CORAL REEFS OF THE ASIA PACIFIC:
WORKING TOGETHER AMIDST
CONTEMPORARY CHALLENGES

BOOK OF ABSTRACTS

4-8 JUNE 2018
CEBU CITY
PHILIPPINES

2018
APCRS

4th Asia-Pacific
Coral Reef Symposium

Contents

Conference Sessions

SESSION CODE	SESSION NAME
AAC	Adaptation and Acclimation of Coral Reef Species as a Response to Global Change
AMC	Assessment and Monitoring of Coral Reefs in the Asia-Pacific
BCC	Bioactive Compounds in Coral Reefs
BEC	Biodiversity and Evolution of Coral Reef Organisms
CRA	Coral Reef Assessment, Monitoring and Technological Methods and Innovations
CRG	Coral Reef Geology
CRM1	Emerging Trends in Coral Reef Management: Citizen Science for Reef Management
CRM2	Emerging Trends in CRM: Fisheries Ecology and Management
CRM3	Emerging Trends in CRM: MPA and Coral Reefs
CRO	Coral Reefs and Other Associated Ecosystems
CRR	Coral Reef Restoration: Research to Reality
DCC	Connectivity of Coral Reefs and other Habitats in the Asia-Pacific
EEM	Exploration and Ecology of Mesophotic Coral Ecosystems in the Asia-Pacific
GCL	Bringing Back the Giants: Best Practices, Management and Conservation Research on the Giant Clams
OA	Ocean Acidification
RTS	Response to Stressors: Natural and Human-induced
SC	Student Competition
TBE	Taxonomy, Biology, and Ecology of Cnidarians
TBO	Taxonomy, Biology, and Ecology of other Reef Organisms
PT	Plenary Talks
MS1	Oceans, Climate, and Coastal Communities
MS2	Biodiversity and Evolution of Coral Reefs in the Asia-Pacific
MS3	Amidst the Science of Coral Reefs: Why Talk About Financing?
MS4	Coral Reef Ecosystem Services and Impacts of Climate Change and Anthropogenic Disturbances
MS5	Sustainable Coral Reef Tourism

General Program

3 June (Sunday)							
1300/ 1700	Early Registration						
4 June (Monday)							
0800/ 0900	Registration						
0900/ 0945	Opening Program						
0945/ 1000	*health break*						
1000/ 1100	KEYNOTE SPEECH 1 **Speaker: Loren Legarda**						
1100/ 1200	KEYNOTE SPEECH 2: THE FUTURE OF CORAL REEFS: BRIDGING SCIENCE TO POLICY AND KNOWLEDGE TO ACTION **Speaker: Robert Richmond**						
1200/ 1330	*lunch*						
1330/ 1415	PLENARY SPEECH 1: CORAL REEFS OF EAST ASIA- MESSAGES FROM LONG-TERM MONITORING **Speaker: Loke Ming Chou**						
1415/ 1430	*health break*						
1430/ 1600	Grand Ballroom BCC	MNL A BEC	MNL B TBE	Hong Kong AMC	Shanghai CRG	Beijing SC	Seoul
1600/ 1800	Poster Sessions						
1800/ 2100	*welcome dinner*						

5 June (Tuesday)							
0830/ 0915	PLENARY SPEECH 2: BLUE FINANCE SOLUTIONS: INVESTING IN LIFE BELOW WATER **Speaker: Andrew Seidl**						
0915/ 0930	*health break*						
0930/ 1200	Grand Ballroom AAC	MNL A BEC	MNL B TBE	Hong Kong AMC	Shanghai CRO	Beijing SC	Seoul MS 1
1200/ 1330	*mentor-mentee lunch*						
1330/ 1415	PLENARY SPEECH 3: CONSERVING CORAL REEFS THROUGH THE LENS OF ECOLOGICAL AND EVOLUTIONARY HISTORY **Speaker: Danwei Huang**						
1415/ 1430	*health break*						
1430/ 1600	Grand Ballroom AAC	MNL A BEC	MNL B TBE	Hong Kong AMC	Shanghai WS 1	Beijing SC	Seoul
1600/ 1800	Poster Sessions						
1800/ 2100	*students' night*						
6 June (Wednesday)							
0830/ 0915	PLENARY SPEECH 4: VARIOUS CONNECTIVITY PROCESSES IN TROPICAL LAND-COASTAL-OCEAN COUPLING SYSTEMS UNDER CHANGING ENVIRONMENTAL CONDITIONS **Speaker: Kazuo Nadaoka**						
0915/ 0930	*health break*						
0930/ 1200	Grand Ballroom MS 3	MNL A RTS	MNL B TBO	Hong Kong AMC	Shanghai DCC	Beijing SC	Seoul MS 2
1200/ 1330	*lunch*						
1330/ 1415	PLENARY SPEECH 5: MANAGEMENT CHALLENGES IN MAINTAINING THE CONDITIONS OF INDONESIAN CORAL REEFS FROM INCREASING STRESSORS **Speaker: Jamaluddin Jompa**						
1415/ 1430	*health break*						
1430/ 1600	Grand Ballroom AAC	MNL A RTS	MNL B TBO	Hong Kong CRA	Shanghai WS 2	Beijing SC	Seoul
1600/ 1800	Poster Sessions						

7 June (Thursday)							
0830/ 0915	PLENARY SPEECH 6: THE RESILIENCE OF CORAL REEFS FROM LOCAL TO SYSTEMIC PERSPECTIVES Speaker: Peter Mumby						
0915/ 0930	*health break*						
0930/ 12:00	Grand Ballroom MS 4	MNL A RTS	MNL B TBO	Hong Kong CRA	Shanghai EEM	Beijing	Seoul
1200/ 1330	*lunch*						
1330/ 1415	PLENARY SPEECH 7: DENR POLICIES AND PROGRAMS FOR REEF MANAGEMENT IN THE PHILIPPINES Speaker: Crisanta Marlene Rodriguez						
1415/ 1430	*health break*						
1430/ 1600	Grand Ballroom CRM 3	MNL A RTS	MNL B WS3	Hong Kong CRA	Shanghai CRM 1	Beijing	Seoul
1600/ 1800	Poster Sessions						
1800/ 2100	*banquet*						
8 June (Friday)							
0830/ 0915	PLENARY SPEECH 8: SEX, DEATH AND CORAL RESTORATION Speaker: Peter Harrison						
0915/ 0930	*health break*						
0930/ 1200	Grand Ballroom CRM 3	MNL A RTS	MNL B CRM 2	Hong Kong CRR	Shanghai GCL	Beijing MS 5	Seoul OA
1200/ 1330	*lunch*						
1330/ 1500	Grand Ballroom CRM 3	MNL A RTS	MNL B CRM 2	Hong Kong CRR	Shanghai GCL	Beijing	Seoul
1800/ 2100	*farewell dinner and closing ceremonies*						

KEYNOTE SPEAKER 1

LOREN LEGARDA

Senator
Republic of the Philippines

Monday, 4 June 2018
1000 – 1100
Marco Polo Plaza Grand Ballroom

Senator Loren Legarda is a three-term senator who chairs the Senate Committees on Finance, Foreign Relations, and Climate Change.

As one of the country's leading champions for environmental protection, she has authored several landmark laws, namely, the Clean Air Act, Clean Water Act, Ecological Solid Waste Management Act, Environmental Awareness and Education Act, Renewable Energy Act, Disaster Risk Reduction and Management Act, Climate Change Act, and the People's Survival Fund Law. Aside from authoring legislation, as Chairperson of the Philippine Senate Committee on Finance, she ensured the funding of government programs aimed at improving the lives of Filipinos and promoting inclusive, sustainable and resilient development.

She has represented the Philippines in many important international assemblies. In 2013, she was Head of the Philippine Delegation to the 37th UNESCO General Conference in Paris, France. In 2014, Japan Prime Minister Shinzo Abe invited her as the lone Philippine delegate to join the World Assembly for Women in Tokyo, Japan. In 2015, Legarda was co-head of the Philippine delegation to the Third United Nations World Conference on Disaster Risk Reduction (3WCDRR) in Sendai, Japan. In 2017, she was Head of the Philippine Delegation to the 23rd Session of the Conference of the Parties (COP 23) to the United Nations Framework Convention on Climate Change (UNFCCC) in Bonn, Germany. In January 2018, she was the lone Philippine delegate to the 26th Asia-Pacific Parliamentary Forum in Hanoi, Vietnam. In March 2018, she was also Head of the Philippine Delegation to the 138th Assembly of the Inter Parliamentary Union in Geneva, Switzerland. In April 2018, she was Alternate Head of Philippine Delegation to the World Bank Group-International Monetary Fund Spring Meetings in Washington, DC, USA. She was again chosen as the Head of Philippine Delegation to the UN Climate Change Conference in Bonn, Germany in May 2018.

Her inspiring advocacy on environmental protection has earned her global recognition. She is the UNISDR Global Champion for Resilience and UNFCCC National Adaptation Plan Champion. She has been recognized as a Global Leader for Tomorrow by the World Economic Forum and a UNEP Laureate.

KEYNOTE SPEAKER 2

ROBERT RICHMOND

Research Professor and Director
Kewalo Marine Laboratory
University of Hawaii at Manoa

Dr. Bob Richmond is a research professor and director of the University of Hawaii's Kewalo Marine Laboratory. He received a PhD in Biological Sciences from the Dept. of Ecology and Evolution, SUNY at Stony Brook, and subsequently spent 2-years as a postdoctoral fellow at the Smithsonian Tropical Research Institute in Panama, 18 years on the faculty of the University of Guam Marine Laboratory, and has been a research professor at the Pacific Biosciences Research Center, University of Hawaii at Manoa, since 2004.

He has spent his career studying coral reef ecosystems in the Caribbean and the Pacific, including the Virgin Islands, the Grenadines, the Galapagos Islands, Hawaii, Japan and Micronesia. He has served as President of the International Society for Reef Studies, the convener for the 13th International Coral Reef Symposium, the science advisor to the All-Islands Committee of the US Coral Reef Task Force and a science advisor for the Joint Ocean Commission Initiative. He is both an Aldo Leopold Fellow in Environmental Leadership and a Pew Fellow in Marine Conservation. He presently serves as a member of the U.S. National Academies of Science expert committee on Interventions to Increase the Resilience of Coral Reefs.

His research interests include coral reef ecology, marine conservation biology, ecotoxicology, bridging science to management and policy, and the integration of traditional ecological knowledge with modern approaches to resource use and protection. His childhood fascination with "Dr. Doolittle" helped inspire his approach to studying coral reefs by "listening" to corals and other reef creatures through the use of ecological indicators and molecular biomarkers.

"The Future of Coral Reefs: Bridging Science to Policy and Knowledge to Action"

Monday, 4 June 2018
1100 – 1200
Marco Polo Plaza Grand Ballroom

Abstract

Both the value and plight of corals reefs are well established. During the past five decades, researchers have identified the key problems affecting reefs, including sedimentation, pollution, overfishing and climate change. We have also documented extensive losses, with an estimated 50% of reefs having been severely impacted during this period, as a result of human activities. Some reefs are thriving and have demonstrated the capacity for recovery from both local and global level stressors. Others have passed a tipping point and reached an alternate stable state, dominated by fleshy algae and are unlikely to recover without intervention. With the frequency and magnitude of mass coral bleaching events increasing since the 1980's, both ecological models and observational projections predict further losses and a future with coral reefs of lower biodiversity, structural complexity and ecosystem services. Interventions are under consideration, including active restoration, selective breeding for resistant genotypes, ecosystem engineering and genetic manipulation. The most recent assessment of coral reef status and trends indicate inaction is the path of greatest risk. New tools in biology such as genomics, proteomics, metabolomics and transcriptomics provide answers on how corals respond to stressors at levels from ecosystems to molecules and provide metrics to evaluate the effectiveness of management practices over periods of weeks to months rather than years to decades. The social sciences are also critically important to guide the changes in human behaviors responsible for coral reef losses. New approaches to valuing reefs and their ecosystem services support the political will needed at the policy level. As a community of practitioners, we need to energize efforts to better bridge the best knowledge to developing and implementing sound policies and actions if leaving a legacy of vital reefs for future generations is to be achieved.

PLENARY SPEAKER 1

CHOU LOKE MING

Adjunct Research Professor
Tropical Marine Science Institute
National University of Singapore

Prof. Chou Loke Ming is an adjunct research professor at the Tropical Marine Science Institute of the National University of Singapore. He obtained his PhD in Zoology from the University of Singapore in 1976 and has been with the university since 1977. His research on coral reef ecology and integrated coastal management covers Southeast Asia and he coordinated and edited the 2009 State of the Marine Environment Report for the East Asian Seas for the United Nations Environment Programme.

His current research focus is reef restoration and he is particularly interested in how corals can be re-established in the highly turbid conditions of rapidly developing coastal areas. Prof. Chou has been a member of the Scientific Advisory Committee of the Global Coral Reef Monitoring Network (International Coral Reef Initiative), serving as its chairman from 2003 to 2005. He is currently an honorary fellow of the Singapore Institute of Biology and a fellow of the Singapore National Academy of Science. He has provided consultancy services in the field of marine environment management to international agencies like UNEP, FAO and the World Bank, as well as many national agencies.

"Coral Reefs of East Asia - Messages from Long-term Monitoring"

Monday, 4 June 2018
1330 – 1415
Marco Polo Plaza Grand Ballroom

Abstract

The importance of coral reef monitoring cannot be underestimated as it provides the scientific basis for management. Interest in establishing the status of East Asia's coral reefs began in the 1970s amid widespread reef destruction from coastal development and destructive fishing. Survey methods differed among countries and trends across the region could not be meaningfully assessed. The 8-year ASEAN-Australia Living Coastal Resources project initiated in 1987 addressed this gap. A common survey method was agreed to between the five participating countries – Indonesia, Malaysia, Philippines, Singapore and Thailand. This allowed the first regional analysis of the status of Southeast Asia's coral reefs. Less than 20% of the 49 reefs monitored in the five ASEAN countries supported live coral cover in excess of 75% and many of the reefs showed a steady temporal decline of live coral cover. Reef monitoring has since expanded to include most countries of East Asia and a wealth of long-term monitoring data has been accumulated but its full potential has yet to be fully exploited. Summaries of country-based reef condition have appeared in the periodic status reports compiled by the Global Coral Reef Monitoring Network since 1981 and the Status of Coral Reefs in East Asian Seas reports published by Japan's Ministry of the Environment since 2006. Many messages can be uncovered from the database such as coral reef adaptation and or resilience to chronic or acute impacts. Community change apart from coral cover change can provide a better understanding of how coral reefs have responded to various impacts as well as to management action and such information can be obtained from the long-term monitoring data. There are sufficient data points to support more accurate and reliable analysis of trends. Such an effort requires effective collaboration between data providers, the willingness to share data and responsive participation in the data analysis process. A pilot project commenced recently with the sharing and analysis of long-term monitoring data by a few collaborating countries and the initiative will be expanded to include all East Asian countries.

PLENARY SPEAKER 2

ANDREW SEIDL

Professor, Colorado State University
Senior Technical Advisor,
Biodiversity Finance Initiative (BIOFIN)

Dr. Andy Seidl's work focuses on natural resource-based economic development. He employs economic approaches to help decision makers identify, quantify and capture the wealth of nature. He has been a senior technical advisor to the UNDP Biodiversity Finance Initiative (BIOFIN) since 2015. Part of the BIOFIN Global Team, he is directly responsible to Indonesia, Malaysia, Fiji, Belize and Brasil. He has been a professor & public policy specialist in the Department of Agricultural and Resource Economics at Colorado State University since 1997. From 2009-12, he was head of the Global Economics Programme, International Union for Conservation of Nature (IUCN), based in Switzerland. Previously, Andy was a natural resource economist at the Brazilian Center for Agricultural Research in the Pantanal (CPAP-EMBRAPA) in Brazil, and commodity analyst at the FAO in Rome, Italy.

Through Erasmus Mundus, Fulbright and other support, he has served as a visiting scholar at a variety of academic institutions, including the University of Trento, Italy, the University of Manchester, UK, Central European University, Hungary, and the Central American Institute for Business Administration (INCAE), Costa Rica.

His recent work appears in professional journals including Ecosystem Services, Tourism Economics, Ecological Economics, Journal of Regional Science, Journal of Environmental Management, Journal of Environmental Policy and Management, Journal of Environment and Development, and Economic Systems Research and in popular press including New Europe, the OECD Observer and World Conservation.

Dr. Seidl holds a BA in Economics and International Relations from the University of Wisconsin and a PhD in Food and Resource Economics from the University of Florida, USA.

"Blue Finance Solutions: Investing in life below water"

Tuesday, 5 June 2018
0830 – 0915
Marco Polo Plaza Grand Ballroom

Abstract

Sustainable Development Goal #14: Life Below Water seeks to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development.' Goal #14 has ten targets and associated indicators addressing concerns around ocean eutrophication and acidification, plastics, protected areas, small scale and subsistence fishing, unregulated commercial fishing, adequacy of protected areas, and special consideration for fragile coastal zones and small island developing states. Solutions to these global, regional and local challenges can include regulatory, technical, institutional and financial or economic tools, often employed in combination to reach the greatest degree of success for the least cost. In this talk, we will first explore the anthropogenic causes and consequences of coral reef damage and loss in the Asia Pacific Region. Next, we will draw on the economic valuation literature to highlight the dimensions and magnitude of the economic damage to social welfare due to human action, inaction and/or mismanagement of the benefits of healthy coral reef ecosystems. Finally, we will discuss the emerging case history of public and private sector driven solutions within the subsector of green finance and policy applied to marine and coastal management. Increasingly known globally as blue finance, examples of solutions toward achieving SDG #14 drawn from around the world potentially include: debt for nature swaps, green bonds, impact investment, environmental trust funds, biodiversity and natural infrastructure offsets and regulatory tools, marine protected/managed area finance tools, and climate funds for biodiversity. Highlighted solutions will be drawn from the experiences of UNDP Biodiversity Finance Initiative, the UN Convention on Biological Diversity, and the International Coral Reef Initiative among others. In this, the 3rd International Year of Reefs, it is high time we make the compelling case for public and private investment in healthy reefs for current and future generations.

PLENARY SPEAKER 3

DANWEI HUANG

Assistant Professor
Department of Biological Sciences
National University of Singapore

Danwei Huang focuses on the biodiversity, ecology and evolution of corals and reef-associated organisms. His work is based primarily on the coral reefs of Singapore and the Southeast Asian region. Using a variety of field, genetic and computational methods, and by integrating across morphological, genomic and phylogenetic approaches, his research team evaluates spatial and temporal patterns and drivers of reef biodiversity. Overall, the team is interested in how the environment and biological processes of the past have driven the present, and applies this information to project the future of coral reef biodiversity, distribution and health.

Danwei received his education and training at the National University of Singapore, Scripps Institution of Oceanography and University of Iowa, before returning to the National University of Singapore as a member of its faculty and the Reef Ecology Lab.

"Conserving coral reefs through the lens of ecological and evolutionary history"

Tuesday, 5 June 2018
1330- 1415
Marco Polo Plaza Grand Ballroom

Abstract

Anthropogenic impacts are endangering many coral reefs and reef species, leading to extinction and ecosystem declines. As ecological baselines shift rapidly, we are losing ground in understanding how biodiversity has changed. Clearly we need to maintain perspective on the histories of species and ecosystems to set biologically-relevant conservation targets. For corals, while long-term community-level data remain sparse, a consistent picture has been emerging for East and Southeast Asian reefs. Where reefs still thrive, coral cover appears to undergo decadal trends but changes are not strongly directional over longer timescales. However, pronounced changes in community structure have been recorded and these have serious implications for coral diversity and ecosystem functioning. For many reefs in the Asia-Pacific region, it may be difficult to disentangle anthropogenic effects from natural variabilities. Therefore it is important to extend the coral record back before human activity became dominant, and to integrate historical and modern-day approaches for understanding how coral reefs have managed to persist through time. Beyond the history of modern reefs, past diversity and distributional changes can be informative. In particular, examination of the selectivity of species losses during extinction events has provided important insights into the nature of the extinction process. Critically, corals susceptible to stresses and declines tend to be close relatives, and possible losses of evolutionary diversity and other biodiversity components may not be predicted by richness alone. Therefore, we need to consider the evolutionary and ecological histories of corals and reef regions explicitly when setting priorities to safeguard biodiversity.

PLENARY SPEAKER 4

KAZUO NADAOKA

Professor
School on Environment and Society
Tokyo Institute of Technology

Dr. Kazuo Nadaoka is a professor at the School of Environment and Society, Tokyo Institute of Technology. He is currently an executive board member of Japanese Coral Reef Society (JCRS) and a council member of International Society for Reef Studies (ISRS). He was also the former vice president of JCRS and chair of the Coastal Engineering Committee in Japan Society of Civil Engineers (CEC/JSCE).

His main research fields are coastal ecosystem conservation studies, integrated coastal zone management, and coastal oceanography & engineering. His recent research topics cover wide areas: 1) Analysis and prediction of multiple environmental stresses on coastal ecosystems, 2) Coastal ecosystem modeling for analyzing its dynamic response to various anthropogenic impacts and global environmental changes, 3) Monitoring and modeling of physical and bio-chemical processes in coastal zones, 4) Development and application of remote sensing methods to monitor coastal environments, 5) Reef connectivity study for establishing desirable MPA networks based on larval dispersal simulation and population genetics, 6) Establishing a decision support system for ICZM, and 7) Comprehensive assessment and conservation of blue carbon ecosystems and their services.

"Various connectivity processes in tropical land-coastal- ocean coupling systems under changing environmental conditions"

Wednesday, 6 June 2018
0830 – 0915
Marco Polo Plaza Grand Ballroom

Abstract

For properly understanding and predicting coastal ecosystem dynamics under changing local and global environmental conditions, various "connectivity" processes should be considered in additional to reef connectivity process, because any coastal ecosystem including reef ecosystem is an open system strongly connected with all the surrounding systems. Some recent examples of the development of integrated computer simulation models in our research group will be introduced for highlighting the importance of coupling approaches for elucidating and predicting the connectivity processes. The first example is development and application of an atmosphere-watershed-coastal ocean coupled model for analyzing coastal turbidity dynamics under complex terrestrial loads characterized by a 'stress connectivity matrix'. The model system was applied to Panay Island in the Philippines for elucidating causal relationship between an inter-watershed terrestrial system and coastal turbidity which may cause decline of seagrass beds. The second is the development of an integrated model system for analyzing possible linkage between the outbreak of crown-of-thorns starfish (COTS) (*Acanthaster planci*) and terrestrial system. The model system is a coupling of a nested 3-D ocean current model, low-trophic coastal ecosystem model, terrestrial runoff model, COTS population dynamics model and COTS larval dispersal model, and has been applied to Sekisei Lagoon in Japan. As the last example, an on-going 5-years project under SATREPS program by JST-JICA entitled "Comprehensive assessment and conservation of blue carbon ecosystems and their services in the Coral Triangle (*Blue*CARES)" will be introduced. As one of the main subjects, this project is aiming at developing an integrated model system to analyze and predict blue carbon ecosystem dynamics under changing local and global environmental conditions. The model system is a multi-scale coupling model with local-scale models like coral reef model, seagrass bed model and mangrove model and regional-scale models based on a nested 3-D ocean current model, bio-geochemical ocean model and terrestrial model to properly introduce the part of green carbon contribution in the entire carbon dynamics in the Coral Triangle region.

PLENARY SPEAKER 5

JAMALUDDIN JOMPA

Senior Lecturer
Faculty of Marine Science and Fisheries
Hasanuddin University

Prof. Jamal Jompa received his PhD at the 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 formerly served as dean of faculty of Marine Sciences and Fisheries at Hasanuddin University (UNHAS) (2013-2017). In the past few years, he also has been involved in various programs of the Indonesian Academy of Science (AIPI), including chairing the study committee of Indonesian Science Agenda and now serving as the president of Indonesian Young Academy of Science (ALMI). From 2004-2013, he served as director of research and development at the Center for Marine, Coasts, and Small Islands, UNHAS. 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. He is also active in several organizations including serving as the secretary general of Indonesian Coral Reef Society, chairman of South Sulawesi Sea Partnership Program, president of Association of Diving School International-Indonesia, member of National Fisheries Stock Assessment, etc.

In 2007, in addition to his ongoing duties at UNHAS, 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 and successfully brought the project to a successful completion in December 2011. Jamal is now the chairman of the Center of Excellence on Marine Resilience and Sustainable Development (MARSAVE) at UNHAS, MARSAVE welcomes any parties/individuals to collaborate in education, training, research, and development to save our ocean!

"Management Challenges of Maintaining the Conditions of Indonesian Coral Reefs from Increasing Stressors"

Wednesday, 6 June 2018
1330 – 1415
Marco Polo Plaza Grand Ballroom

Abstract

Indonesian coral reefs, at the center of Coral Triangle biodiversity hotspot, have experienced long term degradation due to destructive fishing practices, overfishing, coral mining, sedimentation, pollution, eutrophication, anchoring, predators, and recently from coral diseases and global warming. Global warming has caused serious coral mortality due to mass bleaching around the globe in the last decades. Emerging diseases and more frequent outbreaks of coral predators such as Crown of Thorns starfish have also occurred in many reefs. Due to long-term pressure and decreased population of herbivores and increase of nutrient inputs, many reefs have experienced phase shift from coral to rubble, sand, or algal dominated reefs. Combinations of these factors have contributed to coral reef degradation in Indonesia, where only around 5% of coral reefs remain in very good condition. Science based adaptive and effective management strategies have to find the delicate balance among and between the people and the reefs to create more resilient and productive coral reef ecosystems. Contemporary strategies include: introducing Marine Protected Area Networks, ecosystem approach for reef management, community based and co-management, strong and effective regulations and proactive coral restoration. Can these solve the increasing and alarming pressures on the reefs, with potential benefits to people and ecosystems? We illustrate some of these challenges, and the potential solutions, with examples from eastern Indonesia.

PLENARY SPEAKER 6

PETER MUMBY

Professor
School of Biological Sciences
University of Queensland

Prof. Peter Mumby began his career helping to design marine reserves in Belize and experienced first-hand the limited scientific basis for decision-making. He then began a research pathway with a goal of providing science that can inform practical conservation and management action. His research combines field observations, experiments, remote sensing, and ecological modelling to answer questions about ecosystem resilience, impacts of climate change, marine reserve functioning and design, connectivity of ecosystems, coral reef fisheries, and marine spatial planning to capture ecosystem services. To achieve this, Peter's students and post-docs work on a variety of taxa and processes including corals, algae, sponges, herbivory, predatory fishes, food web models, metapopulation models, and so on. He collaborates extensively with friends in other fields including economics, engineering, oceanography, and business.

Peter undertook a PhD at the University of Sheffield (UK), followed by a NERC post-doctoral fellowship at the University of Newcastle. This was followed by a Royal Society fellowship at the University of Exeter (UK), and a move to Brisbane to take up an ARC Laureate Fellowship in 2010. Peter is a Pew Fellow in Marine Conservation and winner of the Rosenstiel Award for Contributions to Marine Biology, Marsh Award for Marine Conservation, and the inaugural ISRS Mid-Career Award for contributions to reef science. He is happiest on a coral reef with a camera in his hands.

"The Resilience of coral reefs from Local to Systemic Perspectives"

Thursday, 7 June 2018
0830 – 0915
Marco Polo Plaza Grand Ballroom

Abstract

Most studies of the mechanisms underpinning reef resilience have been undertaken at the scale of individual reefs. At this local scale there remain significant questions over the environmental and ecological conditions that precipitate critical losses of resilience and regime shifts to alternative stable states. We begin by resolving the drivers of resilience and risks of regime shifts for Pacific coral reefs and focus on how changing the time scale of analysis can explain some surprising reef dynamics. We then step back and consider resilience across the entire seascape and the role played by connectivity and large-scale disturbance. Here, we identify a strategy to facilitate wider reef recovery that builds systemic resilience. The Great Barrier Reef possesses around 100 reefs that are perfectly aligned to promote coral recovery after major disturbances including bleaching. Not only are these reefs relatively unliely to experience disturbance but they have exceptionally important levels of larval connectivity that can begin a cascade of recovery. We discuss how such patterns are being used to increase the resilience of the GBR.

PLENARY SPEAKER 7

CRISANTA MARLENE RODRIGUEZ

OIC Director
Biodiversity Management Bureau
Department of Environment and Natural Resources

Dir. Crisanta Marlene P. Rodriguez is a forestry graduate from the University of the Philippines Los Baños, with a post-graduate degree in environmental protection management in Bicol University Graduate School. She rose from the ranks as a forester and is currently the newly appointed director of the Philippine's Department of Environment and Natural Resources - Biodiversity Management Bureau (DENR-BMB).

Her role then as a community environment and natural resources officer, assistant regional director for technical services, and regional director of DENR V, moulded her knowledge in addressing key environmental concerns which include biodiversity, climate change adaptation, environmental law enforcement, air shed protection, foreshore management, land titling and environmental governance.

Being the new person-in-command of the DENR-BMB, one of her marching orders is to immediately get on board to rehabilitate the pollution-challenged Boracay Island, a top global beach destination.

As a budding manager, she is able to integrate her experiences on the ground and conform with emerging perspectives and technologies of the present generation.

"DENR Policies and Programs for Reef Management in the Philippines"

Thursday, 7 June 2018
1330 – 1415
Marco Polo Plaza Grand Ballroom

Abstract

The story of coral reef management in the Philippines has been evolving – from seeing the signs of habitat degradation and depletion of fisheries and determining the nationwide state of the reefs in the 1970s, to the rise of community-based resource management (CRM) in the 1980s, to building local government capacity through the Coastal Resources Management Project, to adopting the ridge-to-reef approach through the Integrated Coastal Resources Management Project, and to promoting sustainable management while improving socioeconomic conditions of coastal communities through the Sustainable Coral Reef Ecosystem Management Program in the 2000s.

As issues identified from previous initiatives in CRM continue to prevail, it is paramount to learn from these efforts and understand the current situation alongside the factors that underlie complex problems. A holistic programmatic framework that envisions an effectively-managed coastal and marine biodiversity and employs science-based policies, integrated approaches, and precautionary principles should thus be implemented as an urgent intervention.

The Coastal and Marine Ecosystems Management Program (CMEMP) of the Department of Environment and Natural Resources is the Philippine government's nationwide program (2017-2028) designed to comprehensively and effectively reduce the drivers and pressures to the coastal and marine environment and ensure the sustainability of ecosystem goods and services for the benefit of present and future generations of Filipinos.

Implementation of the CMEMP which involves updating the nationwide baseline data through habitat assessment and mapping, building capacities, transforming behavior, strengthening multi-sectoral partnerships, and supporting biodiversity-friendly enterprises will help refine existing policies, apply site-specific interventions, and harness appropriate technologies. Only through solid and sound science, rational planning, and strong monitoring can strategic policies be developed and long-term, sustainable management of the ever-evolving challenges of the coastal and marine environment be achieved.

PLENARY SPEAKER 8

PETER HARRISON

Director
Marine Ecology Research Center
Southern Cross University

Prof. Peter Harrison is the founding director of the Marine Ecology Research Centre at Southern Cross University, Australia. Peter is an internationally recognised researcher on coral reproduction ecology and has been actively researching and teaching a wide range of marine science and ecology programs for more than 35 years. He was a key member of the coral research team at James Cook University that discovered the mass coral spawning phenomenon on the Great Barrier Reef, resulting in a Eureka Prize for Environmental Research with colleagues. He is passionate about marine ecology and environmental science and their applications to conservation management, and has led many successful international and national research projects and teams including work for the UN.

His current major research focus is coral restoration and he leads a 1.2 million USD grant from ACIAR to develop the world's first large scale coral reef restoration project using millions of coral larvae to restore damaged reefs in the Philippines, working with colleagues from the University of the Philippines. He has been awarded more than 10 million USD in research grants and Antarctic field support and published more than 150 scientific research papers, books, invited major review chapters and major reports. He has successfully supervised more than 50 postgraduate and Honours students, and been awarded various prizes for excellence in science research and University teaching. He also manages the whale and dolphin research at SCU, and was a long-term member of the Australian Threatened Species Scientific Committee. He has also been appointed to a wide range of other science and environmental management research panels, and enjoys communicating scientific research discoveries and their implications for managing our extraordinary planet.

"Sex, Death and Coral Restoration"

Friday, 8 June 2018
0830 – 0915
Marco Polo Plaza Grand Ballroom

Abstract

Sexual reproduction is essential for the maintenance, recovery and evolution of hermatypic coral populations and communities that form the foundation of reef ecosystems. The global coral crisis resulting from human impacts has decimated breeding corals on many reef systems, which threatens the integrity of reef communities and reef function. Coral populations are naturally resilient but when larval supply becomes limiting, natural recruitment rates fail to restore depleted populations. Passive management for conservation is proving inadequate for promoting reef recovery; therefore active interventions and effective restoration techniques are urgently needed. Most coral restoration projects have used fragmentation, nursery rearing and transplantation, but relatively few projects have been successful and most are small scale and relatively expensive with limited genetic diversity. Mass coral spawning events provide access to many millions of genetically diverse larvae that can be used for larger-scale larval rearing and settlement to enhance recruitment on recoverable reef areas. Recent larval restoration field experiments in the Philippines have demonstrated that supplying millions of larvae directly onto reefs can significantly enhance larval settlement and recruitment rates, even on degraded reef systems. Juvenile coral survivorship stabilises after six to nine months, and rapid colony growth can produce sexually reproductive adults within three years, thereby rapidly re-establishing breeding coral populations and initiating restoration of degraded reef areas. The challenge now is to engineer coral and reef restoration at larger reefal scales to sustain genetic diversity and enhance evolutionary potential in the Anthropocene era plagued by increasing climate change impacts and other anthropogenic threats.

oral presentations

AAC-1-371

Evaluating the influence of parental thermal conditions on transgenerational plasticity of a coral reef fish (*Acanthochromis polyacanthus*)

Moises A Bernal, Jennifer Donelson, Philip Munday, Timothy Ravasi

Global climate change is broadly recognized as one of the major threats to marine ecosystems. It has been estimated that an increase in sea surface temperature could compromise the persistence of multiple species, as thermal conditions directly influence a plethora of physiological processes. However, in the particular case of coral reef fishes, studies with *Acanthochromis polyacanthus* indicate that metabolic and reproductive compensation to elevated temperatures is possible when fish lineages are exposed to elevated temperatures for several generations. This growing body of research suggests transgenerational plasticity is an important mechanism for acclimation to warmer conditions. However, it is still unclear whether metabolic compensation observed in juveniles is influenced by thermal experience of previous generations, developmental conditions of juveniles themselves, or a combination of both. Phenotypic traits and patterns of liver gene expression were evaluated in third-generation offspring whose grandparents, parents and themselves had been subject to various combinations of normal present-day temperatures or warm water conditions (+1.5°C). Abnormal years with elevated temperatures can be beneficial to future generations if compensation in third-generation juveniles can be mostly attributed to grandparental and parental developmental conditions. Alternatively, if juveniles require exposure to elevated temperatures to achieve metabolic compensation, prolonged warm water conditions across generations would be necessary to initiate beneficial plasticity. The results from this long-term study represent a step forward in understanding the molecular mechanisms of transgenerational plasticity, which is essential to elucidate the response of coral reef fishes to the imminent effects of climate change in coming decades.

AAC-2-65

Elevated water temperatures affect predator-prey interactions of selected reef fish species

Miya Isabelle McGlone, Patrick Cabaitan

Thermal fluctuations in the ocean can affect different behavioral capacities of marine organisms, and short-term increases in average temperatures are known to affect prey escape behavior and predatory behavior in reef fish. However, studies have yet to focus on determining the effects on predator-prey interactions of short-term increases beyond the current water temperature limits, which may possibly be brought about in the future by anthropogenic-driven climate change. This study examined the effect of elevated temperatures on predator-prey interactions by comparing the behavioral responses of predator and prey reef fish species exposed to elevated temperatures both within and above current thermal thresholds, with the thermal regimes being at ambient condition (29°C) and elevated conditions (32°C and 34°C). Initial experiments were conducted on the predator (*Epinephelus merra*) and prey (*Chromis viridis*) over a period of 3 days. Observations were made in triplicate on individual behavioral changes of prey and predator individuals placed in tanks alone, and on changes in predator-prey interactions by placing a prey and predator together. Preliminary findings show that shoaling and sheltering behavior of prey fish may differ with moderate (32°C) versus higher (34°C) increases in temperature. However, water temperature changes did not highly alter the behavior of the predator species, with their hiding behavior remaining consistent throughout trials. Alterations in predator-prey interaction were also observed, with searching behavior of predator and hiding behavior of prey being heightened in particular with moderate increases in temperature (32°C). Understanding the implications of climate change-driven temperature changes in altering predator-prey interactions is important for determining the possible extent of changes in future predation pressures and subsequent effects on reef fish community structure and function.

AAC-3-224

Epigenetic modifications and differential gene expression in *Acropora digitifera* during heat acclimation

Sarah Lemer, David Combosch, Bernardo Lemos

Scleractinian corals vary in their susceptibility to bleaching in response to increased sea water temperatures. For example, corals previously subjected to high temperatures have shown higher resilience towards subsequent heat stress. One hypothesis to explain this intraspecific variation is phenotypic plasticity generated by epigenetic modifications after exposure to sub-lethal heat stress leading to differential gene expression patterns. We investigated this hypothesis by exploring both gene expression and DNA methylation changes in *Acropora digitifera* collected on Guam. We acclimatized clonal fragments of *A. digitifera* to two temperature regimes for 8 days in flow through tanks: ambient (29C) and increased temperature (32C). We then submitted all coral fragments to an acute heat stress for 4 hours (35C). Twenty-four hours after the acute heat stress, individuals acclimated to increased temperature showed only mild bleaching while all individuals acclimated to ambient temperature showed signs of severe bleaching and 20% died. Tissue samples for RNA and DNA extractions were collected at different steps during the experiment: after 7 days of acclimation to high and ambient temperature, after 1 hour at 35C and 24 hours after the acute heat stress. Differential gene expression analyses were conducted between the two acclimation groups. In parallel, a whole genome bisulfite sequencing approach was implemented to explore DNA methylation changes occurring between the two acclimation groups during the experiment. Here, we present and discuss our ongoing research on transcriptome and methylome responses to heat acclimation.

AAC-4-398

Hope for the future? Tolerance to temperature and salinity changes of *Platygyra* and *Acropora* coral larvae from marginal environment, Hong Kong

Apple Pui Yi Chui, Put O. Ang

Elevation of sea surface temperature is projected under global climate change, and future increase in precipitation extremes related to the monsoon is also expected. Thus, the lowering of salinity could become a more common phenomenon and its impact on corals could be significant as extreme precipitation usually occurs during the coral spawning season. Here we investigated the interactive effects of temperature [24, 27 (ambient), 30, 32 ℃] and salinity [33 psu (ambient), 30, 26, 22, 18, 14 psu] on larval settlement and post-settlement survival of the corals *Platygyra acuta, Acropora pruinosa* and *A. valida* from Hong Kong, a marginal environment for coral growth. The results indicated that elevated temperature (+3°C ambient) may not have significant effects on settlement and post-settlement survival of all coral species examined for up to 30 days of prolonged exposure. The robustness of *P. acuta* settlement and post-settlement survival, however, was affirmed with no significant effect of elevated temperature detected up to +5°C ambient for up to 56 days. The two *Acropora* species revealed an inconsistent effect, with negative effects on settlement and post-settlement survival recorded in *A. valida* and *A. pruinosa*, respectively. Interestingly, a protective effect of elevated temperature (+3°C ambient) in enhancing larval settlement under lowered salinities of 26 psu and 30 psu were observed in *P. acuta* and *A. pruinosa*, respectively. This ability to extend the range of tolerance to reduced salinity with a slight increase in temperature suggests a great flexibility of coral settlement to cope with environmental changes. Overall, these coral species that have long pre-empted the space and shaped the community structure in Hong Kong will likely persist in a warmer and intermittently less saline, future ocean.

AAC-5-514

Subtropical temperature regimes support persistence but not proliferation of corals

Shelby E McIlroy

Ocean warming is accelerating, leading to an increasing prevalence and severity of mass coral bleaching through the global tropics. Concomitant to this extirpation is the poleward range expansion of species into marginal, sub-tropical and temperate regions with wider annual temperature ranges and lower minimum temperatures. As such, poleward expansion is posited as a mechanism for coral persistence in the Anthropocene. Extant coral communities in environments with high seasonality provide key information to understand the physiological trade-offs associated with adaptations to more variable and cooler environments and to predict potential range expansions. We followed natural variability in holobiont metabolism in five common coral species within an environment that varies annually from 14 to 31ºC. Thermal performance curves broadly divided the metabolic strategy by either a uni-modal or relationship between productivity and temperature and revealed that many sub-tropical corals have shifted their temperature optima lower by 4-7 ºC relative to tropical counterparts. However, a bimodal distribution of temperature frequency with proportionally more time spent at seasonal extremes rather than the annual mean meant that no strategy observed was able to optimize productivity beyond approximately half the days of the year. Thus coral proliferation within the sub-tropics will be limited by constraints on rapid reef accretion.

AAC-6-604

Variability in the thermal stress response of four coral species from Bolinao, northwestern Philippines

Jeric Da-Anoy, Cecilia Conaco

Corals exhibit different responses to environmental disturbances, such as elevated sea surface temperatures. This variability shapes coral community structure in the face of a changing climate. However, little is known about specific effects of thermal stress on corals inhabiting Philippine waters. In this study, we assessed the physiological and transcriptomic responses to elevated temperature of *Acropora digitifera*, *Favites colemani*, *Montipora digitata*, and *Seriatopora caliendrum*, from Bolinao, northwestern Philippines. These corals harbor different dominant *Symbiodinium* types. Upon exposure to thermal stress, *S. caliendrum* and *M. digitata*, but not *A. digitifera* and *F. colemani*, exhibited a significant decrease in photochemical efficiency and symbiont density. Shifts in gene expression induced by elevated temperature were detected in all species, although overall transcriptome profiles were highly variable across biological replicates. Thermal stress-responsive transcripts originated mostly from the coral host rather than the symbionts. *S. caliendrum* exhibited the greatest number of differentially expressed transcripts, with an enrichment for genes involved in cell signaling, cell proliferation, cell adhesion, immune response, proteolysis, and apoptosis. Based on physiological and transcriptomic responses, it is evident that the impact of elevated temperature is influenced not just by symbiont type but also by host-specific factors. This highlights the importance of further comparative studies on corals and symbionts from different regions to gain insights into potential mechanisms mediating their responses to recurring thermal stress events.

AAC-7-629

East meets West: Identifying the Common Denominators that Drive Coral Bleaching Resistance and Resilience in the Atlantic and Pacific

Derek Manzello

Identifying the factors that lead to bleaching resistance and resilience is an urgent priority given the catastrophic consequences of recent large-scale bleaching events and the global decline of coral reefs. This presentation will present research from inshore reefs in the Florida Keys that have exhibited unexpected bleaching resilience and have key similarities with bleaching resilient sites in Palau and Singapore. The Florida Keys have experienced seven mass bleaching events since 1987. Coral cover has declined to ≤ 5% on offshore reefs. An exception to this trend is found on the inshore patch reefs located between the islands of the Florida Keys and offshore reefs, where coral cover is ca. 15-35%. This is counter-intuitive because inshore sites experience marginal conditions for reef development (greater thermal variability, increased turbidity/depressed light, increased sedimentation). 2015 and 2014 were the warmest and second warmest years on record, respectively, for the Florida Keys. Despite increased thermal stress in 2015, both bleaching and mortality significantly declined in > 4000 corals that have been monitored with photo-mosaics since 2012 at an inshore study site. Total colony mortality was low with 94.7% of colonies surviving. The reduction in bleaching severity and mortality with a second stronger thermal anomaly suggest that acclimatization may be possible with short recovery. We found that inshore sites, despite higher temperatures (+0.5-1.2°C) demonstrated better recovery and often higher bleaching resistance that offshore sites. For the endangered coral species *Orbicella faveolata*, we found that host genotype influenced the proportion of thermotolerant clade D symbionts, bleaching resistance, as well as how much heat tolerance was gained by hosting clade D. We will compare the similarities and differences between the trends from Florida with those in Palau and Singapore with a goal of highlighting those reef areas that may be adapted and/or acclimatized to thermal stress.

