reducing the impact of this greenhouse gas on the climate. However, this massive input of CO_2 is generating global changes in the chemistry of seawater, especially on the carbonate system. These changes are collectively referred to as "ocean acidification" because increased CO_2 lowers seawater pH (i.e., increases its acidity). Quantitatively, ocean acidity has increased by 30% (0.1 decrease in pH) since the beginning of the Industrial Revolution. It is predicted that the future CO_2 absorption into the ocean will result in a decrease of pH of 0.3-0.4 and a 16% decrease in carbonate ion concentrations by 2100. According to geological records, this acidification is happening at rates not seen for at least 50 million years.

Recent studies have shown that the resulting decrease in ocean pH will make it more difficult for marine calcifying organisms, such as corals, mollusks, and calcareous plankton, to form biogenic calcium carbonate, and existing calcium carbonate structures will become vulnerable to dissolution. Thus, ongoing acidification of the oceans poses a threat to ocean-based security. Since this ocean acidification may be occuring more rapidly than prior ocean acidification events that are thought to have coincided with mass extinction events, there are concerns that marine ecosystems will change, that biodiverity will be lost, and that important ecosystem services that human societies depend upon for food security, livelihoods, and coastal protection could be significantly impacted. Unfortunately, the effects of ocean acidification on organisms and ecosystems remain poorly understood, with most of our knowledge based on simplified laboratory experiments.

The Western Pacific and its adjacent regions are among the richest and most productive in the world as a home to more than 600 coral species (more than 75% of all known coral species) and ~53% of the world's coral reefs. Most Southeast Asian coastal communities are socially and economically dependent upon coral reef ecosystems and an estimated 70-90% of fish caught in Southeast Asia are dependent on coral reefs. Globally, it has been estimated that coral reefs support greater than 25% of all known marine species.

Despite the recognition that ocean acidification from increasing levels of atmospheric CO_2 represents a major global threats to coral reefs and other calcifying marine organisms, awareness of the impacts of this 'other CO_2 problem' has emerged only over the last decade. The ecosystem responses to ocean acidification are poorly understood in the region and more research and long-term monitoring are critically needed to develop meaningful projections on future impacts of ocean acidification on marine ecosystem, especially on coral reefs, in the region to enable resource and fisheries managers, and policy makers to develop effective long-term mitigation and adaptation strategies for the people of the region.

In this context, the IOC Sub-Commission for the Western Pacific (WESTPAC) aims to establish regional research and monitoring network on ocean acidification in the Western Pacific and its adjacent regions, and develop a regional program, as one regional component of the Global Ocean Acidification Observing Network (GOA-ON), to monitor the impacts of ocean acidification on coral reef ecosystems, *mainly through a series of regional workshops*

& trainings, selection of pilot areas, and transfer of knowledge and technology among experts, institutions within and outside the region.

Workshop Objectives

To this end, upon the generous support of the National Commission of Thailand for UNESCO, the first Regional Workshop was scheduled for 19-21 January 2015 with the host of the Phuket Marine Biological Center.

The first regional workshop aims to

- Improve the understanding, and develop regional capability of research and monitoring on ocean acidification in the Western Pacific and its adjacent regions;
- establish an ocean acidification monitoring and research network among scientists, institutions, and agencies in the region;
- share existing and proposed ocean acidification monitoring and research approaches, methods, and techniques;
- recommend efficient, robust, and cost-effective monitoring approaches;
- identify challenges and gaps in the development of a regional program to monitor the impacts of ocean acidification on coral reef ecosystems;
- explore the possibility, building on existing coral reef monitoring initiatives, of a joint long-term monitoring program on the impacts of ocean acidification on coral reefs, and of joint research on ocean acidification and its related changes/process in seawater chemistry in the region.

Based on outputs of the first workshop, the second regional workshop, supposed to be organized about 6 months after the first one, will focus on defining and agreeing upon a suite of metrics, which could discern, to the extent possible, attribution of changes to coral reef ecosystems in response to ocean acidification; recommend the most efficient, robust, and cost-effective monitoring approaches for these defined metrics; map gaps in current capabilities; and select pilot study areas for the application of the identified monitoring approaches.

The third workshop, one year after the second one, will be convened to evaluate and refine monitoring approaches, provide solutions to any technical problems incurred, and come up with a roadmap for the future.

Tentative Program for the first workshop

The first workshop will take place in Phuket, Thailand, 19-21 January 2015. The workshop would comprise plenary and breakout sessions.