AAC-8-155

Short-term exposure to heat and sediment triggers changes in coral gene expression pattern and photo-physiological performance

Rosa Celia Poquita Du, Loke Ming Chou, Danwei Huang, Peter Alan Todd

Corals are known to exhibit a suite of mechanisms for survival under stressful conditions. However, due to their close association with photosynthetic algal symbionts, our understanding of how the coral host (alone) responds to varying environmental conditions remains unclear. In this study, we tested two relevant environmental factors that are known to have deleterious impacts on corals: heat and sediment. We examined among-genotype responses of Pocillopora acuta to individual and combined factors with RNASeq in concert with widely-used tools for assessing physiological conditions of corals. Coral fragments from different genotypes of P. acuta were exposed to the following conditions: (1) sediment-only (~30°C, with sediment), (2) heat-only (~32°C, no sediment), (3) heat + sediment (~32°C, with sediment) and, (4) control (~30°C, no sediment), over four consecutive days (5-h daily exposure) in ex situ controlled conditions. A clear differentiation in gene expression pattern was observed in corals exposed to heat alone and in heat with sediment. Very few transcripts (~3) were found to be differentially expressed for corals exposed to only sediment, suggesting heat is the key driver of changes in gene expression levels. This is corroborated by photo-physiological measurements which showed significant effects of heat on maximum quantum yield and average symbiont density among genotypes of P. acuta. Furthermore, we were able to characterise host-specific genes that were expressed differentially which may not be related to their interactions with algal symbionts. These genes are involved in a variety of biological functions including, but not limited to, cilium biogenesis and degradation; cilia motility, innate immune response and processes involved in the cell cycle, and implies a more complex response driven by the host alone.

AAC-9-426

Corals in a Changing Climate: Exploring the capacity for transgenerational acclimation in the reef building coral, *Pocillopora damicornis*

Crystal McRae

Coral reefs are in crisis. Dramatic declines in corals globally pose a threat to the many marine organisms that use these critical ecosystems, and the millions of people that depend on their services. There are many reasons for coral decline, including natural and human-induced local stressors; however, climate change-induced ocean warming is a chronic anthropogenic global stressor that poses the greatest threat to the persistence of corals. Given the time lag of effect for any reductions in greenhouse-gas emissions, novel interventions are necessary. Of particular interest is assisted evolution, which might harness the capacity to increase coral resilience by enhancing their thermal tolerance. Building on foundational work exploring this approach, I assessed the potential for transgenerational acclimation in the reef-building coral Pocillopora damicornis at the larval and recruit stages. Parental colonies collected from southern Taiwan were held for 3 months at 25°C or 29.5°C (n=12 colonies/treatment), and their offspring were in turn allowed to settle and grow at both 25°C and 29.5°C. A shift in reproductive timing between treatments was observed across all study months, with colonies in the 29.5°C treatment consistently releasing larvae earlier in the lunar cycle. No difference in larval length was observed during the first month of reproduction, but in the following months larvae in 29.5°C water were significantly smaller. In contrast, there was no difference in larval Fv/Fm between treatments over the 3 months of reproduction. Analysis of recruit settlement rates, survival, growth, and Fv/Fm data is underway. These findings will shed light on (1) the feasibility of enhancing thermal tolerance of corals by transgenerational acclimation, and (2) the influence of increased temperature on two critical coral life-history stages: reproduction and recruitment.

AAC-10-278

Selective breeding of white and colored corals for thermal tolerance

Yuna Zayasu, Chuya Shinzato, Noriyuki Satoh

Previous studies have demonstrated that fluorescent and non-fluorescent proteins impact corals in all life history stages. Colored colonies have relatively better survival rates than white colonies in warmer waters. In this study, we assessed whether different responses to thermal stress among sympatric colonies are inherited. Gametes from three *Acropora tenuis* color morphs, white (4 colonies), yellow (5 colonies) and green (1 colony) were cross-fertilized and raised. Thirty planula larvae from each of 39 different cross-combinations were exposed to thermal stress for 7 days under the following conditions: dark, without symbionts, at three water temperatures (27°C, 30°C, 33°C). Larval survival rates differed significantly between water temperature treatments. Survival rates of larvae also differed significantly for each cross-combination at 30°C and 33°C. We also found that survival rates of planula larvae under thermal stress were significantly higher when the two parents had different color morphs, and when eggs came from colored colonies. These results indicate that thermal tolerance is at least partially heritable, especially from the maternal side. Moreover, they confirm the importance of maintaining morphological and/or genetic diversity in each population.

AAC-11-46

The effect of temperature on growth and toxicity of the benthic dinoflagellates *Coolia malayensis* and *C. canariensis* isolated from Hong Kong waters

Meng Yan, Priscilla TY Leung, Jiarui Gu, Xin Li, Veronica TT Lam, Tak-Cheung Wai, Sam KF Yiu, Paul KS Lam

The emerging threat of benthic and epiphytic toxic algae (BETA) to coral reef ecosystems has attracted worldwide attention. Seawater temperature is one of the major factors influencing the growth and distribution of BETA. *Coolia* spp. are one of the cosmopolitan group of BETA, and are potentially toxic. In this study, we aimed to elucidate the effect of different seawater temperatures on growth performance, photosynthetic responses, toxicity, and transcriptome profile of *C. malayensis* (a toxic species) and *C. canariensis* (an apparent non-toxic or less toxic species). *Coolia* monocultures were exposed to 7 temperatures i.e., 16, 18, 20, 22, 24, 26 and 28°C. At each temperature, *Coolia* were acclimated for at least 5 generations before sampling for growth curves determination and photosynthetic parameters measurement. In addition, the amount of phaeo-pigments (Chl *a*, Chl *b*, Chl *c* and carotenoids) were estimated by the spectral absorbance at wavelengths 750 nm, 664 nm, 647 nm, 630 nm, 510 nm and 480 nm. In general, *Coolia* showed intra-specific variations under temperature effects in terms of growth and photosynthetic response. Our results showed that the optimal temperature for growth of *C. malayensis* was 24°C while its photosynthesis was steady across the range of temperatures. The growth rate of *C. canariensis* was highest at 20°C. Lower temperatures, i.e., 16 and 18°C inhabited its growth and photosynthesis. The amount of phaeo-pigments (in 1 x 10^5cells) reached the highest at 26°C for both *C. malayensis* (3.06 µg/ml) and *C. canariensis* (15.61 µg/ml), but the level reached the lowest at 20°C for *C. malayensis* (0.90 µg/ml) and at 16°C for *C. canariensis* (2.76 µg/ml), suggesting that *Coolia* may produce more pigments as temperatures increased. With more upcoming results on toxicity characteristics and transcriptome profiles, we could have gain further insight on possible mechanisms that would associate with different toxicities of *Coolia* species at different temperatures.

AAC-12-239

Subtle winter temperature difference could affect *Drupella* corallivorous activity, hence the survival potential of *Acropora* in a marginal non-reefal community

Ryan Ho Leung Tsang, Put, Jr. Ang

Long-term studies could provide invaluable information about changes in an ecosystem. The effect of *Drupella* corallivory on*Acropora* was monitored in Tung Ping Chau Marine Park (TPCMP), Hong Kong on a monthly basis from 1999 to 2013. Both the activities of the snails and the response of *Acropora* to corallivory were correlated with *in situ* seawater temperature collected in TPCMP. Based on the temperature change, the winters (November to April) and summers (May to October) within the monitoring period could be categorized into cold and warm winters; and mild and hot summers, respectively. *Drupella* snails were generally more active following the rise in seawater temperature from winter to summer, and more snails could be found in summer than in winter. Similarly, significantly more snails were spotted during a warm winter than a cold winter. However, such difference in snail density was not detected between a mild and a hot summer. Furthermore, the effects of *Drupella* corallivory, measured in terms of the increase in areas of new feeding scar observed on corals from 2010 to 2013, revealed the corallivorous effect to be stable under different summer conditions. But the effect in a warm winter was similar to that in summer, as the snail activities were not being suppressed, compared to that in a cold winter. Corals were much more stressed in a cold winter, making them more vulnerable to *Drupella* attack in the following spring. These differences under different winter conditions, although subtle, could affect the activities of *Drupella*, hence the effect of corallivory on *Acropora* and coral ability to recover. These subtle changes, when accumulated over a long period, could potentially contribute to the shaping of the coral community structure in Hong Kong.

AAC-13-75

Effect of temperatures on coral susceptibility to *Drupella rugosa* (Gastropoda: Muricidae) predation

Mark Alvin Reyes Restan, Patrick Cabaitan, Put Ang, Cecilia Conaco

Predator-prey dynamics between corals and the corallivore gastropod *Drupella* spp. in the context of global warming is relevant to the survival of coral populations. Corals have different susceptibilities to thermal stress. Yet, few have examined the effect of thermal stress on corallivory by *Drupella*. In this study, prey choice experiments were conducted to quantify the corallivory of *Drupella rugosa* on corals that had been subjected to elevated (32°C and 35°C) or lowered (26°C and 23°C) temperatures relative to the ambient temperature of 29°C. Initial experiments revealed that *D. rugosa* preferred to feed on *Acropora millepora* and *Pocillopora damicornis* and favored corals exposed to both elevated and lowered temperature. *Drupella* demonstrated no preference for *Porites cylindrica* and *Heliopora coerulea* exposed to elevated temperature but showed significant attraction to both species exposed to 23°C. As observed in the field, *D. rugosa* formed feeding aggregations on individual coral pieces. The measured grazing rates of *D. rugosa* were greatly influenced by seawater temperature, increasing at both elevated and lowered temperature. However, *D. rugosa* were found to be less mobile at elevated temperature. Results of this study have implications on the survival of coral communities and interaction with their predators in the face of global climate change.

AAC-14-284

A re-evaluation of coral's adaptive strategies based on species plasticity to environmental changes

Vianney Denis, Nicolas Sturaro, Shan-Hua Yang, Sen-Lin Tang

Environment filters individuals on the base of the traits they exhibit. For tropical corals, species' trait averages have been used to distinguish four contrasted life-history strategies to interpret how different coral species may respond to disturbances. However, aggregate response at species level occults individual trait variation, which represents a fundamental aspect in the mechanism of natural selection and in the survival of coral species in the face of environmental changes. In this study, we developed a research framework integrating intra-species variation into our re-evaluation of coral's adaptive strategies. Our multidisciplinary approach encompasses detailed descriptions of three major characteristics of the coral holobiont (their physiology, trophic ecology, and associated microbiome) which together help us to delineate coral species niches. In addition, it directly informs us on trade-off in energy sources and allocation in contrasted habitats. Generalist species adjust their traits to environmental variations and display various phenotypes across habitats. To contrast, specialists perform better in a narrow range of environmental conditions and are characterized by few inter-individual variations. A generalization of this framework in studies on coral physiology is critical for our understanding of coral response to environmental changes.

AAC-15-588

Symbiodinium association with brain coral, _Platygyra verweyi_ (Scleractinia; Merliinidae), hints towards local adaptation to seawater thermal histories

Shashank Keshavmurthy, Hwee-Sze Tee, Kuo-Wei Kao, Jig-Terng Wang, Chaolun Allen Chen

While substantial attention has been paid to understanding the effect of high temperature on coral survival, little is known about the effect of seasonal temperature fluctuation on the diversity, stability and flexibility of *Symbiodinium* in reciprocally transplanted corals between three environments experiencing different temperature regimes. We conducted two sets of in situ reciprocal transplant experiments (RTEs) in 2014 (RTE2014) and 2015 (RTE2015) with nubbins of the coral *Platygyra verweyi* collected from sites proximal to a nuclear power plant outlet and a nuclear power plant inlet and from a site at Wanlitung located within Kenting National Park Taiwan. Tissue samples from reciprocally transplanted nubbins were collected in April, September 2014 and January, March, May, July, September and November 2015 for RTE2014 and in April, September, November 2015 and January and April 2016 for RTE2015. Symbiodinum clade dynamics was analyzed using quantitative real time PCR. Results indicated a small scale of temporal changes in the *Symbiodinium* compositions from 2014-2016. Our results suggested that, *Platygyra verweyi* associated with thermal-sensitive clade C *Symbiodinium* has potential to undergo shuffling to thermal-tolerant clade D Symbiodinium in order to acclimatize to high SST during summer and maintained this state in areas with prolonged thermal stress, then revert to clade C types when the stress disappears. Our results provide a basis for studying acclimatization of *P. verweyi* coral species in heterogeneous environment located in Kenting. Microsatellite analysis of the *P.verweyi* host showed no genetic differentiation between NPP-OL and other sites. Accordingly, changes in the composition of *Symbiodinium* clades among closely located sites in Kenting suggest that *P.verweyi* did not undergo genetic adaptation but acclimatized to the constant thermal stress by selective association with heat-resistant *Symbiodinium* clade D instead of heat-susceptible *Symbiodinium* clade C.

AAC-16-361

Functional diversity of resource acquisition traits between *Symbiodinium*

Jane CY Wong, David M Baker

Shifting of symbionts has been observed in rare occasions, in which hosting the 'right' symbiont has promoted performance and survival of the host, yet little is known of the mechanism that regulates the association between the two partners. Knowlton and Rohwer (2003) first proposed the 'host as a habitat' theory for corals which serves as a foundation for explaining changes in symbiont communities via succession over time through resource competition. Here, we demonstrated species-specific characteristics on nitrogen and carbon assimilations on cultured *Symbiodinium*, with their uptake kinetics represented by a traditional Michaelis-Menten enzyme kinetics model. We then tested the resource competition theory on two *Symbiodinium* species, with predictions based on measured traits matching outcomes from in vitro competition experiments, regardless of species starting ratios. We concluded that functional differences on resource acquisition is quantifiable with trait-based approaches, and the relative abundances of *Symbiodinium* species in nature could be shaped by their competiveness to colonize and dominate intracellular niches.

AAC-17-54

Transcriptomic profiles of the tropical corallimorpharian *Ricordea yuma* (Ricordeidae, Corallimorpharia) after re-infection with homologous and heterologous *Symbiodinium* clades

Mei-Fang Lin

Reef-building corals associate the symbiotic relationship with the dinoflagellate in the genus *Symbiodinium*. Since *Symbiodinium* is a highly diverse taxon, physiological responses happen in the host differ among them. The presence of different symbiont types is known to affect expression levels of specific host genes, but effects on the transcriptome more broadly have not been investigated. In the present study we applied the transcriptome profiling during the establishment of symbiosis to the tropical corallimorpharian, *Ricordea yuma*, with either the natural ("homologous") clade C1 *Symbiodinium* or a compatible but heterologous D1a *Symbiodinium* isolated from a different corallimorpharian host (*Rhodactis indosinesis*). Transcriptomic analyses showed that enzymes related to the glycogen biosynthesis pathway are highly induced in the host with the C1 compared to the host with the D1a. Furthermore, genes involved in ammonia assimilation showed different expression pattern between them. Interestingly, some of the most highly up-regulated genes during the re-infection process were unique to symbiotic corallimorpharians, suggesting that this trait may have evolved independently in corallimorpharians. Our results demonstrated that symbionts influence on the wide range of gene expression in the host during the establishment of symbiosis.

AAC-18-389

Insights into the prokaryotic composition and functional profile of the demosponge *Haliclona amboinensis* from Bolinao, Philippines

Michael Angelou Nada, Cecilia Conaco

Marine sponges are vital components of reef ecosystems because of their high abundance and efficient filtration system that influence reef nutrient dynamics and trophic structure. The sponge microhabitat supports diverse communities of microbes that contribute to the host metabolic potential and adaptation to different environmental conditions. However, the associated microbial communities in Philippine sponges remain underexplored. In this study, the microbial community composition of the sponge, *Haliclona amboinensis,* and seawater samples from Bolinao in northwestern Philippines were determined using 16S rRNA sequencing. This analysis revealed that the *H. amboinensis* community was dominated by Actinobacteria, Planctomycetia, and γ-Proteobacteria, while the seawater microbial community was dominated by α-Proteobacteria and Bacteroidetes. Actinobacteria and Planctomycetia were rarely detected in the seawater community, suggesting that these taxa are specific to *H. amboinensis*. Based on the affiliation of its members, the *H. amboinensis* microbiome is predicted to be enriched for functions relating to energy metabolism, stress response, environmental information processing, and production of secondary metabolites. These results highlight the core microbiome of the demosponge, *H. amboinensis*, and reveal the potential functional contribution of these symbionts to the host, as well as their likely impacts on nutrient cycling within the ecosystem. This information provides a valuable contribution for future studies aiming to identify microbial function and the potential response of the sponge holobiont to environmental perturbations and climate change.

AAC-19-462

Sponge-microbe partnership under eutrophication pressure due to mariculture activity

Jake Ivan Perez Baquiran, Cecilia Conaco

Marine sponges harbor a great diversity of symbiotic microorganisms. However, this relationship can be affected by shifts in environmental conditions, which may subsequently influence the abundance and distribution patterns of the host sponge species. Here, we transplanted fragments of the marine sponge *Gelliodes obtusa* from its natural habitat in a seagrass bed to a eutrophic fish farm area in Bolinao, Pangasinan, Philippines, to directly assess the influence of elevated nutrient levels on the microbial community of the sponge. Microbial communities associated with sponge samples from each site were characterized using high-throughput sequencing of the 16s rRNA V4 hypervariable region. The microbiota of *G. obtusa* transplanted at the different sites for 6 weeks remained similar, with a dominance of Proteobacteria. Significant changes in relative abundance were only observed for members of class Chlamydiia and class Opitutae. Predictive metagenomics using PICRUST, as well as targeted gene quantitation using QPCR, revealed greater abundance of the ammonia oxidation gene marker, amoA, in sponge transplants from the fish farm area compared to the other sites. This difference in gene abundance was in concordance with the higher level of ammonia detected at the fish farm site. The findings from this study point towards potential applications of this sponge or the microorganisms within its tissues in clearing organic matter and nutrients from mariculture areas.

AAC-20-681

Dominance of *Porites* spp. in Buluan Island, southern Philippines, a turbid near-shore reef exhibiting high coral cover

Darryl Anthony Maglalang Valino, Maria Vanessa Rodriguez Baria, Hazel Ouano Arceo, Porfirio Miel Aliño

Turbidity and sedimentation are major threats in the global reef ecosystems. However, several studies are emerging that show some areas under turbid conditions exhibit high coral cover, reef development, and extent amidst global stressors. This implies that such reefs could be possible refugia against catastrophic bleaching events. In the Philippines, there is paucity of existing studies regarding these types of reefs. This study was conducted to provide an initial assessment of the benthic community in a turbid marine sanctuary of Buluan Island. Located in Sibuguey Bay, southern Philippines, it is approximately 2 km away from the mangrove areas of Ipil City where four river mouths exit. The study aims to characterize the general benthic community condition and focus on the distribution of the turbid tolerant *Porites* compared to other thriving genera. Coral assessment was conducted from 2012 to 2017 in permanent transects established around the island. Data obtained from line intercept transect (LIT) were used to compare changes in benthic conditions over time. Meanwhile, data from phototransects were used to determine size frequency distribution in three sites (6 – 8 m depth) located around the island. Also, data loggers were deployed around the island to monitor light and temperature levels. Results show that mean live hard coral cover of the area was over 40% with 21 identified genera while having an average mid-day irradiance (9:00h – 14:00h) of 166 ±95 μmol$m^{-2}s^{-1}$. *Porites spp.* branching colonies with >16 cm in diameter were the most dominant genera, followed by *Acropora spp.* The Buluan Island Marine Sanctuary experienced bleaching (<25%) during mid-2016 but the data collected from early 2017 suggest that the sites were able to fully recover with no significant changes in coral cover. Insights from this study may serve as a basis for future studies of Philippine coral reefs persisting in turbid environments.

AMC-1-723

Advances in coral in-situ metabolism of Hong Kong coral communities

Walter Dellisanti, Jiajun Wu, Leo Chan

Physiological rates of corals have been an object of investigation for a long time and different tools have been developed both for field and laboratory studies. Metabolic *in-situ* measurements enable non-invasive quantification of energy expenditure, making them well suited for measuring both healthy and stressed organisms. The use of new diver-portable respirometers designed to measure coral respiration and photosynthesis by *in-situ* analysis of dissolved oxygen, pH and temperature variations is now under investigation. Corals living in turbid waters are frequently exposed to acute sedimentation events, such as Hong Kong coral communities. Moreover, they may have not subjected to tissue mortality since they are adapted to low light and increased feeding rates. However, the increase in the frequency and severity of acute sediment stress events in coastal waters provides an additional stress for corals surviving at the edge of their environmental and physiological tolerances. Corals can survive in these marginal reef environments, even with slow growth and physiological rates. Unfortunately, how corals metabolically response to local perturbations (such as bleaching, phytoplankton bloom and hypoxia events) in their natural environment is still poorly understood. Here we propose tools and strategies to evaluate the coral health by combining classic scientific diving techniques with novel technologies. The aim is to provide a better definition of coral health by integrating the complexity of the coral holobiont with its associated microbes and the co-influence of biotic and abiotic factors in a changing climate scenario.

AMC-2-66

A comparative study on coral recruitment among reef areas in the coastal waters of Vietnam

Si Tuan Vo, Kim Hoang Phan, Minh Quang Thai

The study on coral recruitment was conducted at 84 study sites of 10 reef areas in central, south and southwest waters of Vietnam (the western South China Sea). One or two contour transects were laid at shallow or/and deep water at each site. Scientific divers counted number of young colonies (less than 5cm in diameter) in four replicates (4m * 5m belt) along each transect. Identification at the genus level was done for all colonies, using also photos which were recorded in the field. There existed wide rank of young colony density at the site level, varying from 5 to 30 colonies per 20 sq.m in average. Some possible findings from data analysis included: (1) Low potential for recruitment on the reefs which were under degradation, especially with high pressure of sediment deposits; (2) Poorest young colonies in northeast monsoon in central waters, comparing with south and southwest ones; (3) Cool water caused by upwelling limited recruitment ability with the evidence of lower density of young colonies during post-upwelling than that in pre-upwelling period; (4) It seems recruitment ability increased in the period following mass bleaching which occurred in Con Dao and Phu Quoc islands; (5) *Acropora* genus had high potential for recruitment in the south waters; (6) The sites where soft coral recruited well were mainly in open fringing reefs or submerged banks.

AMC-3-104

Composition, spatial distribution and driving factors of coral communities in Wuzhizhou Island, the South China Sea

XiuBao Li, Sheng Liu, Aimin Wang, Huili Xu

In order to understand the composition and spatial distribution of coral communities in Wuzhizhou Island and to discuss its main driving forces, we conducted a systematic investigation of the coral communities and environmental factors from July to August in 2017. The survey recorded a total of 86 Sclearactinia coral species, belonging to 40 genera and 12 families. The dominant coral groups are *Acropora*, *Pocillopora*, *Porites*, *Montipora* and *Galaxea*. Based on the nMDS analysis of coral reef benthos communities, the research stations at Wuzhizhou Island can be divided into the southern undeveloped areas and the northern development areas. In Wuzhizhou Island, the average coral coverage was 19.1%, ranging from 3.9% to 44.1%, with coral coverage of 24.3% and 13% on the south and north sides, respectively. The average coverage of soft corals was 9.1 %, ranging from 0% to 37.6%. The coverage of soft corals on the south and north sides were 16.3% and 0.6%, respectively. The average species diversity of reef-forming corals was 6.7 indi. /20m transect, ranging from 2.5 to 10.8 indi. /20m transect, in which the species diversity on the south and north sides were 7.6 indi. /20m transect and 5.7 indi. /20m transect, respectively. The average of juvenile coral density were 3.7 indi. /m^2, ranging from 0.8 to 7.0 indi./m^2, of which the south and north were 4.7 indi./m^2 and 2.6 indi./m^2.

Analysis of the two-way variance (partition * depth) showed that there was no significant difference in coral coverage and juvenile coral density at different depths (3m and 8m), but the southern values were significantly higher than the northern values ($p<0.05$). There is no interaction between zone partition and depth. Correlation analysis showed that environmental factors (e.g. turbidity, NH_3 and sand coverage, rock (especially gravel) coverage) have good negative correlations and indication of the spatial distribution of corals. Compared with other areas in Sanya, the southern undeveloped area of Wuzhizhou Island still retains relatively good coral reef resources and is effectively protected by the Wuzhizhou Island tourism company. However, coral reefs in the northern area are in obviously degraded condition under pressure from human activities, such as the island project, tourism activities, sewage pollution, just like the other coral reefs in Hainan Island. Water quality deterioration and habitats destruction may be important drivers for the reef degradation in northern Wuzhizhou Island, and their specific processes and mechanisms have yet to be further studied.

AMC-4-553

Current status of coral reef ecosystems in Xisha Islands and some advices for coral reef restoration and protection

Hui Huang

Xisha Islands have the largest number of islands in the South China Sea Islands, the islands with the largest area (Yongxing Island) and the highest elevation (Shidao island), the only cemented rock island (Shidao island) and the only non-biogenic island (Gaojian island) Of the island. Xisha Islands are composed by 41 island geographic entities and 11 dark beaches and low tidelands.

The survey results show that coral cover rate between 40 and 80% in the Xisha Islands in 2006. Between 2008-2012, our team conducts coral reef ecology surveys annually on all the islands and reefs in the Xisha Islands. The coral reefs of Xisha Islands changed dramatically from 2007 to 2009. Due to the large-scale outbreak of Crown of Thorn Starfish (COT), Coverage of living coral was less than 1% in most reefs, and only several reefs had corals left. The reefs in the Paracel Islands began to recover slowly from 2010 to 2012, but the recovery was restricted in some area. The main problems in the Xisha Islands were serious over-exploitation of coral reefs and serious depletion of biological resources; irrational economic structure of fisheries, serious damage to coral reef ecosystems, lack of planning and management and island shoreline erosion.

Basing on the situation of Xisha Islands, how to protect and recover coral reefs is a key issue at present. We suggest the following aspects should be taken account into: 1) Cooperate with local governments to promote the establishment of protected areas and ecological red line areas; 2) Cooperate with local residents' committees and fishing villages, and set up a special fund for locals to protect the ecological environment 3) Determine the ecological restoration area in the region for ecological restoration and restoration of resources.

AMC-5-171

The biodiversity assessment of hard coral in dive spots within Dampier Strait Marine Protected Area in Raja Ampat

Yuanike Kaber, Fredinan Yulianda, Dietriech Geoffrey Bengen, Rokhmin Dahuri, Jemmy Souhoka

This research is an assesment of hard coral biodiversity in several dive spots within Dampier Strait Marine Protected Area of Raja Ampat, West Papua. The LIT (*line intercept transect*) data collected from 0-10 m, 30-40 m, and 60-70 m. Marine biota and other components under line transect were recorded with a precision level up to centimeters (cm). The morphometric code of benthic component used as a reference as the code published by Australian Institute of Marine Science (AIMS). The data of hard coral biodiversity was collected by random sampling within the range 0.5-20 m depth. Data obtained from transect then analyzed for the percentage of coral coverages done with excel method, biodiversity index and similarity index with Biodiversity Pro 4 application. There are many kinds of coral reefs species in 10 dive spots. We found 141 species and they are included in 16 families. The biodiversity of hard coral is very rich, especially the hard coral life forms. They live in the entire water in Dampier Strait marine protected area. Coral reefs ecosystem consists of exotic biota with the colourful and various forms of coral life. The assessment of coral reef ecosystem found that the condition of hard coral are in good to very good conditions. Biodiversity index (H) range in 0,84 (Station 8) – 1,23 (Station 4). The value of species similarity index (j) range in 0,73 (Station 10) – 0,94 (Station 4). The value of species dominance (D) range in 0,05 (Station 2) – 0,25 (Station 10). In general, coral reef ecosystem in 10 stations within Dampier Strait waters are in good condition and having productive to very productive stability of coral growth.

AMC-6-283

Urban coral reefs of East and Southeast Asia

Eliza C Heery, Nikki Browne, Bert W Hoeksema, James Davis Reimer, Put O Ang, Daniel A Friess, Danwei Huang, Loke Ming Chou, Andrew G Bauman, Lynette H L Loke, Peter A Todd

Urbanization is widespread in tropical and subtropical regions of the world and is increasingly transforming nearshore ecosystems. Hard corals and coral reefs are common in many urban waterways, yet there have been few efforts to compile current knowledge of coral reef ecosystems across cities. Given predicted increases in global urbanization, understanding the composition and dynamics of urban coral reefs is essential for anticipating future conservation challenges. In this review, we compiled available data on hard coral composition and abundance for cities throughout East and Southeast Asia with the aim of identifying unifying patterns and characteristics of urban coral reefs. Our analysis focused on four main case studies: Singapore, Jakarta (Indonesia), Hong Kong, and Naha (Japan). Qualitative information from a series of other case study cities in the region were also used to provide additional insights. We found several key characteristics of urban coral reefs. Reef compression, whereby reefs occur over a relatively narrow vertical range with a shallow maximum depth, was common. Urban coral reefs tended to exhibit inshore-offshore gradients with respect to coral cover and richness, although these patterns were less distinctive in smaller cities such as Naha. Over the course of the 20th Century, urban coral cover declined and species composition shifted away from competitive, branching corals, such as *Acropora* spp., towards others with stress-tolerant and generalist life strategies. We postulate that numerous urban-related stressors have contributed to these patterns, especially pollution, exploitation, and habitat conversion. Interestingly, coral cover in some coastal cities appears to have rebounded rapidly following thermal bleaching events in recent decades. Coral colonization of urban infrastructure and artificial shorelines has also been documented in several cities, and constitutes an important component of restoration and enhancement efforts for coral reefs in urban areas. We present these findings, highlight data and research needs for urban coral reefs, and discuss the potential for modifying urban shorelines to serve as a tool, rather than a hinderance, for broader coral conservation efforts.

AMC-7-296

Status and trends of Malaysia marine park's coral reefs: 2007-2016

Izarenah Md Repin, Lim Ai Gaik, Ab Rahim Gor Yaman, Julian Hyde

Marine Parks in Malaysia are designated under the Fisheries Act 1985 (Act 317). To date, a total of 42 islands have been designated as Marine Park under this Federal Law covering a total area of 248,613 hectare. The Department of Marine Park Malaysia (DMPM) is the Federal Agency responsible for managing and protecting the marine parks. Main marine ecosystem in these marine parks are coral reefs. In identifying the current status and changes of coral reefs, DMPM in collaboration with Reef Check Malaysia (RCM) conduct annual coral reef status survey since 2007 on permanent transects within marine parks. This study presents the analyse from 10 years of surveys showing the current status and trends of coral reefs. The surveys are carried out by certified officials from the DMPM as well as certified volunteers using Reef Check standard methodology. The 10 years survey results indicate that the coral reef in Marine Park are in 'Good' condition with an average live coral cover (LCC) of 51.02% according to the Coral Reef Health Criteria. Meanwhile the average of the National Reef LCC is at 46.42% which comprise of other protected and un-protected reef area. The reefs in Marine Parks were at the lowest percentage of 44.01% in the year 2011, which is a year after the mass coral bleaching event. Beside the impacts of warming oceans, there are other anthropogenic factors that contribute to the changes of the reef health. Only with regular monitoring such as this study can detect the changes and allow for proactive intervention to improve the management of this valuable natural resources.

AMC-8-637

Coral cover and assemblage on fringing reefs around Sepangar Bay Kota Kinabalu, Sabah, Malaysia

Mohd Firdaus Akmal Nooramli, Zarinah Waheed, Muhammad Ali Syed Hussein

Sepangar Bay is located approximately 10 kilometres away from Kota Kinabalu city. The area is rapidly losing its original mangrove, seagrass and coral reef habitats to rapid urbanization. Two rivers discharge sediment plumes into the surrounding waters. The area is exposed to urban development, port and shipping activities, as well as destructive fishing. Seven fringing reef sites at Sepangar Bay and nearby islands (Sepangar and Udar) were surveyed between 2015 to 2016 to determine the percentage coral cover and genera composition. Three replicate transects of 100 metres were deployed at 8-10 m depth in each site. Photo quadrat method was used, whereby 50 images were photographed along each transect for analysis using the Coral Point Cover with Excel extensions (CPCe) software. The percentage coral cover ranged between 11.11% and 53.73%, with the lowest recorded at the sheltered reef sites within the inner bay and the highest coverage at the islands and along the exposed coastline. The sheltered sites also had a higher percentage of silt and coral rubble on the reefs compared to the site at the islands and exposed coastline. There was a significant difference in percentage coral cover among the site. A total of 53 coral genera was identified (49 scleractinian and 4 non-scleractinian corals) with seven genera present at all sites and three observed at all transects (*Dipsastrea* spp., *Favites* spp. *Porites* spp.). Diversity indices were higher at the sites located at the islands and exposed coastline reefs with low dominance by any particular coral genera as compared to the sites that were sheltered. In general, results indicate that the coral reefs around Sepangar Bay and nearby islands can be considered fair despite the anthropogenic pressure from Kota Kinabalu.

AMC-9-597

Status of coral reef communities in Lamawan Pony MPA, San Jose de Buenavista, Antique, Philippines

Mirasol Azcuna Montano, Judith Ramos Silapan

The Lamawan Pony Marine Protected Area (MPA) in San Jose de Buenavista, Antique, Philippines was created to improve marine conservation and fisheries management. This study evaluated the current status using the biophysical indicators on the MPA and the reef systems. The biophysical parameters include coral cover quality and diversity, fish composition and baseline sedimentation rate employing Coral Point Count Excel Extension (CPCe), Fish Visual Census (FVC) and sediment traps, respectively. Two study sites were established: inside the core zone and within the buffer zone to assess possible significant difference in the status of marine resource at sites. Results of the study showed that the estimated total area of the MPA core zone was 0.0586 km^2. The mean percentage of coral cover is poor (15.99%) that includes the vulnerable species of *Heliopora coerulea* (0.24%). Fish composition is generally low (M=1.15 individuals/m^2). Baseline sedimentation rate is high (M=6.5 mg/cm^2/day). Between sites, coral cover (t=2.24, p=0.028) and baseline sedimentation rate (t=4.65, p=0.00097) significantly differed, while fish density do not differ significantly (t=-0.374, p=0.3554) at sites. Generally, the MPA status is poor due to anthropogenic impacts. Despite these conditions, results suggest that increasing the no-take zone area to at least 20% of the total MPA size is necessary to achieve the goals set for an MPA. Data in this study are imperative in improving sustainable fishery management in the future that balances the economic need of its coastal populace.

AMC-10-391

Results of the biophysical assessment conducted in Mabini Protected Landscape and Seascape

Dominic Jone Campeon Cabactulan

Mabini Protected Landscape and Seascape (MPLS) was created through Presidential Proclamation No. 316 on May 31, 2000. It is located in the Municipality of Mabini, Compostela Valley Province, Davao Region, with the combined total area of 6,106 hectares. The seascape comprises the entire 14.5 km (406.83 has. of coral reefs) shoreline that include the six coastal barangays of Cadunan, Cuambog, Del Pilar, San Antonio, Pindasan and Tagnanan. On 2013, the personnel of then Coastal and Marine Management Division of DENR 11 had conducted its baseline biophysical assessment of the entire Seascape under the Sustainable Coral Reef Ecosystem Management Program (SCREMP) using Line Intercept Transect Method (LIT). It was then followed with similar assessment in 2016, this time, under the Coastal and Marine Ecosystem Management Program (CMEMP) using Phototransect Method. The results of the assessment in 2016 varied slightly with the result of the baseline assessment with +0.8% increase in live coral cover. Same trend was also observed in the number of fish families. Furthermore, *Cromileptis altivelis*, or the Barramundi grouper was seen on the same site in both assessments. Same assessments have made record the number of existing coral genera of the Seascape that was used by the Mabini LGU and Mabini Protected Landscape and Seascape Protected Area Management Board in promoting various activities and conservation efforts to its designated zones.

AMC-11-627

An updated rapid assessment study of coral reefs in the Calamianes Group of Islands, Palawan

Reynante Vega Ramilo, Ginelle Jane Gacasan

The Calamianes Group of Islands, located in the northern portion of the province of Palawan, hosts a diversity of life living in its reefs, mangroves, seagrasses and iconic limestone cliffs and caves. As fisheries still remain the primary source of livelihood, several other sectors now depend on the marine resources most especially the coral reef ecosystem. Coral and shipwreck diving, pearl farm development and marine protected area establishment are widespread for tourism, fish stock recovery and biodiversity conservation. However, several studies have proven the continued degradation of the coral reefs in Calamianes affecting fish abundance, richness and diversity from overexploitation of these resources mainly by anthropogenic activities. The Department of Environment and Natural Resources Coastal and Marine Ecosystem Management Program aims to update the current status of the coral reef ecosystem in Calamianes to provide ecotourism potentials and livelihood opportunities for the communities. On June 2017, a total of 36 survey sites, in 18 sites covering 3, 142 hectares underwent rapid coral reef assessment through a photo transect method processed using the Coral Point Count with excel extension (CPCe) software. Overall results showed 28.25% live coral cover, categorized in a fair coral reef status. Dead corals attributed for 20% coverage, and algae attributed for 23% of the coverage. Coron has the highest live coral percent and categorized having good coral reef status. All municipalities are dominated by non-acropora coral having the highest percent cover in the major benthic lifeform categories. Coral cover confirm a trend of decline. Threats identified in earlier studies continue to bombard the area such as illegal fishing methods, uncontrolled and unregulated coastal development, and poor solid and waste water management. Main recommendations include: more effective enforcement of marine protected areas, better spatial planning at the municipal level, and provision of alternative livelihoods that reduce dependence on the marine resources.

AMC-12-396

Towards building a national monitoring system : the Coral Reef Visualization and Assessment (CoRVA) program

Laura David, Kristina Cordero-Bailey, Maricor Soriano, Porfirio Aliño, Wilfredo Licuanan, Vincent Hilomen, Victor Ticzon, Cleto Nañola, Jerome Cabansag, Hildie Maria Nacorda, Rene Rollon, Fernando Siringan, Ronald Villanueva, Cherry Ringor, Cesar Villanoy, Aletta Yñiguez, Ma. Josefa Pante, Gay Perez, Ariel Blanco, Theresa Mundita Lim, Marlynn Mendoza

As Filipinos are highly dependent on the coral reef ecosystem, the conservation of these natural resources is crucial in contributing to the food security for the Filipino population. In the late 1970's, the first national coral mapping program highlighted that our reefs were generally in a fair condition. The **Co**ral **R**eef **V**isualization and **A**ssessment (CoRVA) program attempts to undertake the task of contributing to the re-evaluation of the state of the Philippine coral reefs, particularly the NIPAS sites. CoRVA is a comprehensive program focused on assessing the reef ecosystem by means of reef visualization and monitoring, associated habitat (seagrass & mangrove) assessment, reef fish assessment and deep reef exploration. Along with outputs from the analysis of the coastal integrity, an ecosystem assessment approach allows us to select sites which require additional protection and rehabilitation. By including ocean connectivity, we can establish or effectively strengthen MPA networks that will offer more sustainability and/or conservation to the reef systems. Potential rescue sites can be identified when these results are assimilated with historical data from remote sensing. We would like to introduce this approach to be the guiding framework for the integrated management of the NIPAS sites. To be able to implement this framework on a national level, CoRVA has included a project dedicated to the training of DENR regional counterparts on the reef and coastal integrity assessment protocol and the development of a national database to be maintained by our DENR counterparts for monitoring that shall promote the continuity of the program.

AMC-13-31

Coral reef community structure in Palau's inner reefs

Takashi Nakamura, Marine Gouezo, Yeong Shyan Yuen, Golubuu Yimnang

During 2014 to 2019, we deployed 15 permanent quadrats around the inner and the near-outer reef sites in order to facilitate the monitoring information on benthic community mainly consisted by reef-building corals. Along with the quadrat survey, we also deployed temperature loggers a the designated quadrats to monitor the dynamic changes in seawater among the sites. In order to capture the general trends in benthic community as well as fish community, random line-intercept transect surveys at the sites were conducted accordingly. Benthic compositions around Palau has been kept coral-dominated over the years with Poritidae corals highly dominating inner reef sites. However, few sites especially pre-dominated by Acroporid corals lost significant coral cover due to series of bleaching events during June to July with high water temperature conditions recorded. Fish composition are partially explained by the presence of certain coral genera. Our results suggests highly stable but thermally threatened coral communities in the inner reefs of Palau while Acroporid dominated outer reefs will be at the edge of thermally-induced bleaching in the near future.

AMC-14-594

Spatio-temporal confounding in reef survey frequencies; dynamic reefs of Singapore

Yee Keat Tan, J Tanzil, AC Lee, I Baula, K Vicentuan, TM Sin

Line transect survey are often used to assess benthic coral reef assemblages. To determine temporal changes in reef assemblage, such surveys are typically conducted at regular time intervals, with annual survey frequencies being the most common. Here we explore potential spatio-temporal bias in estimation of benthic reef assemblage using line transect data collected at fortnightly, monthly, quarterly and annual intervals along reef crest (~3–4 m below chart datum) environments from three selected sites around the Singapore's southern islands. Surveys were conducted over the period 2011–2017, with high frequency fortnightly data collected during the first year of monitoring and all subsequent surveys conducted at quarterly interval. On some reefs, live coral, abiotic and turf algae covers were found to be influenced by the seasonal dynamics of Singapore's macroalgal community, which was captured at the fortnightly, monthly and quarterly survey frequencies but not at the annual interval. Our preliminary analyses show that inter-annual patterns can vary markedly depending on the time of year during which the reef surveys were conducted. Consequently, depending on reef site and survey period, annual "once-a-year" surveys may create a biased estimate of how benthic reef assemblages change over time, especially in dynamic reef environments such as those found in Singapore. Taking survey periods and frequency into account when designing long-term monitoring programmes will not only provide the most representative data from target reefs, but also allow an *a-priori* approach for interpreting the reef survey data.

AMC-15-102

Spatio-temporal patterns of coral community at the Johor Archipelago, Peninsular Malaysia

Jen Nie Lee, Jani Tanzil, Kee Alfian Abd Adzis, Affendi Yang Amri

The islands off the southeastern coast of Peninsular Malaysia belong to the largest federal marine protected area in Peninsular Malaysia, the Johor Marine Park, and boasts diverse coral reef, seagrass and mangrove ecosystems. Here, we explore spatio-temporal patterns in the coral reef benthic assemblage and scleractinian coral biodiversity of the Johor Marine Park. Benthic reef assemblages following the Reef Check substrate categories was represented by a total of 96 transects from 41 reefs around 14 islands over 17 years (2000 – 2016). Live coral cover (LCC) of reefs in the Johor Marine Park ranged from 5.0–87.5 % (hard and soft corals), with an average of 48.6 %. Only 6 sites surveyed had LCC of >75 %. No clear temporal trends in reef benthic assemblage was found. There were, however, some discernable spatial patterns – nutrient indicator algae were observed to dominate the reef assemblage around inhabited islands (e.g. P. Aur, P. Pemanggil, P. Dayang, P. Tinggi and P. Besar), and there was an inshore to offshore gradient in variations in assemblages. Reefs around inshore islands (<20km) were associated with higher silt cover, while offshore reefs (>50km) were characterized by higher cover of rubble. A total of 247 scleractinian coral species from 17 sites at shallow water (<7m depth). Genera absence/presence also showed an inshore to offshore shift in composition. Human population (villagers or tourists) pressures most possibly alter the shifts in coral generic composition and disrupt dynamics of coral–algal interactions. Fluctuations in reef health can be in response to oceanographic seasonal differences and environmental change. This study provides a preview of the coral reef community complexity at the Johor Archipelago and its possible ecological function. The diversity and ecological function between ecosystems in Johor Marine Park is yet to be comprehended.

AMC-16-535

Changing reef, vulnerable people: Poverty, population, and coastal development in near-reef communities in the Philippines

Ma. Simeona Medina Martinez, Hannah Eunice Amihan, Carla Alessandra Anna Dario, Paul Andrew Gravoso, Dexter Tabada, Eileen Peñaflor, Ma. Josefa Pante, Laura David

Coastal areas are the interface of dynamic physical and social processes. Developments such as urban centers, ports, roads, and other anthropogenic elements tend to concentrate along the coast, while sensitive ecosystems such as coral reefs serve as immediate sources of livelihood and other economic and environmental benefits to coastal communities. In some respects, the nature of coastal zones and the lands proximate to the shore renders them vulnerable to disruptive events such as typhoons, elevated sea surface temperatures, or to changes brought about by human activities.