During plenary sessions, invited keynote presentations will be given about ocean acidification, including changes in seawater chemistry, known and projected impacts on marine organisms and ecosystems at global and regional levels; global programs on ocean acidification research and monitoring efforts; and present practices of monitoring the ecological impacts of ocean acidificaiton on coral reef ecosystems. National experts

nominated and/or identified from each country will be invited to provide reports on research and monitoring efforts on the effects of ocean acidification on coral reefs, or related activities, in their respective countries.

The participants will break into several groups (probably by sub-regions) to have detailed discussions about gaps, challenges, and opportunities to initaite a cooperative regional network to monitor and conduct research on the impacts of ocean acidification on coral reef ecosystems.

Qualification of invited experts

Preferably two scientists will be invited from each country with one on marine biology with focus on coral reefs and coastal ecosystems, and the other on marine chemistry specialized in carbonate chemistry. Ideally, *they should have experience conducting ocean acidification related research and monitoring, and are able to lead and carry out ocean acidification research and monitoring in their countries moving forward.*

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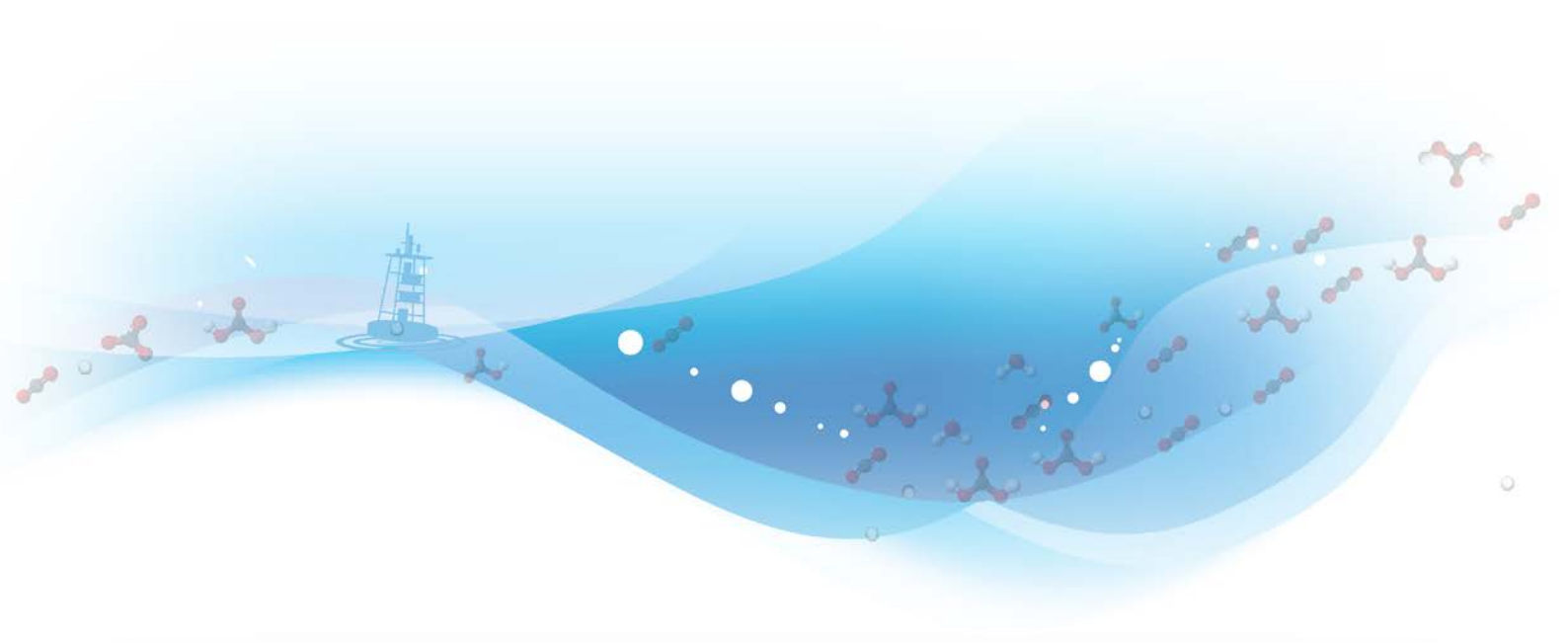


Information Note for Participants

Dear Participants,

Welcome to Phuket for the WESTPAC Workshop on Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems which will be held from 19 to 21 January 2015 at the Cape Panwa Hotel, Phuket, Thailand. To facilitate your travel preparation, please find below the information on logistic arrangements.

1. Workshop Venue

The workshop will be held at

Cape Panwa Hotel
27, 27/2 Mu 8, Sakdidej Rd. Cape Panwa, Phuket 83000 Thailand
Tel: (66) 76 39 1123-5 ext. 117
Fax: (66) 76 39 1177
Email: meeting@capepanwa.com
Website: http://www.capepanwa.com/

Free WiFi is available in the meeting room.

2. Hotel Accommodation

Sino House Phuket Hotel
1 Montree Rd., Talad –Yai, Muang Phuket 83000 Thailand
Tel: 66 76 232 494-5, 221 398
Fax: 66 76 221 498
Email: reserv@sinohousephuket.com, info@sinohousephuket.com
Website: http://www.sinohousephuket.com

Mei Zhou Phuket Hotel
1/5 Luangpoh Rd., T.Taladyai, A.Muang, Phuket 83000, Thailand
Tel: 66-76-233496-8
Fax: 66-76-233499
Website: www.meizhouphuket.com

PMBC will provide all participants with the hotel reservation service in order to ensure the application of a special rate set for participants to this workshop.

In-room internet WiFi: Free WiFi is available in the room.

Please contact Ms Varintha Vasinamekhim at varinthavasi@gmail.com with a copy to Ms Nachapa Saransuth (n.saransuth@unesco.org) and provide her with your flight itinerary to ensure hotel room reservation. Kindly note that hotel check-in starts at 13:00 hrs.

Please be advised to pay your hotel bills directly with the hotel upon your departure.

3. Airport Pick-up and Drop-off Service

WESTPAC and Phuket Marine Biological Center (PMBC) will provide assistance on local travel arrangement from and to Phuket International Airport.

All participants are requested to send your flight itinerary to Ms Varintha Vasinamekhim at varinthavasi@gmail.com with a copy to Ms Nachapa Saransuth (n.saransuth@unesco.org) to ensure the pick-up and drop-off time.

Picking up

When you enter the Passenger Hall, **please look for our representatives holding up a sign with "WESTPAC Ocean Acidification Workshop".** They will be standing in front of the exit from the customs checkpoint of International Arrival Hall.

In case of a flight delay or other unforeseeable circumstances, our representatives will wait for you. **In case that you can't find our representatives, please call our mobile for assistance at 66 (0) 83 909 9732 (Ms.Varintha Vasinamekhim) and 66 (0) 89 894 1690 (Ms Nachapa).**

Dropping off

We also arrange group transportation for dropping off all participants at the airport. The details and schedule of group transportation for your departure will be distributed during the meeting days.

4. Transportation between hotel and workshop venue

WESTPAC will also provide round trip transportation between the Sino House Phuket Hotel and the Cape Panwa Hotel (the workshop venue).

Picking up time on 19-21 January 2015: All participants are advised to meet at the lobby of the Sino House Phuket Hotel at 08:00 a.m.

5. Registration

The registration desk for the WESTPAC Workshop on Research and Monitoring of the Ecological Impacts of Ocean Acidification on Coral Reef Ecosystems will open on Monday 19 January 2015 from 08:30 a.m. in front of the meeting room "Tamarind" on the lobby floor of the hotel. For our reference, kindly provide the secretariat with your name card during registration.

6. **The Secretariat** will be located inside the meeting room.

7. **Coffee break** will be arranged for all participants outside the meeting room.

8. **Lunch** will be arranged free of charge for all participants on the days of the workshop, 19-21 January 2015 from 12:30-14:30 hrs.

9. **Welcome Dinner** is planned for the evening of Monday 19 January 2015 for all participants from 18:30 to 20:30 hrs at the Tangke Seafood Restaurant. Please feel free to wear casual clothing.

10. Visa Information

Participants requiring an entry visa to Thailand are strongly advised to contact the nearest Thai Embassy and Consulates in your country as soon as possible in order to secure the required entry visa prior to the departure.

Information on visa requirement and procedure can be found on the website of the Ministry of Foreign Affairs of the Kingdom of Thailand at http://www.mfa.go.th/main/en/services/123

11. Weather and Time Zone

In January, temperatures in Phuket range between 24ºC to 32ºC. Current weather conditions can be found at: http://www.worldweather.org/en/city.html?cityId=579

The standard time zone in Thailand is GMT/UTC +7 hours.

12. Currency

The currency in Thailand is Thai Baht (THB). The current exchange rate as at December 2014 is US$ 1 = THB 32.88. You can view exchange rates at www.xe.com.

Participants are advised to exchange some local currency prior to your departure, or at the airport upon your arrival. Alternatively, banks and exchange offices are widely available in the city.

13. Electricity

The electrical currents in Thailand are 220 volts with the following electrical outlets:

14. Disclaimer

WESTPAC Office disclaims all responsibilities for medical, accident and travel insurances, for compensation for death or disability compensation, for loss of or damage to personal property and for any other losses that may be incurred during travel time or the period of participation. In this context, **it is strongly recommended that participants will**

secure international medical, accident and travel insurances for the period of participation prior to departure.