This study aims to spatially examine the socioeconomic characteristics of coastal municipalities and cities in the Philippines in conjunction with the changes in coral reef extent from the year 2000s to recent years (2016/2017). It identifies coastal towns in the country that have high population density and coastal developments such as roads and ports in describing the spatial distribution of potential threats to coral reefs, while exploring the pattern of vulnerabilities such as poverty incidence, illiteracy, and population growth rates. Analyses are based on the coral reef temporal datasets and socioeconomic statistics compiled and generated through the Philippine Coral Reef and Mangrove Remote Sensing (Phil-CoMaRS) project under the Department of Environment and Natural Resources (DENR) Coastal & Marine Ecosystems Management Program (CMEMP), in partnership with the University of the Philippines Marine Science Institute.

AMC-17-710

Status and recent trends in coral reefs of the Philippines

Wilfredo Roehl Y. Licuanan, Regine Robles, Michelle Reyes

Coral reefs are important, if not central, to Philippine national identity and economic well-being. This has prompted recent efforts to reassess the status of the nation's coral reefs and begin a systematic monitoring program, focusing on the abundance and diversity of corals. Surveys over the last three years in over 200 stations show average coral cover in upper fore-reef slopes of fringing reefs to be 23.9% (+/- 1.0) and generic diversity of 16 (+/- 0.5). At the assessment station level, coral cover tends to be higher for offshore reefs but diversity is the same. Based on such benchmarks, new assessment scales for cover and diversity are proposed to better guide managers, policy makers, and coastal communities. Use of these scales reveal reefs in the Sulu Sea bioregion is currently in the best status among six Philippines bioregions. Conversely, reefs in the nation's Pacific Ocean coasts have lower cover and diversity. Unfortunately, the recent surveys show that Philippine reefs have declined significantly since the initial studies over four decades ago.

Concurrent monitoring in 91 stations provide possible bases to remain hopeful about the future of Philippine reefs. These monitoring stations are in priority reef areas and benefit from some level of management and protection. Consequently, hard coral cover (33.6 +/- 2.9) are higher in these reefs. Hard coral cover in the 91 stations increased at over 6% per annum despite the concurrent global bleaching event in the last two years, although this increase was significant only in 20 monitoring stations. Most of variability in hard coral cover are mostly at the station and location level, suggesting the increases may be attributed to local management action and uneven impacts of widespread stressors such as ocean warming. However, most Philippine reefs remain poorly managed and are not monitored. Thus, our immediate response will determine if the overall decline of Philippine coral reefs is reversed and not left to chance.

AMC-18-165

Multi-taxon analyses of community assembly, functional diversity and trait distributions over latitudinal gradients to aid conservation management

Katie Midori Cook, Maria Beger, James Davis Reimer, Iori Kawamura, Masaru Mizuyama

The Japanese coastline spans over 20° in latitude and is characterised by a strong environmental gradient, ranging from tropical to temperate marine ecosystems. It provides a good ecological system to study latitudinal effects, and the effects of tropicalisation, as tropical species are shifting to higher latitudes. Species diversity generally decreases towards the poles, and trait-based functional diversity also broadly follows this pattern. However, this pattern is less clear for abundance-based measures for reef fish, and it is unknown whether it holds for other taxa and the abundance distributions of the traits themselves. This study investigates whether community assembly, functional diversity and the distribution of functional groups follow a latitudinal pattern in Japan for multiple reef taxa, and if tropicalising species share similar traits. 32 reefs along Japan's east coast were surveyed and the abundance of fish, mollusc and algae species was recorded. A trait matrix was created for all species in the dataset, including morphological, physiological and life history traits. Preliminary results show a latitudinal shift in community assembly in all taxa, with a slight decline in overall functional diversity. The effects of latitude on functional diversity may not be as large as expected, as there is a high level of functional redundancy in the mega-diverse tropics, whereas fewer, highly adapted species share the same functional roles in the sub-tropics. Functional trait distributions were also found to differ between tropical and subtropical communities. It is important to understand how these ecosystems differ ecologically, so that appropriate management actions can be taken to ensure healthy functioning. For example, tropicalising fish species were found to share similar traits, providing valuable information for researchers predicting poleward range shifts, to further aid conservation plans for the future.

AMC-19-138

Coral reef fishes in South China Sea, what we known about it

Colin KC Wen

Coral reef fish is the most dominant vertebrates in coral reef ecosystem. The important functional roles of coral reef fishes have been studied in resilience and resistance of coral reefs ecosystem under human disturbance for climate change projection. However, one of the largest marine ecosystem regions – South China Sea has got less studies due to any movement from surrounding countries. Until latterly, we have been quantitatively surveyed in Dongsha atoll and Taiping island (Spratly) and examine the fish community associated with benthos. In Dongsha, we found limited correlation of fish abundance and species number with corals. We found high correlation of fish number with fishing boat pattern of Dongsha atoll. We also compared our fish data from Dongsha and Taiping to other coral reefs around South China Sea (Xisha islands, Penghu islands and Kenting of south Taiwan). We found coral reef fish from Taiping has higher abundance than others, but not in species number. We concluded that illegal poacher is one of the most critical drivers to structure the coral reef fishes in South China Sea. We found the enforcement from Dongsha and Taiping clearly affects the illegal fishing boat pattern. We also noticed some fishing activity from local coastguard, lack of education and regulation might also reduce fish population in these islands.

AMC-20-400

Temporal comparison of fish assemblages before and after designation of a Marine Protected Area in Hong Kong

Hiu Ning Leung, Put O. Ang

To protect marine resources in Hong Kong, Marine Protected Areas (MPAs) have been employed as a major conservation strategy. To assure sustainable development and the protection of natural resources, it is important to demonstrate that MPAs are effective in the protection of marine resources. We examine how protection effect influences the rate and extent of recovery in fish communities following the creation of Tung Ping Chau Marine Park (TPCMP).

Fish assemblage data were collected by underwater visual census at the two core areas (A Ma Wan and A Ye Wan) in 1998-1999 (before designation), 2002-2004 (shortly after designation) and 2013-2015 (10 years after designation). In general, little marked differences in fish assemblage were found before and after MPA designation. The most marked change was fish abundance in AMW during spring where the numbers doubled after 2013. This was due to the dominance of Pomacentridae. Abundances of *Cephalopholis boenak* were higher than those in pre-protection years. Shannon-Wiener Index of diversity H' at AMW in spring was higher shortly after designation than those in other years. Decrease in H' in recent years was related to the increased dominance of the Pomacentrid. The abundance of *Monacanthus chinensis* increased after protection but dropped after 2013, related possibly to the loss of seaweed bed in Lung Lok Shui nearby. Changes in composition were detected in AMW where *Chromis notatus* and *Cephalopholis boenak* increased in number. Poaching was occasionally observed in AYW where changes in fish assemblages were less pronounced.

These two core areas could only protect the resident species, and are ineffective in promoting abundance of fishes with large home range. With such a shallow reef in Hong Kong, sizes of MPA should be much larger. The MPAs should also include different kinds of habitat which are the nursery ground of many commercial species.

AMC-21-660

Functional diversity of ichthyofaunal assemblages in a reef with anthropogenic influence from South Andaman, India

Narayani S, Arun Kumar M, Venu S

A functional entity is defined as a unique combination of ecological or functional traits. Functional redundancy is a situation where many species perform similar functions. When fishes in coral reef ecosystems face species loss, it is hypothesized that other species belonging to the same functional entity might provide ecological insurance through replacement. In the present study, a reef with a moderate anthropogenic influence from South Andaman Island in India was analyzed. Surveys of ichthyofaunal assemblages were conducted using fish belt transect and underwater visual census. Functional Diversity was assessed based on various ecological characteristics: Diet (11 categories), Activity Period (3 categories), Mobility (3 categories), Size (6 categories), Schooling pattern or gregariousness (5 categories) and Position in the water column (3 categories). A total of 245 species of fishes belonging to 104 genera and 47 families were recorded during the study. 122 functional entities were identified, with a mean of 1.9 species per entity. 56% of these entities had a single species representing them, indicating functional rarity. 8 functional entities were redundant, expressed by 5 species or more. A high functional rarity is prevalent in this region, indicating that the functional diversity is highly vulnerable to species loss. It could be predicted that if there is species loss among these fishes, their functional role will also be lost. Since loss of function imperils ecosystem processes and services in reefs, functional diversity studies are to be preferred to biodiversity studies for a better understanding of the resilience of reef communities.

AMC-22-322

Partitioning the beta diversity of wrasses (Labridae) in northern Verde Island Passage coral reefs across a temporal and spatial scale

Kent Elson Salem Sorgon, Victor Ticzon, Alvin Nowell Simon, Marion Michael Bacabac, Maria Eleanor Aurellado

Wrasses (Labridae) are a diverse group of fishes occupying various marine habitats and are the second most abundant group of reef fishes in Philippine coral reefs. Many studies have delved into the ecological and biological factors that influence their composition and distribution in coral reefs, but the current understanding of inter-community variations and how they behave across time and space is limited. By employing beta diversity and beta decomposition, how do wrasse assemblages behave across a spatial and temporal scale? In this study, the beta diversity of wrasses in northern Verde Island Passage (VIP) coral reefs were studied by comparing sites and across sampling months. Spatial and temporal beta diversity were decomposed into replacement and biomass difference components to determine which one mainly contributes to the observed beta diversity. The average variation in communities across space was observed to be higher than in observations across time. Partitioning spatial and temporal beta diversity yielded replacement as the main driver of variation in wrasse communities, while biomass difference was a minor component of beta. The strong influence of replacement to beta diversity may suggest the effect of processes such as competition and environmental filtering on wrasses, most of which have yet to be studied. Communities were observed to have a high degree of similarity, the inverse of beta diversity, across both time and space. This high similarity may indicate a level of stability among communities in terms of species composition. While the mechanisms such as compensatory dynamics and assembly rules that underlie the beta diversity of wrasses in the northern VIP remain unknown, partitioning beta diversity across various temporal and spatial scales present a useful ecological tool in assessing communities in high-diversity coral reefs.

AMC-23-281

The status of reef fish communities in protected seascapes of the Philippines

Victor Ticzon, Cleto Nañola, Jerome Benedict Cabansag, Laura David

Majority of the coral reefs in the Philippines are in a constant state of stress from chronic anthropogenic disturbances and episodic, large-scale natural perturbations. Managing reef-associated fishes is one of the more important positive actions that promote ecosystem resilience and assist in the recovery of disturbed coral reefs. However, a pre-requisite in formulating strategies to effectively manage and sustainably utilize reef-associated fish, require an accurate and up to date information on its' current condition. The study aims to address this data gap and examine reef fish community structure in nine protected seascapes of the country. Among the protected seascapes, the Northern Verde Island Passage, yielded the most number of species, had the most abundant aggregation of reef fishes and registered the highest biomass of fish. In contrast, the reef fish communities in sites along the country's Pacific coast were found to consistently fall at the lower end of the measured community parameters. Overall, the reef fish communities remained speciose across study sites. However, in terms of abundance and biomass, majority of the reefs surveyed fall under the poor (less than 22% hard coral cover) to fair category (>22% but <33% hard coral cover) suggesting strong fishing pressure and habitat degradation in the supposedly protected seascapes. The results also showed that the establishment of marine protected areas (MPAs) within the nationally managed seascapes sustained biodiversity and facilitated the recovery of reef fish communities from disturbance. This was not consistently observed in all sites and suggests the importance of other factors in the recovery and resilience of reef fish communities. The challenge now is to develop appropriate regional coral reef conservation strategies that prioritize specific actions at specific sites to assist in the recovery and resilience of reef fish communities.

AMC-24-581

Quality more than quantity: Positive changes in trophic structure of fish communities in protected Philippine reefs

Asuncion Bina De Guzman, Denmark Bagsican Recamara

The popularity of marine protected areas (MPAs) as coastal management tools in the Philippines is mainly due to their ability to improve habitat and reef fish community structure, and their contribution to sustaining coastal fisheries and marine biodiversity. Time-series changes in trophic structure of reef fish in Mindanao, southern Philippines were investigated as a means of evaluating the role of 'no take' MPAs in improving the quality of fish assemblages after years of protection. In five out of eight sites surveyed fish species richness and biomass increased after only 2-4 years of protection. Reef fish in the eight MPA sites are classified into six trophic guilds based on main diet and trophic level (TL) of each species. Perhaps of more significance than improvement in overall species richness and biomass is the change in the quality of fish trophic structure in these protected reefs. Mean trophic level has increased in most MPAs indicating that protection from fishing had increased the diversity, abundance, and biomass of carnivore groups compared to other trophic guilds. Across MPA sites in Mindanao the mean TL of carnivores increased from 3.60 – 4.13 (2006-2009) to 3.70-4.19 (2011-2013), indicating an improvement, albeit modest, in species quality through time. Large fish or carnivores are the primary target of capture fisheries on unprotected reefs and their decline is often accompanied by increase in the abundance of lower trophic groups such as herbivores and detritivores. The increase in diversity and abundance of carnivores in coral reefs can indicate the important role of MPAs in restoring the trophic structure of fish communities under effective management. Longer time-series monitoring, on the other hand, is needed to show significant impacts of coral reef protection on fish community structure.

AMC-25-455

Loss of diversity, relative abundance, and potential biomass of reef fishes in the Kalayaan Island Group, West Philippine Sea

Joey Pueblo Cabasan, Frederico B Sabban, Porfirio A Aliño, Cesar A Villanoy, Hazel O Arceo

The Kalayaan Island Group (KIG), located in the West Philippine Sea, is a key traditional fishing ground and provides massive economic, social, and ecological services to the Philippines. However, increasing demands and levels of exploitation within the region persist, affecting the overall health condition of the reefs in the area, including the collapse of fish standing stocks. The last intensive reef assessments in this area were conducted in the 1990's. To determine the present condition of reef fish assemblages (i.e. species richness, density, and biomass), underwater fish visual surveys were conducted in May 2017 in four sites and compared with data obtained from the 1990s. Of the 273 recorded species for both years, 82 species were no longer observed in 2017, including; *Bolbometopon muricatum*, an IUCN Red List species, and target species: *Aethaloperca rogaa* and *Plectorhinchus lineatus*. Comparative analyses showed that species richness dropped from 63 to 48 per 500m^2, mean fish density decreased by 72 percent (or approximately 1800 individuals per 500m^2), and reef fish biomass has been reduced to 32.7 from 102.6 metric tons per km^2. Consequently, the status of reef fishes has markedly shifted from high and excellent to moderate and "poor" conditions. Although statistical analyses of the mean size estimates were not significant, the maximum sizes of most species were relatively smaller in 2017 than in 1993, suggesting the long-term effects of size-selective fishing, and that current conditions in the area were insufficient for recovery. These findings are concordant with global trends of serious decline in fish stocks. Hence, proper management interventions are urgently needed in this area, especially since heavy commercial fishing and the use of destructive fishing practices remain unregulated within the KIG and the West Philippine Sea, in general.

AMC-26-657

Biodiversity at risk: A status of reef fishes in the Philippines

Joseph Benedict Tion Garcia, Denmark Recamara, Jemelyn Grace Baldisimo, Ma. Czarmayne Victoria Jude Escoro, Maryjune Cabiguin, Jerome Genilan, Mary Joyce Velos, Hazel Ouano Arceo

The Philippines, as part of the world's coral triangle, is considered a biodiversity hotspot. Increasing threats to biodiversity highlights the need for continuous update of the status of its marine resources for effective management implementation. With the goal of providing an updated information on the present condition of coral reef fishes in the country, a systematic nationwide survey was conducted from 2014 to 2017. More than 700 transects in over 400 stations within 75 localities in the Philippines were surveyed using the standard underwater Fish Visual Census Method. Around 790 reef and reef-associated fish species belonging to 75 families and subfamilies were identified in the survey areas. Most (76%) of the sites have high to very high levels of species richness (≥75 species/1000m^2), of which the majority can be found within the Visayan Sea region in central Philippines. Despite the high levels of species richness, mean fish density was observed to be in the low to moderate levels only (≤2267 individuals /1000m^2) in almost 95% of the sites. Mean reef fish biomass was observed to be in very low to moderate levels (≤20 metric tons/km^2) in 72% of the surveyed sites. A high number of sites with low levels of fish density and biomass poses a great urgency to conserve and manage the country's reef fish diversity, especially since many coastal communities depend on this marine resource for food and livelihood.

AMC-27-405

CoRVA-DB: Development of an information system on the National Integrated Protected Areas System (NIPAS) Sites

Theresa Mundita Lim, John Christopher Azcarraga, Reuben Campos, Ma. Josefa Pante, Kristina Cordero-Bailey, Talna Lorena dela Cruz, Laura David

In order to adequately protect the Philippine reefs, the Department of the Environment and Natural Resources - Biodiversity Management Bureau (DENR-BMB) has identified that there is a need to have a working knowledge of state of reefs and the imminent threats that may affect these reefs. The Coral Reef Visualization and Assessment (CoRVA) Program has been working hand-in-hand with the BMB to develop a web-based database to serve as repository of data collected from the National Integrated Protected Areas System (NIPAS) sites. This national database is essential for the DENR-BMB in the assessment of the current status of NIPAS areas. The system was developed using PHP scripting, MySQL database connection, and JavaScript technologies. A map-based interface, powered by Leaflet JS, serves as the main interface of the database. Markers in the map, which represent NIPAS sites, are clickable. The NIPAS DB is populated using data from the different project components of the CoRVA Program and from contributions from the different regional DENR offices. Included in this development of a National Information System, is a project dedicated to the training of DENR regional counterparts on the reef and coastal integrity assessment protocol. This is envisioned to support the continuity of the population and updating of the database. Currently, the database contains data from NIPAS sites of Regions 3, 4B, 8, 9, 10,11 and 13.

BCC-1-745

Bioactive compounds in the coral reefs: The Philippines in focus

Lilibeth Salvador-Reyes

Organisms from coral reefs are emerging as front liners in the race for new antibiotics and other drugs. The multiple associations between organisms serve as the driving force for the unprecedented chemistry and potent biological activity of marine natural products. The Philippines has over 20 years of history in drug discovery from marine organisms. We have undertaken the screening and identification of antimicrobial, antimalarial and antiproliferative compounds from sponges and sponge-associated microorganisms. The chemistry and biology of these bioactive compounds from Philippine coral reefs will be presented.

BCC-2-736

Bioactivities of glycosaminoglycans from silver-banded whiting Fish (*Sillago argentifasciata*) heads

Bernadeth Figueroa Ticar, Z Rohmah, B D Choi, V H Pomin, A A Vasconcelos, P Azadi

Glycosaminoglycans isolated from silver-banded whiting fish heads were evaluated for their bioactivities which include antioxidant assay and hyaluronidase inhibitory effects. For its antioxidant activity, it showed an IC_{50} of 29.45 ppm which is comparable with that of ascorbic acid as the standard used. It also showed increasing hyaluronidase inhibitory effects at 100, 500, and 1000 µg/ml concentrations. This was further purified and three fractions (F1, F2, and F3) were obtained through anion-exchange chromatography. Its size-exclusion chromatography showed molecular weights of 191140, 82310, and 6420 kDa for F1, F2, and F3, respectively. Further characterization using NMR experiments showed the presence of two significantly important glycosaminoglycans (hyaluronic acids and chondroitin sulfates). The bioactivities of the glycosaminoglycans can be attributed to the presence of these compounds detected on the extracts which are very beneficial in the field of nutraceuticals and in the engineering of healthy food supplements with immunological functions.

BCC-3-744

Bioactive peptides from the deep-water cone snail, *Conus rolani*

Iris Bea Ramiro, Julita S. Imperial, Joanna Gajewiak, Helena Safavi-Hemami, Neda Barghi, Arturo O. Lluisma, Gisela P. Concepcion, Baldomero M. Olivera

The venom of *Conus rolani* was investigated and screened for biological activity primarily by intracranial injection in young mice. Venom fractions were obtained by High Performance Liquid Chromatography (HPLC); thirteen out of fifteen major fractions tested elicited various behavioral phenotypes such as hypoactivity, shaking, losing balance, and paralysis. Bioactivity-guided purification was performed on one of the major fractions (L516 16), by following the hypoactivity in young mice. Two peptides were identified to cause hypoactivity, Conantokin-R04 (MH^+: 2174.0089) and Contulakin-R01 (MH^+: 1573.6487). Both peptides contain post-translationally modified residues. Conantokin-R04 is similar to the γ-carboxyglutamate-containing conopeptide, conantokin-G; while, Contulakin-R01 has sequence similarity to the somatostatin family of neuropeptides. Contulakin-R01 activates somatostatin receptor 4, which is involved in nociceptive and inflammatory processes.

BCC-4-515

Patterns of chemical diversity in the Philippine blue sponge, *Xestospongia* sp. in relation to some ecological factors

Geminne Manzano, Clairecynth Yu, Viviene Santiago, Porfirio Aliño, Lilibeth Salvador Reyes

The Philippines being part of the coral triangle harbors diverse marine sponges which produce numerous bioactive compounds with promising pharmaceutical properties. The secondary metabolite production of these organisms has multiple ecological functions that exhibits variation at different scales. Few studies focus on understanding the factors behind the observed patterns of variability. In this study, the degree of variation in chemical diversity of the renieramycin-producing Philippine blue sponge, *Xestospongia* sp. was investigated. Multiple spatial scale comparison of diversity was conducted at biogeographic, regional, and intra-individual level. Ecological surveys were performed on two collection sites, representing two distinct Philippine marine biogeographic regions – in Oriental Mindoro located on the West Philippine Sea (WPS) and Zamboanga del Sur located at Celebes Sea (CS). Regional scale of variation was conducted within Oriental Mindoro. Sponge fragments were collected using SCUBA and were transported to the laboratory for taxonomic identification and chemical analysis. Biological and environmental factors were investigated to determine their relation to the extent of variability secondary metabolite production. Chemical profiling using HPLC was performed to compare the diversity among samples obtained. Differences in secondary metabolites were observed at different scales. Blue sponges were more abundant in WPS than CS. The benthic and fish communities in Oriental Mindoro, WPS and Zamboanga del Sur, CS sites were characterized by high species diversity and abundance and a very high biomass category. Environmental factors like depth and monsoonal exposure were also compared showing that wave exposure and depth are associated with the abundance and distribution of the sponges. Understanding the chemical variation as derived from ecological and environmental conditions can provide insights to evolutionary and ecological function of secondary metabolites.

BCC-5-548

Antibiofilm and anti-virulence potential of coral associated bacteria against aquatic bacterial pathogens: As an alternate to antibiotics

Arumugam Veera Ravi, Arunachalam Kannappan

The main target of this work is to evaluate the effect of coral associated bacteria against the biofilm formation and virulence factors production in aquatic bacterial organisms. Among aquatic pathogens, multidrug resistant vibrios are the major cause for the problems faced by aquaculture industries. Biofilm formation by vibrios can cause life-threatening infections in both humans and aquatic animals. Since the pathogenicity of the vibrios in part is controlled by quorum sensing (QS) system, attenuation of such QS would prevent the impact of vibrios without developing any resistance. Initially, coral associated bacterial culture supernatants were assessed for its QS interfering potential against biomonitor strain *Chromobacterium violaceum*. Isolate 4 (I-4) was only the isolate showed anti-QS activity against *C. violaceum*. Further, I-4 was evaluated against *Vibrio* spp. biofilm formation. I-4 cell free culture supernatant (CFCS) effectively reduced the biofilm formation of test *Vibrio* spp. More, analysis by light microscopy and confocal laser scanning microscopy ascertained the devastating potential of I-4 CFCS on the test pathogens' biofilm formations. Estimation of carbohydrate and proteins in EPS and FT-IR analysis showed a reduced EPS production in the test pathogens upon I-4 CFCS treatment, which is one of the important requirements for biofilm formation. GC-MS analysis of I-4 CFCS revealed the presence of bioactive compounds responsible for antibiofilm activity. In depth view of the antibiofilm activity of identified bioactive compound using molecular techniques will pave the way to identify a novel drug target which can have potential application in the prevention of vibriosis in marine aquaculture settings.

BEC-1-209

Parrotfish: Born in disturbance, flourishing in adversity

John Howard Choat, Brett M Taylor, Kendall D Clements

Parrotfish comprise the dominant herbivores on shallow reef systems over both the tropical Indo-Pacific and the western Atlantic. However, their functional biology is poorly understood due largely to the erroneous assumption that their feeding and foraging biology is focused on the cropping of turfing and macroscopic algae on coral reefs. This assumption is misplaced as parrotfish lack the digestive functions that would allow them to process a carbohydrate-based food source. This is critical as with most labrid fishes parrotfish require a protein based diet to support the episodes of rapid somatic growth and high but variable reproductive outputs that characterize their life histories. Recent analyses have demonstrated that parrotfish possess highly modified oral and pharyngeal structures that provide for harvesting and processing protein-rich microbes embedded in this calcareous matrix and carbonate particles of coral reefs. In providing a functional basis for harvesting, retaining and processing microbial food items parrotfish are effectively precluded from using larger algae as the primary food source. Parrotfish achieve their greatest abundance and feeding activities on the exposed reef areas where frequent hydrodynamic disturbance provides the calcareous substrata and coral debris that support the endolithic autotrophs and microbes on which they feed. This is especially characteristic of reef habitats dominated by acroporid corals. In evolutionary terms, parrotfish represent one of the few groups of piscine herbivores that have undergone the rapid diversification that has characterized other trophic groups of reef fishes. The evolutionary history of parrotfishes matches the Pliocene and Pleistocene emergence of Indo-Pacific reefs dominated by the branching acroporid that have provided the disturbance-prone reef habitats required by parrotfishes. This presentation will link parrotfish evolution to the advent of acroporid-dominated reefs which have had such a profound effect on reef fish evolution.

BEC-2-96

Relationship between genetic and ecological diversity in coral reef fish feeding guilds

Laura Gajdzik, Giacomo Bernardi, Gilles Lepoint, Bruno Frédérich

Genetic diversity is fundamental for species persistence as it provides the raw material for evolution. Although its determinants are numerous, the pelagic larval duration (PLD) and population size are known to affect genetic diversity of marine organisms with an expected corollary that a short PLD and small population size can decrease genetic diversity. Likewise, the ecological diversity of organisms could lead to pronounced genetic structuring and be conducive to reduced genetic diversity. We aimed to test whether groups of species with narrower ecological niches exhibited lower genetic diversity than those with more diverse ecological attributes. Then, we explored whether PLD and population size were effective predictors of genetic diversity. To test those predictions, we used different trophic guilds (i.e. groups of species having similar trophic habits) of coral reef damselfishes from Moorea (French Polynesia): (i) pelagic feeders picking zooplankton in the water column, (ii) benthic feeders mainly grazing on algae and (iii) the intermediate group feeding on zooplankton, filamentous algae and small benthic invertebrates. For each guild, we determined their genetic diversity using Restriction site-associated DNA sequencing (RADseq) and their trophic ecology with stable isotope analysis. We found that pelagic feeders exhibited the lowest genetic diversity despite displaying the longest PLD and the largest population size. However, stable isotope analysis suggested that this trophic guild had the lowest variation in habitat and dietary requirements compared to benthic feeders and the intermediate group. In other words, our results revealed that the less ecologically diverse guild (i.e. having more homogeneous/similar dietary and habitat characteristics) tends to exhibit lower genetic diversity than guilds having less limited ecological requirements. The observed correlation between levels of genetic diversity and those of trophic ecology emphasizes their inherent feedbacks that should be more globally considered when investigating population genetics.

BEC-3-132

DNA barcodes for teleost fish species from protected coral reefs in Mindanao, Philippines

Ephrime Metillo, Diva Licel A Sipalay, Youn-Ho Lee

Biodiversity database systems that include DNA barcodes are relevant to resource conservation and management. The Philippines hosts a threatened high diversity of reef fishes that may be best protected from threats and extinction through the marine protected area framework. However, most species identification of reef fishes are based mainly on gross morphology leaving the important molecular aspect wanting. This study was aimed to DNA barcode teleost fishes from Philippine protected coral reef areas as input to a biodiversity database accessible from the website of the UNESCO Intergovernmental Oceanographic Commission (IOC) Sub-Commission for the Western Pacific (WESTPAC) under the initiative entitled Enhance the Capacity for Species Identification and Genetic Analysis on Marine Organisms in the Coral Reef. A total of 96 COI barcodes were generated from 82 morphologically identified teleost fish species representing 36 families. Barcodes generated for 26 species were new records on the basis of absence of reference sequences in GenBank. The output of the study will be a contribution to future evolutionary studies of coral reef fish.

BEC-4-636

Nemo's Genome. A chromosome level genome assembly of the clownfish *Amphiprion percula*

Robert Lehmann

The iconic orange clownfish is a popular model organism to study ecology and evolution of coral reef fish, such as patterns of population connectivity, sex change, social organization, marine mutualisms, and habitat selection. Recent progress in climate change research has extended this diverse list further to include the impacts of ocean acidification. Due to an excessive uptake of CO_2 from the atmosphere, oceans are becoming progressively more acidic. The clownfish was the first fish species for which it was demonstrated that fish distinguish predators based on their olfactory cues and that this ability is impaired by ocean acidification. Here we present the first ever sequenced genome of a clownfish species. The *de novo* genome of *Amphiprion percula*, an endemic species from the Australian's Great Barrier Reef, was sequenced using the Pacific Biosciences SMRT sequencing technology. We sequenced the genomic DNA from the brain of a wild-caught clownfish to a coverage of 121X. The final genome was selected from several candidate assemblies based on both measures of quality and contiguity. It features a contig's N50 of 1.86 Mbp, is 903 Mbp long and contains 29746 predicted genes covering 98.6% of the expected orthologs. By phasing the genome using the Phase Genomics Hi-C technique we were able to arrange 1,073 contigs into 24 chromosome scale scaffolds spanning 98% (890 Gbp) of the initial assembly, resulting in a final genome with an N50 of 38 Mbp across 365 scaffolds. This represents the highest-quality and most complete genome of a tropical reef fish presently available. The availability of a high quality clownfish genome makes this species an emerging model system for evolutionary, ecology and climate change studies.

BEC-5-738

Uncovering diversity in coral-dwelling gall crabs (Cryptochiridae)

Sancia E.T. van der Meij

The biodiversity of coral reefs is dominated by invertebrates, many of which live in close association with scleractinian corals. This associated fauna relies on their coral hosts for food, habitat and/or settlement cues. There are at least 860 invertebrate species that have been described as coral associated, of which 310 are decapod crustaceans. There are varying levels of dependence on coral hosts, with over half of the coral-associated invertebrates having an obligate dependence on live coral. The evolution of these symbionts is shaped by the evolution of their host organism, and coevolution studies can be used to infer the chronicle of events that determines the distribution of symbionts on their hosts. Adding complexity are the various events that constitute coevolution; e.g. cospeciation, sorting, host switching, and intrahost speciation events. Here I will discuss cryptic diversity in obligate coral-dwelling gall crabs (family Cryptochiridae), which is uncovered using morphological and genetic approaches, as well as coevolutionary analyses. Moreover, the current advancements in scleractinian systematics also provide new insights in the taxonomy of this diminutive crab family.

BEC-6-124

Facultative and obligate mutualism of crypto-benthic fishes and mushroom corals (Scleractinia: Fungiidae)

Arthur R Bos, Bert W Hoeksema

Scleractinian corals mostly feed on minute zooplankton, but fish larvae and even adults of relatively small fishes (TL < 5 cm) may also be preyed upon. In contrast, scleractinian corals constitute micro-habitats where fish may find shelter. The balance between these two ecological processes has resulted in a wide variety of facultative and obligate symbiotic relationships.

Mushroom corals (Fungiidae) have never been observed hosting fish, apart from the obligate white pipefish *Siokunichthys nigrolineatus* living in the polyps of *Heliofungia actiniformis*. Results of a preliminary study conducted in the Davao Gulf, Philippines, suggested that many other fish also use *H. actiniformis* corals as habitat.

The goal of the present study was to describe the role of various fungiid coral species as micro-habitat for crypto-benthic fish and to provide an overview of fishes found dwelling in their polyps as a result of co-evolution. Data were collected in the Davao Gulf, Philippines and in the Red Sea, Egypt between 2014 and 2017.

Representatives of the fish families Apogonidae, Blenniidae, Gobiidae, Labridae and Tripterygiidae used various mushroom corals as micro-habitat showing that crypto-benthic fishes as well larvae of larger fish species inhabit these corals. Twenty mushroom coral species regularly hosted small fish, whereas 18 coral species were never observed hosting fish. In some cases, two or more fish species were found cohabiting on a single host coral.

Facultative mutualism between small fish and scleractinian corals may occur more frequently and have a more important function in coral reef ecology than previously thought.

BEC-7-235

Cnidarian phylogeny: Current status in the era of phylogenomics

Bastian Bentlage

The phylum Cnidaria arose in the Precambrian with crown group taxa appearing in the fossil record some 600 million years ago. The ecological success of Cnidaria is predicated on several innovations including photo-symbiosis, colonial body plans and diverse life cycles. Understanding the origins of these traits and their role in the success of cnidarians remains difficult due to the fact that the phylogeny of Cnidaria has been subject to debate for decades with numerous mutually exclusive topologies being proposed. I will discuss recent advances in cnidarian phylogenetics using phylogenomic datasets, including a recent comprehensive analysis I was part of that integrated data from several studies while also generating new phylogenomic data using transcriptome sequencing of key taxa. Our results provide a robust phylogenetic hypothesis for Cnidaria at large. So far phylogenomics of Cnidaria relied largely on transcriptome sequencing using RNA extracted from tissues. This approach has several disadvantages: per sample cost of sequencing is high, recovery of orthologous genes for phylogeny reconstruction is dependent on which genes are expressed at the time the tissue was sampled, and RNA is notoriously unstable, making collection of appropriate tissues often challenging. Reduced representation genome sequencing may provide an alternative to transcriptome sequencing. Here, a subset of genes from the genome are enriched and subsequently sequenced. This approach can in theory be applied to tissue samples that were preserved using a variety of techniques, thus opening the door to extracting phylogenimc data from difficult-to-collect specimens already housed in collections. A lack of reference genomes for cnidarians has hampered development of this technique for cnidarian phylogenetics. Recently, however, this approach was applied to anthozoan cnidarian and my work has focused on medusozoan cnidarians (jellyfish, hydroids, and their kin), for which I present the results of a pilot study.

BEC-8-724

Establishment of a western Pacific regional database on coral reef organisms in the IOC/ WESTPAC DRMREEF project

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Western Pacific Sub-commission (WESTPAC) of Intergovernmental Oceanographic Commission (IOC) has launched a multinational cooperative project entitled 'DNA Taxonomy and Recruitment Monitoring of the Coral Reef Marine Organisms (DRMREEF)' in 2013. Its objectives are to enhance national and regional capacity for species identification with genetic markers, to build a common inventory of coral reef organisms for assessment of their regional scale distribution, and to monitor recruitment of their larvae and fries. Seven countries including Republic of Korea, Bangladesh, Indonesia, Malaysia, Philippines, Thailand, and Vietnam have participated in the project and contributed building the common database called WESTPAC Marine Biodiversity Portal (WMBP, http://118.219.45.145:999/ westpac/). Each data set for a specimen consists of taxonomy, morphological description, photograph, collection time and place, DNA barcode, and specimen depository. Currently, WMBP contains information on more than 2,500 specimens of 1,410 species, 428 specimens of which also present DNA barcode sequence information. The 428 registered species include 22 species of Sponge, 247 Cnidaria, 1 Mysozoa, 41 Annelida, 383 Mollusca, 113 Arthropoda, 131 Echinodermata, and 472 Chordata. This collated information on coral reef organisms from the seven WESTPAC countries will help understand not only the coral reef marine biodiversity, but also their regional scale distribution patterns, which would then enable us to make a plan of regional level conservation for the coral reef organisms.

BEC-9-202

Molecular diversity of zoantharians in the Strait of Hormuz, the Persian Gulf

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Studies investigating zoantharian species in the Persian Gulf are scant. In the current study, molecular phylogenetic of zoantharian species in the PG has been analysed using DNA markers. Therefore, 123 colonies of zoantharians were collected from Larak, Hengam,Qeshm and Hormuz Islands, all of which are located in the Strait of Hormuz. Based on 16S rDNA and COI regions, presence of five putative species-level clades were identified; *Zoanthus sansibaricus* (n=65), *Palythoa tuberculosa* (n=19), *Palythoa mutuki*(n=2), *Palythoa* aff. *mutuki* (n=36) and *Neozoanthus* sp. (n=1). While the first three were known species, the last two were potentially novel species in the region. Apparently, *Palythoa* aff. *mutuki*, one of the most common species in the world's hottest sea, has morphological similarity to *Palythoa mutuki*. However, mitochondrial DNA sequences obtained from these specimens were only identical to *Palythoa* aff. *sakurajimensis* from the Red Sea. Interestingly, *Neozoanthus* sp. was both morphologically and molecularly different from previously described *Neozoanthus*. This is the first record of this genus from the PG and neighbouring regions. Since there hasn't been much work on zoantharian identification in the PG, further sampling and investigation is needed to speculate on the accuracy of these potentially new species and to complete the knowledge of zoantharian diversity in this area.

BEC-10-23

Variation in bacterial community of *Terpios hoshinota* in the western Pacific Ocean

Sen-Lin Tang

Terpios hoshinota is a coral-killing, encrusting sponge and enables to cause massive mortality of stony corals. However, the understanding of the sponge is mostly unknown. This study collected *T. hoshinota* samples from different reefs across the western Pacific Ocean in the past 10 years. Close attention is paid to cyanobacterial species in the sponge because they are frequently observed inside the sponge. Moreover, an *in-situ* light shading experiment has shown discontinued expansion of *T. hoshinota* suggested cyanobacteria played an important role in sponge growth (Soong et al., 2009). This work focuses to answer following questions: (1) is there any geographic variation in *T. hoshinota*-associated bacterial community composition from all study sites? And (2) does dominant cyanobacteria species in *T. hoshinota* the same from all study sites? The sponge-associated bacteria were identified by 16S rRNA amplicon sequencing. The statistics analysis suggested that no geographic variation were detected in the samples. The dominated cyanobacteria were the same species in all the samples suggesting an intimate symbiotic relationship between the sponge and its symbiotic cyanobacteria.

BEC-11-368

How coral reef-associated Arthropoda respond to well-established environmental gradients in the Red Sea basin?

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The Red Sea has attracted the attention of the scientific community because of its extensive coral reef system set in a context of high salinity and temperature that changes along the latitudinal extent. The knowledge of cryptic biodiversity in coral reefs is deficient, yet it comprises the majority of the mobile species in coral reefs, with arthropods being the most abundant group. In the present study, we assess the arthropod assemblages (those larger than 2mm) along the Saudi Arabian coast of the Red Sea using Autonomous Reef Monitoring Structures (ARMS) as a standardized method. ARMS were deployed for 24-36 months in 19 reefs (three units per reef deployed between 8 and 12m). Listed from North to South: Duba (18 units), Thuwal (12 ARMS), Jeddah (6 units), Al-Lith (12 units), and Farasan Islands (6 ARMS). *In situ* sea surface temperature (SST, from loggers attached to ARMS) and remote sensing data (chlorophyll *a*, and salinity) were analyzed as explanatory variables. Specimens collected were barcoded using a short region (651 bp) of the COI mitochondrial gene and assigned to operational taxonomical units (OTUs). Preliminary results show that more than 50% of the 250 OTUs identified were restricted to a single region and only a small fraction spanned across the whole latitudinal gradient. Preliminary results also suggest an increasing trend in the OTUs number towards the south. Mean abundance was significantly lower in the north (9 individuals) compared to the central (66 individuals) and southern regions (55 individuals). The northern Red Sea seemed to support the most distinct communities that were associated with the conditions of highest salinity and lowest SST. The present findings contribute to a better understanding of the biodiversity patterns in Red Sea region, an area of high conservation interest but where adequate measures to protect biodiversity are still insufficient.

BEC-12-97

Secondary contact and genetic admixture of the Indo-Pacific sister lineages in coral reef sea stars

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Genetic divergence in many coral reef organisms between Indian and Pacific oceans stems from vicariance caused by sea level fluctuations during the past climate oscillations. However, few studies have examined genetic admixture of Indo-Pacific vicariance as a consequence of secondary contact in coral reef benthic organisms. Using population genomic technique (MIG-seq) as well as traditional mitochondrial DNA and microsatellite analysis, we examined the population genomic structure of three coral reef sea stars in the Indian and Pacific oceans. Secondary contact of Indian and Pacific mitochondrial lineages of *Acanthaster* spp. and *Culcita* spp. occurred in north Jakarta and partly in Spermonde. While clear genetic differences were found between Indian and Pacific *Acanthaster* spp. based on microsatellite analysis, genetic admixture was found between those of *Culcita* spp. based on MIG-seq analysis in the sympatric secondary contact zones. Blue *Linckia* and mottled *Linckia* also showed Indo-Pacific genetic clades based on mitochondrial genes in accordance with previous studies. Mitochondrial DNA of these two nominal species is, however, partly shared in each genetic clade, indicating introgression in each of the oceans during Pleistocene. On the other hand, nuclear DNA analysis indicated genetic difference between Blue *Linckia* and mottled *Linckia* irrespective of geographic locations. Several loci showed high inter-species F_{ST} values and some of them were fixed in each morph species even at sympatric populations. These data imply that current hybridization is limited between blue *Linckia* and mottled *Linckia* but mitochondrial introgression occurred in the past, suggesting possible reticulate evolution. In summary, *Acanthaster* spp. that have the longest expected coalescent time showed almost no hybridization while *Culcita* spp. that have shorter expected coalescent time showed intensive hybridization in the secondary contact zone. *Linckia* spp. that have the shortest estimated coalescent time did not speciate between Indian and Pacific Oceans, but rather sister species were possibly hybridized during Pleistocene period.

BEC-13-432

Dead Fungiidae corals as refugia for cryptic biodiversity

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The role of free-living mushroom corals (Fungiidae spp.) in reef building is well documented. The large skeletons of such corals are known to provide valuable substrate for numerous organisms including facilitating recruitment of other scleractinian taxa in sandy or dynamic benthos. Recent findings have highlighted the role of living mushrooms corals as hosts of exceptional biodiversity and indeed as opportunistic predators in the benthic trophic system of coral reef habitats. Studies at Koh Tao, Thailand, have highlighted the threat faced by these corals due to predation by corallivores, resulting in mortality. Transect surveys at 5 sites around the island between 2017 and 2018 compared the biodiversity supported by over 1000 dead fungiid coral skeletons to assess their role as refugia for certain key taxa. Diversity and abundance of heterobranch sea slugs, cowries, platyhelminthes and sea urchins were compared between small (< 20 cm max diameter) and large (> 20 cm max diameter) skeletons. These numbers were also compared to 20 cm quadrats of reef rubble taken along the transects, and passive observations of reef habitats. The findings indicated that sea slugs, cowries and sea urchins were significantly more abundant finding shelter underneath fungiid skeletons than in typical reef rubble, with numerous sea slug taxa being found either exclusively under these skeletons, or at far greater abundances than previously recognised. Additionally, all taxa investigated appeared in greater abundances under dead fungiid skeletons and among rubble than on the open reef. All surveys were carried out during day time, and may provide insights into the role of aposematic, cryptic and physical defences in reef-associated fauna and their behavioural adaptations to protection in coral reef ecosystems.

BEC-14-384

Same but different: DNA barcoding reveals cryptic diversity in marine invertebrate species

Jia Jin Marc Chang, Ywee Chieh Tay, Yin Cheong Aden Ip, Hui Ping Ang, Karenne Phyu Phyu Tun, Loke Ming Chou, Rudolf Meier, Danwei Huang

Species delimitation is the sine qua non for biology, since species as a taxonomic unit forms the praxis through which most biological studies are undertaken. This in turn has material implications on areas such as biodiversity conservation. DNA sequences have become major sources of information for furthering our understanding of organismal genetic and evolutionary relationships over the years. The technique of DNA barcoding, which employs short, standardised DNA sequences (i.e. barcodes), is generally sufficient to distinguish species in most taxonomic groups. A major contribution of this technique centers on the discovery of cryptic species complexes using the cytochrome c oxidase subunit I (COI) gene, which is one of the most widely-used DNA barcodes with a fairly robust global database to match. Using this gene, our results suggest the presence of cryptic species complexes in reef-associated species in Singapore – *Peronia cf. verruculata* (Gastropoda: Onchidiidae) and *Halobates hayanus* (Arthropoda: Gerridae). Intraspecific and interspecific COI distances ranged from 0–1.8% and 4.6–6.0% respectively in the *P. cf. verruculata* complex, and 0–1.8% and 4.5–7.7% respectively in the *H. hayanus* complex; signifying a clear barcode gap in each case. Furthermore, these species are potentially undescribed to science. A suite of integrative taxonomic approaches such as scanning electron microscopy (SEM), phylogenetic analyses, as well as the Automatic Barcode Gap Discovery (ABGD) supported our COI-delimited species boundaries. These case studies exemplify the need for more in-depth discourses on cryptic diversity, integrative taxonomy and species delimitation methods. Our findings highlight important implications of hidden diversity on managing biodiversity as it can influence species diversity estimates.

BEC-15-241

The morphology of F1 hybrids of the coral genus *Acropora* in the Indo-Pacific

Hironobu Fukami, Kenji Iwao, Masaya Morita, Naoki H. Kumagai, Naoko Isomura

In the coral genus *Acropora*, multiple species spawn synchronously at same site in the Indo-Pacific, suggesting that the F1 hybrids would have been produced. The F1 hybrids, however, have never been found in the field so far. In this study, to detect the morphology of F1 hybrids of *Acropora*, we have grown the F1 hybrids and examined the morphology. Two morphologically distinct species, *Acropora florida* (bottle-brush–like colony) and *A. intermedia* (long branch-like colony) can hybridize at high fertilization rates (but variable: 2.7–98.7%) in both directions via eggs and sperm. We produced artificially the F1 hybrid larvae and have grown the F1 hybrid juveniles and also ones of each purebreds. These juvenile corals had been kept in the cage in the harbor for four years after larval settlement. Then, we examined their morphology such as colony shape, colony size and branch length. At present, only two colonies of these F1 hybrids with different maternal species remain alive, which are 10-year old. We also checked the skeletal morphology of each of these matured colonies. Our results showed that F1 hybrids had more similar feature at the branching number per branch length to maternal species than paternal species. Moreover, the juvenile F1 hybrids produced from *A. florida* eggs ′ *A. intermedia* sperm were morphologically more closely related to *A. florida*, whereas the F1 hybrids produced from *A. intermedia* eggs ′ *A. florida* sperm were more closely related to *A. intermedia*. This data suggests that eggs affect determination of colony shape to some extent. On the other hand, two matured F1 hybrids with different maternal species tend to be similar to each other in colony shape although still they look more similar to the maternal species. Thus, to understand the morphological diversification of *Acropora*, we need more examples of F1 hybrids.

BEC-16-236

Evolution of photosymbiosis in corals: Patterns of gain and loss of an ecologically important trait

Jordan A Gault, Bastian Bentlage, Danwei Huang, Alexander M Kerr

Of the ~1500 species of scleractinian corals, around 55% form a nutritional mutualism with photosynthetic dinoflagellates of the genus *Symbiodinium*. This mutualism, termed photosymbiosis, is key to the ecological success of corals in shallow-water, oligotrophic reefs. Despite the importance of this trait, we know little of the evolutionary history that has led to its current distribution within the order. Of the basal sister clades in Scleractinia, photosymbiosis is present in the larger "complex + robust" clade, while its sister is exclusively non-photosymbiotic. It remains unclear whether scleractinians were ancestrally photosymbiotic followed by multiple losses of the trait or ancestrally non-photosymbiotic followed by one or more gains. Using the posterior set of both a 1472-species supertree of Scleractinia and a 579-species, 12-gene molecular phylogeny, we reconstruct the deep evolutionary history of photosymbiosis. To account for uncertainty in topology and in the rates of trait evolution, we use Markov Chain Monte Carlo techniques to estimate the posterior probability of ancestral states at interior nodes. Both the root and complex-robust split are confidently reconstructed as non-photosymbiotic. Photosymbiosis evolved independently as many as three times in the complex clade, at least once in the robust clade and was subsequently lost at least once in both. Thus, the distribution of photosymbiosis in Scleractinia is best explained by a non-photosymbiotic origin followed by multiple independent gains and instances of subsequent loss.

BEC-17-222

A genome and transcriptome-based phylogeny of reef corals

David Combosch, Sarah Lemer, Rüdiger Bieler, Gonzalo Giribet

Stony corals (Order Scleractinia) have been studied for decades because of their fundamental role in reef building. Nevertheless, our understanding of their evolution and systematics has changed profoundly over the last two decades with the advent of molecular phylogenetics. Most phylogenetic studies, however, are based on only a handful of markers and tend to focus on individual genera and families. A robustly supported phylogeny across this important order is therefore still missing.

Here, we present the largest phylogenomic study of Scleractinian corals to date. Our greatly expanded dataset is comprised of newly sequenced and published genomic and transcriptomic data for deep and shallow water Scleractinia. At present, our analyses include over 100 samples that span 18 scleractinian families, including all major reef-building genera, and additional sequencing is currently underway to further extend our taxonomic range. Our results are based on comprehensive phylogenetic analyses of multiple different data matrices that between 50 and 1000 orthogroups. Our results provide a well-resolved, robust, phylogenomic backbone for Scleractinia, addressing long-standing questions about the monophyly and evolution of the so-called complex and robust clades.

BEC-18-524

Molecular phylogeny and morphological variation of *Euphyllia ancora*

Yuko F Kitano, Takuma Fujii, Yutaro Oku, Keiichi Nomura, Hiroyuki Tachikawa, Hironobu Fukami

Euphyllia ancora is widely distributed in the Indo-west Pacific. This species has anchor, kidney, or T-shaped tentacles and a flabello-meandroid to flabeloid colony shape forming long valleys with several polyps. It is known that width of valley of this species varies greatly. Veron and Pichon (1982) mentioned that width of valley depended on environmental conditions and the colony size. In contrast, Sugihara et al. (2015) treated the specimens with wider valleys to a different species from *E. ancora*. In addition, at Ogasawara Islands in Japan, we found that several colonies contained both flabello-meandroid and phaceloid shapes within a single colony. Taxonomically, specimens of phaceloid shape with same characters of tentacle as *E. ancora* are identified as *E. paraancora*. Thus, these intermediate-shaped colonies can be identified as either *E. ancora* or *E. paraancora*.

In this study, we examined the phylogenetic relationships of *Eupyllia* spp., especially for *E. ancora* with morphological variation, in Japan to clarify their taxonomic status at the species level. As a marker of the analysis, we used 3'end of cox1 gene because it has been reported to be very useful to separate *Euphyllia* at the species level (Akdam et al. 2017, Luzon et al. 2017). We collected all of known species *Euphyllia* from Japan except *E. baliensis* which is an endemic species in Indonesia. Our results showed that *Euphyllia* spp. were divided into two major clades, as reported by previous studies. One clade included *E. glabrescens* and *E. cristata*, and the other included *E. ancora* and other five species. Notably *E. ancora* was clearly divided into two subclades. In addition, Ogasawara specimens were included in both of these subclades whereas *E. paraancora* itself formed a single subclade. At present, we try to find the morphological characters corresponding to each subclades based on our molecular phylogenetic data.

BEC-19-479

Genomic data reveals cryptic genetic structure and potential host symbiont co-evolution in the *Porites lobata* species complex

Zac Forsman, Raphael Ritson-williams, Kaho Tishammer, Ingrid Knapp, Robert Toonen

Reef building corals are challenging to identify and often coral 'morphospecies' are components of a larger species complex. This pattern of genetic and morphological variability is not clearly understood, which confounds a wide variety of studies. The genus *Porites* has several unresolved species complexes such as the '*P. lobata* species complex' with very distinct branching and mounding mophospecies that likely interbreed according to recent genomic data. Here, we analyze new genomic data from additional samples in this complex in an attempt to better understand how such morphological differences could be maintained in spite of evidence for introgression. The resulting complete (or nearly complete) mitochondrial genomes show three clades within the species complex; one that contains mostly the mounding form *P. lobata*, one that contains mainly the branching form *P. compressa*, and an intermediate clade where both *P. lobata* and *P. compressa* share completely identical mitochondrial genomes. Examination of putative *Symbiodinium* loci also indicate similar patterns although with some additional individual mixing. Interbreeding across a habitat gradient with some level of host-symbiont co-evolution is a hypothesis that would explain these patterns and warrants further investigation

BEC-20-49

The phylogeography of *Galaxea*

Patricia H Wepfer, Yuichi Nakajima, Makamas Sutthacheep, Veronica Radice, Zoe Richards, Put Ang, Atsushi Fujimura, Mareike Sudek, James Davis Reimer, Allen Chen, Tullia Isatto Teraneo, Robert Toonen, Alexander S. Mikheyev, Evan P Economo, Satoshi Mitarai

Our understanding of coral diversity and diversification processes is still underdeveloped despite their fundamental role in one of the world's most diverse ecosystems. Due to morphological plasticity, potential hybridization and generally high rates of dispersal it has been difficult to unravel the systematics of corals and both spatially and molecularly extensive studies are needed to improve our understanding of coral species.To this end, we took a phylogeographic approach on the example of *Galaxea* and conducted genus-level samplingacross the Indo-Pacific, Field collections were gathered from the Red Sea, Maldives, Chagos, western and eastern Australia, Thailand, Japan, Hong Kong, Guam and Samoa. Additionally, museum specimens were used to increase the geographical coverage of the study. Over 150 individuals were genomically characterized by restriction site-associated DNA (RAD) sequencing and analyzed by phylogenetic methods. The relationship between morphologically cryptic genetic lineages and taxonomic species was evaluated based on five out of seven currently accepted species (*G. fascicularis, G. astreata, G. cryptoramosa, G. paucisepta, G. horrescens*) and the validity of the current taxonomy in this genus is discussed from a phylogenetic perspective.

BEC-21-271

Comparative genomics reveals the distinct evolutionary trajectories of the robust and complex coral lineages

Hua Ying, Ira Cooke, Susanne Sprungala, Weiwen Wang, David Charles Hayward, Yurong Tang, Gavin Huntley, Eldon Edward Ball, David John Miller

Although the timing of the origins and major divergences remain equivocal, all of the available molecular data imply that most extant corals fall into two major clades known as the Complexa (complex corals) and Robusta (robust corals). This dichotomy is well supported in molecular analyses - the split is recognised as real, despite the fact that few morphological or biological criteria resolve the two groups. One reason for the lack of features distinguishing the two clades is the relative paucity of large molecular datasets for a representative range of corals. To provide a platform for investigation of both differences between individual species and general differences between complex and robust corals, genome sequencing and assembly was carried out on number of corals selected to reflect phenotypic and physiological diversity.

Whilst phylogenic analyses based on a dataset of three complex and two robust coral genera, along with two sea anemones, strongly support a deep complex/robust split, synteny analyses revealed a high level of gene order conservation between all corals, but not between corals and anemones or between sea anemones. Clusters of HOX-related genes were, however, well preserved across all of these combinations. Differences between species were apparent in the distribution and numbers of protein domains, and an apparent correlation observed between numbers of HSP20 proteins and stress tolerance.

The most significant implication of the comparative genomic analyses, however, was that, uniquely amongst animals, robust corals are capable of de novo histidine biosynthesis. Previously, the only known difference between corals with respect to biosynthetic capacity was the lack of the enzyme cystationine b-synthase (suggesting a requirement for cysteine) in Acropora spp. but not other corals. Whilst these metabolic differences may play roles in the selection of compatible Symbiodinium strains, experimental support for this idea is presently lacking. Indeed, the robust corals studied here host strains of clade C and clade D Symbiodinium, as do many complex corals. Note, however, that enormous variation exists within the clades, and few genome data are available, so the possibility of metabolic influences on strain selection cannot be dismissed.

CRA-1-244

See the unseen: revealing hidden diversity of planktonic organisms in an Indonesian reef system using environmental DNA

Hawis Madduppa, Christopher Lane, Beginer Subhan, Sunita Ayu Purnamaningsi, Austin Humphries

Planktonic organisms are important drivers of productivity in marine ecosystems. Data suggest that there is likely an enormous amount of hidden diversity in planktonic communities on coral reefs, regardless of their location, not to mention the micro-communities within corals themselves. However, lack of data in Indonesia on these important species remain to be discovered, which underpin coral reef fisheries food webs and thus coastal food security. In this study, we strategically sample planktonic, sessile, and motile organisms along gradients of fishing pressure and fisheries management in coral reefs of Lombok Island, Nusa Tenggara Barat. We used a suite of methods, including environmental DNA (eDNA). Water filtering of 4 liters occured using 20µm and 0.4µm filters at surface, mid-water, bottom and sediment for each site. We confirm that the most biodiversity originates from benthic planktonic organisms. These results suggest that sedimentary eDNA could be used to estimate the ecological structure of the entire pelagic community in the coral reef ecosystems.

CRA-2-401

Environmental DNA metabarcoding for biomonitoring of Singapore's marine environment

Yin Cheong Ip, Jia Jin Marc Chang, Hui Ping Ang, Karenne Phyu Phyu Tun, Loke Ming Chou, Danwei Huang, Ywee Chieh Tay, Rudolf Meier

Traditional tools for monitoring marine species diversity are expensive and require specific taxonomic expertise, but recent sequencing technologies provide high-throughput solutions for identifying species. Today, rapid species detection from bulk environmental samples is becoming routine with metabarcoding procedures. Even seawater can harbour trace environmental DNA, or eDNA, left by organisms that are in the vicinity of the water sample. Our present study explored the feasibility of eDNA metabarcoding as a biomonitoring tool, by utilizing a short fragment of the cytochrome c oxidase subunit I (COI) gene to characterize water samples from Singapore's Southern Islands. Obtained from both shallow (1 m) and deep (10 m) water at 8 sites, metazoan communities detected within these samples show distinct signatures that could be monitored over time to track ecological change. We also present here another application of eDNA biomonitoring as a less invasive alternative for monitoring coral spawning events. Seawater sampling was conducted at two sites before and after the coral spawning period in Singapore, to track spawning species using a Scleractinia-specific marker (internal transcribed spacer 2, ITS2). Results show that scleractinian reads were elevated after spawning across several species, which is also consistent with species richness and coral abundance patterns between sites. Challenges remain in our understanding of species diversity assessments via eDNA metabarcoding, primarily due to sampling constraints and database inadequacy. We consider this eDNA work the beginning of a sustained, systematic effort for biomonitoring applications, which will ultimately contribute to developing more targeted conservation strategies.

CRA-3-291

Airborne hyperspectral remote sensing for mapping benthic substrates over Pirotan reef, Gulf of Kachchh region

Mohit Arora

Coastlines and reefs are one of the most dynamic and constantly changing region on the Earth. Remote sensing is a valuable tool for identification of benthic substrates in coral reef environments. Benthic substrates on the reefs are sometimes heterogeneous and homogeneous in nature. In the past studies, many researchers have applied different remote sensing technique like multispectral and hyperspectral for mapping benthic substrates in coral reef environments. Hyperspectral data have a high potential for characterizing and mapping benthic substrates. This study used an Airborne hyperspectral image for mapping benthic substrates with high spatial and spectral resolution. Airborne Visible Infrared Imaging Spectrometer – Next generation (AVIRIS - NG) hyperspectra image was acquired over Pirotan reef, Gulf of Kachchh region, Gujarat in February 14, 2016 at low tide period to get the maximum exposure of the reef above mean sea level. AVIRIS-NG data with 425 bands, has an advantage to identify benthic substrates based on their spectral signatures. The in-situ spectral reflectance of benthic substrates has been measured during the same period of airborne campaign. A total number of 48 different benthic substrates spectral reflectance have been collected. The main living benthic substrates over Pirotan reef were corals, green algae, brown algae, red algae, seagrass, sand, silt, mangroves, rubble, etc. Using the Spectral Angle Mapper (SAM) classification technique, benthic subsrates like: corals, green algae, brown algae, red algae, mixed endmember, seagrass, sand, silt, mangroves, rubble, etc were mapped with an overall accuracy of 65%. Comparison SAM classification with in-situ data indicate that, SAM classification has been useful at identifying benthic substrates from hyperspectral imagery. A spatial distribution of benthic substrates type has been obtained using AVIRIS-NG hyperspectral data.

CRA-4-730

Evolution of coral monitoring and management with respect to climate change: Paleoecology to innovative technologies and way forward

Bhumika Vaghela, Hitesh A Solanki

The effects of climate change are recognized as one of the greatest threats to coral reefs worldwide. One of the most serious and immediate threats is mass coral bleaching associated with unusually high sea temperatures. Coral reefs are very important as they accumulate vast thickness of biogenic sediments and therefore, it is possible to acquire time-series ecological data in the form of variations in the coral community structure during past episodes of environmental change. Many of the proxies that we use to understand past climate on the earth can be found in the major architectural components of reefs. Over the last decade, threatened reefs have increased by 30%, and global and local stressors currently threaten nearly 75% of the world's reefs. Local environmental variation associated with runoff from the land had greater influence on reef coral community composition than variation in global climate and sea level.

Monitoring is an important tool for effective management and provides information to detect changes in condition that might trigger a management response, determine the cause of changes of concern, and evaluate the effectiveness of management actions. Coral reefs are increasingly recognized as foundation for socio-economic development. Effective management of coral reefs has become an important focus to help protect reef biodiversity and facilitate sustainable use. This paper brings together a range of historical coral monitoring practices to advance geo-informatics technology and introduces key strategies utilised worldwide by coral reef managers to address local stressors and build resilience of coral reefs as part of Integrated Management Approach.

CRA-5-728

Filling in the gaps: benthic habitat maps using random forest models with ARAICoBeH system and remote sensing

Patrick Lawrence Cadelina, Aletta Yniguez

Resource maps are essential tools for management and conservation since they represent key spatial information such as where resources are distributed, their connections and conditions. However, benthic habitat maps in the Philippines are still scarce since most surveys are limited in scale and resolution. The performance of Random Forests (RF) classifier in tandem with *in situ* data from the A Rapid Assessment Instrument for Coastal Benthic Habitat (ARAICoBeH) System and remotely sensed information was explored as a means to provide better resolution yet larger scale benthic habitat maps in four sites. The sites that were sampled under the National Assessment of Coral Reef Environments program were: (1) Looc, Romblon, (2) Coron, Palawan, (3) Pujada bay, Mati, and (4) San Andres, Catanduanes. The Landsat-8 Operational Land Imager and Thermal Infrared Sensor satellite data was used to derive environmental predictors used in RF models such as depth, underwater slope, nearest distances both from coast and rivers; while the benthic cover data taken from ARAICoBeH System. Goodness-of-fit test for predicted percent coral cover versus field data from ARAICoBeH System suggest moderate to strong (r-squared values: 0.7, 0.56, 0.52, 0.5) for San Andres, Pujada Bay, Coron, and Looc, respectively.

CRA-6-511

Minimum parallax reef video mosaicking

Ralph Aaron Sison Aguinaldo, Maricor Narvaez Soriano, Karol Giuseppe Abellaneda Jubilo

We present a novel software for mosaicking underwater coral reef video captured by a towed platform. The algorithm, named "Paaronama v.2", aims to minimize parallax-induced errors such as ghosting, seams and data loss. It approximates a zero angular field of view by mosaicking exclusively along thin central strips of consecutive video frames perpendicular to the general camera motion. The final mosaic has a minimized field of view. Frame selection was implemented to filter out redundant frames caused by camera pitching. The width of the central strips were also made adaptive to each image-pair to allow larger translations. To further reduce the visible seams, optimal seam finding was implemented along the minimum differences in the frame overlaps. The optimal seams also allows the centermost portions of each strip to be prioritized, rather than be overwritten by outer portions of the next strips. Color correction methods were added to remove the visible color transitions within the time interval of each mosaic. Results were compared with Kiko&Stitch, Paaronama v.1, AutoStitch and Microsoft ICE in terms of mosaicking speed, memory costs and mosaic quality.

CRA-7-554

Kite aerial photography of shallow marine resources using pose-controlled smartphone cameras

Gerome Jan Morilla Llames, Creo Baylon, Roston Simene Jr., Maricor N. Soriano

Kite aerial photography (KAP) has applications in varying fields where the use of an unmanned aerial vehicle (UAV) is impractical. Although it cannot fly without wind and has less positioning controls, for mass deployment in coastal communities (e.g. citizen science campaigns) it outweighs the UAV's disadvantages such as susceptibility to sea-mist corrosion, battery-dependent flight, and most significantly, high purchase and maintenance cost. The main problem with using regular kite-mounted cameras is that majority of the pictures taken are oblique photographs due to the unstable nature of the setup. It is a tedious task to select vertical photographs in over a thousand photos taken within a span of a 10-minute flight. This paper presents a kite and a smartphone with an android application mounted on a stabilization system with the goal of providing a low-cost alternative in mapping shallow marine resources. Two picavet stabilizing designs were compared using the images taken by the smartphone. Aside from the fact that this can be assembled using local materials, smartphones with excellent camera resolution and sophisticated sensors are becoming more affordable. Through the built-in camera and accelerometer sensor in a smartphone, we developed an application that only takes photo whenever the smartphone is level to the ground. We tested our system by taking aerial photographs of an area located along the shore in Tanza Oasis Hotel and Resort.

CRA-8-152

ImExT: Developing modular express image analysis tools for coral benthic imagery

Val Randolf Morales Madrid, Maricor N Soriano, Eliezer A Albacea

Timely and accurate assessment of the state of coral reefs in the Philippines is paramount, because the ecosystem and economic services that coral reefs play are critical in sustainable fisheries and food security. Rapid advances in image and video capture now allow marine scientists to easily gather coral reef images. This paper presents the design and pilot testing of a suite of modular image analysis tools to answer the challenge of analyzing large volumes of coral reef image data generated during coral assessment and monitoring. Image Express Tools (ImExT) is a suite of cheap, computationally efficient, and modular open source automated image analysis tools. The five modules (i.e., texture dataset, feature extraction, texture classifier, thematic map labeler, and validation) in ImExT identify and mark coral mosaic images as live coral, dead coral, sand, or rubble.

ImExT was tested on coral mosaic images of coral reefs off the coast of Lobo, Batangas, Philippines, which were generated by the Automated Rapid Reef Assessment System (ARRAS) project. Of the 50 images (total of 17,100 patches), 28 were passed into the first three modules for training and the remaining 22 images were analyzed for their coral reef benthic cover. With 90 percent accuracy and taking 2 hours to run, ImExT reported 36 percent live coral, 29 percent dead coral, 19 percent sand, and 16 percent rubble for Lobo Reef.

Even with limited training data, the tools were able to label regions correctly and subsequent iterative tweaking of parameters improved labeling accuracy. Because functions are dynamically loaded at runtime, ImExT makes adding more texture samples for the dataset, re-training the classifiers, and choosing which features or distance measure (in the case of k-NN classifier) easy and swift, allowing marine scientists to assess the state of Philippine coral reefs accurately with minimal manpower and computational efficiency.

CRA-9-255

Reef extent and 3D bathymetry estimation from side scan sonar imagery

Jacqueline Mae Virtudes, Maricor Soriano

We reconstruct the 3d bathymetric profile of fringing and patch reefs from swaths of side scan sonar images. Using the method proposed by Coiras et al. [IEEE Trans Image Proc. 2007], we estimate depth at each point of a swath from the optimization of a Lambertian model of the sea floor with the sonar image intensity modeled as a product of reflectivity, seabed elevation, and intensity of the incident sound wave. The same sonar images are also used to determine the extent of the reef through automatic texture segmentation. Mapping the location and extent of reefs can help improve the management of marine protected areas and establishment of new ones since reefs serve as fish sanctuaries. Reconstruction results are validated from actual measurements of reef extent and spot depth soundings using a single beam sonar.

CRA-10-140

Fish-i: Towards an automated assessment of reef fish biodiversity

Prospero C. Naval, Laura T David

Fish species count and biomass estimation are typical activities used in assessing the health of a tropical marine environment. Conducted within reef areas, an Underwater Visual Census (UVC) carried out on a regular basis helps monitor the success (or lack thereof) of reef protection and rehabilitation initiatives. The monitoring results are also crucial as input to decision making process for the improvement of reef resilience and increased productivity of reef fish communities. Typically this census is done by a fish expert swimming along a transect with the aid of a scuba. Attempts at incorporating videos in fish census aimed to reduce dive hours and have permanent transect records. However, subsequent manual analysis of the collected video data is tedious and very time consuming.

Additionally, UVC methods tend to underestimate fish density measurements due to fish behavioral avoidance response in the presence of the observer diver. Observational bias also arise from variation of diver's skill in accurately counting and identifying fish as well as diver fatigue. Furthermore, the observer is burdened with the decision to include or exclude an individual fish as it moves into or away from the sample area.

We propose Fish-i, a semi-automated fish population density, species identification and biomass estimation system from raw input underwater videos. Through this method, there is minimal disturbance in the water environment, thus greatly reducing observer bias. With Fish-I, even divers with minimal knowledge of fish can obtain high quality population and species distribution measurements using a stereo camera rig and fish video analyzer software that we have developed. The software produces video clips containing estimates of species count and biodiversity, fish size and biomass and a report in csv format for further end user analysis. A permanent visual record of the census is also available for later review and archiving.

CRA-11-655

Automating change detection on large-scale image mosaics to quantify coral mortality and growth rates

Laurice Dagum, Roston Simene Jr., Wilfredo Licuanan, Maricor Soriano

We developed an automated change detection method to quantify mortality and growth rates of stony corals in fixed plots using large-scale image mosaics captured through time. This method was tested on coral reef images taken within a span of eight years from a plot in Lian, Luzon Island, Philippines. The method used shape detection and feature extraction techniques to identify Porites coral colonies in ortho-rectified image mosaics. Significant differences in shape properties and texture vectors from the same pixel locations of the corals were then quantified across the geometrically aligned mosaics. Unlike previous techniques, which used energy-intensive classification algorithms on series of images and required training data validated by experts, this method is novel because it outlines objects of interest on a rectified mosaic covering a relatively larger area than a single image captured from the same altitude, and it quantifies mortality and growth rates without preliminary input from experts. With this method, we aim to address the urgent need for extensive, large-scale, and rapid monitoring of coral reefs amidst the greater threats they face.

CRA-12-385

Using deep learning for automated classification of benthic images

Henry Victorio Lee, Maricor Narvaez Soriano

A convolutional neural network (CNN) is developed for automated identification of objects in benthic survey images. The survey images are generated with the use of Automated Rapid Reef Assessment (ARRAS) technology, which utilizes a towed camera platform that takes videos of the seabed and a video stitching algorithm that creates the final image. Using expert-annotated survey images, a CNN based on the MobileNet architecture was trained to classify images according to eight benthic classes. The data is split into 80%-20% training and validation set respectively. The training phase of the neural network yielded a training accuracy of 98.97% and a validation accuracy of 82.15%.

CRA-13-417

Assessing fish assemblages in different deep benthic habitats using a Baited Remote Underwater Video System (BRUVS)

Frederico Bunuan Sabban, Joey Cabasan, Hazel Arceo

The apparent degradation of shallow-water coral reef ecosystems due to anthropogenic activities pose the need for baseline ecological studies of deep (mesophotic) coral reefs which are inferred to be a potential refuge for shallow water fish species. We used a Baited Remote Video Systems (BRUVS) to describe the fish communities in different benthic habitats found in upper mesophotic depths (30-70m). A total of 24 deployments were done from March to October 2017 in seven locations across the Philippines. Benthic habitats were categorized into four types: 1) Sand/rock-dominated, 2) Hard coral-dominated, 3) Algal-dominated, and 4) Silt-dominated. Differences were observed in the taxonomic and trophic structure of fishes found in the different habitat types. Unsurprisingly, species richness, abundance and biomass were highest in hard coral dominated habitats, and lowest in silty habitats. However, abundance of carnivores, planktivores, and large-bodied fishes was higher in sand/rock dominated substrate, while benthic invertivores were higher in algae dominated habitats. Herbivores are relatively scarce across all habitat types. Lastly, cryptic and vulnerable species (e.g. eels and sharks) were recorded in some instances in hard coral habitats. Insights from this study may provide inferences on how mesophotic benthic habitats support different fish communities, and that the characterization of mesophotic habitats should also be incorporated when planning for the spatial management of shallow water ecosystems, such as coral reefs, if these areas were to provide refuge amidst increasing environmental disturbances.

CRA-14-379

New innovations for fisheries and conservation solutions

Reniel Cabral

Fisheries and conservation problems are becoming more complex, thus requiring new and innovative solutions. Using novel data from satellite technologies, we empirically assess the effect of policies combatting illegal fishing in Indonesia. We discuss how these technologies can support fisheries transparency and sustainability in Asia-Pacific. We propose a pathway to better improve the utility of these tools, particularly for nearshore coral reef areas, by integrating these technologies to local and regional management efforts.

CRA-15-358

Modeling historical cyclone-generated wave heights and return periods in the Philippines for coral reef disturbance applications

Socorro Margarita Tan Rodrigo, Cesar Laurel Villanoy, Princess Hope Tagayuna Bilgera, Olivia Cantaveros Cabrera, Gemma Teresa Narisma

Cyclone-generated waves often cause disturbances to coral reefs and coastal zones. The Philippines experiences many cyclones annually and its vast coastlines are susceptible to their damage. This study thus aims to map the coastal areas and coral reefs prone to cyclone-generated wave damage and the frequencies of such events. Cyclone track data from 1980-2014 has been taken from the Joint Typhoon Warning Center best tracks archive. Their windfields were generated using the Deltares software called Delft Dashboard. Each cyclone was run on a 2-dimensional hydrodynamic and wave model. The model developed has a 4-kilometer resolution and encompasses the whole of the Philippines with bathymetry taken from GEBCO 08. The hydrodynamic component was developed on the Deltares software Delft3D-FLOW, while the wave component using a Simulating Waves Nearshore model under Delft3D-WAVE. The output will be the maximum wave heights per cyclone for every grid point of the model. The map produced can be superimposed on coral maps of the Philippines or those experiencing accreting or eroding shorelines. For each grid location, the return periods will be computed using the maximum wave heights per cyclone and number of cyclones per year. These methods will elucidate which areas around the Philippines experience the highest cyclone-generated waves and how frequently such events will recur.

CRA-16-390

C30 - a simple, rapid, and low-cost procedure for citizen-scientists to monitor coral reefs

Wilfredo Roehl Y. Licuanan, Princess Zyrlyn B Mordeno, Marco V Go, Regine C. Robles, John Opina

The extent and speed of recent changes in reef coral abundances due to ocean warming and human impacts require the development of capability among citizens of coastal communities to map and measure these changes. Citizens that are empowered to monitor changes in reefs by themselves are more likely to respond to and comply with local reef management and conservation imperatives, such as the restriction of access to reefs experiencing coral bleaching. The challenge is to develop appropriate procedures to allow citizen-scientists to undertake monitoring of their local coral reefs. We present a simple, rapid, and low-cost procedure for free divers to take random photo-quadrat images as well as alternative procedures for citizen-scientists to estimate coral cover from the images produced. The cover data that these procedures yield are comparable to those collected using more specialized methods, and can be as powerful in detecting small changes and differences in reef cover over time and space. The images produced can also be processed further by specialists to derive more information such as, coral diversity, size-structure, and disease incidence.

We present suggestions on how to incentivize participation in citizen-scientists' efforts to monitor and manage coral reefs. We also present a scheme by which these procedures could be integrated into protocols that serve as basic elements of a nascent, nationwide reef monitoring system for the Philippines. Such a system is urgently needed in efforts to help build resilience in coral reefs.

CRA-17-555

Does assessment of live coral cover from the underwater photo transect methods represent the live coral cover in an area?

Giyanto Giyanto

Assessment of live coral cover becomes important in monitoring the coral reefs. One of the methods used in monitoring coral reefs in Indonesia is the Underwater Photo Transect (UPT). In this method, the data is taken by photographing perpendicular to the substrate. There are 50 photo frames taken for each 50 m transect line representing a site. The area for each photo frame is about 2500 cm^2 per frame. Based on the analysis using 30 samples of random points per photo frame, it can be calculated the percentage of live coral cover. The purpose of this study was to compare the results of live coral cover obtained by UPT method with the estimated value given by observers who are experts in monitoring of coral reefs. To test this, we used monitoring data obtained from 13 sites located in district of Biak Numfor, Papua, Indonesia. The results showed that live coral cover obtained from UPT method did not significant different from the value estimated by the experts. Thus it can be concluded that its value can be considered representative to assess the live coral cover in an area

CRA-18-19

Hyperspectral behaviour of selected coral species from Andaman reefs, India

Nandini Ray Chaudhury, Ashwin Gujrati, Ch. Satyanarayana, P. Krishnan, Grinson George

Underwater spectroscopy offers an essential support towards the evolving field of hyperspectral remote sensing of coral reef ecosystem. Spectral reflectance of corals is considered as a key parameter in coral reef remote sensing as it potentially indicates coral health, source pigments, fluorescence contribution and colony morphology. In situ hyperspectral signatures of corals help to establish the spectral behaviour of corals: the major functional group in a reef ecosystem. This paper reports in situ hyperspectral signatures of eleven hard or stony corals and one soft coral species sampled from Andaman reefs: the most biodiverse reef of India. The hyperspectral signatures of these twelve selected coral species were collected from two different reef sites: North Bay (11°41'06" -11°42'47" N; 92°44'57" - 92°45'50"E) and Chester Island (11°34'30"- 11°35'10" N; 92°34'39"- 92°35'14" E) in South Andaman with the help of Satlantic underwater hyperspectral radiometer - HyperOCRduring two field campaigns in 2011.HyperOCR has a spectral range of 300 to 800 nm with a spectral resolution of 10 nm.Quality-controlled, simple average spectra or Mean Representative Spectra (MRS) were computed and later normalized for each coral target to generate unique spectral shapes.It is found that these twelve coral species exhibit two major spectral modes: i) brown mode of coral reflectance with the well-known triple-peaked pattern with slight deviations and ii) green fluorescence mode with a strong reflectance feature near 570 nm and a shoulder near 650 nm. The occurrence of green fluorescence mode among Andaman coral species indicates that there can be unknown modes of coral reflectance other than the globally known brown and relatively rare blue modes.

CRA-19-176

A RS and GIS approach to assess vulnerability to sedimentation for coral reef areas in the Philippines

Carla Alessandra Dario, Eileen Langamon Penaflor, Merced Mylanie Panganiban, Laura Tenmatay David

Sedimentation constitutes a source of stress to coral reef health. Sediment-rich waters result to turbidity in the water column thereby reducing light penetration needed for photosynthesis necessary for coral growth and metabolism. In excess amounts and periods of chronic exposure, sediments that settle on coral can lead to coral bleaching, disease and even mortality. Monitoring sediment plumes is therefore an essential component in coastal management; however, temporal trend investigations by in-situ data can often be costly, time and labor intensive. In this study, remote sensing data (MODIS and SeaWIFS) are used as a proxy to identify areas in the Philippines that are exposed to sedimentation driven by tropical storms and precipitation. Specifically, the spatial extent of sediment plumes from satellite imagery during selected time periods is demonstrated to highlight areas that are likely affected by event-driven sedimentation. In addition, sediment delivery potential of nearby watersheds is used to compute and classify areas of risk (low to high) for protected areas under the National Integrated Protected Areas System (NIPAS) act. For the first time at a nationwide scale, the investigation presents a preliminary profile of coral reef sites susceptible to sediment disturbance which can provide spatial management prioritization for local coastal managers.

CRG-1-162

Accreting coral reefs in a highly urbanized setting

Fraser Andrew Januchowski-Hartley, Andrew G Bauman, Danwei Huang, Peter A Todd

Scleractinian corals, the key ecosystem builders on coral reefs, use energy from their symbiotic photosynthetic algae to produce their calcium carbonate ($CaCO_3$) framework that provides shelter and food for many reef organisms. However, increasing anthropogenic stressors have often resulted in higher mortality of faster-growing coral species, shifts towards slower growing, stress-tolerant species, and declines in overall abundance. Low light levels in turbid waters caused by coastal development may have further implications for coral reef growth potential. Here, we report on coral reef carbonate budgets (net $CaCO_3$ deposition rates) including coral growth and bioerosion for reefs in Singapore, which persist in a chronically and highly anthropogenically disturbed environment with less than 20% light penetration to 2m depth. Using a census-based technique we estimated the biologically derived carbonate budget on seven reefs across Singapore that vary in exposure to anthropogenic influences. We found that despite the low cover of fast-growing Acropora species cover (< 1%), net carbonate budgets were relatively high (3.4 ± 0.4 kg m-2 year-1, range -0.5 – 6.1) compared with the mean carbonate budgets on reefs in Chagos and the Maldives pre-2016 bleaching (~3.7 kg m-2 year-1). Mean gross carbonate production on Singaporean reefs was dominated by stress-tolerant columnar Goniopora, and plating Echinopora and Merulina, and was ~1.5 kg m-2 year-1 lower than Chagos and the Maldives at 5.25 ± 0.6 kg m-2 year-1, while bioerosion, particularly by parrotfishes, was only 60% of that on found on reefs in the Western Indian Ocean. Of the seven reefs surveyed, one had a net negative, or erosional budget, due to near-complete loss of coral cover (<5% remaining coral). Our results indicate that even in highly disturbed environments, dominated by slower-growing stress-tolerant corals, reefs can still be accretional, due to changes in other reef carbonate budget processes.

CRG-2-129

Multi-colony coral proxies from Singapore's urban reefs: relationship of skeletal Ba/Ca and luminescence with contemporaneous in-situ seawater parameters

Jani Thuaibah Isa Tanzil, Nathalie Goodkin, Meng Li Chen, Tsai Min Sin, Ed Boyle, Kok Ben Toh, Gareth Fabbro

The ratio of barium to calcium in coral skeletons (Ba/Ca_{coral}) is broadly used as a proxy for tracking terrestrial/river runoff. There are, however, inconsistencies in Ba/Ca_{coral} records that have prompted caution in its reliability as an environmental proxy. Direct comparisons between in-situ seawater measurements and coral Ba/Ca are therefore needed to ensure accurate proxy calibration and interpretation. The current study represents the first to test Ba/Ca_{coral} against years-long monthly-resolution contemporaneous measurements of several in-situ seawater parameters i.e. dissolved seawater barium (Ba_{SW}), temperature, salinity, suspended sediments, sedimentation rate and photosynthetically active radiation. We analysed the Ba/Ca_{coral} of six *Porites lutea* corals sampled from two reefs in Singapore, and explored relationships with in-situ seawater parameters over the period 2009–2015. Our study found poor agreement in Ba/Ca_{coral} from replicate corals sampled from the same reef. There was also no relationship between Ba/Ca_{coral} and Ba_{SW} and between Ba/Ca_{coral} and luminescence G/B (a coral proxy strongly linked with salinity and river runoff, and shown to be highly reproducible across replicate colonies). This implies that the incorporation of dissolved terrestrially derived humic-like substances into the coral is independent of Ba, and that factors aside from freshwater discharge/flood events are driving the poor reproducibility of Ba/Ca_{coral} and disconnect with Ba_{SW} at our study sites. The relationships found between Ba/Ca_{coral} and organics suspended solids and total sedimentation rate suggest the role of Ba-supply through spatio-temporal variability in reef sediment fluxes, or possible Ba-enrichment through biological mechanisms such as feeding, or combination of both. Ba incorporation into coral aragonite, especially in dynamic settings such as those found in Singapore, may be more complex than previously thought. Our results highlight the possibility of high heterogeneity in coral responses to environmental conditions, and the need for careful selection and multi-colony representation when attempting to apply Ba/Ca_{coral} as a trace element proxy.

CRG-3-50

Using coral Sr/Ca, Mg/Ca and δ18O to track environmental changes in the Singapore Straits

Maria Rosabelle Kwan Ong, Jani Thuaibah Isa Tanzil, Nathalie Goodkin

Understanding the relationship between coral proxies and environmental parameters will give us insight not only into the past environment in which the coral lived, but also aid us in understanding the conditions corals in highly turbid, non-homogenous coastal environments face. To investigate this, we sampled massive *Porites* sp. cores from Kusu Island, Singapore (1.225°N, 103.86°E) in April 2017. Cores were sub-sampled at a high resolution (0.05–0.1cm) along the maximum growth axis and analysed for Sr/Ca and Mg/Ca to evaluate their robustness as proxies for sea surface temperature (SST). Preliminary results of a 27-year (1989–2016) calibration reveal significant relationships between Sr/Ca and SST ($r=0.63$, $p<0.001$) and Mg/Ca and SST ($r=0.35$, $p<0.001$). These relationships, however, capture less variability than the calibrations published from open ocean corals. Singapore experiences low annual SST variability (annual range of ~3°C), which may be contributing to the weak correlation found. It is also possible that other environmental factors, such as terrestrial runoff and sedimentation, are affecting the incorporation of these elements into the coral skeleton. To further investigate these hypotheses, we examine the trace element content of seawater through time to evaluate the drivers of the Sr and Mg concentrations of seawater. In addition, we have analysed the $\delta^{18}O$ of the coral subsamples to investigate the role of changes to sea surface salinity (SSS).

CRG-4-249

Reconstructing Singapore's coral communities through the Holocene

Ambert Chiam Foong Ang, Samuel Yong Kit Chan, Michael John O'Leary, Giada Bufarale, Nicola Browne, Andrew Geoffrey Bauman, Peter Alan Todd, Danwei Huang

Coral reefs are accretionary structures that contain a rich archive of palaeoecological and palaeoenvironmental information. Carbonate organisms and in particular scleractinian corals which eventually become incorporated in the reef framework preserve a temporal record of reef growth. Coral reefs in Singapore are expected to have accreted over the last few thousand years. However, historical reef growth and the geological structures associated with reef development in Singapore have yet to be investigated, despite them supporting a rich assemblage of marine fauna and flora. The persistence of Singapore's coral reefs demonstrates a level of resilience to many decades of anthropogenic impacts and environmental change, and understanding their development through time would provide valuable information for local reef management. To determine whether Singapore's coral reefs are simple coral communities veneered over older antecedent bedrock (suggesting long-term marginal environmental conditions) or massive accretionary reef framework structures (suggesting long-term favourable environmental conditions), we obtained sub-bottom (seismic) profiles through Singapore reefs and reconstructed the geomorphology of these reefs with further substrata mapping. We will also extract reef cores for radiocarbon and uranium-series dating, and to identify calcifying organisms for understanding Holocene community structure through time. Here, we present preliminary findings from high resolution seismic profiles and what they reveal regarding Singapore's reef development.

CRG-5-489

A link to the past: The story of Hong Kong's coral assemblages through time

Jonathan D Cybulski, Stefan Husa, Nicolas Duprey, Briony Mamo, Toby Tsang, Moriaki Yasahura, James Y Xie, Jian-Wen Qiu, David M Baker

Coral ecosystems are degrading worldwide. Regional anthropogenic and global climate stressors are decreasing both live coral cover and coral diversity at an alarming rate. Without assisted migration and restoration, certain coral ecosystems may be lost forever. But what goals do we set for ecosystem restoration? Can natural ecosystem functioning be restored or will we simply return it to a previously degraded state? Restoration efforts benefit from historical baselines that illustrate the diversity and persistence of an ecosystem through time (Kidwell 2015). This work represents the first paleoecological study to investigate coral assemblages in Hong Kong during the Holocene. Results show that coral community composition change, species richness and diversity decline, and sedimentation fluxes have shaped the story of Hong Kong's corals for the past 5000 years. We show that there are significant qualitative and quantitative shifts in coral assemblages through time, resulting in decreased rugosity and habitat structure. These changes are likely linked to past anthropogenic stressors such as increased sedimentation and pollution. Our findings represent the first known quantitative comparison of modern versus historical baselines of a coral ecosystem in this region. Furthermore, this story illustrates that the marginal coral communities of Hong Kong, impacted by eutrophication, high sediment loads and turbidity for hundreds if not thousands of years, constitute useful analogs for the futures of other similarly impacted reef ecosystems.

CRG-6-680

Dating of coral heads in Laie Bay, Hawaii, to determine cause of death

Emmalee Buss, Rachel Fears, Samantha Zuro, Mark Cannon

Laie Bay, on the island of Oahu in the U.S. state of Hawaii contains numerous coral heads, many of which are dead. It is unknown whether this coral die-off has anthropomorphic or natural causes. The current study seeks to determine the dates of coral death in the bay using radioisotopic methods. Samples of dead coral were collected from several coral heads in multiple locations around Laie Bay. The samples were cleaned, crushed, and analyzed using X-ray diffraction to determine the percentage of aragonite and calcite. The aragonite samples were dissolved into carbon dioxide gas and converted into graphite for AMS radiocarbon-14 dating analysis. Approximately 80% of the samples were determined to be aragonite. Preliminary results suggest that coral die-off in Laie Bay may be the result of multiple factors. This report will discuss the results of our C-14 dating and analysis.