Should you have any questions or require any assistance on the logistic arrangement, please feel free to contact:

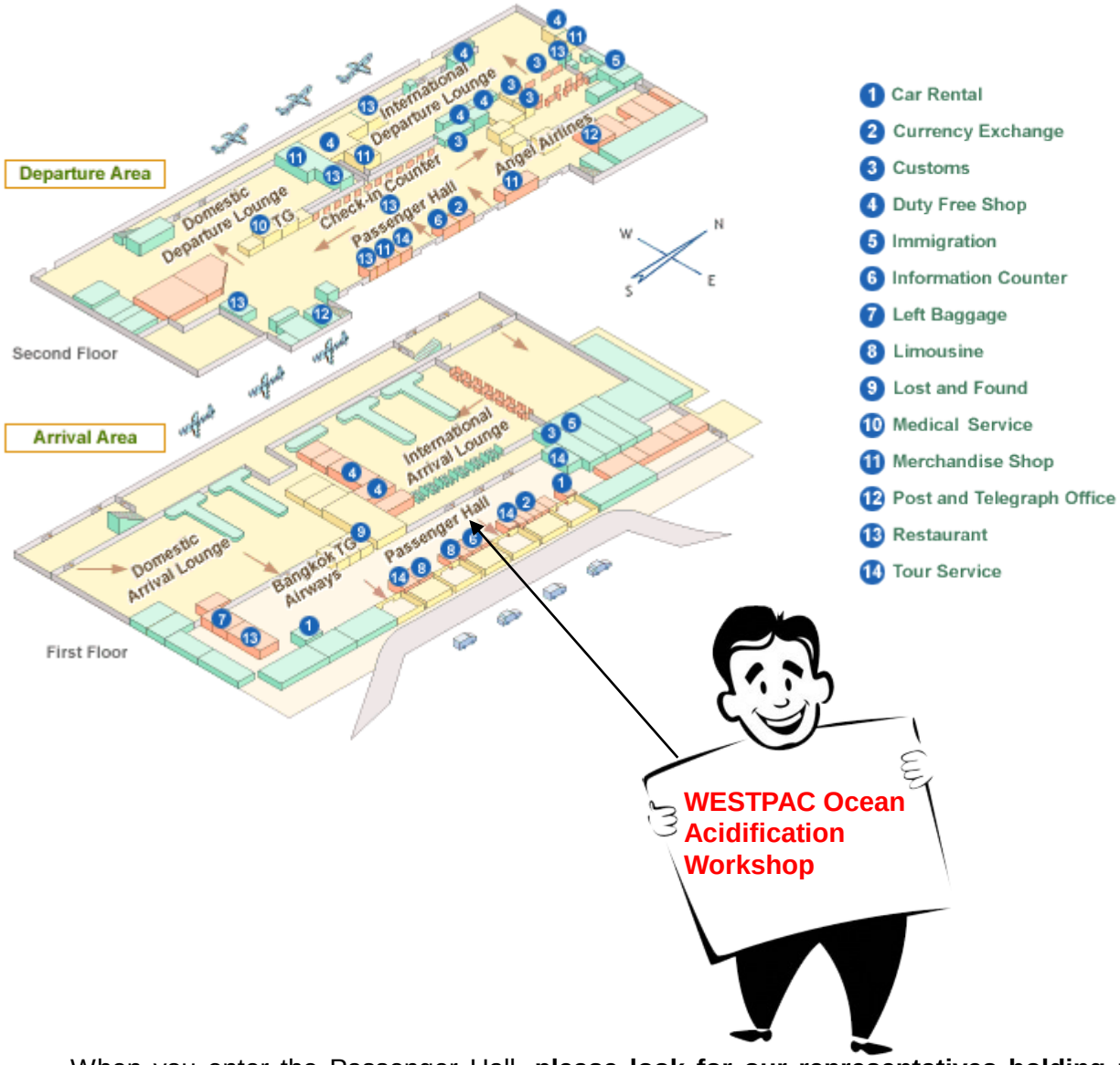
Phuket Marine Biological Center (PMBC)
Ms Varintha Vasinamekhim
Tel: +76 391 128; Fax: +76 391 127
Cell phone: +66 (0) 83 909 9732
Email: varinthavasi@gmail.com

Finally, we wish you a pleasant stay in Phuket, the Pearl of Andaman Sea!

IOC Sub-Commission for the Western Pacific (WESTPAC)

Annex A

Phuket Airport Terminal Map
(http://www.phuketairportonline.com/node/8)



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IOC Sub-Commission for the Western Pacific (WESTPAC)
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