CRM1-1-522

Citizen science project fills gap in long-term coral reef monitoring in Taiwan

Kah Leng Cherh, Colin Wen

Shortcomings in government structure and lack of stable funding presents a challenge for long-term monitoring of coral reefs, especially in developing countries where reefs are under greatest threat. A citizen science program using a rigorous scientific protocol to provide an important baseline and filling the knowledge gap of the reefs. In Taiwan where fishery and tourism are dependent on reefs, there is currently no government agency solely responsible for management and long-term monitoring of its coastal and coral reef ecosystems. Scientific surveys are often conducted by academic institutions at few sites and on a short timescale (1-3 years), offering at best a snapshot status of reefs. In contrast, Reefcheck Taiwan, a citizen science project, has consistently surveyed reefs island-wide since 2009, culminating in a database essential for elucidating long-term trends. However, it is unknown how effectively Reefcheck data represents Taiwan's reefs. Here, we compared data from Reefcheck Taiwan with scientific reports and publications on temporal and spatial scales. We found that no scientific report or publication covered as many reefs over a period of time as long as Reefcheck. The breadth of Reefcheck monitoring on both temporal and spatial scales allows us to see island-wide long-term trends,but is limited in resolution as Reefcheck surveys are only focused on selected indicator species, disregarding other marine life. We recommend widening the scope of Reefcheck surveys to include other species and rigorously training citizen scientists to ensure accuracy of data. In absence of a government agency for coral reef management, Reefcheck data is crucial in the evaluation of Taiwan's reefs in the past and future.

CRM1-2-24

Fishing for answers: Understanding obstacles to sustained participatory coral monitoring in community co-managed MPAs in the Central Visayas.

Rina Hauptfeld

Citizen science (i.e. participatory monitoring) is increasingly hailed as a cost effective means (Fox et al. 2017) to generate geographically and temporally dispersed data, particularly in coastal systems within resource poor regions (Cigliano et al. 2015). The democratization of the scientific process is thought to provide the opportunity for people to address community-driven questions, placing resource management decisions more fully into the hands of the people affected by the outcomes, (Dickinson et al. 2012, Bonney et al. 2014), in turn empowering local communities to better manage their resources (Danielsen et al. 2009), and closing the adaptive management cycle (Uychiaoco 2005). Widespread support for participatory monitoring in marine systems in the Philippines is indicated by the designation of '*Regular Participatory Monitoring*' as a threshold activity to advance to higher levels in the MPA Management Effectiveness Assessment Tool (MEAT), used throughout the Philippines and Coral Triangle.

However, despite potential benefits, in the Central Visayas region of the Philippines, efforts to capacitate locals in coral monitoring in MPAs are largely unsustained following the withdrawal of the training organization. I will present results from interviews and focus group discussions with fishers, municipals officials, and training organizations to shed light on the question 'Why, despite substantial regional investment over the past two decades, is coral monitoring not being sustained by fishers and municipal officials?' A Grounded Theory method was used to understand the expectations and perceived capacities of the various actors in monitoring following the training efforts; as well as their resource priorities, the value of data, and their theory of change regarding participatory monitoring.

CRM1-3-381

Validating long-term coral reef monitoring data collected by volunteers at Marine Conservation Philippines

Jonathan William Baines, Ashley Marie Carreiro, Laura Schram

Citizen science provides a means to collect large datasets where scientists are limited by time and cost restrictions, but questions are often raised about the validity of data collected by volunteers. Marine Conservation Philippines (MCP) has developed a monitoring method to collect accurate and precise data for assessing coral ecosystems along the Negros Oriental coastline. Stratified random sampling is used to monitor fish, substrate morphology and invertebrates by laying 30m transect lines over continuous reef. Monitoring is conducted across twelve sites at depth ranges of 3-7m, 9-13m, and 15-19m. Replicates of each survey per site and depth are completed seasonally, resulting over 2,000 surveys annually. The number of replicates required to collect statistically-viable data for the site of highest biodiversity was ascertained by calculating the inherent variability at each depth range.

Volunteers at MCP are rigorously trained and undergo dry and underwater tests before performing surveys. A proportion of volunteers from each survey group are chosen at random to assess the accuracy of the volunteer collected data. Volunteer recorded observations are compared to those collected by an experienced staff member to determine the inter-observer error and the Reliability is then calculated using the Technical Error Measurement. Using a 95% reliability statistic, it is possible to assess the accuracy of the data, highlighting the learning deficits for volunteers. Upon validating the volunteer data, MCP can inform volunteer agencies on training advances and share potential solutions. Our study shows that volunteer data can be trusted and used by scientists, providing standardized measures are implemented for data validation.

CRM1-4-288

TurtleSpot Taiwan: Citizen science for an open sea turtle database

Chialing Fong, Huai Su, Pengyu Chen, Marco Chang, Daphne Z. Hoh

TurtleSpot Taiwan is a citizen science project initiated by a group of divers using social media as a platform to collect photo sightings of sea turtles. The photographs are then used to identify individual turtles by their facial scute pattern. The collected information was then used to establish an online open database. We have received 264 records from 44 participants, identifying 176 individuals (165 of *Chelonia mydas* and 11 of *Eretmochelys imbricata*) from June to December 2017 (data collection is ongoing). Among the records, 86.7% of sightings were contributed by local instructors. To increase both project popularity and quality of data, various activities have been implemented, including: (1) new turtle sightings can be named by the observers, (2) hosting an array of public speeches and workshops (3) organizing additional routine monitoring with trained participants. We believe this project could apply to other locations in the Southeast Asia, by working together there is a potential to build an open regional database for sea turtles beyond national barriers.

TurtleSpot Taiwan: https://www.facebook.com/groups/turtlespotintw/

CRM1-5-312

Philippine Coral Bleaching Watch in the age of the instantaneous: Climate change, action cameras, and mobile applications

Tara Alessandra Abrina, Miledel Christine Quibilan, Darryl Anthony Valino, Porfirio Aliño

The past three decades saw the rise in frequency of sea surface temperature (SST) anomalies. These SST anomalies caused simultaneous coral bleaching events in many parts of the Philippines in 1998, 2010, and 2016-2017. Thus, citizen scientists were tapped to provide instantaneous reports of thermal stress-related reef health during the 2010 and 2016-2017 events. The Philippine Coral Bleaching Watch (PH Bleaching) in 2016-2017 was an online, user-generated database with a social media information, education, communication (IEC) counterpart. As an online survey, PH Bleaching 2016-2017 was able to identify and map out the reefs that were both affected and not affected by bleaching during this time. However, it was identified that there was a lack of instantaneous feedback and mobilization efforts following the reporting stage that could explain the decline in user engagement in 2017. Hence, PH Bleaching sought to improve its user relationships by organizing offline events and developing a mobile phone application. In so doing, the platform is now being used by citizen scientists around the country to report the general state of the reefs they visit. The information collected can be used in real time to monitor coral recovery and inform management interventions.

CRM1-6-144

Ask and you shall receive: reducing scuba diver impacts on coral reefs with a coral-safe diving reminder

Ashton Williams

Scuba diving is generally considered an "eco-friendly" activity, and diving tourism accounts for a significant part of the economy in many places, especially developing island nations. In low numbers, scuba divers typically have negligible effects on coral reefs. However, overuse is a serious problem plaguing coral reefs worldwide, and high-intensity diving activity is strongly correlated with declines in reef health and live coral cover. Limiting or reducing the number of divers is usually not a practical solution; reducing diver impacts on reefs by improving diver behavior is the next best option. In developing island nations, where most divers are tourists, educating and empowering local diving professionals could have broad impacts. Many diving professionals, who recognize that their livelihoods depend coral reefs, are concerned about diver-inflicted damage to corals and are eager to take action to protect their reefs. Most dive operators conduct a short dive briefing about the dive site and weather conditions before each dive. The dive briefing is an ideal time to encourage divers to be mindful of themselves and their effects on the reef. Reminding divers to avoid touching corals costs nothing and requires little or no training. This study evaluates the effectiveness of dive briefings in reducing damaging diver behavior. Divers were given either a standard or 'reminder' briefing, then clandestinely observed for a five-minute period during their dive.

Preliminary results suggest that a simple reminder to avoid touching corals during a dive briefing was highly effective, reducing both intentional and accidental contact with the reef by roughly 75%. Tourist divers were found to contact the reef significantly more than resident divers, and tourists were more likely to exhibit poor buoyancy control. Divers wearing gloves and using cameras contacted the reef significantly more than those without, and tourist divers were significantly more likely to use both. Diver contact rates were correlated to guide/instructor contact rates, implying that diving professionals can influence their clients' behavior. The results of this study will be used to inform and train local diving professionals to identify potentially poorly-behaved or unskilled divers, and will empower them to reduce diver-inflicted damage to Guam's coral reefs through client education and training.

CRM2-1-279

Assessing the effects of the 'dry' summer season and northeast monsoon season: Its implications on the food consumption and nutrient intakes of children of the fisherfolks in Mabini, Compostela Valley

Pedro Alviola IV, Chino Joquino, Leo Estana, Cleto Nañola

Monsoons affect the Philippines' weather and climate in different regions during the year which consequently leads to significant changes to coastal ecosystems. More, specifically, the Northeast Monsoon (NEM) season does not only bring less rainfall, but it can also lead to windy and rainy weather. The NEM season is followed by the "dry" summer season where the weather becomes hotter and drier. In this case, the two seasons present climatic conditions that impact fish resource availability in coastal waters. Thus, maintaining a robust coastal habitat is critical because it is the main source of income and food for communities residing in coastal areas. Hence, this study will assess if significant changes in the food and nutrient intake patterns will be observed in children residing in Mabini, Compostela Valley when monsoon seasons changed. The study used a 3-day diet recall and utilized the National Nutrient Database of the United States Department of Agriculture, and the Philippine Dietary Reference Intake to determine the food items and nutrients consumed for the past three days. This will be then compared to the percentage recommended energy and nutrient intake (RENI) published by Food Nutrition and Research Institute. Lastly, t-tests will be used to evaluate if the food and nutrient intake patterns are significantly different across the NEM and dry seasons.

CRM2-2-286

Quantile regression analysis of fishing income in Mabini, Compostela Valley, Southern Philippines

Evette S Giray, Leo Manuel B Estana, Pedro IV A Alviola, Cleto Jr. L Nañola

Fish has been considered the cheapest source of protein in lower income Filipino household wherein 80% of fisher folks live below the poverty threshold. Thus, the aim of the paper is to examine the changes of household income determinants across varying income distribution of local fisher folks in Mabini, Compostela Valley, Southern Philippines. In this study, the quantile regression approach is utilized to analyze the differences of the impact of the income determinants to the total income of fisher folks across varying income quantiles. The quantile regression is a robust statistical procedure that measures the effect of the changes of independent variables across varying quantiles. This approach also allows flexible distribution of response of the dependent variable across different factors. We surveyed and gathered data from six coastal barangays of Mabini. This study also considers the seasonal changes in the Philippines and the climate condition during northeast monsoon (Amihan). Thus, income levels are classified across 4 quartile distributions with the model coefficients having varying effects across different quantiles.

CRM2-3-446

Species selectivity of reef fishes towards the line fishing

Grace Hutubessy

Some types of line fishing which are commonly used to catch reef fish include hand lines, longlines and trolled lines. It is a common knowledge that the size selectivity of fish towards the line fishing is determined by the hook size. Meanwhile, studies on species selectivity of reef fish to fishing gear have rarely been done. This study aims to understand the factors that affect the species selectivity based on multispecies approached. Coral fishes caught by hand lines, longlines and trolled lines in the waters of the Kotania bay, Maluku province, Indonesia, were identified and measured according to length (cm) and weight (gr). Morphological information especially the shape of the fish mouth of every single species caught was observed from *fishbase.org*. From the size spectrum based on the catch abundance, the selectivity of fish species is determined by the method of fishing. Passively deployed fishing method, such as hand lines and longlines, is dominated by species with terminal mouth shape. Active fishing method like trolled lines tend to catch fish with superior mouth type. It is concluded that fishing method is the main factor affecting the species selectivity of fish caught. Knowledge of species selectivity is important for fisheries management. Species with superior mouth type tend to long lived and categorized as medium to high vulnerable species.

CRM2-4-622

Impacts of fish trap fisheries on coral reefs in Ko Kood and Ko Mark Islands, Thailand

Wichin Suebpala

Fish trap is commonly used to catch demersal fish, especially groupers and snappers, in or near coral reefs. It is likely to generate habitat impacts. This study aimed to analyze possible impacts of the fish trap fishery on coral reefs at Ko Mark and Ko Kood Islands, the Eastern Gulf of Thailand through underwater observation. With collaboration with local fishers for operation of normal fish trap fisheries during January - October 2016, a total of 82 fish traps were investigated. We found that about 24% of the fish traps studied touched juvenile corals and coral communities, such as *Fungia* spp., *Astreopora* sp., *Favia* spp., resulting in breakage of some touched corals, especially *Fungia* spp. Sediment dispersion generated during setting and moving of traps was also observed, as another factor that may obstruct growth of corals. Catching reef fish, especially carnivorous fish, is another concern that may possibly link to the dynamics of coral reefs. As many as 22 species of bycatch were found including 17 species of fish (9 species of them were carnivorous fish), 4 species of crustaceans and one species of sea cucumber. This study adds to the understanding about impacts of fish trap fisheries on coral habitats, which can be incorporated in an ecosystem-based fisheries management in Thailand.

CRM2-5-293

Estimating the fisheries potential of two offshore reefs in the Kalayaan Island Group, West Philippine Sea

Lovely Joy Heyres, Rhea Mae Luciano, Joey Cabasan, Frederico Sabban, Darryl Anthony Valino, Antonio Samuel Mamauag, Hazel Arceo

The Kalayaan Island Group (KIG) is considered to be one of the most economically and ecologically important fishing area in the Philippines. Around 20% of the annual fish catch comes from these waters. However, this marine ecosystem is heavily threatened by different stressors both anthropogenic and natural in origin. In this study, experimental fishing was done using spearfishing and hook-and-line fishing to estimate the fisheries potential of two offshore reefs in the KIG, namely Pagasa Island and Sabina Shoal. Catch rate (kg/hr), catch composition and biomass obtained from each fishing method were compared between the two sites. Results showed that for catch composition, a higher percentage of target fishes was observed in Sabina than in Pagasa island when using hook and line. This may be attributed to the presence of island settlers in Pagasa who rely primarily in fishing as their main source of food.

Meanwhile, there was no significant difference observed in fish biomass between the two sites when using either method. Statistical analysis also revealed that there is no significant difference in catch rate between the two sites when spearfishing is used. However, catch rate was significantly different between the sites for hook and line fishing. Estimated total annual catch (mt/yr) per fisher is higher in Sabina than in Pagasa. Finally, the estimated total annual catch was significantly higher in Sabina for spearfishing but there were no differences observed for hook and line fishing. This information could be a valuable tool in different management practices especially to those remotely isolated areas where access is open to all and lack management restrictions.

CRM2-6-678

Assessing the productivity of coral reef fisheries in the Scarborough Shoal and select reefs along the West Philippine Sea, Philippines

Rhea Mae Amparo Luciano, Joey Cabasan, Maryjune Cabiguin, Lovely Joy Heyres, Frederico Sabban, Antonio Sammuel Mamauag, Hazel Arceo

The Scarborough Shoal, also known as Panatag Shoal and Bajo de Masinloc, is a 150-km^2 lagoon that is home to high-valued fish species. It is a traditional fishing ground and a primary source of income for fishers from this region. However, there is very little information about fisheries production from the shoal. In February 2017, fisheries assessment using focus group discussions, key informant interviews and market surveys was conducted in Masinloc, Zambales in northwestern Philippines. This site was selected because it has the most number of fishers known to be dependent on the Scarborough Shoal as their fishing ground based on initial scoping visits of different areas along the Zambales coast. Catch composition, catch rates, fishing gears used and market flow were documented. Anecdotal reports from the fishers revealed that they can sometimes catch around 10,000 to 30,000 kilograms of fish in one fishing trip although access restrictions in the area have made their fishing time short and limited. The estimated reef fisheries production of Scarborough Shoal was then compared with estimates from Quezon, Palawan which is also located along the West Philippine Sea. Results show that Scarborough Shoal produces a higher catch rate ranging from 7.68 - 234.96 kg/day/fisher compared with Quezon, with 7.44 – 21.84 kg/day/fisher. For both sites, groupers were the most preferred species among all reef fishes, possibly due to its high market value that ranged from Php 200-700/kg. In fact, some fishers in Quezon catch groupers for the live fish trade. In terms of gear usage, spearfishing and multiple hook-and-line appeared to be more efficient in Scarborough than in Quezon. This is one of the first few studies that described the fisheries profile of the Scarborough Shoal relative to another area in the West Philippine Sea, and the continued economic loss to Filipino fishers due to access restrictions.

CRM2-7-667

The Major Coral Reef Fishes at the Market and Fish Warehouses in Bongao, Tawi-Tawi

Ahalnida Majid Tambihasan, Richard Nami Muallil

The species richness of coral reef fishes differs for every geographic region in the country. Tawi-Tawi, being the southernmost part of the Philippines, is situated between the known and distinct rich marine biodiversity key areas, the Sulu and Celebes (Sulawesi) Sea. However, overfishing and other anthropogenic disturbances can cause local extinction of these species. This study documented the major commercially important coral reef fishes sold at the public market and fish warehouses in Bongao, Tawi-Tawi. The survey started from November 2015 and will end on May 2018. The initial result showed that Tawi-Tawi compared to Palawan and Panay Island has consistently higher proportion of species recorded for the nine major coral reef fish families namely Serranidae, Acanthuridae, Haemulidae, Siganidae, Lethrinidae, Lutjanidae, Scaridae, Mullidae, and Balistidae. In addition, there were species which are only present in Tawi-Tawi. Thus, there is a need to effectively managed the marine resources of the province of Tawi-Tawi which can be a potential source of other neighboring reefs.

Keywords: Tawi-Tawi, Coral reef fishes, species richness, marine biodiversity

CRM2-8-480

Density and distribution of top exported reef fish species for the aquarium trade in the Philippines

Jemelyn Grace Baldisimo, Maryjune Cabiguin, Ma. Czarmayne Victoria Jude Escoro, Joseph Benedict Garcia, Jerome Genilan, Denmark Recamara, Mary Joyce Velos, Hazel Arceo

Aquarium trade heavily relies on coral reef resources. For the Philippines which is a top exporter of aquarium fish, the sustainability of the trade is a concern due to capture methods, unreliable trade figures and lack of clear management policies and regulations. In this study, information from underwater fish visual census and fisheries surveys from 75 localities across the Philippines were used to determine the density and distribution of the top ten aquarium species being exported from the Philippines based on www.aquariumdatatrade.org: *Chromis viridis, Dascyllus trimaculatus, Chrysiptera cyanea, Dascyllus aruanus, Chrysiptera parasema, Nemateleotris magnifica, Chrysiptera hemicyanea, Amphiprion ocellaris, Sychiropus splendidus* and *Centropyge bispinosus*. Socio-economic information, including extraction rates, were determined through key informant interviews. Of the 75 sites, only 5 sites had active aquarium fishers. These municipalities were Lian, Batangas; Bongao, Tawi-Tawi; Cawayan, Masbate; Kawayan, Biliran; and San Andres, Catanduanes. The top ten species exported were found in 71 of the 75 sites. Mean densities of the ten species ranged from 1.42 to 21.52 individuals/500 m^2. The top exported species, *C. viridis*, had the highest density and was observed in all biogeographic regions. Fish species *D. trimaculatus, D. aruanus, C. parasema, A. ocellaris* and *C. bispinosus* were found in all biogeographic regions, although with lower densities compared to *C. viridis*. *C. cyanea* was only observed in the Sulu Sea and Celebes Sea, while *C. hemicyanea*was only observed in the Celebes Sea. All ten species were found in sites located in the Celebes Sea. Other biogeographic regions had six to nine of the targeted aquarium fish species present. Average fish size ranged between 2 to 7 cm, with fish sizes not varying greatly across biogeographic regions. Fish species targeted by aquarium fishers in Lian, Bongao, Cawayan and Kawayan, varied and were not necessarily in the listed top ten. Aquarium fishing provides relatively high income compared to other type of capture fisheries but is driven by the demand for certain species. Fishers assert that aquarium fish come from deeper and farther reef areas. Continuous monitoring of extraction rates, standing stock, as well as other studies on population biology of targeted species, are needed to formulate urgent regulations on the aquarium trade if these reef fishes were to persist.

CRM2-9-497

The use of DNA metabarcoding in food web construction to support coral reef fisheries management in Raja Ampat

Inna Puspa Ayu, Christoper Lane, Austin Humphries, Eko Burhanuddin, Ester Geulis, Luky Adrianto, Yusli Wardiatno, Nurlisa Butet, Mufti Aprizan, Alan Koropitan, Beginer Subhan, Beginer Subhan, Hawis Madduppa

Overfishing plagues many coral reef fisheries, compromising food from the sea and self-sufficiency of coastal communities. Indonesia's coral reefs are the most biodiverse in the world but are under threat from overfishing and other stressors. Surveys of key species in fisheries have been performed in multiple places around the Coral Triangle. Coral cover and fish diversity are commonly recorded, but these numbers only reflect a snapshot of time. Rather than focusing on the edges of the food web, we propose to follow the food web from the edges to the center. DNA metabarcoding as an innovative method could improve feeding ecology information. The aim of this study is to analyze all components of the gut contents of grouper using DNA metabarcoding. Commercially targeted fish from Serranidae (groupers) was caught or purchased from fish market and their gut contents was analyzed using a high throughput sequencing approach and by morphology of prey components. Stomach contents were preserved in DNA shield liquid. DNA extraction was amplified using universal, fish, invertebrate, and plant primer. Seventy five grouper were observed from fish landing at Raja Ampat within eight species such as *Chepalopholis cyanostigma, C. boenak, Epinephelus areolatus, E. malabaricus, E. bleekeri, E. ongus,E. coioides,* and *Anyperodon leucogrammicus*. Our preliminary research result shown that grouper at Raja Ampat not only feed fishes but also invertebrate such as crab, shrimp, and lobster.

CRM2-10-198

The impact of climate variability and climate change on nearshore coral reef fisheries in American Samoa

Domingo Galgo Ochavillo

We assessed the impact of climate variability and long-term climate change on the catch rates of gleaning, thrownet and rod and reel coral reef fisheries in American Samoa from 1987 to 2016. This period covered the 3 strongest El Nino and 2 strongest La Nina events since 1950. Current data also indicate long-term sealevel rise and rising seas surface temperature in the Territory. We analyzed over 700 fishing events for each fishery throughout this period with the variables: Multivariate El Nino Index (MEI), Pacific Decadal Oscillation (PDO), Southern Oscillation Index (SOI), rainfall, sea surface temperature (SST), sealevel, chl a, and wave energy anomalies. The analyses of MEI revealed a diversity of El Nino and La Nina events but rainfall anomalies as the variable accounting for this diversity. There are indications that PDO has a cooling effect on SST during El Nino events and a warming effect on SST during La Nina events. The Generalized Linear Model analyses of catch rates indicate significant impact of climate variability and long-term climate change on the catch rates of gleaning, rod and reel and thrownet fisheries. Both long-term sealevel and SST rise have negative impacts on catch rates especially on octopus and mullet of gleaning and thrownet, respectively. Catch rates for these species are significantly higher during La Nina events that have higher rainfall. In addition, the sealevel rise seems to have negatively impacted the participation on gleaning throughout the years. The negative impact of long-term climate change on catch rates and participation on subsistence fisheries has cultural and economic implications. These analyses provide a framework to assess the biological and socio-economic impacts of climate variability and climate change for various fisheries in American Samoa.

CRM2-11-374

Effectiveness of locally managed marine protected areas as a conservation tool for coral reef fisheries in the Philippines

Richard Nami Muallil, Melchor R Deocadez, Renmar Jun S Martinez, Wilfredo L Campos, Samuel S Mamauag, Cleto L Nañola Jr., Porfirio M Aliño

The Philippines has more than 1,600 locally managed marine protected areas (MPAs), the most in the world. However, most of these MPAs are new, small and threats from overfishing and habitat destruction are high. In this study, we assessed the fish biomass of commercially important coral reef fishes (e.g. Surgeonfish (family Acanthuridae) was the most dominant group, in terms of biomass, followed by parrotfish (subfamily Scarinae), snapper (family Lutjanidae), grouper (subfamily Epinephelinae), sweetlip (family Haemulidae), goatfish (Mullidae) and emperor (family Lethrinidae)) in 54 locally managed MPAs in the Philippines for conservation of commercially important coral reef fishes. We used the fish biomass level at the nationally managed, large (33,200 ha), remote, old and well enforced (i.e. protected for >20 years) Tubbataha Reefs National Marine Park (TRNMP) as a proxy for "unfished" ecosystems (B_o). We also considered fish biomass levels between 25-50% of B_o as biomass within the maximum sustainable yield for multi-species coral reef fisheries (B_{MMSY}). Results showed that fish biomass levels in 7%, 25% and 68% of the surveyed MPAs were "above B_{MMSY}", "within B_{MMSY}" and "below B_{MMSY}", respectively. All of the reefs outside MPAs were either "within B_{MMSY}" (16%) or "below B_{MMSY}" (84%). Fish biomass inside MPAs were not significantly associated with size or age of MPAs. Overall, this study showed that the current locally managed MPAs are not effective enough for coral reef fish conservation and fisheries management but, nonetheless, better than no MPAs at all. Tradeoffs between fishing and conservation, particularly in setting fisheries management targets that would take into consideration both the social and ecological sustainability of coral reef fisheries are discussed.

CRM2-12-512

An integrated analysis to determine patterns of biophysical, fisheries, socio-economic and governance aspects in the small-scale fisheries in the Philippines

Antonio Samuel Mamauag, Von Yip, Melchor Jacinto, Richard Muallil, Remelyn De Ramos, Porfirio Aliño

Reef fisheries in the Philippines is mainly small scale and artisanal in nature mostly affected by increasing fisher density, and declining catches and incomes. This study attempts to identify relative importance of factors affecting the small scale reef fisheries in the Philippines in order to pinpoint specific cause/s of fisheries degradation and thus prompts appropriate management interventions specific to the site through priority setting mechanisms. In 2013 and 2014, bio-physical, socio-economic and governance data were collected from 24 coastal municipalities with varying geomorphologic characteristics, exploitation levels, gear types, catch composition, habitat conditions, incomes, and management capacities. Multivariate analysis (e.g. clustering, PCA) was employed to determine the relative importance of factors affecting sensitive variables to human impact such as catch rates and fish biomass of the sites.

Results indicate that although exploitation levels were generally important, other factors (geomorphology, extent of habitat and fishing ground, depth, small pelagics in the catch, and management capacity) were also influential. Moreover, there appears to be clustering of sites based on these factors proving that in some sites specific factors also need to be examined together with the degree of exploitation. These results are important to understand better the complexity of issues and threats in the fisheries, and allow the identification of opportunities for better ecosystem approach to fisheries management.

CRM2-13-429

Philippine coral reef fishes at risk: focus on globally threatened species

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The Philippines, which sits at the Coral Triangle or the region considered as the center of marine biodiversity in the world, has one of the highest incidences of stressors since the advent of the Anthropocene. Concern over increasing threats to marine biodiversity, particularly to coral reefs, has led to studies on valuable coral reef species. This study aims to investigate the influence of threats to globally threatened reef fish species classified according to the IUCN Red List categories found in Philippine reefs. Using standard underwater fish visual census done from 2015 to 2017 in over 70 municipalities and cities around the Philippines, six threatened species were found in only 26 sites. Five species (*Bolbometopon muricatum, Cromileptis altivelis, Oxymonacanthus longirostris, Plectropomus areolatus, and P. laevis*) are considered Vulnerable and one species (*Cheilinus undulatus*) is under the Endangered category. Visayas Region in central Philippines has the highest mean species richness with more than 100 species/1000 m^2 but threatened species are virtually absent in the region. Factors such as habitat quality and fishing pressure could be some of the driving forces that influence the presence of these species in the reefs. Understanding the causes of local extirpation of valuable species could help prioritize action plans relevant to conservation and management efforts, provide inputs towards the development of a national Red List of aquatic species, and raise awareness on coral reef species facing extinction.

CRM2-14-541

The economic value of the capture fisheries and coastal habitats in representative municipalities west and east coast of Albay, Philippines

Ronnel Romano Dioneda, Sr.

This research was undertaken to estimate the economic value of the coastal habitats and capture fisheries in selected municipalities in the province of Albay to be able to heighten awareness of its economic and ecological importance to promote responsible utilization. Using the total economic valuation (TEV) framework, the estimated economic value of the ecological functions performed by the coastal habitats in the municipalities of Pioduran, Oas, Libon, and Rapu-Rapu and in the city of Ligao ranges from Php112 to Php126 million per year. The present value of these resources considering its recurring poor to fair health condition is not improved, the present value of future benefits foregone is at least Php 2.214 billion for a period of 20 years. It is therefore recommended that there should be an Integrated Coastal Resources Management Program in the province of Albay to promote responsible utilization of coastal habitats and its ecosystem services, promote coral reef and mangrove rehabilitation, minimize the use of destructive fishing activities, and regulate the emergent industries that would further harm the coastal habitats and resources. This research was a partnership between the DENR Region V and the Bicol University under the auspices of then Sustainable Coral Reef Ecosystem Management Program (SCREMP) in CY 2015.

CRM2-15-509

Pathways to sustainability for coral reef tourism to Koh Sak and other islands in Pattaya Bay, Chonburi, Thailand.

Wayne Phillips, Napas Somsawad, Chen Po-Tsao, Tawin Kim

In the 1960s and 70s the small island of Koh Sak in Pattaya Bay, Thailand was a showcase for visiting Royalty and dignitaries who left behind their handprints, footprints and signatures in cement casts. Now the island and its reefs are impacted by mass tourism, manifested as (i) intense and poorly managed speedboat and jetski traffic (ii) intense use of anchors, (iii) increased nutrient loading and ineffective waste management, (iv) over-fishing, fish-feeding and other activities that alter fish assemblage structure and (v) guides who actively encourage visitors to contact the reef and handle marine organisms for photo opportunities. Because the same tour operators visit other islands in Pattaya Bay their impacts are replicated at other reef systems.

Our efforts to document impacts and causes of change in the reef and to network with Stakeholders have recently given us the opportunity to work with key tour operators to modify working practices at Koh Sak and near-by islands to reduce negative impacts. In this presentation we will share our experience gaining the trust and cooperation of the Seawalkers to establish professional, well trained and knowledgeable guides and staff that have the skills and motivation to exhibit and pass on reef-friendly behaviour and knowledge. Visitors will gain an understanding of coral reef ecology and can contribute to reef restoration and rehabilitation by maintaining artificial reef structures, and by helping SCUBA divers to populate the structures with coral fragments of opportunity and/or sexually-reared recruits. As the reefs are restored visitors can contribute to Citizen Science Projects monitoring the return of species by recording what species they see while underwater. In this way mass tourism will sustainably contribute to the local economy and improve visitors' understanding of coral reefs at the same time as protecting and restoring essential reef services.

CRM2-16-716

Exploitation rates of selected fish species in various fishing grounds in the Philippines

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The Philippines has been considered as a global marine biodiversity hotspot because of the number of threats including unsustainable fishing, habitat degradation, pollution, alien and invasive species, and even climate change. To address such issues, the Bureau of Fisheries and Aquatic Resources (BFAR) has mandated the National Fisheries Research and Development Institute (NFRDI) through the National Stock Assessment Program (NSAP) to determine reference points to assess, monitor, and evaluate the status of the fish stocks in the country relative to the fishing pressure. In this study, the reference point used was exploitation (E) values to determine the status of dominant small pelagic, demersal, neritic, and oceanic tuna in 51 fishing grounds in the country. Landed catch and effort, and length frequency data were gathered from 840 NSAP landing centers and growth and mortality parameters were computed using FiSAT II. Results showed that most of the fishing grounds are subjected to unsustainable fishing activities. In 2008, length-frequency analysis of 129 commodity species across major Philippine fishing grounds pointed to predominantly high E values. These findings also suggest continuous fishing pressures, brought about by increasing fishing effort and the availability of more efficient fishing gears, have posed major threats to the country's fishery stocks. It is important to note that typhoon path areas such as Northern Philippines (Batanes) and the Pacific seaboard, areas where there are armed conflicts (Jolo-Sulu), and areas with existing management strategy such as seasonal fishing closures implemented in Northern Palawan, Davao Gulf and Zamboanga Peninsula generally show "better" stock status than the rest of fishing grounds in the country. This suggests that fishing grounds in the country could be utilized sustainably if proper management is in place and implemented effectively.

CRM3-1-683

Comparison of the fish community structure in areas with varying levels of protection

Ethel Wagas, Melchor Deocadez, Dana Manogan, Michael Atrigenio, Porfirio Aliño

Territorial Use Rights for Fisheries (TURF) is a fisheries management system that gives a select group of fishermen exclusive fishing rights within a designated area. By regulating fishing pressure, TURF sites are expected to create sustainable fishing practices, promote conservation of fish stocks and the reef ecosystem, in general. In 2016, two pilot TURF sites were established in Cantilan, Surigao del Sur and Tinambac, Camarines Sur. Fish biomass and abundance were measured, analyzed and compared among the three MPA zones with varying degrees of protection: (1) closed access (inside MPA) (2) regulated access (TURF) and (3) open access (outside MPA) using Fish Visual Census. Permanent transects were established within the different study sites and monitored over a 2-year period. Data analysis showed a significant difference (p = ≤0.05) in the biomass and abundance of fish inside and outside the MPA, inside MPA and TURF sites but none between TURF sites and outside the MPA. Specific analysis on the biomass and abundance of fish species that are commonly harvested by fishers (target species) also followed a similar pattern with TURF site values not showing significant differences to that outside the MPA. Being still in its infancy, detecting significant changes in fish community structure inside TURF sites may take some time. This data can serve as a benchmark for future monitoring purposes. Thus, continued assessment is highly recommended for determining ecological trends that may occur in the studied areas and for evaluating the affectivity of the TURF sites in the coming years.

CRM3-2-282

Trophic spectrum analysis of reef fishes as indicators of reef health in selected marine protected areas and adjacent reefs in the Philippines

Alvin Nowell Perez Simon, Marion Michael Apistar Bacabac, Kent Elson Salem Sorgon, Victor Sanchez Ticzon

Trophic spectrum analysis is a useful method in describing the health of reef associated fish communities. It illustrates a continuity of reef fish species and how their corresponding abundance and biomass interact at the community level. In this study, fish visual census was conducted in a total of 213 transects spread almost evenly inside and outside established marine protected areas (MPAs) located in 8 different sites. Collected reef fish data were categorized under several trophic signatures that represent the different food items the species consume. These trophic signatures and their average biomass and abundance were plotted in a continuum to illustrate the trophic spectrum of reef fish communities across sites, between protected and adjacent unprotected reefs. The results showed that different locations registered different spectrum depending on the current status of the reef. Furthermore, average biomass of reef fishes across the spectrum were generally higher inside MPAs compared to reefs located outside the protected zone. Overall, MPAs inside the Northern Verde Island Passage Marine Biodiversity Corridor had the highest contribution in the average biomass and abundance of reef fishes among all study sites. This was followed by El Nido and Romblon. Protected areas in Biri-Larosa, Guiuan and Zambales exhibited low average abundance and biomass, attributed to the disturbed state of the reefs, both inside and outside established MPAs. Based on the trophic spectrum trend, MPAs in the Philippines were characterized by high biomass and abundance of iconic species such as herbivores and facultative piscivores. Studies on resilience consistently emphasized the importance of these trophic groups in coral reefs, and their increased biomass inside MPAs indicates the effectiveness of the intervention and its implementation, at least in the areas studied.

CRM3-3-404

Removing barriers, changing behaviors: Documenting biophysical improvements of selected marine protected areas in the Philippines

Dean Apistar, Elliot Lam, Rizaller Amolo, Pablo Rojas Jr., Arturo Faburada, Roquelito Mancao

Since 2010, Rare, partnered with Local Government Units in the Philippines in the implementation of Pride Campaigns aimed at enhancing improving and sustaining management of MPAs. Pride Campaign strategies combined science, technical and social Marketing strategies to achieve positive behavior change among community stakeholders. To monitoring and evaluate the biophysical attributes of the MPAS, Rare enlisted the services of the Marine Environment and Resources Foundation (MERF) to conducted periodic biophysical monitoring in selected MPAs. MPAs presented in this paper shows a positive trend in the biophysical components for the period of 6-7 years. Further, findings illustrate that continued and improved protection of MPA's and their adjacent waters through positive behavior had shown positive impacts to the reefs and its associated fish species. Though attributions were not investigated here, the continued tracking of MPA performance have positively motivated the communities to adaptively managed their MPAs as a fisheries management strategy.

CRM3-4-387

The role of no-take marine reserves in supporting dynamic Philippine coral reef communities

Eva McClure, Katherine T. Sievers, Rene A. Abesamis, Andrew S. Hoey, Garry R. Russ

No-take marine reserves (NTMRs) have been successfully implemented in many Asia-Pacific countries to conserve marine biodiversity and provide food security. NTMRs have proven an especially important tool in island nations such as the Philippines, but whether NTMRs can continue to provide social, economic and conservation benefits considering ever-increasing threats to coral reefs remains unresolved. Here, we use coral reef fish community survey data from 16 habitat paired NTMR-Control sites associated with six islands in the Central Visayas, Philippines, to explore NTMR performance in boosting large fish biomass and small fish density under a suite of reef conditions. More specifically, this study compares the structure of reef fish communities in NTMRs associated with populated large islands, to NTMRs of low-lying relatively isolated islands, all subject to varying degrees of disturbance such as land-based runoff, fishing and typhoons. Results from this study indicate that 1. NTMRs increase the biomass and density of large- and small-bodied fish (respectively) relative to adjacent fished areas of similar habitat characteristics, regardless of typhoon damage or island type, and 2. NTMR protection is one of four key reef characteristics (of 15 potential variables tested) in explaining the variability of fish biomass and density among 16 sites, but NTMRs do not need to be large to boost fish communities. Results from this study are expected to contribute to our knowledge and practical application of coral reef biodiversity conservation and safeguarding fisheries, with implications for improving coastal resource management in the Philippines specifically, and island nations globally.

CRM3-5-605

Construction of tropical marine ranching and coral reef conservation in Wuzhizhou Island, Sanya, China

Aim Wang

Tropical marine ranching is to put in a lot of the artificial reefs around the coral reefs. Its purpose is to create a new habitat for marine organisms, especially for fish, crabs and shellfish, and to form a new ecological food chain. Because the structure of artificial reefs belongs to biophile that can be attached to a large number of marine organisms, in particular due to the adhesion of some coral larvae, the surface of the artificial reefs is gradually covered with different coral species. There are two advantages for artificial reefs to conserve coral reefs. Firstly, because the artificial reef is heavy and stabilized on the bottom of the sea, the coral normally growing on the surface of the artificial reefs are less impacted by typhoon or storms. Secondly, the artificial reefs protect and gather together a large number of coral reef fishes, especially herbivorous fishes. These fishes will benefit to the balance of coral reef ecosystem. With the construction of the Wuzhizhou Island marine ranching in Sanya, China, the restoration and protection of the coral reefs there will be introduced.

CRM3-6-94

Analysis of threats to coral reef ecosystems and their sustainability strategies in the Pangkajene and Kepulauan Regency, Spermonde Archipelago, Indonesia

La Ode Muhammad Yasir Haya, Masahiko Fujii

Coral reefs have widely been under threats in various tropical/subtropical oceans in the world. This study aimed to identify types of threats for the coral reefs, conduct sensitivity analysis to the sustainability of coral reef ecosystems, and suggest alternative policies and strategies that need to be undertaken to improve the status of coral reef ecosystems in the Pangkajene and Kepulauan Regency, Spermonde Archipelago, Indonesia. Obtained data were analyzed by using Rapid Appraisal for Fisheries (RAPFISH) and analytical hierarchy process (AHP) approaches. Results of the RAPFISH analyses indicate that there were 41 types of threats to the status of coral reef ecosystems based on five indices of economic, social, technological, legal and institutional, and ecological. Overall, the averaged cumulative index of the sustainability status of coral reef ecosystems was 45.95, within a value between 25 and 50 which was evaluated as less sustainable. Results of the AHP analysis suggested that several alternative policies and strategies are necessary to improve the status of coral reef ecosystems, including socialization, campaigns, and education regarding Act and specific regulation of environment had the highest score and was followed by strict law enforcement, selection and restriction of fishing gear used, rehabilitation of coral reef ecosystems, enrichment of fish stock on the reefs, community empowerment, environmentally friendly alternative livelihoods, business capital aid, marine products certification, and institutional arrangement. It is considered that these strategies could reduce the threats to coral reefs and improve the status of coral reef ecosystems in the study area.

CRM3-7-199

Human impacts to EDGE corals in Semporna, Malaysia and potential solutions

Poh Leem Choo

Semporna's waters harbour the highest concentration of coral reefs in Malaysia. These reefs not only provide livelihoods to local communities, but also support an intensive recreational SCUBA diving industry, activities which are threatening the health and abundance of Evolutionary Distinct and Globally Endangered (EDGE) [AR1] coral species; *Heliofungia actiniformis and Lithophyllon ranjithi*. Destructive fishing activities (Wood, 2006) and unsustainable tourism development (Aw et. al., 2006) are the two major threats to coral reefs locally. Fish bombing and cyanide fishing threatens 85% of Malaysia's reefs (Burke et.al., 2012), while an 86% increase of Chinese tourists from 2011 to 2013 [AR2] is driving unsustainable development. Conservation actions are needed to prevent further deterioration of local reef systems and the distribution and abundance of the EDGE coral species. The aim of this project is to develop a conservation strategy to protect EDGE coral species *Heliofungia actiniformis* and *Lithophyllon ranjithi*, and their habitat through Semporna Marine Spatial Planning. Reef Check surveys were conducted to map these species, and identify their abundance, distribution and status in Semporna. Results were compared with data from 2009 and 2014. Our recommendation for local authorities is to establish locally managed marine conservation zones in key areas which harbour EDGE coral species. In addition, the project is raising awareness on the impact of fish bombing by building local conservation capacity to conduct outreach programmes in local schools. The project also promotes sustainable dive tourism by hosting stakeholder consolations where local dive operators are encouraged to become Green Fin certified. All recommendations were proposed to the local authorities within a Marine Spatial Planning meeting for the Semporna area.

CRM3-8-248

Structural model of diving site management based on coral reef conservation in Tulamben, Bali. Indonesia

Rahmadi Prasetyo

Bali marine tourism development is tend to increase significantly since 2003 after first Bali bombing incident. However, the total numbers the destination of diving site in Bali is not comparable with total number of tourist, both of domestic and non-domestic. Recently, the total number of diving site in Bali are 16 (sixteen) dive sites and total numbers of dive operator are 330 (Three hundred and thirty) members in totally. These phenomena is absolutely causing business competition to survive for their companies. The impact of these business competition is careless of marine environment especially on the damage of coral reef and also other underwater objects. Based on the statistics of tourist arrivals on certain marine destination such as in Tulamben dive site, Karangasem Regency, total numbers of divers come to this site in 2003 is 15,235 divers, but in 2014 is achieve 77,842 divers. That is almost 5 times within 11 years and the attraction of dive site is not change and as consequence the coral reef and underwater object such as Wreck and other marine biota are potentially damage.

The purposes of this research are first, to analyzing coral reef damage caused by marine tourists. Secondly, to analyzing differences in perceptions and expectations of diver in dive site Tulamben Bali. Third, to evaluate and analyze willingness to pay of diving tourists in Tulamben Bali. Fourth, to analyze the influence of the beauty of water conditions, access, diversity, to the satisfaction of diving tour in Tulamben, Bali. Fifth, to analyze the influence of satisfaction of travel diving satisfaction on willingness to pay (willingness to pay) and finally to develop a structural model of management of conservation-based diving tourism destinations in Tulamben Bali.

The location of this research is in Diving site Tulamben village, Karangasem regency, Bali. The attraction of this Tulamben Diving site area are Ship Wreck, Coral garden and Drop off. The methodologies to analyzing coral reef damage caused by marine tourists is using CPCe (*Coral Point Count with Excel extension).* To analyzing differences in perceptions and expectations of diver is using IPA (*Importance Performance Analysis.* To evaluate and analyze willingness to pay of diving tourists is using WTP analysis compare with Karangasem local regulation. To analyze the influence of the beauty of water conditions, access, diversity, to the satisfaction of diving tour and also to analyze the influence of satisfaction of travel diving satisfaction on willingness to pay (willingness to pay) is using SEM (*Structural Equation Modelling*) analysis. And finally, to develop a structural model of management of conservation-based diving tourism destinations is using ISM (*Interpretive Structural Modelling*) analysis.

CRM3-9-571

Performance of coral reef marine reserves in Panay Island, Western Visayas, Philippines

Ronald Maliao

The performance of coral reef marine reserves in Panay Island, Western Visayas, Philippines was surveyed using Ostrom's Institutional Analyses and Development (IAD) Framework as an analytical paradigm. A total of 19 marine reserves were surveyed covering the provinces of Iloilo, Antique, Aklan, and Capiz with a total of 900 respondents. I evaluated the perceived performance of marine reserves using 9 performance indicators categorized in 3 performance criteria (economics, environment, and sustainability). The respondents viewed a ladder-like diagram with 10 steps, where step 1 represented the worst possible scenario and step 10 the best possible scenario for each indicator in 3-time frames: before marine reserve, present (2016-2017) and 5 years into the future. Overall, marine reserves in Panay Island were perceived to have a significant positive performance. However, the performance of each of the indicators was mixed across reserves. In general, although marine reserves were perceived to be effective in empowering the local fishing communities, their perceived impact on improving the state of the local fisheries resources remained limited. This highlights the importance of incorporating ecological and socio-economic considerations in setting reef fisheries management regimes.

CRM3-10-689

2018 Status of Philippine Marine Protected Areas

Diovanie Onod De Jesus, Dane Erlo Matorres, Graceous Von Yip, Porfirio Aliño

The establishment of MPAs is one of the major strategies in the Philippines to address biodiversity conservation and fisheries management in coastal communities. There are currently about 1800 MPAs listed in the Philippine MPA database. Most MPAs are established and managed by local government units (LGUs) while some are managed by the national government under the National Integrated Protected Area System (NIPAS). The total area based on available data from 1,460 MPAs is 2,792,288 hectares. NIPAS MPAs cover 1,713,469 hectares or 61% of this total area. Based on 477 MPAs rated using the Management Effectiveness Assessment Tool (MEAT), 48 % MPAs are paper MPAs or in Level 0 because of lack of adopted management plans and approved legal instruments. Only 40% of these are effectively managed or at least Level 2. Prevalent management gaps for lower level MPAs are adoption of MPA management plans, enforcement and performance monitoring of the management body while prevalent management gaps for higher level MPAs are impact assessments and community development. Correlational analyses of coral cover and fish biomass with MEAT levels and scores in 40 MPAs showed positive but weak correlations suggesting that these biological indicators of effectiveness may be affected by biological interactions, environmental conditions and threats. Several strategies are suggested to improve the status of MPAs such as increasing MPA coverage, improving MPA management, databasing, regular monitoring and evaluation, reviewing management and policy gaps and addressing threats

CRM3-11-158

Effective management through community involvement

Lincy Lee Marino, Marine Gouezo, Randa Jonathan

Worldwide, coral reefs are in decline and for small island nations, this is a worrisome phenomenon, as coral reefs are important habitats for food fishes, in addition to providing crucial ecological services, such as storm protection. In Palau, in order to effectively conserve and protect its marine ecosystem, the Protected Areas Network (PAN) was created to ensure that Palau's natural resources are sustainably managed. In 2014, PICRC started conducting socioeconomic surveys of the states that had marine PAN sites to collect baseline data on the community's knowledge, perceptions and support for their respective protected areas. The study consisted of an extensive household questionnaire that was implemented across two states---Ngatpang and Melekeok. 71 and 79 households were interviewed in Ngatpang and Melekeok, respectively. This study focuses on these two states to illustrate the difference between the management, community involvement, and support for the PAN. Although the PAN was created in 2003, not all the states joined the PAN at the same time. Thus, the study also looks at longevity of the established MPA and PAN membership. In comparing the communities' perceptions of impacts (positive or negative) of the MPAs to their livelihoods, most of the residents in Ngatpang reported no change, while most respondents in Melekeok reported positive feedback. Furthermore, respondents also reported their level of support for the PAN and MPA's. In Melekeok, more people showed high to extensive level of support (56%) for the PAN and state MPAs as compared to those in Ngatpang (24%). On the other extreme, 21% of Ngatpang respondents reported no support for the PAN or MPA's, and in Melekeok, only 10% showed no support. This may be attributed to the fact that Melekeok has a long established and strong enforcement and outreach program that promote their conservation areas in a positive light. On the other hand, Ngatpang State, a new member of PAN with newly established MPAs, is working to establish and solidify their conservation program. In the end, conservation is about people, thus, careful consideration needs to be given to the people of the community in which the protected area is located, in order to manage them efficiently and effectively.

CRM3-12-602

Reef Baybe: Eeny, meeny, miny moe, which management option should I do?

Aldwin Torres Almo, Jose F De Leon, Mark John Panti Manalo, Laura Tenmatay David

Reef BayBe is a java-based decision support tool (DST) that was developed using a Bayesian Belief network model of reef stressors in the Philippines. The tool aims to aid decision makers and coastal managers in assessing different management options. The used of a DST is vital when there is a limited resources available and the goal is to achieve a maximum impact with minimum effort The Bayesian Belief network model incorporates both qualitative and quantitative information from reef experts as well as results from data mined literatures. The tool was set to work best on locations with 10 square kilometer contiguous reefs but can still be used on other sites with some precaution. The Reef Baybe make use of the information on hand on the status of critical habitats, human activities in the area as well as information on weather and climate experience in the area. Management options can influence the first two variables. Management options could either be habitat enhancement, or coastal resource management, or ridge-to-reef developments. With these information the Reef Baybe provides trajectories of reef health—hard coral cover, likelihood of a phase shift and potential fish biomass. The potential impact of weather and climate factors to reef trajectories with the implementation of these management options can also be assess using the Reef Baybe. Reef BayBe provides the advantage of assessing the potential impact of a certain management option without risking any financial resources, manpower and time. The Reef Baybe was beta-tested by several LGUs, institutions, organizations in the country.

CRM3-13-695

Development of a competency assessment tool for marine protected area managers

Jue Alef Avanzado Lalas, Janine Bobadilla, Melchor Jacinto, Ma. Czarmayne Victoria Jude Escoro, Hazel Arceo, Ma. Vanessa Baria-Rodriguez, Porfirio Aliño

Philippines is known to have the highest number of marine protected areas (MPAs) globally. The establishment of MPAs is a popular conservation tool used in coastal resource management to achieve biodiversity and fisheries objectives. However, most of these MPAs are not well-managed due to lack of competency of MPA managers. Several tools have been developed to evaluate the effectiveness of MPAs. However, it is also equally important to assess the competency of MPA management body to improve its performance and to attain management success. This study presents the development of a competence assessment tool. Six components were identified based on functionality; (1) enforcement, (2) information, education and communications, (3) monitoring and evaluation, (4) governance in the planning and zoning guidelines, (5) physical development, and (6) livelihood. Relevant questions were identified to evaluate each functionality. Pilot testing for the tool was done in selected MPAs in the Philippines. Qualitative results were then integrated with the MPA Effectiveness Assessment Tool (MEAT) scores. Preliminary results show that MPAs with higher levels of management – more effectively managed – have higher management body competency scores. Results of this study highlight how MPA management body competency gaps influence the MEAT performance ratings. Aside from identifying the gaps in coordinating governance, we derived minimum competency standards for each functionality. This can be an enabling tool to identify gaps as well as capability building needs to improve MPA management.

CRM3-14-538

Ecological Resilience Index: A tool to support zonal management of marine protected areas in Malaysia

Chun Hong James Tan, Muhammad Hafiz Borkhanuddin, Md Nizam Ismail, Nurzahirah Kamarudin, Putri Asma Megat Yusop, Seng Chee Poh, Yusri Yusuf

Establish of marine park as a total no take zone aim to protect and conserve the marine resources. Conflict of interest commonly occurs include disagreement with the local stakeholders such as islanders that harvest the marine resources for their livelihood. Consequently, many locals ventured into tourism industry as the permitted alternative within the marine park that later became one of the major threats to marine environment. This study aimed to examine the resilience of coral reefs in marine park, and to further support the potential of zonal management within the no-take MPA. Pulau Payar Marine Park (PPMP), the only MPA located on the west coast of Peninsular Malaysia was selected as study site. No tourist operator was allowed to station on PPMP, and all day-trip tourism activities (e.g., snorkeling and SCUBA diving) were operated from a pontoon. The resilience of 16 selected reefs within the PPMP were examined according to IUCN Resilience Index. Nearly half (43.8%) of the reefs were categorized as good resilience site. High and moderate resilience sites each constituted a quarter (25%) of surveyed reefs. Only one site was found to be in poor resilience level. Moreover, the nutrients (nitrate: 0.04 – 0.13ppm; phosphate: 0.004 – 0.015ppm) and fecal coliform (1.8 – 16,000 MPN/100mL) concentration tested in most of the sites were not compliance to Class I of Marine Water Quality Criteria and Standard. This was empirical evidence of anthropogenic impact resulting from tourism activities which affecting the resilience of coral reefs at PPMP. To reduce the anthropogenic impacts, tourism activities should be limited at general zone to enable close monitor of the management authority. Then, selected good resilience sites could be the buffer zone served as alternative site during peak tourist season. Lastly, high resilience sites are recommended as conservation zone where no human activity is allowed.

CRM3-15-562

Characterization on right sizing of coastal fisheries in the 5 Marine Key Biodiversity Areas in the Philippines

Tom Gerald Taer Genovia, Timothy Joseph Quimpo, Janine Bobadilla, Ma. Alendra Milan, Ma. Vanessa Barria Rodriguez, Wilfredo Licuanan, Aliño Porfirio

Marine Protected Areas (MPAs) are recognized as vital tool in attaining biodiversity conservation and fisheries management objectives in the Philippines However, many MPAs in the country remain to be ineffectively managed; hence, most MPAs fail to improve fish stocks and derive subsequent economic gains. In this study, we examine how spatial geographic delineation; extent of fishing area relative to area identified to be protected in selected Marine Key Biodiversity Areas (MKBAs) (Verde Island Passage, Southern Palawan, Tanon Strait, Lanuza Bay, and Davao Gulf) in the Philippines can affect fisheries sustainability, by taking into consideration fishing population of the small-scale fishery in the 5 MKBA sites. Using a fisheries decision support tool called "Fisheries Industries Support in Handling Decision Application" (FISDA), we provide vital estimates on how varying MPA sizes can affect fisheries production in the 5 selected MKBAs based on biophysical inputs in the model. Results showed that due to the large population of municipal fishers, sizing of area for protection should increase by as much as 30% of municipal waters to ensure the sustainability of the fisheries in 20 years. Among the five MKBA sites, VIP obtained the highest fishing capacity with an estimated production of 25,000 M.T/year while Lanuza Bay obtained the lowest fishing capacity of 3,000 M.T/year. These findings could be attributed to varying biophysical inputs such as the areal extent of fishing ground, fisher's population, catch rates and composition (i.e., demersal or pelagic), and fishing effort. The result of the study focuses on estimates of available area for protection and doesn't consider the quality of habitats. However, its findings emphasized the current catch trend of the small-scale fisheries in the 5 MKBA sites where it provides "rule-of-thumb" if the area is beyond of its capacity considering biophysical embayment principles.

CRM3-16-700

Gaining value-added benefits from establishing marine protected area networks

Janine Bobadilla, Maria Vanessa Baria-Rodriguez, Hazel Arceo, Porfirio Aliño

Marine protected area (MPA) network is a conservation strategy that offers greater ecological benefits in marine biodiversity, fisheries, and in the protection of natural resources than a single MPA. It is essential to present the potential economic and value-added benefits to encourage stakeholders of single MPAs to join MPA Networks. Previous efforts in estimating economic values of coastal and marine resources have been undertaken; however, benefit-cost analysis of MPA networks in the Philippines is largely unexplored. This study estimated and compared the total economic benefits and costs of establishing single and network of MPAs in selected Marine Key Biodiversity Areas in the Philippines. Economic value of coral reefs, management costs and fisheries data were used in the computation. We hypothesized that managing a network of MPAs provide value-added benefits per unit area (more cost-effective) than managing MPA singly. Based on our initial analysis, higher benefit-cost ratio can be achieved when a network is able to reduce transactional costs, and considering social, ecological and geomorphologic attributes in municipal area and management jurisdictional area upon comparing to management of single MPAs. In this manner, we may help accelerate our efforts in protecting our marine ecosystems, its biodiversity and resources.

CRM3-17-16

A case study on Tioman Island: Moving from top down management to co-management at an existing marine protected area

Alvin Chelliah, Julian Hyde, Sue Yee Chen, Hasnieza Razali, Shahir Yaman

Tioman Island was gazetted as a Marine Park in 1994 and is managed entirely by the Department of Marine Park Malaysia (DMPM). Conflicts exist between the local community and DMPM because locals were neither consulted nor invited to participate in the decision making and planning process when the Park was established. This created a sense of lack of ownership among the locals which is still very strong because they are still not involved in any aspect of the management of the Park, a situation made worse by the communication gap between the locals and the Department. In 2014, Reef Check Malaysia initiated its first community programme, Cintai Tioman. Cintai Tioman is a 5-year programme to build ecological and social resilience on Tioman with particular emphasis on involving local stakeholders in managing Tioman's reefs. Under the programme, the Tioman Marine Conservation Group (TMCG) was established; its members consist of locals who are trained to assist in coral reef conservation efforts such as Reef Check surveys, reef rehabilitation and net removal. The Tioman Dive Association was also established and has been working hand-in-hand with TMCG in conservation efforts and reporting illegal activities. The Cintai Tioman programme is in its 4th year now and the TMCG has successfully acted as a platform to get local stakeholders such as local and federal government authorities (DMPM, Tioman Development Authority and Department of Environment), business operators (dive centre, snorkel guides and resort operators) and members of the local community working together. The TMCG has successfully incorporated local stakeholders in the management of Tioman's reef and demonstrates one way to tactfully introduce co-management and gradually replace top down management.

CRM3-18-231

Designing equitable marine reserve networks for fisheries management

Vera Horigue, Adrian Chester Balingit, Patrick Pata, Cesar Villanoy, Miledel Christine Quibilan, Porfirio Aliño

Establishing marine reserves to support fisheries management usually require protection of large expanses of waters to protect different life stages and movement ranges of commercially important finfish species. However, large marine reserves are unlikely to be implemented, particularly in countries with high resource dependence and highly exploited stocks, due to the great social and economic costs associated with protecting such large areas. Hence, it was suggested that establishing networks of reserves as a more appropriate solution to support fisheries management. Marine reserve networks have been advocated because they are known and, in some cases, empirically proven to provide greater ecological, social and economic benefits compared to individual reserves. However, properly designing and establishing reserve networks to support fisheries management is more likely to be challenging, because of the difficulty of determining appropriate sizes and locations to mitigate fisheries collapse. Moreover, it is also quite difficult for most decision-makers and managers to design equitable marine reserve networks. In this talk, we present scenarios using the Fisheries for Sustaining People's Access through Conservation and Equitable Systems (Fish SPACE) model, and discuss different factors to consider for designing marine reserve networks for fisheries management in the Philippine context. Moreover, we present the trade-offs associated with these factors, which are critical to the establishment and sustainability of marine reserve networks.

CRM3-19-238

Integrating fisheries management with protected areas network: example from Palau

Steven Victor

Management of coral reef fisheries in Micronesia has been a challenging endeavor with high reliance on fishing for subsistence by communities. Marine protected areas has been a tool employed to address declining fisheries as well as the protection of biodiversity. However, with small reef system, communities can only afford to close off small reef areas that have not been enough to address declining fisheries. Managing fishing activities beyond these protected areas is necessary to ensure that investments in MPA can have longer term impact on the management of coral reef fisheries in Micronesia. In an effort to integrate fisheries management with protected areas program, The Nature Conservancy has worked with two communities in the northern reefs of Palau to develop a fisheries management strategy that integrate with their protected areas network program. The initial investments is showing positive signs with increased size and biomass for selected species. While, these are early results it is showing a positive trend that when fishers are engaged and incentivized, there are opportunities to implement fisheries harvest control rules that can lead to recovery of coral reef fish populations. The example from Palau provides a framework for integrating fisheries management with existing protected areas programs to meet communities livelihood needs as well as protection of coral reef habitats and biodiversity.

CRM3-20-663

Protecting resilient coral reefs through multisectoral partnerships

Michelle Baird, Aileen P Maypa, Reaan Gerald Osmold Catitig, Darrell T Pasco

As super typhoons frequent the coastal areas of the central Philippines, efforts to contribute to capacitate coastal community resilience against adverse impacts of climate change are on-going. In a larger framework, CCEF and SUIEMS utilize MPA as a tool for coral reef recovery with coral reef rehabilitation and through the protection of resilient reefs. For this initiative, we define "resilient reefs (RRs)" as those reefs sheltered from the typhoon track or, those reefs along the typhoon track but the resulting damage was low. We identified three RRs in Siquijor Province wherein the assessment of these reefs followed standard scientific survey methods. Protection proceeded following legal processes for MPA establishment using a government-community-NGO partnership model. We discuss a combination of the different MPA management approaches which includes bottom-up management, co-management, government led, and private-public partnership. The role of NGOs and academes in providing long-term and continuous technical assistance to LGUs and coastal communities in marine conservation and coastal resource management general, is crucial to the success of these initiatives.

CRM3-21-258

Why corals need legal rights

Danielle Michaela Bilecki

Corals reefs are unique in that the entire ecosystem they create, in addition to the coral species themselves are on the verge of extinction. While existing coral management approaches address regional and point source problems associated with reefs, there are few legal tools accessible to address global scale nonpoint source pollution problems, such as ocean warming and acidification. These known but largely unaddressed hazards to reefs have been the 'elephants in the room' when creating marine management policies, especially at an international scale. Protecting reefs requires a new approach. The social and ecological characteristics associated with reef death represent an opportunity to apply "rights-of-nature" laws at an international scale, where corals would be given the legal right to exist, and perpetrators of climate injustice would be held accountable for their CO_2 emissions. Humans, corporations, and even boats have legal rights, but nature still exists merely as property. Policies designed to protect this "property" merely regulate the extent of destruction in relation to its quantified value to humans. Through an environmental justice lens, this paper will explore the potential of the rights-of-nature approach to modify how we conceptualize Marine Protected Areas. It will analyze case studies where rights-of-nature laws have been instituted at the community, national, and ecosystem scales in the past. I expect to find evidence that suggests that the rights-of-nature approach can be effective on an international level. In addition, since it is a new concept in shaping Marine Protected Areas that focuses attention on the reef itself rather than regulatory mechanisms generated by our current environmental management paradigm, this legal tool can be applied to corals specifically. I argue that the rights-of-nature approach can improve coral reef management by by creating new legal obligations, shifting the focus of environmental management resources, and by catalyzing global awareness and action.

CRO-1-406

Subtidal scleractinian assemblages are more diverse on sloping than vertical seawalls in Singapore

Yuichi Preslie Kikuzawa, Lionel Chin Soon Ng, Shu Qin Sam, Wan Ting Sim, Teck Wei Wee, Tai Chong Toh, Yen-Ling Lee, Loke Ming Chou, Koh Siang Tan

Decades of urbanisation have replaced much of Singapore's natural shorelines with seawalls. While diverse marine communities have been documented in such habitats, little is known whether seawall inclination affects the diversity of sessile organisms. Employing line intersect transects, subtidal surveys of the scleractinian and other sessile seawall assemblages at Lazarus Island indicated that hard coral and other sessile communities were significantly different between four sloping (about 33° inclination) and three vertical seawalls of similar age (pseudo-$F_{1,29}$=2.35, p<0.01). Sloping seawalls were dominated by rocks covered with short (<2mm) turfing algae (31.2±29.5%) with hard coral comprising 14.6±71.2% of the total surface, while vertical seawalls were dominated by sponges (21.2±25.8%) with hard coral comprising only 4.5±40.4% of the total surface. The scleractinian assemblages on sloping seawalls were significantly more diverse (H'=1.71) than vertical seawalls (H'=0.88) (p<0.01), with a total of 31 hard coral genera recorded from sloping seawalls, in contrast to 18 genera on vertical seawalls. The results showed that sloping seawalls were better at facilitating colonisation by corals and sessile communities possibly due to limited light on vertical seawalls, and highlight the importance of designing new ecological engineering methods to enhance marine biodiversity on seawalls.

CRO-2-254

Herbivory as a driving force of phase-shift between *Sargassum* bed and coral communities

Chung Wing Yeung, Tsz Ching Wong, Put Jr. Ang

Both coral and macroalgal communities are important marine habitats that serve as nursery and nesting ground for a large variety of invertebrates and fish larvae of economic and ecological significance. Yet phase-shift in community structure has often been referred to the transformation of a coral dominated reef to one dominated by algae and is regarded as an unfavorable change. Though not well-documented, the reverse direction of phase shift could also occur if algal-dominated habitat is decimated, due either to natural causes or to human disturbances. We report here the formation of a barren ground from *Sargassum* bed in Lung Lok Shui (LLS), Tung Ping Chau Marine Park, Hong Kong, caused mainly by overgrazing of the sea urchin *Anthocidaris crassispina* in 2006-07. We further document the potential transformation of this barren ground into a coral community with an increase in coral recruitment in the absence of *Sargassum* canopy.

Manipulative experiment on subtratum heterogeneity was also conducted to understand how sea urchin grazing and physical barrier could affect this phase-shift dynamics. As *A. crassispina* is strongly associated with hard substratum, sandy bottom was found to be an effective physical barrier to create refugia for macroalgae, preventing *Sargassum* from completely being grazed down. With the substratum in LLS being composed mainly of continuous hard bedrock without any significant extent of sandy bottom that could serve as a physical barrier to restrict sea urchin movement, this lack of substratum heterogeneity facilitated the devastation of *Sargassum* bed by *A. crassispina* urchins. Substratum heterogeneity could thus affect the phase-shift dynamics and allow reverse phase-shift from a *Sargassum* dominated habitat to one that could potentially be dominated by corals. Such deeper understanding of the processes behind phase-shift is critical in providing the basis to develop management options for the protection and conservation of these ecologically important habitats.

CRO-3-60

Long-lasting bloom of a harmful macroalgae on degraded patch reefs in the lagoon of Dongsha Atoll, South China Sea

Carolin Nieder

The red macroalgae genus Galaxaura is well known for its allelopathic effect on corals and low susceptibility to herbivory. Secondary metabolites of Galaxaura were shown to poison adult corals and repel coral larvae from settling. Therefore, an overabundance of Galaxaura may be detrimental for the resilience of degraded coral reefs. In this case study, we investigated the abundance of the filamentous Galaxaura divaricata on degraded patch reefs in the lagoon of Dongsha Atoll, an isolated coral reef ecosystem in the northern South China Sea. We surveyed G. divaricata on reef tops (1-5 m) and reef slopes (5-12 m) over the course of 18 months, and identified epiphytes growing on the alga using DNA barcodes. The benthic cover on reef tops and slopes exhibited an average of 26-29% live coral, 39-48% dead coral and rubbles, 29-33% macroalgae, and 2-3% CCA, indicating a high level of reef degradation. G. divaricata was dominant on degraded patch reefs in the southeast lagoon, where it formed substantial canopies with large thalli (20-30 cm diameter), covering up 18-40% of the substrate. The algae did not show any significant seasonal variation in abundance and formed blooms that have persisted for at least four years at certain sites. Furthermore, G. divaricata hosts a high diversity of epiphytic macroalgae, some of which are harmful to coral. Among these, we identified a species of Lobophora sp. that frequently uses G. divaricata as a substrate but also overgrows coral. Observations of this study illustrate that the allelopathic and unpalatable Galaxaura can become dominant on degraded reefs in shallow lagoon ecosystems, which may inhibit coral growth and recruitment, ultimately impeding coral reef recovery.

CRO-4-726

Assessment of sea hares in Camotes Islands, Cebu, Philippines: Their abundance, seasonality, uses and people's perception

Romnick A Sostino, Beberlie M Miao, Jhoeiy Meigh B Formentera, Serapion N Tanduyan

Sea hares locally known as "donsol" were the subject of the study in order to determine their species diversity, abundance, seasonality and people's perception. A transect-quadrat method for independent surveys was used.. A total of 12 sampling stations in Camotes Islands were surveyed in which the municipalities are, San Francisco,Poro, Tudela and Pilar.

Results showed that during night and day assessment two species of sea hares noted: Dolabella auricularia, Lightfoot, 1768 which is the common species of sea hare and is distributed in almost all the sampling sites and Pleurobranchus forskalii, Ruppel and Leuckart, 1828 which is distributed only in Consuelo, San Francisco, Cebu. A total of 30 individuals surveyed in all the sampling sites of Camotes Islands where San Francisco has 13 individuals of Dolabella auricularia and one for Pleurobranchus forskalii ; Poro has two (2) individuals of Dolabella species; Tudela has seven (7) and Pilar has four (4) individuals of Dolabella species.

Dolabella auricularia inhabits grassy to rocky substrates in all the sampling sites with the association of seagrasses and algae while for Pleurobranchus forskalii was found in purely in grassy substrates.

People's perception on their abundance, seasonality and habitat for the last 20 years revealed that sea hares are abundant during the months of September to December each year where they gathered during night time and tend to inhabit in rocky-grassy substrates. Sea hares and eggs are plenty for the last ten to twenty years from year 1998-2006.

CRO-5-18

Influence of substrate type and predator presence on the movement of *Drupella rugosa*

Jiema Alyanna Danielle Serafica Manaid, Patrick Cabaitan

Population outbreaks of *Drupella* have been causing significant coral mortality across Indo-Pacific coral reefs, and effective preventive or control measures are still not established due to our lack of understanding on the initiation and spread of these outbreaks. Understanding the ecology of *Drupella* in terms of movement is fundamental in remedying these outbreaks. This study examined the behavior of *D. rugosa* through quantifying aggregation and movement rates and how these rates are affected by different substrates (sand and coral rubble), predator presence (*Coris batuensis*), and the light cycle under controlled laboratory conditions. *Drupella* tended to aggregate more and moved faster when provided with sand than with coral rubble, probably due to a lack of refuge found in the former. In the presence of a predator, movement rate was generally higher, while aggregation was lower, possibly due to active predator avoidance, but when provided refuge by coral rubble, the *Drupella* tended to settle, whether or not in an aggregation. The same pattern was also seen when the *Drupella* were left to move at night, reinforcing the claim that *Drupella* are nocturnal. These observations indicate that the *Drupella* would be able to easily transfer between reef substrates even when faced with disadvantageous conditions, such as the lack of food and refuge, and predator threats, allowing them to easily initiate and spread a population outbreak.

CRO-6-113

Two co-invasion scenarios: Leucothoid amphipods and their fouling hosts from coral reefs of the Asia-Pacific

Kristine Nicolle White

The rate at which contemporary environmental issues impact marine biodiversity is increasing. Invasive species are a major concern in light of potential climate change scenarios and increased anthropogenic activity. Biofouling invertebrates such as sponges and tunicates are commonly introduced to new locations on ship hulls and frequently house endosymbionts that typically exhibit narrow ranges, including leucothoid amphipods. Two co-invasion scenarios are presented here, both of which implicate transport by U.S. Naval vessels or merchant shipping. *Leucothoe eltoni* was originally described from *Herdmania*tunicates in Raja Ampat, Indonesia, and also recorded from *Polycarpa* sp. tunicates in the Philippines. *L. eltoni* was introduced to Hawaii, USA in the invasive sponges *Mycale grandis* and *Monanchora clathrata* when a U.S. Navy drydock was transported to Pearl Harbor from the Subic Bay Navy base in the mid-1990s. The author has recently collected *L. eltoni* from *Styela* sp. tunicates on U.S. military piers in Okinawa, Japan; yet, previous studies did not document *L. eltoni* in the Ryukyus Archipelago. *Leucothoe nagatai* was originally described as endemic to Japanese waters. It is now documented inhabiting the invasive tunicate *Ciona robusta* in California harbors and the invasive tunicate *Styela plicata* in New Zealand harbors. *Leucothoe nagatai* was not reported in previous studies from California or New Zealand, suggesting that it has been introduced more recently. Taxonomic clarification is hindered by cryptic diversity of coral reef invertebrates, creating difficulty in understanding host-symbiont relationships and potential impacts on marine ecosystems. This can be addressed with increased attention to cryptic species, such as leucothoid amphipods and their host distribution and ecology. The establishment of sampling and reporting networks will be discussed and updates on recent research will be presented.

CRO-7-559

Intraspecific morphological variation in two *Terapon jarbua* (Forsskal 1773) populations in Mindanao, Philippines

Maybelle A. Fortaleza, Merlene E. Elumba, Cleto L. Nañola, Jr.

The crescent grunter, *Terapon jarbua* is a catadromous species commonly harvested in coastal areas of Mindanao. The eventual migration of *T. jarbua* from brackish to deeper waters results to morphological changes yet the preponderance of environmental gradients to these changes is yet to be explored. In this study, landmark-based geometric morphometrics was employed to assess the variation in 18 morphological characters of two *T. jarbua* populations obtained from Davao Gulf and Iligan Bay. Results of Multivariate Analysis of Variance (MANOVA) and pairwise Hotelling's Test (Bonferroni corrected) indicated significantly different populations. Relative warps for Davao Gulf population revealed narrowing of body depth and expansion in pelvic and anal fin areas. A broader morphotype was observed for Iligan Bay population with pronounced expansion in all fin areas. Adaptive changes in the pectoral, pelvic, and anal fins are related to an enhanced swimming ability while the expansion of caudal fin area indicates an adaptive mechanism for predator avoidance. Changes in their mouth position also revealed variation in their feeding niche where Davao Gulf population is exhibiting terminal mode of feeding whereas Iligan Bay population have downturned mouths designed for bottom feeding. Davao Gulf and Iligan Bay are areas with different exposures and varying productivity, which indicates that morphological disparity between the two populations is response to their respective habitat characteristics. Further, the upwelling in Iligan Bay provides greater food availability in the area, allowing predator-prey dynamics to occur hence, the *T. jarbua* population is directed to exhibit adaptive plasticity against predation.

CRO-8-670

Antibacterial activity of extract mangrove *Avicennia* sp., *Rhizophora* sp., and *Bruguiera* sp. against *Vibrio harveyi* and *Vibrio parahaemolyticus*

Rara Diantari, Oktora Susanti, Maulid Wahid Yusup, Herman Yulianto, Wardiyanto, Qadar Hasani

Exploration of new bioactive compounds from nature has been conducted. *Avicennia* sp., *Rhizophora* sp., and *Bruguiera* sp., are of mangrove species which has potent as a source of antibacterial compounds. The aim of this research is to investigate the potency of leaves, fruit, and calyx from mangroves as a source of anti bacterial *Vibrio harveyi* and *Vibrio parahaemolyticus* substances. Leaves of *Avicennia* sp., *Rhizophora* sp., and *Bruguiera* sp. were collected from Sari Ringgung and Pasaran coastal, Lampung. Experimental laboratories method was used in this research, while data was analyzed descriptively. Sample was extracted by using methanol, etil asetat and hexan. Agar diffusion method was utilized on anti bacterial test against *Vibrio harveyi* and *Vibrio parahaemolyticus* with concentration 50, 100, 200, 400 dan 650 mg/disk.

The result of the test showed that *Avicennia* sp., *Rhizophora* sp., and *Bruguiera* sp. methanol extract inhibit the growth of the *Vibrio harveyi* with inhibtion zone between 0,34-5,01 mm. *Avicennia* sp., *Rhizophora* sp., and *Bruguiera* sp. methanol extract inhibit the growth of the *V. parahaemolyticus* with inhibtion zone between 0,49-6,36 mm.

CRR-1-130

Environmental strategies used in community-based coral reef rehabilitation in northern sector of Rodrigues Island, Mauritius

Chitra Ramphul

Community-based coral rehabilitation in Rodrigues Island is a new concept and is becoming an essential tool to the locals in response to a decline in coral cover and fish catch. The fishermen, youngsters and government were involved in all aspects of the project. Over 3000 of coral nubbins were transplanted by using a simple low cost method with the assistance of the researchers and locals. The transplanted corals were mainly Acroporids as they were freely available at the source site (Totor) owing to human and current activities. Corals nubbins which were transplanted to the new sites showed an average survival rate of 70% through visual observation. Five main villages were fully involved in the project through massive education and sensitization campaigns. A high presence of fishers (92%) was noted at those sessions, however a low participation was perceived. Nonetheless, seven fishers were wholly integrated into the project. These fishers showed strong commitment to the project as they felt very concerned. Youngsters who participated into the project showed the same endeavor. As a result, the low-cost coral transplantation method and environmental strategies used in this project showed to be effective and successful.

CRR-2-318

Routine maintenance of in situ nursery enhances coral growth in sedimented waters

Shu Qin Sam, Chin Soon Lionel Ng, Yuichi Preslie Kikuzawa, Wan Ting Sim, Teck Wei Wee, Tai Chong Toh, Loke Ming Chou

Intense coastal development has accelerated coral reef degradation and increased sediment load in the sea. Such anthropogenic impact impedes natural recovery of corals prompting the need to actively restore the impacted reefs. However, chronic sedimentation poses a challenge to coral restoration efforts. To mitigate these impacts, coral nursery frames were elevated above the substrate and designed with mesh-net platforms, providing stable attachment for coral fragments and reducing sedimentation accumulation. However, these frames promote colonization of macroalgae and biofouling organisms that inhibit coral growth. We examined the effectiveness of different cleaning maintenance routines (no maintenance, once a month and twice a month) on the survival and growth of nursery-reared *Pocillopora acuta*. A total of seven macroalgae genera were recorded over six months and algal assemblages on the nursery frames were significantly different across all treatments (Overall PERMANOVA: $F = 5.02$; $p = 0.001$). Benthic biofouling organisms on frames that were cleaned twice a month were significantly different to those without maintenance ($t = 2.37$; $p = 0.002$). While there were no significant differences in coral survivorship among the different treatments, coral growth was significantly higher ($F_{2,14} = 4.005$, $p = 0.042$) in frames that were maintained twice a month (74.47 ± 42.67 cm^2) than those that were not maintained (12.51 ± 20.03 cm^2). Our findings highlighted the importance of maintaining *in situ* nurseries to improve coral growth in sedimented waters.

CRR-3-431

Feasibility of coral transplantation to restore degraded coral communities in Tolo Harbour and Channel, Hong Kong

Kwan Ting Wong, Put Jr. Ang

Coral communities in Tolo Harbour and Channel, northeastern Hong Kong, were severely degraded in 1980s due to pollution. Although sewage divergence in 1998 brought significant improvement in water quality, no significant coral recovery was recorded thereafter. Thus, the feasibility of coral transplantation in assisting coral recovery was investigated. Natural coral fragments (corals of opportunities) of four species were transplanted to four sites along Tolo Harbour and Channel and attached using cement. Overall one-year survivorship of coral transplants was satisfactory (mostly >90% survival). Loss of transplants due to detachment was low (<5%), indicating that attachment with cement was reliable and inexpensive. Out of the four coral species, transplants of branching *Acropora pruinosa* and plating *Pavona decussata* showed significantly higher growth rate, but were also more susceptible to physical damages due to their morphologies. Transplants of the massive *Platygyra acuta* and *Porites* spp. showed almost 100% survivorship but much slower growth rate. Species-specific predation was observed on transplants of *P. decussata* by the nudibranch *Tenellia* sp. and on *P. acuta* by the sea urchin *Diadema setosum*. Nonetheless, all species experienced high survivorship and mostly with net tissue growth, thus were considered as suitable candidates for coral transplantation. In terms of restoration site, it was found that degree of human activities and abundance of potential corallivores were more important factors than distance from pollution source in determining transplantation success. The results suggested that coral transplantation could be a potential tool to accelerate coral recovery in Hong Kong. Besides transplanting fast growing species, addition of massive species could enhance the sustainability of restoration projects with their high survivorship.

CRR-4-503

Issues on the ecological foundation for coral reef restoration or rehabilitation

Jiansheng Lian

Restoration or rehabilitation of coral reefs have become a hotspot research theme due to the severe degradation of the global coral reef ecosystem. In mainland China, many restoration practices and studies for degraded coral reefs have been carried out where a large number of artificial interventions were used. Thus it is an urgent need to reconsider the ecological foundation on restoration, otherwise it may waste a lot of resources without achieving the desired results.

The restoration of degenerate ecosystems is a reverse processes of degradation, which is a regime shift or phase shift of the ecosystem, such as a transition between a coral-dominated and an algae-dominated system. From the system theory, there is a "time lag" effect, that is, the process of restoring to the original state is more difficult and time-consuming than the degenerate process. This seems to be the reason for human intervention on reef restoration. The question is whether the use of existing knowledge and technical reserves to actively restore is effective? How to intervene? And how to evaluate the effect of the restoration?

In our recent 10 years experiences and practices, the principle of ecological restoration for coral reefs should firstly set the target system to be restored. Secondly, it is critical to follow and rely on the process of natural recovery. Thirdly, human intervention should be limited in reversing the direction of the degrading system, let the system go into the orbit of the natural recovery, and then accelerate the process towards the target. Human efforts is not supposed to build the target system directly.

The key to reversing system degradation trends and promoting the system's natural recovery is to identify the limiting factors that affect recovery and to remove the stress or disturbance factors that cause the degradation. While the long-term stress factors still working, manual intervention for reef restoration is often ineffective.

CRR-5-568

Strategic intervention for enhancing recovery of reef communities after impacts

James Dominic True

After large-scale mortality events the wide variation in the ability of coral populations to recover naturally, and subsequent preservation of ecosystem goods and services provides a natural experiment in reef resilience. An important factor in this "resilience" is the presence of a source of larvae for replenishment. In a case study of North Andaman reefs presented here, sites more proximally "downstream" of source reefs tend to receive larger volumes of larvae, and recover relatively quickly. Sites that are either further away, or "upstream" of source reefs tend not to recover on their own, and may undergo permanent phase shift away from coral-dominated ecologies. Reefs with no clear proximate sources of larvae may have historically relied on entrained larvae (self-seeding) for replenishment, and are similarly slow to recover. Strategic use of assisted recovery techniques (larval or asexual propagation and replanting, and the use of artificial reefs) have the most impact at these latter sites. Here, I argue that decisions regarding human intervention in reef recovery need to take into account the likelihood of unassisted recovery, and the consequences of allowing the reef community to undergo phase shift. Moreover, large mortality episodes such as the 2010 bleaching event can provide insights into optimal allocation of resources for rehabilitation. Assisted restoration may have a more marked long-term impact if targeted at upstream reefs that will seed those downstream in the future, rather than focussing on the downstream reefs that are furthest away from a source of propagules. Engagement of external stakeholders such as tourism enterprises in rehabilitation efforts can markedly improve both the spatial coverage of intervention efforts and the cost-benefit equation of intervention by subsidising rehabilitation costs. Without strategic intervention, the lag between reseeding and propagule export, however, may allow permanent and unrecoverable loss of ecosystem services in the downstream reefs.

CRR-6-613

Coral reef rehabilitation in South China Sea

Yuyang Zhang, Hui Huang

The coral reefs in South China Sea have severe degradation due to the outbreak of Crown of Thorn Starfish (*Acanthaster planci*), coral disease, overfishing, global warming, cyclones, etc.The worse situation is most of degraded coral reefs had no sign of recovery, and coral recruitment kept at a low level which cannot rebuild coral community in short time. Therefore, if only depending on these degraded coral reefs themselves, coral reefs will take decades to recover or may fail to recover, especially under threats of global warming, ocean acidification, diseases and human activities. To restore the coral reefs in South China Sea, we have worked on coral reef rehabilitation for 8 years, and tested several methods on coral rehabilitation. Four types of coral nurseries have been built up on several reefs, and have cultured more than 30,000 coral fragments, and the corals on nurseries were transplanted to coral reefs when they reached 10 cm long. More than 1000 artificial reefs were used for coral transplantation, fish aggregation, and coral rubble fixing. On degraded coral reefs, branching and foliose corals skeleton break into plenty of small rubbles by erosion and waves. Small rubbles rolling on coral reefs substrate inhabit coral larvae settlement and post-settlement survivorship. To eliminate this threat, we laid 1250 m^2 plastic net on a shallow reef with rubbles, and fixed the net with nails and artificial reefs, then corals were transplanted to this area. One year later, most of rubbles were stuck to reef bottom, and coral recruitment reached to 19 individuals m^{-2} which is much higher than other reefs.

CRR-7-696

Successes and failures of using sexual propagation to restore coral populations in northwestern Philippines

Maria Vanessa Baria Rodriguez, D dela Cruz, R D Villanueva, T C Toh, A J Edwards, J Guest

Both sexually and asexually propagated corals have been used in reef restoration experiments. Although there are data on long-term (>5 year) outcomes for some transplantation studies using asexually propagated corals, there is little data on the long-term outcomes for sexually propagated outplants. This study was carried out to revisit the status of sexually cultured corals transplanted in Bolinao- Anda reef complex, northwestern Philippines in 2008-2017. Gravid colonies of *Acropora hyacinthus*, *A. granulosa*, *A. millepora*, *A. valida*, *Favites colemani* and *F. abdita* were collected. Spawned coral larvae were collected, cultured, settled on substrates and reared in an ex situ outdoor hatchery facility. Juveniles were later transferred to *in situ* coral nursery for a few months before being outplanted on selected reef sites. During the initial studies outplanted colonies were monitored for a maximum of three years after outplanting. In this study, these coral colonies were revisited and measured at least 8 years after outplanting. Preliminary result show that only *F. colemani*and *F. abdita* colonies survived while sexually reared *Acropora* did not survived. These results suggest that *Favites* species is a good candidate for restoration using sexual mode of propagation in Bolinao-Anda reef complex. More sites will be revisited and assessed for long-term survival and the implications of our results for reef restoration practice will be discussed here.

CRR-8-713

Grazing effected on transplanted coral from sexual reproduction technique

Se Songploy, Suchana Chavanich, Voranop Viyakarn

The purpose of this study was to test the direct effect of grazing of herbivore on outplanted coral growth. Field experiments were conducted at Samea San Island, Chonburi Province, and all corals, 2 - year - old *Acropora millepora* and 4 - year – old *Platygyra sinensis* used in the experiments were cultured via sexual propagation. They were transplanted to artificial substrates laid in a natural reef in Sattahip District, Chon Buri Province, Thailand. To test the hypothesis that the exclusion of grazing would result in increasing outplanted-coral growth, grazing exclusion cages were deployed for 4 months. There was no significant difference in growth rates between treatments in any coral species. *A. millepora* tend to be higher growth rate in exclusion of grazing while *P. sinensis* tend to be lower growth rate due to high density of macroalgae. Thus, this study showed that exclusion of herbivore tended to be varied depending on different species of corals.

CRR-9-380

Determining optimal density for release of competent coral larvae to maximise settlement on degraded coral reefs

Dexter Wabe dela Cruz, Charlon A Ligson, Elizabeth Jordan Gomez, Peter Lynton Harrison, Kerry Cameron

Coral reefs have very high biological, economic and social values, however, these important ecosystems are in decline around the world. While urgent action to reduce anthropogenic stressors such as climate change remains the key priority to protect and conserve coral reefs, active restoration is also needed for preservation at local scales. Enhancing supply of coral larvae has proven to be an effective method for restoring corals onto degraded reef systems in experimental trials in the Philippines and Australia. A key question for the further development of this method is to determine optimal density of coral larvae to supply to a degraded reef site. Commencing in 2017, we examined the effect of supplying different densities of competent coral larvae on initial settlement and subsequent survival of juvenile corals to 12 months at Magsaysay Reef in Anda Province, Luzon. Coral spawn from *Acropora tenuis* colonies was collected in the field at Magsaysay Reef and transferred to UPMSI's Bolinao Marine Laboratory for rearing, then larvae were returned to the natal reef site when competent to settle. A range of densities equivalent to 330–170,000 larvae/m^2 was tested, using recruitment tiles conditioned *in situ* and with individual flow-through settlement chambers placed around each tile during a five day larval settlement period. Initial settlement was monitored after 5 days and subsequent survival was monitored every 2-3 months for one year. A weak correlation was found between larval density and initial settlement, however later monitoring periods indicate greater survivorship from the lower to mid-range initial larval densities. These results highlight the importance of managing initial larval density to maximise juvenile coral survival in future coral reef restoration work.

CRR-10-437

Assessing non-coral species in reef restoration efforts

Wan Ting Sim, Tai Chong Toh, Shu Qin Sam, Chin Soon Lionel Ng, Yuichi Preslie Kikuzawa, Teck Wei Wee, Loke Ming Chou

Although corals and other reef-associated species form the basis of reef ecosystem function and resilience, reef restoration efforts have focused on scleractinian corals as focal organisms. Indicators of restoration success primarily involve evaluating the growth and survival of transplanted corals. We reviewed 88 reef restoration studies and only 14 documented the presence of non-coral organisms, with 10 and four recorded in rehabilitated reefs and *in situ* nurseries respectively. This highlighted the paucity of information on the recovery of non-coral organisms in reef restoration interventions. Moreover, most studies focused on documenting fish taxa (64%) and only 1% recorded invertebrates and 35% documented both. The results suggested that while coral restoration can mitigate biodiversity losses, non-coral taxa are largely unaccounted for. We recommend future restoration initiatives to also assess the abundance and diversity of non-coral groups. This approach will provide better evaluations of the effectiveness of reef restoration in achieving reef ecosystem functioning recovery.

CRR-11-473

In situ coral nurseries support mobile epifauna communities

Crystle Wee

Nurseries play key roles in generating coral material for transplantation in reef restoration efforts. As artificial structures in the marine environment, they can also support epifaunal communities, but such ecological functions are poorly studied. We compared the abundance, diversity and community composition of invertebrate epifauna associated with three common coral species (*Pocillopora acuta*, *Echinopora lamellosa*,*Platygyra sinensis*) reared in an *in situ* table nursery. Four hundred and twenty-seven mobile invertebrates spanning 85 taxa were recorded from 22 coral colonies. Invertebrate communities differed significantly across the three coral species, suggesting that epifauna had differing preference for coral hosts. Our findings show that coral nurseries can facilitate biodiversity enhancement beyond coral propagation, underscoring the importance of restoring a variety of coral species to maximise biodiversity recovery.

CRR-12-15

Early outplantation of two-sized sexually-propagated *Acropora verweyi* coral juveniles

Charlon Ascutia Ligson, Tracy Dofeliz Tabalanza, Ronald D Villanueva, Patrick C Cabaitan

Coral sexual propagation has become an option in providing coral materials for transplantation efforts to hasten recovery of degraded coral communities. However, sexual production of corals often yields juveniles of different sizes and it is not well understood whether corals of different sizes perform differently. In this study, the post-outplantation performance and costs of small (4.32 ± 0.64 mm) and large (12.53 ± 1.60 mm) 4-month old coral juveniles were investigated, with the hypothesis that large and small juveniles will have different survivorship, growth and costs regardless of outplantation site. After 1 year, large *A. verweyi* coral outplants had better survivorship than small outplants in Site 1, but equal survivorship was observed between the two size groups in Site 2. Large *A. verweyi* coral outplants remained to have higher growth rates than the smaller ones. The difference in the costs of large and small *A. verweyi* outplanted corals after a year was almost negligible for Site 2 (11.18 vs. 11.06 US$, respectively) and slightly varied for Site 1 (11.45 vs. 12.51 US$, respectively). When costs are expressed per unit volume, the small outplants of Site 1 (0.02094 USD/mm^3) was one-magnitude more expensive than those of Site 2 (0.00449 US$/mm^3). Results suggest that the performance of sexually-derived small coral outplants is highly affected by the condition of the outplantation site, while the large outplants showed consistently better performance. In the midst of increasing perturbations in the marine environment, especially on highly-disturbed degraded sites, outplanting with larger corals may provide an advantage.

CRR-13-310

Scaling up larval supply to increase settlement for coral and reef restoration

Peter Harrison, Dexter dela Cruz, Kerry Cameron, Grant Cameron, Nadine Boulotte

Loss of foundation reef corals is threatening the integrity of coral communities and reef ecosystems in many reef regions globally. Coral populations are naturally resilient but when larval supply becomes limiting, natural recruitment rates are insufficient to maintain or replenish coral populations, requiring active intervention and restoration. Mass coral spawning events provide access to millions of larvae that can be used for larval rearing and settlement on degraded but recoverable reef areas. Initial published studies using larval settlement on reefs were done at very small scales and produced inconclusive results. This presentation highlights the results from recent larval restoration experiments on the southern Great Barrier Reef, Australia. Millions of coral larvae from *Acropora* and brain coral species were reared *ex situ* after spawning until they were competent to settle. In addition, a floating spawn catcher was successfully deployed on the reef to capture floating coral gametes and embryos following coral spawning events. In 2016, three larval densities were tested using *A. spathulata* larvae added to 2x2 m replicate underwater mesh enclosures on Heron Island reef, and settlement and recruitment patterns exhibited a strong density-dependent effect. In 2017, larvae from four species were added to each of three replicate larger-scale 100 m^2 larval mesh enclosures placed around patch reefs with low coral cover, at both Heron Island and One Tree Island reefs. Significantly higher larval settlement occurred on biologically conditioned tiles in experimental plots supplied with coral larvae, compared with control plots in which no larvae settled on tiles. Our results highlight the importance of larval density on initial settlement patterns, and the potential for increasing larval supply for larger scale larval restoration of coral communities on degraded reefs in future.

DCC-1-551

Connectivity of coral reefs in the Coral Triangle

Marc Kochzius

A fundamental question in marine ecology is the connectivity of populations: are they open or closed? Most marine animals of coral reefs are rather sedentary. Adults are strongly site attached and connectivity among populations can only be facilitated by pelagic early life history stages (eggs and/or larvae). In an open population the majority of the offspring will not recruit to the parental population, but will disperse and recruit to other populations. In the contrary, offspring of a closed population will mainly recruit to the parental population, which is also called self-recruitment. Connectivity of populations is a key element for resilience, which is the ability of ecosystems to absorb shocks, resist phase-shifts, and regenerate after disturbances. Therefore, the degree of connectivity among populations is crucial for re-colonisation and knowledge about connectivity is important for the management of marine protected areas. Since the open ocean does not show any obvious barriers for dispersal, it was generally assumed that marine populations are open. However, recent studies have shown restricted connectivity in many different coral reef taxa and a substantial amount of self-recruitment in coral reef fish. Examples of different taxa, such as anemonefish, sea star, coral and giant clams show congruent patterns of genetic population structure in the Coral Triangle, which can be attributed to Pleistocene sea level fluctuations separating populations, as well as contemporary ocean currents.

DCC-2-463

Genetic diversity and population connectivity of corals *Acropora digitifera* and *Heliopora coerulea* along the western Philippine coast

Inggat Laya Napatal Casilagan, Kenneth M. Kim, Iris Diana C. Uy, Marylette B. Roa, Rachel Ravago-Gotanco

Coral reefs are in serious decline due to threats associated with human activities and impacts of the changing global climate. Amidst these disturbances, population dynamics of corals as the structural species, significantly influence demographic persistence and function of entire ecosystems. Insights on connectivity and genetic diversity of coral populations have important implications for the development of resilience-based management strategies for coral reefs. A population genetic survey on two reef-building coral species, *Acropora digitifera* and *Heliopora coerulea* was carried out using microsatellite and single-nucleotide polymorphism (SNP) markers. Coral colonies were sampled along the western Philippine coast. Genotypes were generated using fragment analysis methods for microsatellites and restriction site associated DNA sequencing (ddRAD-seq) for SNPs. Genetic diversity and measures of clonality were calculated. For both species, populations exhibit fairly high genotypic diversity and low frequency of clones, indicating that sexual reproduction represents a significant contribution to the maintenance of local coral populations. Genetic structure and the spatial scales of connectivity reflected dispersal potential based on the species' life history traits. The brooding blue corals (*H. coerulea*) had significantly higher levels of genetic structure relative to the broadcast-spawner acroporid (*A. digitifera*). For *H. coerulea*, the apparent limits of gene exchange was estimated to be ~40-km, while gene flow for *A. digitifera* was estimated to be ~150-km distance. These scales of genetic connectivity have direct implications for coral reef conservation and restoration across the western Philippine region.

DCC-3-500

A Lagrangian particle-tracking approach to model larval dispersal and connectivity patterns of corals and reef fishes in Verde Island Passage

Benedict Zambales Castro, Evangeline Magdaong, Jeniffer De Maligaya, Cesar Villanoy

The Verde Island Passage, which is part of the well-known Coral Triangle region, is considered to be the world center of marine biodiversity and endemism. The network of reef systems existent in the area plays a very important role in both economic and ecological aspects. Thus, the need to adequately assess these reef areas can be regarded as an important factor in coastal management and protection. This study aims to utilize the Connectivity Modeling System (CMS), a probabilistic modeling tool which employs a Lagrangian particle-tracking framework, to simulate the larval dispersal of corals (*Acropora millepora*) and reef fishes (*Acanthurus triostegus*) in the Verde Island Passage. The larval particles subjected to the stochastic model were parameterized based on their physical attributes and were advected using the Hybrid Coordinate Ocean Model (HYCOM) with 1/25°(4.4 km) resolution. Reef connectivity runs on the aforementioned test species were made for their reproductive seasons in 2014 and 2015. Locations for both source nodes and arrival nodes of modeled larvae were produced from the simulations, including relative levels of connectivity and dispersal trajectories. Connectivity indices were also derived to estimate the relative isolation of a given node or its potential as a source. Results from the model reveal valuable insights on the population dynamics in the region which can describe possible priority areas for conservation and can be used for future reef distribution assessment.

DCC-4-702

Connectivity of reefs along the eastern coast of Mindanao, Philippines

Wilfredo Lopez Campos, Lucas R Felix

The ecological connectivity of reef areas along the eastern coast of Mindanao in southern Philippines is inferred from results of plankton surveys conducted from 2003 to 2017, drift card experiments in 2003 and hydrographic studies to simulate larval dispersal in 2006. Plankton surveys covering different parts of the coast and at different seasons and years show local concentrations of fish eggs and larvae that are consistent with the overall southward flow of water in the study area. The results strongly support the dispersal patterns predicted by the hydrographic model, and they also provide additional insight to the extent of connectivity along the southeastern coast of the country.

High egg and larval concentrations were found in the inner Leyte Gulf (~ 60 ind/m^3 x 100), with mean densities up to 3X lower further south. Drift card experiments showed that water from the inner part is advected to the outer shelf of the Gulf and further south to Cateel Bay midway along the east coast of Mindanao in about 10 days, well within the typical 2-3 week pelagic larval duration of tropical coastal fish. The overall results indicate that Leyte Gulf serves as a major source of propagules for the entire eastern coast of Mindanao.

DCC-5-335

A study of *Acropora* coral larvae connectivity on West Luzon islands of the Philippines using Lagrangian connectivity modelling system

Jeniffer Dela Pena De Maligaya, Benedict Castro, Evangeline Magdaong, Cesar Villanoy

The adaptation of marine reserves is advocated as a conservation and protection tool against increasing natural and anthropogenic threats to marine habitats. One important input for determining protection efforts and prioritization in designing reserves is the connectivity patterns among marine populations. Hence, this study aims to estimate the dispersal and settlement patterns of *Acropora millepora* larvae in West Luzon region of the Philippines. A multi-scale bio-physical connectivity modelling system (CMS) was used to analyze larval dispersal and connectivity for the region. A nested Hybrid Coordinate Model (HYCOM) with 1/25º resolution was used as ocean model input for physical attribute together with the biological features of *Acropora millepora* such as competency period, mortality, egg properties and vertical migration characteristics. The difference in connectivity between the reproductive season between 2014 and 2015 was simulated. Settlement data from the model results were also used to derive indices to describe sink and source potential for each location. Results showed differences in larval dispersal extent as well as the sink and source indices.

DCC-6-521

Reef connectivity modeling in the Sibuyan Sea, Philippines

Evangeline Magdaong, Jeniffer De Maligaya, Benedict Castro, Cesar Villanoy

Understanding larval dispersal and movement of coral reef organisms is a key factor in designing and efficiently manage individual reserves within a network. Networks of Marine Protected Areas (MPAs) are significant in the persistence of metapopulations and recovery from local disturbance and global impacts of climate change. The placement and small size of MPAs in the Philippines warrant the need to be designed and managed as ecologically connected MPA networks. Hence, this study aims to determine larval dispersal and settlement patterns of two coral reef organisms: Acropora millepora and Acanthurus triostegus in the Sibuyan Sea. Dispersal of virtual larvae was simulated using Connectivity Modeling System (CMS) parameterized with species-specific larval information driven by 3-dimensional (3D), 1/250Hybrid Coordinate Ocean Model (HYCOM) hydrodynamic data. Virtual larvae with ontogenetic vertical migration behavior were released from all reef habitats within the reproductive season in 2014 and 2015. Based on the dispersal trajectories, we determined the extent of larval exchange between reef habitats. We also derived connectivity indices to identify major sources and sinks in the area as potential sites for conservation.

DCC-7-729

Biophysical modelling and habitat data for characterizing sea cucumber connectivity in Palawan, Mindoro and western Panay

Josephine Dianne Deauna, Kevin Yatco, Cesar Villanoy, Mia Shaira S Escabillo, Rey Rusty Quides, Gay Amabelle Go, Ivy Elaine Cadalzo, Charmaine Cruz, Ayin Tamondong, Ariel Blanco, Marie Antonette Meñez

Areas along the coasts of Palawan and Mindoro have been identified as having significant populations of the sea cucumbers *S. horrens*< and *H. scabra*. Conservation efforts are best directed towards ecologically meaningful management units in order to maximize protection of the species. Biophysical modeling coupled with habitat information was used to identify key areas for management. The Connectivity Modeling System was used to simulate connectivity due to passive drift for the northeast monsoon (JFM), transition (AMJ), southwest monsoon (JAS) and northeast monsoon onset (OND) months using hydrodynamic data from a HYCOM regional model. Parameters such as particle release, start and end of settlement and mortality rates were adjusted to better reflect the biology of the species. The areas covered by coral, seagrass and mangrove were estimated in the model domain and the corresponding settlement probabilities were adjusted per source/sink site according to a 10-point scale based on the biology of *S. horrens* and *H. scabra*. On a larger scale, the following areas are highly linked, with a high degree of connectivity: western Palawan and Mindoro, eastern Palawan and western Panay, and eastern Mindoro and Romblon. Based on the application of a habitat filter, these sites were identified as acting mainly as a source regardless of the season: Taytay, Dumaran, Linapacan, Coron, Paluan, Mamburao, Sablayan, San Jose, Magsaysay, Caluya and San Joaquin.

DCC-8-362

A multi-species examination of fine-scale coastal marine connectivity

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The marine environment is open and dynamic, often facilitating dispersal and inter-connectedness among populations even thousands of kilometres apart. In sessile or sedentary species, dispersal is very much dependent on their reproductive strategy and offspring's mobility, which is typically sufficient to maintain high levels of genetic homogeneity at fine scales of <100km. Subtle genetic divergence between populations at these scales however, may sometimes be obscured by the lack of resolving power in traditional genetic markers. Singapore, spanning <60km from east to west and with island habitats <5km apart, presents an ideal system for studying such genetic differentiation. Previous studies on broadcast-spawning species with planktonic larvae found apparent genetic panmixia in this area. The current study presents a comparison of the fine-scale population genomics of several reef-associated animal species in Singapore, each with distinct life history strategies (e.g. broadcast spawning, brooding, direct developers) and habitats. The double digest restriction-site associated DNA sequencing (ddRADseq) method was employed to randomly subsample thousands of SNP markers from across their genomes, which provided sufficient resolving power to identify different patterns of population genetic connectivity across these species, even at such a small geographic scale. Analyses suggest that even such small distances can present significant barriers to dispersal in species which are direct developers, while species which have a planktonic larval phase can easily overcome these barriers. Our findings emphasise the need to sample patterns among a broad range of life history strategies, in in order to make better informed decisions in marine spatial planning efforts, and also the value of genomic methods for revealing subtle genetic differentiation at fine scales.

DCC-9-13

Fish larval dispersal patterns validate coral reef marine reserve network connectivity in the Philippines

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Networks of no-take marine reserves (NTMRs) are advocated as a cornerstone strategy to revitalise reef fisheries in the Asia-Pacific. A main motivation for creating NTMR networks is the probable extent of larval dispersal in reef fish species. However, reef fish larval dispersal is difficult to measure. Over the past 6 years, we have conducted genetic parentage analysis on the vagabond butterflyfish (*Chaetodon vagabundus*, Family: Chaetodontidae) to uncover patterns of larval dispersal among NTMRs and fishing grounds in the central Philippines. To date, we have measured larval dispersal distances ranging from 10 m to 168 km. We have also documented a potentially significant role of monsoon-driven flow reversals in determining dispersal trajectories and uncovered all types of dispersal that may occur in NTMR networks (i.e., between NTMRs, NTMRs to fished areas, fished areas to NTMRs, between fished areas and self-recruitment). Our first estimate of the shape of the larval dispersal kernel predicts a mean dispersal distance of 36.5 km, with 50% of fish larvae settling within 33 km of their natal reef, and 95% within 83 km. These results offer crucial empirical support for the idea that networks of closely-spaced NTMRs could enhance reef fisheries. However, formidable challenges for the creation of large-scale NTMR networks still remain, including: 1) sustaining institutional support for NTMR networks that span multiple political boundaries; and 2) creating more and larger NTMRs and reducing fishing pressure to attain adequate connectivity that may sustain reef fisheries.

DCC-10-114

Habitat use patterns of important fishery species using natural markers

Katie Tanner Sievers, EC McClure, RA Abesamis, GR Russ

Non-reef habitat adjacent to coral reefs such as mangroves, seagrass beds, and macroalgal beds act as nurseries for many juvenile fishes before migrating to coral reefs as adults. Movement of fishes among different habitats create links for which the transfer of materials, nutrients, and individuals are facilitated, and maintaining these connections are essential for population and ecosystem dynamics. However, the specific physical and ecological connections between non-reef habitats and coral reefs remains poorly understood. Rather than empirical data, most research relies on the presence of juveniles in nursery habitat as inferential evidence that species migrate to coral reefs as adults. Stable isotope analysis (SIA) has proven a valuable tool in recent years to empirically identify dietary patterns and record habitat use of individuals. Using SIA, fish habitat use patterns can be integrated across multiple spatial scales, habitat types, and life stages to provide a more ecologically relevant approach to describing fish connectivity patterns. Here we examined stable isotope ratios of Carbon ($\delta^{13}C$) and Nitrogen ($\delta^{15}N$) in fish tissue to describe fish diet and habitat use patterns on the island of Siquijor in the Philippines. Four fish species, *Scarus dimidiatus, Siganus virgatus, Naso lituratus, Naso unicornis* were collected in 2017 to evaluate variation in stable isotope signatures with body size and age. Coupled with detailed habitat maps, we can describe specific habitat use patterns, and explore whether variability in these patterns is influenced by seascape habitat connectivity. Results will be the first to record isotopic signatures of these four fish species to describe spatial habitat use patterns of a tropical seascape in the Indo-Pacific region.

EEM-1-495

High mesophotic coral biodiversity in Okinawa and its implications for the deep reef refugia hypothesis.

Frederic Sinniger

The Deep Reef Refugia Hypothesis states that Mesophotic Coral Ecosystems (MCEs) are relatively protected from stresses (mainly thermal stress) affecting shallow reefs and may serve as source of larvae to contribute to the recolonisation of degraded shallow reefs. However, this hypothesis is based on the assumption that coral species are shared between shallow and deep ecosystems. In order to assess the extent of the potential contribution of MCEs in the recovery of shallow reefs in Okinawa, Japan, we explored the coral biodiversity found along the Ryukyu Islands at depths from 30 to 100 m using a combination of photoquadrats, ROV surveys and sample analyses (morphological and molecular). The data obtained suggest that MCEs in the Ryukyus are highly diverse and several species where found to be distributed deep and shallow.

Here we will present our latest results on Okinawan mesophotic coral biodiversity and discuss on the validity of the Deep Reef Refugia Hypothesis. We will also discuss on the different methods used in this study and the advantages and challenges presented by the various technologies.

EEM-2-333

Pocillopora meandrina and *Pocillopora verrucosa* distribution along the depth gradient in Green Island (Ludao), Taiwan

Stephane De Palmas, Vianney Denis, Derek Soto, Allen Chen

Mesophotic Coral Ecosystems (MCEs) could act as an ecological refuge for reef organisms in the context of worldwide decline of coral reefs and species having a large bathymetric distribution are more likely to benefit from this refuge capacity. However, species taxonomy is sometimes challenging due to the large range of morphological plasticity (both intra- and inter-specific) occurring in response to changing environmental parameters with depth (light, wave actions). *Pocillopora meandrina* and *Pocillopora verrucosa* are both hypothesized to be present from shallow (5m) to deep (60m) around Green Island (Ludao), Taiwan, and both species are known for their plasticity making their field identification particularly challenging. In order to clarify their distribution along the depth gradient, we genotyped the mitochondrial Open Reading Frame (mtORF) of several colonies collected from 7 to 55m in depth at 3 sites around the island. Our results revealed that both species have a differential distribution along the depth gradient. While *P. verrucosa* is found at all depths, *P. meandrina* is restricted to the shallow waters of Green Island. Therefore, *P. meandrina* is more likely vulnerable to the current trend of perturbation responsible for the decline of coral reefs. In contrast, we hypothesize that *P. verrucosa*, with its large bathymetric distribution, could benefit from the refuge offered by the mesophotic zone by persisting when facing adverse environmental conditions. Further studies, especially on the *P. verrucosa* genetic connectivity are needed to confirm this hypothesis. This study illustrates the contribution of the molecular approach for delineating species distribution for biodiversity assessment of the mesophotic habitat and highlights the fact that the refuge hypothesis could be restricted to a limited number of species.

EEM-3-383

Developing technical diver based monitoring protocols of mesophotic coral ecosystems

Ashley Marie Carreiro, Sara Fowell, Isabella Morgante

Mesophotic coral ecosystems (MCEs) are a frontier in marine science and conservation, revealing a gap in the knowledge for ecosystem connectivity and shallow reef refugia. Multiple anthropogenic stressors, including climate change, terrestrial run-off and destructive fishing practices are impacting shallow water coral reefs, particularly in terms of community shifts and high mortality rates. How mesophotic reefs respond to stressors is not fully understood, yet they are proposed to act as a refugia due to cooler waters and spatial buffer from pollution. Technological advances have allowed MCEs to be investigated, but such methods can be costly. Mixed gas technical diving is an underutilised resource in MCE exploration and research, despite extending both the time and depth limits of recreational SCUBA diving. Marine Conservation Philippines is developing technical-diver based exploration and monitoring methods between depths of 30m and 50m to make MCEs more accessible to the wider scientific community.

Before developing monitoring strategies, preliminary exploration of the monitoring site using a video-roaming technique, was conducted to understand the spatial variation and diversity of fish and corals. Following exploration, visual census and point intercept transects are used to monitor fish and benthic life.

The data collection method is designed to test the accuracy of diver-collected data by using three techniques: diver collection validated by camera; diver and camera, and data collected completely by camera. Fish surveys are conducted over a ten-minute time span along a 30m transect. Divers record fish species and size, mirroring shallow reef survey methods. The possibility of divers being affected by narcosis is assessed by comparing divers' data against a video of the survey. From this evaluation we can assess if divers performing surveys at depth is feasible, or if video monitoring is more advantageous. We aim to provide a methodological framework suitable for other scientific technical divers to expand our understanding of MCE composition and it's potential as a refugia.

EEM-4-344

Assessment of the reef fish communities at the Philippine Rise: An update since the 2014 Cruise

Badi R. Samaniego, Alvin Nowell P. Simon, Marianne Pan Saniano, Hildie Maria E. Nacorda, Rhoda S. Bacordo, Kristyl Ckaye E. Pardo, Riczyneth A. Arinque, Robin P. Escriba, Cleto L. Nañola

The Benham Bank Seamount is an extension of the Philippine continental shelf situated near the south of the Luzon trench. The highest point of the Bank rests at a depth of about 50 meters below sea level. It is a promising prospect in terms of fisheries and of interest to the energy sector due to its potential for mineral and fossil fuel deposit. Benthic and fish community surveys at the Philippine rise was conducted in 2014 and 2016. Modified fish visual census technique was used to survey fish in 2014 due to the limitations imposed by depth for conventional SCUBA diving surveys. In 2016, the stereo - baited remote underwater video system (BRUVs) was employed to survey reef fish communities between 50 to 150 meters below sea level. Six locations across the rise were surveyed in 2016. A total of 175 species belonging to 32 families were observed from the 6 survey stations. This was almost four times more than the fish species observed in the 2014 survey. Survey sites at relatively shallow depths of 50 to 65 meters had higher fish diversity, abundance and biomass compared to the deep deployment sites (85 to 150 meters). Target species yielded high biomass due to the presence of large predators such as the tiger shark, blacktip reef shark, sting rays and moray eels, and schools of fusiliers and surgeonfishes. While the fish communities at the Philippine Rise may be characterized as relatively diverse and abundant, the scarcity of top predators such as sharks, large snappers and groupers was noted, potentially indicating stress from fishing pressure. Protection and management of the bank are imperative, and a greater understanding of the structure of these communities and the possible threats to these resources are the first steps towards this goal.

EEM-5-21

Benthic habitat and fish assemblage structure of Philippine mesophotic coral ecosystems

Rene Aberin Abesamis, Tim Langlois, Matthew Birt, Emma Thillainath, Abner A. Bucol, Hazel O. Arceo, Jean T. Utzurrum, Garry R. Russ

Ecological studies of mesophotic coral ecosystems in the Philippines are lacking despite the potential of deeper reefs to serve as refuges from disturbances that degrade shallow reefs or to act as sources of recruits for future recovery of shallow reefs. We used baited remote underwater video to describe benthic habitat and fish assemblage structure from 10-90 m deep at two sites in the central Philippines: 1) Apo Island, an offshore marine protected area that was severely damaged by two storms in 2011 and 2012; and 2) the coastal shelf of Negros Island, off Dumaguete City. Coral reef development was more extensive at Apo than on the coastal shelf of Negros. However, hard corals were limited to a depth of about 40 m or much less. Benthic cover at mesophotic depths at the two sites was dominated by sand/rubble or rock with low cover of soft corals and sponges. Fish species richness and abundance declined with increasing depth in most trophic groups. The taxonomic and trophic structure of the fish assemblage at mesophotic depths differed greatly from those at shallow depths. At Apo, storm damage appeared to have reached mesophotic depths. On the other hand, benthic habitat on the Negros shelf was much more degraded due to siltation and pollution. These findings indicate that some mesophotic coral ecosystems in the Philippines are not immune to disturbances and would provide minimal depth refuge for reef species.

EEM-6-475

Environmental drivers of mesophotic coral ecosystems: Elucidating jungle-to-ocean connections using state-of-the-art chemical tracers

Alex S.J. Wyatt, James Jensen Leichter, Toshihiro Miyajima, Toshi Nagata

While mesophotic coral ecosystems (MCE) may be protected or damped from disturbances impacting shallower reefs, insufficient information is available on long-term environmental drivers of these "deep water refugia". Our recent work demonstrates that MCE can be much more variable environments than is usually assumed, which may influence their refugia potential. Nutrient inputs and recycling have also rarely been quantified over MCE but may differ fundamentally to that of shallow counterparts due to the reduction in light and increasing reliance on oceanic nutrients, leading to increased heterotrophy over autotrophy at species and ecosystem levels and stronger reliance on cross-ecosystem links. For instance, due to the depth of MCE relative to typical water column density stratification, internal waves may be a highly significant process depending on community aspect and exposure. Observations of MCE along a continuum of oceanic exposure in Funauki Bay, Iriomote-jima, Japan indicate that ocean-exposed MCE are subject to semi-diurnal cooling of up to 7 deg C during summer (range 22 to 31 deg C), while inner MCE occur shallower, in more turbid environments, but also experience internal wave oscillations. Strong links between mesophotic corals and the pristine subtropical jungle may be driven by the heterotrophic consumption of ancient terrestrial carbon exported from the catchment, with coral tissue radiocarbon showing evidence of significant depletion relative to zooxanthellae and modern dissolved inorganic carbon. Gradients in oceanic and terrestrial exposure, as well as recurrent typhoons, may determine both the distribution and function of spatially extensive, but relatively homogenous, communities dominated by *Leptoseris* sp. or *Acropora ?horrida*. Combining bulk and compound-specific stable isotope analyses with radiocarbon and eddy covariance-derived productivity estimates promises to be a useful approach for elucidating the functional importance of oceanic and terrestrial gradients in the development and persistence of MCE at local to regional scales.

EEM-7-77

Warm water deep-sea corals - microbiome analysis provides insight into functional adaption to a unique environment

Till Roethig

Recently, deep-sea corals from the Red Sea were re-discovered posing the question how the corals can adapt to the challenging habitats featuring low nutrients and oxygen level (<2 mg oxygen L^{-1}) at warm temperatures (>20 °C). The lack of symbiotic algae may suggest that associated microbes play a role in maintaining a viable coral host via acquisition and recycling of nutrients. To gain insight into potential functions of the bacterial microbiome, we employed 16S rRNA gene sequencing to study bacterial communities of three scleractinian deep-sea corals from the Red Sea, *Dendrophyllia sp.*, *Eguchipsammia fistula*, and *Rhizotrochus typus*. We found diverse, species-specific microbiomes, distinct from the surrounding seawater. Microbiomes were comprised of few abundant bacteria and a high diversity of rare bacteria, thus following a rank-abundance distribution. Interestingly, we identified anaerobic bacteria, potentially providing metabolic functions at low oxygen conditions, as well as bacteria harboring the potential to degrade crude oil components. Considering the presence of oil and gas fields in the Red Sea, these bacteria may unlock this carbon source for the coral host, although further experimental work is needed to confirm this. In conclusion, the prevailing environmental conditions of the deep Red Sea may require distinct functional adaptations, and our data suggest that bacterial communities may contribute to coral functioning in this unique deep-sea environment.

EEM-8-546

Benthic community characterization of the Benham (Philippine Rise) Bank

Victor Ticzon, Hildie Maria Nacorda, Jennie Litan, Marian Saniano

The 2014 exploration of the Philippine Rise yielded significant findings, particularly the existence of a pristine coral reef system in the summit of the seamount. The survey provided a window on the existing biodiversity in this extensive mesophotic reef. However, no characterization or spatial distribution of benthic habitats was conducted that time since only short observational surveys were afforded at the bottom by technical divers. The goal of the current study was to further build on the information on the associated benthic habitats and their distribution on the seamount ridge of the Philippine Rise. Broad area surveys to identify and determine the distribution of different benthic habitats in five stations spread across the 15-kilometer length of the ridge, was conducted using georeferenced videos collected by remotely operated underwater vehicle (ROV). The results showed that significant hard coral cover were located only at the stations at and near the summit of the sea mount (>40% hard coral cover). The substrate of the stations located at the Northern, Southern and Southwestern edge of the ridge, away from the summit, were predominantly covered by the coralline algae *Halimeda* and *Halimeda*-derived coralline sand. In these sections of the ridge, hard corals were patchy in distribution, with an estimated cover not exceeding 10%. The results showed the limited distribution of areas with significant hard coral growth and emphasizes the urgent need to establish, at the least, the summit of the ridge as a no-take marine reserve both for maintaining biodiversity and for the country's food security.

EEM-9-84

Structure of benthic communities in selected mesophotic sites in the Philippines

Edwin Dumalagan, Patrick Cabaitan, Tom Bridge, Kevin Thomas Go, Timothy Joseph Quimpo, Ronald Dionnie Olavides, Fernando Siringan

Coral reefs are vulnerable to threats brought by prevailing climate change and rapid coastal development. Mesophotic coral reef ecosystems (MCEs) - extensions of the shallow water reefs (SWRs), while perceived to be less impacted by these perturbations than their shallower counterparts, may also be affected. Yet, information on the difference in coral community structure between SWRs and MCEs in pristine and impacted locations is limited. In this study, the coral diversity and benthic community composition between SWRs and MCEs in relatively pristine (Apo Reef and Calaguas) and degraded (Patnanungan and Abra de Ilog) sites in the Philippines were investigated. Given that depth exerts a strong influence on community composition, we hypothesize that 1) there would be a considerable difference in community composition between deep and shallow sites at both disturbed and undisturbed sites and 2) mesophotic reefs on undisturbed sites will be characterised by higher cover of corals and other macrobenthos and lower cover of sediment than more disturbed sites. Conventional SCUBA diving employing photoquadrat methodology was used to examine the coral community structure in shallow (8 to 13 m) and upper mesophotic depths (30 to 40 m). In general, branching corals were more abundant in the shallow reefs while encrusting and foliose corals were more abundant in the mesophotic zone. Live hard coral cover decreased with depth. There was an apparent separation in coral community structure between depths in good condition reef sites than in poor condition reef sites. Coral community structure was also significantly different between undisturbed and disturbed sites at each depth. This study provides baseline information on coral distribution and biodiversity in MCEs in the Philippines and offer insights on how coral reef benthic communities vary spatially in MCEs.

EEM-10-69

Role of the benthic community on the ability of mesophotic coral ecosystems to function as a depth refugia for fish communities

Timothy Joseph Rama Quimpo, Patrick Cabaitan, Ronald Olavides, Edwin Jr. Dumalagan, Fernando Siringan

Mesophotic coral ecosystems (MCEs), an extension of shallow-water reefs (SWRs), have gained interest as a potential depth refuge from disturbances. However, differences in the patterns of fish community structure between SWRs and MCEs in different sites exposed to different disturbance regimes is not well understood. Here, we assessed the community structure of fishes and benthos through visual observation across a depth gradient from shallow to upper MCE (i.e., 10, 20 and 30 m depths) in Apo Reef Natural Park (ARNP), one of the few remaining pristine coral reef ecosystems in the Philippines, and Abra de Ilog and Patnanungan, two representative degraded reef sites. ARNP is characterized by high coral cover whereas Abra de Ilog and Patnanungan exhibit high cover of silt and algae, respectively. In general, fish species richness was highest in ARNP and decreased with depth at all sites. Fish abundance and biomass increased with depth, except at ANRP, where fish abundance was highest at 20 m. The fish assemblage in ARNP differed from that of Abra de Ilog and Patnanungan, which corresponded to differences in the benthic community structure among sites. Furthermore, a difference in the fish assemblage between depths was observed only in ARNP, where herbivores were more abundant in the SWRs and planktivores in the MCEs. These results show that disturbances that affect MCE benthic community structure also affect the fish community structure at depth. This emphasizes the key role of the benthic community on the ability of MCEs to function as a depth refuge for fish communities.

GCL-1-550

Molecular evolution of giant clams

Marc Kochzius

A number of molecular genetic studies in the last decade have shown that giant clam biodiversity is much higher than previously known and a number of species have been re-discovered or newly described, providing valuable information for conservation. The centre of giant clam biodiversity, and for marine life in general, is the Coral Triangle (CT). The three main biogeographic models trying to explain the evolutionary mechanisms that produce this megadiversity in the CT are: 1) centre of speciation, 2) centre of overlap, and 3) centre of accumulation. The first model suggests that the CT is exporting species to the peripheral areas of the Indo Pacific. The second model assumes that distinct faunas from the Indian and Pacific Oceans overlap in the CT. During sea-level low stands of up to 130 m during the Pliocene and Pleistocene glacials the exposed shelves in Southeast Asia and Australia formed the Indo-Pacific Barrier (IPB), separating populations. The third model suggests that species evolved in the periphery and have been transported towards the CT by favourable large-scale current patterns. Fine scale genetic differentiation among giant clam populations in the CT suggests a centre of speciation, while strong genetic differentiation across the IPB supports the centre of overlap model. Additionally, endemics and divergent genetic lineages of widespread species in peripheral areas, such as the Red Sea and Western Indian Ocean, point towards a centre of accumulation. It is obvious that not only one biogeographic model can explain the megadiversity in the hotspot of the CT, all three mechanisms are operating in concert. This is summarised in the new biodiversity feedback model, in which the biodiversity centre exports species to peripheral regions, where these eventually evolve into new species due to isolation, which in turn can be exported back to the biodiversity centre.

GCL-2-71

Giant clam conservation in the Philippines: Perspective and future outlook

Vanessa Joy Fano Diamante, Cecilia Conaco, Patrick Cabaitan, Edgardo Gomez

Giant clams are iconic marine bivalves that contribute to reef ecosystems and offer great economic potential for coastal communities. Unfortunately, giant clams have become locally extinct in various parts of the Philippines due to overharvesting. To restore depleted populations, the Bolinao Marine Laboratory of the Marine Science Institute, University of the Philippines, has been culturing and restocking giant clams since the 1980's. To date, the Silaqui Giant Clam Ocean Nursery is home to the largest population of giant clams, particularly of *Tridacna gigas*. Over thirty years, BML has restocked approximately 50,000 giant clams at about 70 sites around the Philippines. Some of the restocked individuals have become reproductively mature and have started contributing to the replenishment of local giant clam stocks. Recognizing the potential of giant clams to boost ecosystem services and ecotourism, various government agencies, local government units (LGUs), as well as private resort owners have partnered with BML in giant clam restocking efforts. Key factors contributing to the success of these activities are education and training, cooperation between stakeholders, and community involvement. Building on these experiences, the town of Bolinao, which is now known as the Giant Clam Capital of the Philippines, has initiated an effort to boost giant clam ecotourism in the area of the Silaqui Giant Clam Ocean Nursery through a partnership between the LGU, Silaqui fisherfolk, and UP MSI.

GCL-3-648

Taklobo tours: Giant clam conservation and livelihood opportunities for coastal communities in Samal Island, Philippines

Girley Santiago Gumanao, Xavier Lopez, Rosie Lynn Tejada, Lemuel Cardona

Taklobo Tours was launched in 2013 at Adecor, Samal Island to promote giant clam conservation, ecotourism, and to provide livelihood to fisherfolk beneficiaries. On top of the in-situ conservation of giant clams in a marine protected area initiated by the UP-Marine Science Institute, capacity building, policy support and site development were among the major interventions. Qualitative and quantitative data from 2013 to 2017 were used to analyze the impacts of the project.To date, the beneficiaries have increased their level of participation to giant clam conservation. Violations are no longer observed in the nearby villages and communities. This became the banner tourism destination in Samal Island. Increasing arrival of guests from 284/month in 2013 to 1050/month in 2017 was noted but usually higher during peak months, in April and May. Local and international guests visited and contributed to the livelihood of direct and indirect beneficiaries. This provided additional income and livelihood to local tour guides. This remarkable journey was due to the strong partnership of academe and Local Government Unit of Samal Island. Regular monitoring and continued capacity building of beneficiaries are recommended to ensure project sustainability.

GCL-4-112

Successful trials of giant calm breeding in China

Ziniu Yu, Yuehua Zhang, Shu Xiao

With the symbiotic single-celled zooxanthellae inhabiting in their mantle tissues, giant clams are a group of fascinating marine bivalve in tropical coral reefs, and play an important role in coral ecosystem. However, in South China Sea, giant calm populations have kept remarkably getting smaller due to ever-growing consumption of clam shell as ornaments and meat as sea food by local people in last decade. In this situation, giant calm breeding and juvenile culture are definitely desired and required from scientific community, marine environment enthusiast and government as well for securing the techniques for clam resource restoration and protection. In the years of 2016 and 2017, a project was funded and trials were successfully conducted for fluted giant clam and other species at Tropical Marine Biological Research Station in Hainan province of our institute.

The breeding trials were performed under the conditions of temperature 27–30 °C, salinity 30–33, pH 8.0–8.3 during March to June. conditioned broodstock kept in fiberglass tanks were induced spawning using serotonin or spawned naturally, and the eggs and sperms were collected separately. Artificial fertilization was done as suggested from the literature, the hatching rate is higher when the ratio of sperm to eggs was maintained at 50~100 : 1 with zygote density of 15–20/mL; and the D-shaped larvae were obtained after 36 h of incubation. It took approximately five days of rearing for D-larvae to develop into the pediveliger larvae, entering metamorphic stage. Introduction or innoculation of zooxanthellae was carried out in 4-6 days of rearing, and then pediveliger larvae were cultured under close observation when larvae developed gills, secondary shell, and the established zooxanthellae tubular system. Spats were cultured using slowly-flowthrough seawater under proper sunlight, which promoted subsequent organ development and spat growth. During this stage, regular cleaning of filamentous algae is required, to prevent entanglement with spats and thus ensure higher survival rate of spats, until spats reach the size of approximately 1.8 mm (shell length) at the age of two month. Subsequent juvenile rearing in the tanks allow them to grow up to 8 cm size at age of one year old in the station. The two-year trials allowed us to gain hands-on experience (positive or negative) and promise us better results in the future.

GCL-5-427

Status and trends in the populations of giant clams (*Tridacna* spp.) on the Island of Koh Tao, Thailand

Chad M. Scott, Spencer Arnold, Rahul Mehrotra, Pau Urgell Plaza, Kirsty Magson, Elouise Haskin, Jarno Verdonk

The island of Koh Tao, Thailand has quickly transformed from a quiet fishing community to the second largest diving industry in the world. Rapid development, exploitation, over-use/extraction, and increased thermal anomalies over the last 3 decades have greatly impacted local populations of Giant Clams on the island's reefs. This study analyses over 10 years of coral reef monitoring data and several years of focused surveys to evaluate changes in the abundance and population dynamics of *Tridacna* species around the island. Furthermore, it documents and evaluates the effectiveness of over two decades of transplanting Giant Clams around the island through a program initiated by HM the Queen of Thailand, the Thai Department of Fisheries, and the Department of Marine and Coastal Resources. The study found that the average density of giant clams around Koh Tao was approximately 1.1 individuals/100m^2(SE +/- 0.2), with the bays on the less developed, Eastern side of the island having a relatively higher density (range 1.5 – 3.0 individuals/100m^2) than the rest of the island. The lowest densities of clams (≤ 0.3 individuals/100m^2) were found in bays with histories of high development, severe bleaching, or both. Overall, the densities of clams were relatively lower than published values from the region, and has decreased slightly through the bleaching events of 2010 and 2014. Although a restocking program has been going on for over 20 years, there was not found to be a higher density of clams in the bays where frequent restocking has occurred versus those that have not. The study indicates the need for more protective measures for Giant Clam populations around Koh Tao, and also contains recommendations to improve the effectiveness of the local nursery and restocking program.

GCL-6-529

Species composition, size structure and recruitment of giant clams, *Tridacna* spp. (Mollusca:Tridacnidae) in restocking site at Samal Island, Southern Philippines

Girley Santiago Gumanao, Xavier Lopez, Medel Silvosa, Matt Tacatani, Lemuel Cardona, Aloha Jane Canales, Edgar Cardoza, Joven Kent Albaran

The Davao del Norte State College of Panabo City is given by the Local Government of Samal the right to manage a 14-hectare Marine Reserve Park in Adecor, Samal Island within the Davao Gulf. This is a Marine Protected Area that became one of the Philippine giant clams stock enhancement sites initiated by the University of the Philippines - Marine Science Institute in 2001 through LGU-Academe collaboration. An assessment was conducted on December 2015 to January 2017 to determine the species composition, size structure and recruitment to find out the achievement of the protection and restocking program. All the giant clams within and in the vicinities of the MRP were identified at species level and measured in shell length (SL).There were 2196 giant clams that belonged to four species,Tridacna gigas (40.4%), Tridacna derasa (25.8%),Tridacna squamosa (33.2%) and Tridacna maxima(3%). Most of the individuals of Tridacna derasa, Tridacna maxima, Tridacna squamosa belonged to large size while Tridacna gigas belonged to medium size. The presence of small-sized juvenile giant clams,T. gigas and T. derasa inside and outside Marine Reserve Park indicate recruitment from natural spawning of the restocked giant clams.This points the success of the Philippine giant clam conservation in Marine Protected Area in this part of the country. A survey of giant clams covering larger areas around the Island is therefore recommended.

GCL-7-55

Clam recruits and natural stocks in Guinsiliban, Camiguin, southern Philippines demonstrates successful giant clam conservation program

Jeremiah Noelle Calvo Requilme, Patrick C. Cabaitan, Sherry-Lyn G. Sayco, Cecilia G. Conaco

Guinsiliban, Camiguin, is one of the successful giant clam restocking sites in southern Philippines and is maintained through a collaboration between the fishers, private sector, and the local government unit. In 2015, the presence of *T. gigas* juveniles were noted in waters surrounding the restocking site based on anecdotal reports of fishermen. Field surveys using belt transect method were conducted last January and April 2017 to verify these reports and to assess natural stocks of giant clam species in the area. A total of 26 *T. gigas* juveniles, with a mean shell length of 15cm, were recorded from the surveys. Majority of the *T. gigas* juveniles were found approximately 240 m up to ~2 km away from the restocking site. Other species of clams, including *Tridacna crocea*, *T. maxima*, and *T. noae*, were also observed. The *T. gigas* juveniles that were found during the surveys were likely to be the product of natural spawning of the restocked individuals, which has been occasionally observed by the local fishers. *T. gigas* were locally extinct in the area and no adult wild clams of this species were observed during the surveys, thus, the only likely source of gametes are the individuals that were restocked as juveniles about 17-18 years ago. The abundance of other giant clam species in the area indicates that the site is well-suited for clam recruitment. These findings also emphasize the importance of strong commitment and cooperation between the private sector and local government units in ensuring the successful conservation of restocked and natural stocks of giant clams.

GCL-8-540

Conservation research for the giant clams (Bivalvia: Cardiidae: Tridacninae)

Mei Lin Neo

The large and charismatic giant clams are almost eaten to extinction, as men exploited them for their meat and shells as a source of food and material respectively. Overharvesting between the 1960s and 1980s had accelerated the pervasive loss of giant clams across the Indo-Pacific, and in some areas driven to local extinctions. The recent status remains critical as a recent global review pointed out that almost 25% of the 66 localities reported at least one species locally extinct. The largest species, *Tridacna gigas* and *T. derasa* are most endangered, and clam fishing remains the major threat. To curb declines, numerous mitigation strategies such as listing all species in the IUCN Red List and CITES Appendix II, introduction of national fishing bans, formation of no-take reserves, and the mass cultures of clams for restocking depleted reefs have been successful. These efforts provided the immediate and effective solutions to local declines. At the same time, they tend to be labour intensive, geographically localised, and mostly of mono-specific cultures that do not adequately benefit/deal with rare species. Here I will share a wide-range of complementary research such as experimental ecology, phylogenetics, maritime laws, and science communication, which has helped to raise awareness of the plight of giant clams and inform their conservation strategies both in Singapore and elsewhere.

GCL-9-615

Physiological response of adult giant clams, *Tridacna gigas*, exposed to varying environmental conditions

Sherry Lyn Grajales Sayco, Patrick Cabaitan, Elizaldy Maboloc

The true giant clam *Tridacna gigas* have been restocked all over the Philippines to replenish their population. However, understanding their response to varying environmental conditions is limited only to investigations on their growth and survival. Giant clams live in symbiosis with the photosynthesising zooxanthellae, which provide most of their nutrition. Same on corals, the response of zooxanthellae also indicates the giant clam's physiological state. Aside from growth and survival, this study investigated other physiological responses such as changes in cell size, cell density and pigment concentration of zooxanthellae isolated from the giant clams restocked in two sites with contrasting environmental conditions for nine months. Giant clams exhibited an increase in shell length through time. Among physiological responses, only chlorophyll a pigment concentration was observed to be negatively correlated with temperature but positively correlated with sediment load. Significant differences in chlorophyll a and carotenoid concentrations and cell density were observed between sites at certain sampling time but no differences observed in chlorophyll c pigment concentration and cell size. This study shows that chlorophyll a, the most predominant pigment and essential for efficient photosynthesis, is more sensitive to changes in temperature and sediment load, thus, these environmental parameters should be considered in choosing suitable restocking sites for giant clams. Also, this study suggests that giant clams can be used as indicator for subtle changes in environmental conditions.

GCL-10-57

Comparison of interspecies and intersite differences in the epibiont community of giant clams

Ian Joseph A. de Guzman, Patrick C. Cabaitan, Cecilia G. Conaco, Sherry Lyn G. Sayco

Topographic complexity of coral reefs provides habitats for many species. Giant clam shells contribute to this complexity by providing a suitable substrate for the attachment of a multitude of epibionts. However, it is not yet known whether there is specificity in the types of epibionts that associate with different species of giant clams or with giant clams found at different sites. In this study, surveys were conducted to compare the epibiont communities on the shells of three species of giant clams, *Tridacna gigas*, *Tridacna derasa*, and *Hippopus hippopus,* in the Silaqui ocean nursery of Bolinao, Pangasinan. The epibiont communities on the shells of *T. gigas* located in a sandy area, a seagrass site, and on a coral reef were also compared. *T. gigas* had the highest prevalence, species richness, total abundance and cover of epibionts among the three species. However, there was no significant difference among the epibiont community composition that were associated with the different species of giant clams. Prevalence, species richness, and total abundance and cover of epibionts were higher on clams in the coral reef compared to those in the sandy and seagrass areas. Epibionts on coral reef clams included various species of algae, sponges, tunicates, corals, bivalves, gastropods, and echinoderms. Clams in both sandy and seagrass sites were associated with a lower abundance of epibionts, consisting mostly algae, tunicates, corals, and gastropods. Results show that giant clams can function as settlement substrates for many marine invertebrates, which makes them ideal for restocking efforts that aim to enhance overall local biodiversity.

GCL-11-469

Eradication methods of ectoparasitic snails (Family Pyramidellidae) on the true giant clams (*Tridacna gigas*)

Lynette SM Ying, Samantha JW Tong, Samuel HR Lee, Ambert CF Ang, ML Neo, Peter A Todd

Giant clam mariculture and hatcheries around the world contribute as important sources of food production and conservation efforts. However, the prevalence of ectoparasite infestations, especially Pyramidellidae snails (or pyrams), in these hatcheries has detrimental effects on tridacnines' growth and survivorship. Physical removal, which includes brushing, washing and picking out individual snails, is the current techniques used by researchers and aquarium enthusiasts. These have proved to be both ineffective and inefficient, and little research has focused on devising more efficacious methods. We examined several aspects of pyram ecology to help identify solutions of eradication, including their position on the clams, its physical resistance to certain chemicals, and tolerance to heat. Pyrams surveyed were mostly found on the hinges, byssal orifice and lower half of the shell valves. After subjecting specimens to various concentrations of tannin solution, ethanol and bleach (sodium hypochlorite) for time periods ranging from 3 to 30 minutes, we identified bleach as the most effective molluscicide out of the three reagents. Pyrams were also subjected to nine temperatures between 39 and 43°C and were able to tolerate high temperatures up to 42.5°C. Finally, 30 infested clams were individually isolated in tanks for three weeks, and underwent two different cleaning regimes. Physical removal method was adopted, however, 15 clams underwent daily pyram removal, while the other 15 underwent biweekly pyram removal. Daily removal was found to be most effective, as after 1 week into isolation, the giant clams were clear of pyrams, and they have remained pyram-free for a year. Although labour-intensive, pyram eradication is possible.

GCL-12-142

Survival rate of the first eight (8) days culture of the seven (7) species of giant clam propagated and cultured in Semirara Island

Ronnie Pamatong Estrellada

The Semirara Marine Hatchery Laboratory of the Semirara Mining and Power Corporation, Semirara Island, Caluya, Antique Province, Philippines, conducted the propagation and culture of the Seven (7) Species of Giant Clams for Marine Biodiversity Conservation and Environmental Enhancement around Semirara coastal waters. The survival rate of the first eight days culture of the seven species of giant clams was studied in Semirara Marine Hatchery Laboratory from January 2011 to December 2014, to determine the survival rate of fertilized eggs from day 0 to day 8 and peak season and spawning months.Two processes of induced spawning was conducted in the seven species of giant clams every month the In-situ and Ex-situ induced spawning to determine the total number of gametes released to fertilized and stocked in the Larval Rearing Tank (LRT) for eight days culture period. The highest average survival rate of fertilized eggs was observed in the month of July to October in *H. porcellanus* (51.45%), *T. squamosa* (17.76%), *T. maxima* (15.18%), *T. crocea* (11.35%) and *T. gigas* (8.08 %) and least on the other months in *H. hippopus* (3.97% and *T. derasa* (3.77%). However, the proper handling/stocking, viability of the eggs and accuracy of counting larvae influenced survival rate of fertilized eggs in LRT. In the month of July it was observed the highest number of fertilized eggs which indicates the peak spawning months of the seven species of giant clams. For seven (7) years, since 2011, operations on the propagation and culture of giant clams, we produced about 122,341 pieces with sizes ranges from 3 cm to 45 cm shell length.

OA-1-340

Effects of three pH ranges on the pre- settlement, development, survival of birdnest coral, *Seriatopora guttata* (Veron, 2000) planulae

Portia Pajares Antig, Filipina B Sotto

Anthropogenic release of greenhouse gases from burning fossil fuels changes the chemistry of the ocean leading to a decrease in pH. Such decrease in carbonate ions can be very detrimental to marine calcifying organisms, such as corals and molluscs that largely depend on the carbonate concentrations present in the ocean to form their skeletons. Mature colonies of *Seriatopora guttata* in Cordova Reef, Mactan Island, Cebu, Philippines and were collected and transported to the wet laboratory in USC Marine Research station in preparation for the experimentation. The planulae collected from each mother colony were exposed to three pH ranges: 8.0-8.2, 7.6-7.9 and 7.3-7.5 where the effects of pH to its development, settlement and survival were monitored for 72 hours. Coral spats that survived the exposure experiment were subsequently monitored for its growth and survival for 30 days. Results showed that lower pH ranges (7.6-7.9, 7.3-7.5) only had a significant effect to the presettled larvae ($p < 0.05$) and its early metamorphosis ($p < 0.05$) during the 72 hr pH exposure. Moreover, faster development was observed at lower pH ranges during its development and no morphological abnormalities were observed. Both settlement ($p > 0.05$) and survival ($p > 0.05$) of *S. guttata* planulae was not significantly affected by the lower pH ranges. The difference of the findings in comparison to other studies mentioned merits that the response each coral species may vary across taxonomic groups and in its developmental stages.

OA-2-467

Effects of ocean acidification and elevated temperature on the tropical reef calcified macroalgae

Khaerul Awaluddin, Pi-Jen Liu

Ocean acidification and warming are a potential threat to marine ecosystems through their influence on marine organisms. One of the most critical effects of increasing ocean acidification (OA) and warming relates to the reduction of calcium carbonate by marine calcified macroalgae. Calcifying macroalgae is sensitive to the increases in seawater temperature and CO_2 predicted with global climate change due to the negative effects of these changes on the process of calcification. In addition, seagrass communities are one of the most productive and dynamic ecosystems. Seagrasses are capable of capturing and storing a large amount of carbon from the atmosphere and act as substrate stabilizers. Thus, the aim of this study is to explore whether seagrasses can help calcifying macroalgae to resistant the OA and warming condition. The experiment was started on March 27, 2017 at a coral reef mesocosm using three species of calcifying macroalgae (*Mastophora rosea*, *Halimeda opuntia*, and *Mesophyllum* sp) and was expected to carry out long-term observations and experiments for more than 12 weeks. The experimental design had two treatments with three replicates: presence seagrass and absence seagrass bed (about 30% cover and density was 63.03 ind/m2). The experiment period was carried out at four stages: the first stage did not change any environmental factors for 2 weeks, the second stage was enriched CO_2 for 4 weeks, and the third stage was enriched CO_2 and elevated temperature at 280C for 4 weeks and the fourth stage will be enriched CO_2 and elevated temperature at 310C for 2 weeks. The results indicated an increase quantum yield of photosynthesis on calcifying macroalgae at both acidification and warming treatments, although calcifying macroalgae with seagrass was higher than absence seagrass. In addition, calcification of macroalgae decreased for all species but at absence seagrass was higher than presence seagrass. However, *H. opuntia* increased calcification rate although only at a modest temperature at 28°C. Furthermore, mortality of calcifying macroalgae increased for all species affected by high pCO_2 and exacerbated by warming. In general, the OA and warming indicate a negative effect on macroalgae calcification and mortality but a positive effect on quantum yield of photosynthesis.

OA-3-237

Acclimation of three coral species to ocean acidification around natural CO_2 seeps: transplantation and gene expression

Julie Ripoll, Véronique Berteaux-Lecellier, Tom Biscéré, Riccardo Rodolfo-Metalpa, Gaël Lecellier

Ocean acidification (OA) has been predicted to have major consequences for marine calcifying organisms, such as reef-building corals. Putative consequences have mainly been evaluated through *ex situ* experiments and suggest that they may vary according to tolerance of species. Globally, coral metabolism is lowered during OA, leading to reduction in growth and reproductive potential (Albright *et al.*, 2011). OA events may reverse the competitive outcome between species due to their different tolerance (Hortwitz *et al.*, 2017). Natural CO_2 seeps in Papua New Guinea have been used as natural analogues to assess coral responses to OA. Here, we present the preliminary results of an *in situ* long-term scale approach of coral acclimation processes to OA after reciprocal transplants of three corals species. We used *A. millepora and Pocillopora damicornis,* as "resistant" species since found at both CO_2 seeps and control site, and *Acropora tenuis* which were only at the control site. Samples were collected before transplantation, three days and four months after, and total mRNAs were sequenced.

All transplanted corals survived to transplantations suggesting that the absence of *A. tenuis* near CO_2 seeps was not directly due to OA conditions and likely due to a competitive effect between species (*e.g.* recruitment). First metatranscriptomic results revealed transplantation effects with different levels according to recipient site, *i.e.* whatever the origin site, control or seeps, *P. damicornis* colonies had lower differential expression level after transplantation to control site, than colonies transplanted near CO_2 seeps. Long-term scale results for *P. damicornis* revealed global reduced gene expression levels, suggesting acclimation to recipient sites. The involved genes/isoforms and metabolic pathways found in our reciprocal transplantation study will be discussed to highlight acclimation mechanisms.

OA-4-612

Scleractinian coral *Acropora gemmifera* in response to elevated pCO_2, transcriptomic analyses

Tao Yuan, Minglan Guo, Hui Huang

Ocean acidification (OA) represents a key threat to the recruitment of scleractinian corals and causes reef dissolution and ecological shifts. OA may negatively impact the early life stages of scleractinian coral, decrease growth and calcification of scleractinian corals. In this study, juvenile reef-building coral *Acropora gemmifera* were cultured in flow-through seawater with 3 targeted pH values (pH = 8.14, 7.83, and 7.54) by exposing to three pCO_2 (446, 1034, and 2142 μatm) treatments, respectively. Transcriptomic approaches had been employed to analyze the mRNA-level response of juvenile *A. gemmifera* to CO_2-mediated acidification for 5 and 45 days. The total genes of 50,097 were found in the transcriptome, of which 38382 and 22225 genes were annotated by comparing with the non-redundant (NR) and SWISSPROT database, respectively. Annotation rations were 28.54%, 13.31% and 31.26% in the statistics analysis of KOG (cluCOSsters of orthologous groups) function classification, KEGG (kyoto encyclopedia of genes and genomes) analysis and GO (gene ontology) classification, respectively. Screening of differentially expressed genes was made for juvenile *A. gemmifera* in ocean acidification experiment. Genes involved in iron icon binding, oxidoreductase activity, intracellular signal transduction, fatty acid metabolic process and so on, were up-regulated in juvenile *A. gemmifera* for 5 days. The down-regulated genes included protein kinase binding, calcium ion binding, actin and microtublule binding, cilium, ATPase activity, extracellular matrix structural constituent, CTD phosphatase activity et al for 5 days. For 45 days, genes of signal transduction activity, lipid binding, protein disulfide oxidoreductase activity, intermediate filament cytoskeleton, cell differentiation, immune response, calcium ion-dependent exocytosis were up-regulated, while genes of cell and/or neuromuscular junction, membrane and envelop, structural constituent of cytoskeleton, enzyme binding were down-regulated. The expressing differences of genes were significant among juvenile from three treatment groups for 5 and/or 45 days. And time-dependent phenomenon was found in expression genes of juvenile *A. gemmifera*. OA regulated many signaling pathways involving in the metabolism of carbohydrate, fatty acid, amino acid, tricarboxylic acid cycle (TCA), vitamin, DNA and RNA, as well as process of development, stress response, calcification, signal transduction, cell cycle and proliferation, and so on.

OA-5-210

Rare *Symbiodinium* lineage hosted by zooxanthellate zoantharian *Palythoa tuberculosa* at river mouth and acidified reef of Japan

Hin Boo Wee, Haruko Kurihara, James Davis Reimer

The zooxanthellate zoantharian *Palythoa tuberculosa* can be found in a wide variety of marine environments and can even thrive in extreme habitats, such as on acidified reefs (CO_2 bubbling, low pH) and near river mouths. Previous work has shown that *Symbiodinium* spp. hosted by *P. tuberculosa* vary at different environments around the main island of Okinawa, Japan. This study aimed to identify the diversity of *Symbiodinium* in *P. tuberculosa* living in extreme environments (acidified reefs, river mouths) in southern Japan. Specimens from acidified reefs in Iwotorishima Island (n=20) and near the mouth of the Hija River, Okinawa (n=35), Japan, were collected between October 2016 and August 2017. Phylogenetic analyses were conducted using the non-coding region of the chloroplast psbA gene ($psbA^{ncr}$). In total, there were three distinctive lineages (based on Noda et al., 2017); one generalist, one 'rare', and one river mouth specialist found in this study; all three lineages were found at Hija River and only the generalist and 'rare' type at Iwotorishima. Iwotorishima was dominated by the generalist lineage, with few 'rare' lineage specimens (n=4 of 20 total colonies). At the Hija River, the 'riverine' lineage was dominant, with the 'rare' lineage found at the tidal pool of the river mouth and the "generalist" found sporadically at shallower areas (2 m). The "rare" *Symbiodinium* lineage was found only at a very small and limited location (river mouth tidal pool and at the edge of acidified reef). These results demonstrate that *Symbiodinium* lineages within certain hosts can vary drastically across tens of meters or less given environmental differences.

RTS-1-203

Is irradiance the major driver of bleaching in the Persian Gulf?

Atoosa Noori Koupaei, Hamed Dehghani, Pargol Ghavam Mostafavi, Seyed Mohammad Reza Fatemi

Reef corals and associated reef biota, including zoantharians, are hosts to a group of exceptionally diverse dinoflagellate symbionts in the genus *Symbiodinium* (commonly referred to as zooxanthellae). It has been established that there are at least nine major clades of this dinoflagellate genus. Each clade consists of numerous subclades, which can exhibit considerable differences in physiology. The obligatory symbiosis between the coral or zoantharian host and its algal symbionts is highly sensitive to environmental conditions. High irradiance and temperature can cause the breakdown of this symbiosis, termed bleaching. Various cnidarians have different sensitivities during bleaching events. These differences have been attributed to thermal and irradiance tolerances exhibited by zooxanthellae. In the Persian Gulf, the world's hottest sea, high temperature is known as the main factor of bleaching events. The present study aimed to specify the zooxanthellae types of Scleractinia and Zoantharia in the Northern Persian Gulf during a bleaching event. For this purpose, seven species of corals and three zoantharian species were collected in August 2013 at several sites off Hengam Island. Sampling was combined with molecular phylogenetic analyses utilizing different DNA markers to determine the presence of *Symbiodinium*type in each colony. Results showed that *Symbiodinium* clade A, the most irradiance-tolerant zooxanthellae clade, was the most abundant symbiont in unbleached anthozoans while clade C and D were dominant in bleached colonies. Contrary to previous findings, anthozoans do not harbor clade D, the heat-tolerant *Symbiodinium* type, to thrive in extreme conditions of the Persian Gulf. Consequentially, anothozoans of the Persian Gulf are likely more sensitive to high light intensity than high temperature. Therefore, they select for clade A to adapt to high levels of UV irradiation.

RTS-2-552

Oxidative stress: Unlocking cellular response in scleractinian corals towards stressor

Siti Nur Tahirah Jaafar, Nur Atiqah Maznan, Wan Aina Mardhiah Wan Mat Nor, Mohd Safuan Che Din, Chun Hong Tan, Zainudin Bachok, David Sheehan

Oxidative stress producing reactive oxygen species (ROS) can modified proteins and thiols of cysteine are mostly susceptible. Production of ROS in corals under stress condition has been recognised as one of the mechanism that can lead to cellular damage and the loss of their zooxanthellae population. Coral samples were collected from three stations in Bidong Island and three stations in Redang Island, off coast of Terengganu, Malaysia in the South China Sea. Biomarker such as glutathione S-transferase (GST) and catalase (CAT) assays, were used as a benchmark against thiol oxidation gel separation. Significant interaction were found between different stations for GST ($p<0.05$) and CAT ($p<0.05$) activities. Thiol proteins were labelled with 5-iodoacetamidofluorescein (IAF) prior to one-dimensional electrophoresis (1DE). 1DE separation of IAF-labelled proteins revealed a decrease in total thiol-containing proteins in samples from Redang Island. Results obtained from this investigation clearly revealed some similarities on a portion of redox proteome across stations indicating oxidative stress mechanism maybe common and the effects are unique for early warning observation. Corals that experienced oxidative stress had higher chaperoning level and protein turnover activity. Further studies should be considered to identify the stressed-protein that response to stressor.

RTS-3-41

Examining gene expression of heat-stressed staghorns under different flow environments

James E Fifer, Bastian Bentlage, Sarah Lemer, Atsushi Fujimura, Laurie Raymundo

Water flow can regulate a number of physiological changes for corals. Increased flow can trigger changes in calcification, respiration, growth, particle capture efficiency, photosynthesis, nutrient uptake, and oxygen transport across concentration boundaries. Additionally, high water flow can decrease susceptibility to bleaching. Staghorn colonies around Guam appear to show differential survival in discrete flow environments. Here we investigate the transcriptomic response of the staghorn coral *Acropora* cf. *pulchra* in both *in situ* bleaching conditions and *ex situ,* in a controlled acute heat stress experiment. Measuring gene expression, as opposed to the use of more traditional biomarkers, to determine a coral's response to heat stress allows for identification of less obvious responses. This is particularly important when looking at small changes in the environment such as flow differences. In this experiment, we sampled 6 colonies, 3 each from nearshore and farshore locations, 1 month prior to the 2017 bleaching event and again during the event. We also placed 16 fragments, sampled from the same population, in an *ex situ* experiment where corals were exposed to low (4 cm s^{-1}) or high (16 cm s^{-1}) flow treatments and high (35 C°) or ambient (29.5 C°) temperature. RNA was extracted from all samples in both the *in situ* and *ex situ* experiments, and analyzed using RNAseq. We discuss genes that are differentially regulated between the two flow environments experiencing either heat stress or ambient temperature conditions. The differentially expressed genes in our experiment are compared to hypothesized heat stress candidate genes from other studies and genes related to flow-derived physiological benefits. These experiments will help to better understand the role of water motion in mitigating coral bleaching.

RTS-4-438

Transcriptomic analyses of the reef-building coral *Pavona decussata* under and post bleaching

Yanjie Zhang, James Y. Xie, Yip Hung Yeung, Jian-Wen Qiu

Global warming has been identified as a leading cause for coral bleaching worldwide. After bleaching, some corals may recover, while others die. However, little is known about the molecular changes in gene expression during the processes of bleaching and recovery. To investigate molecular mechanisms of coral bleaching, we collected four types of samples of the reef-building coral Pavona decussata from Hong Kong: bleached and normal tissues from bleached colonies, and tissues from recovered colonies and healthy colonies. Total RNA was extracted for RNA-seq for each group. We compared the differences in gene expression of both the coral host and symbiotic algae in the four groups of samples. DNA was also extracted from the four groups of samples to compare the differences of microbial community structures under and post bleaching. This study will improve our understanding of the underlying molecular mechanisms of bleaching and recovery.

RTS-5-250

Experimental assessment of heterotrophy on thermal stress recovery of the scleractinian coral *Galaxea fascicularis* (Linnaeus, 1767)

Chuin-Siew Lim, Yii-Siang Hii, Zainudin Bachok

This study investigated the effect of thermal stress on the polyunsaturated fatty acid (PUFA) composition of PUFA-enriched *Galaxea fascicularis*. The effects of different treatments on the coral's PUFA recovery rate after a stress event were also examined. Previous studies on coral's PUFAs are mostly focused on the actual stress event rather than the post-stress recovery period. In coral stress studies, the functions of PUFAs remained unclear. The corals were fed with PUFA-enriched *Artemia* with unfed corals as control for 5 weeks. Then, the PUFA-enriched corals were exposed to thermal stress (33°C) for four days before the application of post-stress feeding. The post-stress recovery rate of fatty acid content of *G. fascicularis* was at ~96% of the total lipids. The PUFA-enriched corals of post-heat stress feeding had fully recovered their pre-stress total PUFA content. A significant increase of 57% in PUFA-enriched corals of post-thermal stress feeding compared to pre-stress corals was recorded. The essential PUFAs, 20:4ω6 (arachidonic acid) and 20:5ω3 (eicosapentanoic acid) were significantly higher in PUFA-enriched corals of post-stress feeding. The PUFA-enriched corals also had high zooxanthellae densities and chlorophyll levels to substantiate the effectiveness of post-stress feeding especially when the corals are recovering from a stress event.

RTS-6-453

Polyp bail-out in scleractinian corals: a survey on three induction methods in different coral species

Po-Shun Chuang

Polyp bail-out is a stress response that has been observed in many scleractinian corals. In facing certain stresses, some corals can dissociate their colonial form by shrinking of coenosarc tissue. From the skeleton these isolated polyps then detach as free-living solitary polyps, which can later resettle once the stress is relieved. From previous studies a variety of induction methods has been published, among which high salinity treatment, low pH treatment, and static culture condition showed positive resettlement potential of the detached polyps. In this study we conducted a follow-up survey of these three methods on inducing polyp bail-out in different coral species. Preliminary data showed that all the pocilloporid corals tested in our study respond to high salinity culture condition. This response might reflect an adaptation in sallow water corals. Contrary to previous reports, low pH method and static culture condition, by which polyp bail-out in *Pocillopora damicornis*and *Seriatopora hystrix* was reported respectively, didn't induce polyp bail-out in all the pocilloporid corals tested in this study. In addition, although polyp bail-out has been reported in many branching corals, it was not observed in *Acropora* by all the three methods tested in this study. It is therefore likely that this stress response is restricted only to certain taxonomic clades, such as Pocilloporidae. Further studies are needed to reveal the mechanism and test our hypothesis of its evolutionary origin.

RTS-7-247

Characterising the relative abundances of *Symbiodinium* clades C and D among *Pachyseris speciosa* colonies during the 2016 bleaching event

Sudhanshi Jain, Jun Wei Phua, Danwei Huang

Thermal stress drives the bleaching of corals, during which the endosymbiotic relationship between Symbiodinium dinoflagellates and coral hosts breaks down. This relationship is a critical indicator of the health of coral reefs as Symbiodinium serves as the primary provider of fixed carbon for corals. These microalgae are extremely diverse phylogenetically, with each major clade and even certain subclades displaying characteristic susceptibilities and tolerances to stress. These symbiotic communities are known to shift in response to disturbances, but how they respond within and between colonies during mass bleaching events remains unclear. During the 2016 global-scale mass bleaching event which hit countless tropical reefs, we investigated the relative abundances of clades C and D *Symbiodinium* within and among *Pachyseris speciosa* colonies in Singapore. Bleached tissue and non-bleached tissue were sampled from each of 24 bleaching colonies, and 23 healthy colonies were sampled for comparison. The nuclear internal transcribed spacer region (ITS) was quantified using clade-specific primers and a highly sensitive SYBR-green and probe-based qPCR method. We found clade C to be highly abundant compared to clade D *Symbiodinium*. The relative quantities of clade D, known to be thermally tolerant, were higher in bleached colonies compared to healthy colonies, underlying the importance of this particular symbiotic relationship and stress response. Further characterisation of *Symbiodinium* clades and their specific subclade identities may provide insights into this crucial symbiosis with implications for their responses during major bleaching events

RTS-8-448

Intracolonial dynamics of co-dominant symbionts as a mechanism to survive high temperature stress and variability in *Leptoria phrygia*

Rodrigo Carballo-Bolanos, Chaolun Allen Chen

One mechanism to survive bleaching events is for species to associate with different symbionts and when seawater temperatures increase they can shift their abundances, so that the stress resistant *Symbiodinium* becomes the dominant clade and allows them to survive. In this study we investigated this mechanism for *Leptoria phrygia* in Kenting, South of Taiwan. Following seasonal seawater temperature variation colonies were sampled between July 2016 and June 2017 from one site that is influenced by a constant hot water effluent from the nuclear power plant outlet (OL), where the water temperature during summer is 2.0-3.0°C higher than at other sites and there is a high daily fluctuation in temperature of 6-8°C throughout the year due to upwelling. The other site is Wanlitong (WLT) located in the West of Kenting and doesn't present any temperature stress or high variability. We wanted to investigate if there is shuffling between clades C and D during different seasons of the year at each site determine by real time PCR and what are the main physiological differences of symbionts between sites. Our main results from three sampling times (n=360 samples) indicate that in OL 92% of all colonies associated with clade D and only one colony (n=12) showed co-dominance of clades C+D. In WLT only one colony (n=13) associated with clade D, 31% presented intracolonial co-dominance of both clades and 62% associated with clade C. Only those colonies that presented symbiotic intracolonial co-dominance exhibited shuffling. Photochemical fluorescence and chlorophyll *a* concentration were significantly different between both sites (ANOVA, $p<0.05$). We hypothesised that in WLT only those colonies with symbiotic multiclade co-dominance and the ones already have clade D will be able to survive future climate change scenarios, similar to what we found in OL.

RTS-9-347

Effects of photoperiod on planular settlement and survival of the birdnest coraL, *Seriatopora guttata* (Veron, 2000)

John Michael Bacus Basaca, Filpina Buroy Sotto

Light has been regarded as an essential abiotic factor that influences behavior, settlement, and survival of coral planula. However, there have been no studies that evaluate the effects of varying photoperiods to coral planula. Thus, this study investigated the effects of photoperiod to planular settlement and survival of the Birdnest Coral, *Seriatopora guttata*. Parent colonies were collected from the reef fronting Cordova Island, Cebu, Philippines, and were transferred to the laboratory. Planulae were collected upon release, exposed to three light:dark photoperiods (i.e. 8L:16D, 12L:12D, and 16L:8D) and monitored for their survival and settlement. Survival for one month after exposure to the three photoperiods was also monitored. Results show that settlement and subsequent survival of *S. guttata* planulae seem to favor non-ambient photoperiods; settlement and survival was higher in both 8L:16D and 16L:8D photoperiods than 12L:12D. Survivability of settled planula from these non-ambient conditions still seem to carry through even after exposure since survival was consistently higher even upon transferring them to the outdoor wet-laboratory with more fluctuating physico-chemical conditions as compared to the highly fixed and controlled conditions of the photoperiod exposure set-up. However, a closer inspection revealed that initial settlement after 12 hours of treatment exposure was uniform and differed after due to subsequent mortality of the newly settled planulae. This clearly indicate that the length of light exposure during the first 24 hours affect the survival of newly settled *S. guttata*. A combination of both cell cycle progression and the length of light exposure to the overall photosynthetic ability of the zooxanthellae could explain the higher survival of newly settled *S. guttata* planulae in both 8L:16D and 16L:8D photoperiods of this study. Further research is recommended to determine interaction between different light intensities, spectral quality, and photoperiod, and its possible effect on survival of coral early life stages.

RTS-10-758

Determining the extent and severity of the 2014-2017 Global Coral Bleaching Event: A call for field observations

Denise A. Devotta, Jacqueline L. De La Cour, Erick F. Geiger, Andrea M. Gomez, William J. Hernandez, Scott F. Heron, Gang Liu, Benjamin L. Marsh, William J. Skirving, Kyle V. Tirak, Robert A. Warner, C. Mark Eakin

In recent decades, rising ocean temperatures have become one of the principal stressors impacting coral reef ecosystems. Increased frequency and severity of anomalously warm ocean conditions have resulted in mass coral bleaching and subsequent deterioration of reef ecosystems worldwide. The third Global Coral Bleaching Event (GCBE; June 2014–May 2017) was the longest, most widespread, and probably the most damaging on record. More than 75% of coral reefs worldwide experienced bleaching-level heat stress during the three-year event. Particularly significant damage occurred in areas exposed to prolonged or consecutive years of bleaching (e.g., Guam; Commonwealth of the Northern Mariana Islands; Great Barrier Reef, Australia; and Ryukyu Islands, Japan). Heat stress during this event also caused mass bleaching of several reefs that never bleached before (e.g., northernmost Great Barrier Reef). This GCBE provides an unprecedented opportunity for NOAA Coral Reef Watch (CRW) to compare its satellite-based indicators of accumulated heat stress (Degree Heating Week, DHW) with field observations of coral bleaching and mortality. Specifically, we will use DHW values derived from our newly-released CoralTemp dataset, a daily global 5 km sea surface temperature re-analysis extending from 1985 to the present. This presentation will highlight preliminary results from global reef sites where CRW already has obtained bleaching and mortality data from collaborators. The Asia-Pacific region is a key region for the study. Observational data are still urgently needed from this region to improve our understanding of the extent and severity of this GCBE, and enhance our satellite monitoring of bleaching conditions.

RTS-11-346

Coral bleaching index of the Coral Triangle

Eileen L. Penaflor, Laura T. David, Cesar L. Villanoy, William J. Skirving

Intense anomalies in sea temperatures have resulted in mass coral bleaching occurrences, and even led to coral mortality in various parts of the world. Studies have also shown that several other factors can contribute to what caused coral bleaching to occur. This study investigates the patterns in the timing and extent of anomalies of some parameters associated with coral bleaching occurrences in the Coral Triangle. These parameters include sea surface temperature (SST), wind speed, cloudiness, and photosynthetically active radiation (PAR). Investigation of the Intertropical Convergence Zone (ITCZ) latitude position is also included since this parameter is said to be affected by El Niño Southern Oscillation (ENSO) and might provide additional insight to the process that favors coral bleaching occurrence.

Prior to 2016, there have been two major recorded coral bleaching events in the Coral Triangle, in 1998 and 2010. Results in this study show that an intense decrease in cloudiness and an increase in PAR has been observed prior to the intense increase in SST in those two years. A strong drop in the wind speed as the ITCZ mean latitude shifts southwards preceded the 1998 and 2010 SST anomalies. The long duration of intense negative anomalies in ITCZ latitude position likely hindered the monsoonal winds in the Coral Triangle during those times. A condition of low cloud, high PAR, low wind, and high SST favors the occurrence of mass coral bleaching. Extended periods of this combination of conditions is more likely to occur when a strong to moderate El Niño is followed by a strong to moderate La Niña.

RTS-12-447

Impact of coral mass bleaching in Japan 2016 and 2017

Tadashi Kimura, Masato Kiyomto, Tomoki Sunobe, Keiichi Nomura, Isao Hirabayashi, Naoko Dewa, Satoshi Nojima, Takeshi Matsumoto, Katsuki Oki, Tomofumi Nagata, Kenji Iwao, Kenji Kajiwara, Hisashi Matsumoto, Go Shimada, Minoru Yoshida, Mitsuhiro Ueno, Tetsuro Sasaki, Humihito Iwase, Kazuhiko Sakai, Hiroyuki Yokochi

The third global coral bleaching event occurred from 2014 to 2017 following the 2015-16 strong El Nino. We have organized a team of scientists to conduct a nationwide coral monitoring in Japan as a government program since 2004. A total of 24 sites were selected in the major coral distribution between Chiba and Okinawa prefectures to track the health of coral communities. To understand the effects of the third global bleaching event and their impact on corals in Japan, we assessed bleaching levels from 2014 to 2017 using data from the monitoring program. Corals of the southernmost reefs experienced considerable mortality in 2016 and moderate damage in 2017. Coral bleaching was 96% in Sekisei Lagoon and 70% at Yabiji Reefs in this area in 2016. The highest mortality was recorded at Yabiji Reefs with 67% and the second worst mortality was 52% at Sekisei Lagoon in 2016. Although coral bleaching was 91% in Sekisei Lagoon in 2017, the mortality was 9%, and there was no bleaching at Yabiji Reefs. Mass coral bleaching also occurred around the northern area of the Ryukyu Islands in 2017, albeit with less damage. Coral bleaching was 32% with 0.7% mortality in Amami Islands and 30% in Okinawa Island with 5% mortality in 2017. These results showed that the mass coral bleaching in 2016 caused much more damage on coral communities than the 1998 mass bleaching event in Japan. Our study also emphasizes the heterogeneous impact on coral reefs spanning the latitudinal and environmental ranges of Japanese reefs, and contributes to our understanding of the coral bleaching phenomenon at the northern limit of reefs in the Indo-West Pacific.

RTS-13-412

Bleaching effects on coral communities and recovery potential in the southern Ryukyu Islands, Japan

Masako Nakamura, Tomokazu Murakami, Hiroyoshi Khono, Youhei Takeshita, Yoshifumi Soyama, Akira Mizutani, Shinya Shimokawa

Extensive coral bleaching events often result in a higher mortality, and weaker growth and reproductive capacity even though corals recovered from bleaching. It could also cause recruitment failure in the following years. In 2016, mass bleaching of corals occurred at Iriomote-Ishigaki National park in the southern Ryukyu Islands, especially in Amitori Bay, Iriomote Island, where nearly 90% of corals bleached and bleaching was observed until 40 m deep. These coral communities in Amitori Bay have been suggested to be maintained by larval supply from within the bay and surrounding areas. Following the extensive bleaching events, decrease in recruitment and slow community recovery were expected. This study therefore estimated impacts of bleaching event in 2016 on coral communities in Amitori Bay from the aspects of local stock and larval supply. For this purpose, local stock was estimated with the abundances and spawning behavior of remnant corals by the belt-transect method and spawning observations. Larval supply was quantified using sets of two 10 x 10 x 0.5 cm settlement panels. These data were compared with ones in 2016, collected before the bleaching event. We found that coral cover in 2017 was 60 to more than 90 % less than in 2016. Particularly, *Acropora* spp. showed catastrophic decrease in cover. For spawning behavior, only a part of observed acroporid colonies (13 over 32 colonies) were spawned. The number of recruits on the settlement panels was less than 3 spats per set in 2017. The rate of decrease from 2016 was more than 90% in maximum. Acroporidae were the major composer of recruits in 2016 but barely found in 2017. These results demonstrated that drastic decrease in local stock and larval supply in 2017, suggesting that the coral communities were maintained by locally-derived larvae and might potentially show slow recovery.

RTS-14-422

A study on coral bleaching in Hong Kong

Jian-Wen Qiu, James Xie, Wing Keun Chow, Chi Chiu Cheang, Leo Lai Chan, Put Ang, Chun Kit Kwok, Keith Kei, Yip Hung Yeung, King-tai Wo

Hong Kong reported a record high of rain fall and temperature in 2017. We present here results of a comprehensive study on coral bleaching in August 2017 - January 2018 in Hong Kong waters based on video transect surveys conducted at 33 reef check sites. Bleaching was moderate, affecting on average 35.9% of colonies at six sites where bleaching was observed. Bleached corals were mainly branching and plate-like corals, e.g. *Acropora* spp. and *Pavona decussata*. Follow-up field surveys of tagged colonies showed that all sites had over 90% recovery. Given that local climate is predicted to become warmer and wetter in the coming decades, there is an urgent need to formulate appropriate management measures and long-term monitoring plan to evaluate coral health, including coral bleaching in Hong Kong.

RTS-15-173

The coral killing sponge *Terpios hoshinota* at Amamioshima Island, the northernmost outbreak

Takuma Fujii, Naoki H Kumagai

The encrusting cyanoacteriosponge Terpios hoshinota Rützler & Muzik (1993) (Porifera, Demospongiae, Suberitida, Suberitidae) came to be known as "black disease", and is a potential threat to the coral reefs around the Indo-Pacific. T. hoshinota can actively overgrow living corals and kill them. This sponge is considered to be a component of coral reef biodiversity in usual situations, but sometimes the species can 'outbreak', and overgrow and harm shallow coral reefs. In the Pacific, T. hoshinota is known from the Samoa Islands to Kakeromajima Island, Japan (the type locality is Tokunoshima Island, Japan), and recently the distributional records were expanded to the Great Barrier Reef and to the Maldives and Indian Ocean. Despite increasing attention being paid to T. hoshinota, its ecological characteristics such as the trigger of outbreaks and its current geographic distribution are open questions.

We found small patches of T. hoshinota along the reef slope at 15 m depth on the west coast of Amamioshima Island in September 2016. In September 2017, the covered area by T. hoshinota expanded up to >50 m2 along the outer reef slope at 10–20 m depth. We surveyed the coverage of T. hosinota and living corals using three randomly placed 30 m line-intercept transects at both the T. hoshinota area and a control area. The coverage of T. hoshinota was 46.6% in the T. hoshinota area. Coral coverage was significantly smaller ($P < 0.001$) in the T. hoshinota area (16.5%) than in the control area (59.1%).

This study reports the northernmost distribution record and northernmost reported outbreak of T. hoshinota. Additionally, this is the deepest record of a T. hoshinota outbreak: previous reports were <5 m depths, although a few patches were found from >10m, which indicates further examination of T. hoshinota in such deeper environments is needed.

RTS-16-319

Adding insult to injury: Ship groundings result in long-term coral disease in a pristine reef

Laurie J Raymundo, Wilfredo L Licuanan, Alexander M Kerr

In 2013, the Tubbataha Reef UNESCO World Heritage Site, in the western Philippines, experienced two ship groundings within four months: the USS *Guardian* (USSG), a US military vessel, and the *Min Ping Yu* (MPY), an illegal Chinese fishing vessel. Here, we present the results of coral disease assessments completed two years post-grounding and recovery patterns monitored annually within these grounding sites. Site assessments revealed three distinct zones: 'ground zero', where corals were scoured to the limestone base by direct ship impact; the 'impact border', characterized by surviving upright but damaged colonies injured during ship movement; and undamaged 'control' sites, remote from the ship groundings but located on the same atoll. Coral diseases were dominated by white syndromes, and prevalence was an order of magnitude higher within the impact border zones than within the other zones two years after the events. Hard coral cover has steadily increased at a mean rate of 3% per year within the scoured USSG site at a rate comparable to control sites. In contrast, recovery has been negligible within the rubble-dominated MPY site (-0.5%), suggesting that substrate quality strongly influenced recovery processes. Despite the pristine condition of these remote atolls, high herbivory, and visible signs of recovery, high coral disease prevalence two years after the initial grounding events suggested persistent long-term impacts.

RTS-17-156

Coral larval supply and recruitment following typhoon disturbance in Palau

Marine F Gouezo, Eric Wolanski, Katharina Fabricius, Peter Harrison, Dawnette Uly Olsudong, Yimnang Golbuu, Christopher Doropoulos

Rates of larval dispersal, settlement and recruitment in coral populations can strongly influence the persistence of coral communities and their recovery post disturbance. The eastern outer reefs of Palau were extensively damaged by two super-typhoons in 2012 and 2013, reducing mean coral coverage to about 6%. As these typhoons were the most intense to impact Palau since at least the 1950s, it is not known how these damaged coral reefs will recover. This study explores how geographic and hydrodynamic differences in larval supply and coral settlement on reefs around the archipelago can drive different recovery trajectories.A coral larval supply model parametrized with environmental conditions during the spawning seasons and the coral coverage of major coral groups in the archipelago was developed, to detect areas of larval retention. Settlement tiles attached onto 12 outer reefs sites at 7-8 m depth, were deployed and retrieved every four months during two years, to quantify in-situ coral settlement. The density of juvenile corals was recorded every two years within five 3 m^2belt transects at each of two depths at most of the sites since 2002-2005. Our field data and models show that hydrodynamic forces influence the retention and settlement of corals. The larval supply and coral settlement within the north-eastern sub-region of the archipelago was low, underpinning a predicted slow pace of recovery compared with reefs located in the center and south-eastern sub-regions. Three to four years after the typhoons disturbance, the density of juvenile corals has reached levels similar to pre-disturbance times at only a third of our study sites.

RTS-18-601

Updates on Hong Kong and Southern China as climate change refugia for corals

Put O. Ang

Southern China, including Hong Kong, is considered to be one of a few places around the world where realistic reef expansion could occur under global climate change. We hypothesized that corals in Hong Kong, being a marginal environment for coral growth, should exhibit higher tolerance to many physiological extremes since they have long been exposed to such conditions that would not have been experienced by their tropical counterparts. We have conducted studies to verify this hypothesis over the last 15 years. This presentation is an update on our recent findings. Several interactive experiments were carried out to evaluate effects of lowered and elevated temperature vs. reduced salinity, increased nutrients, and increased levels of pollution on coral larval stages as well as adults. Our general findings indeed showed that Hong Kong corals, especially *Platygyra acuta, Porites lobata/lutea, Pavona decussata*, and *Acropora* spp. can survive under elevated temperatures from +3 to +5°C above ambient in summer or -3 to -6 °C below ambient in winter, reduced salinities up to 18 psu or lower, nutrient or copper levels at least 10 times that of ambient. All these levels are higher than many of those reported for other corals in the tropical seas. Further studies are now underway to evaluate comparative studies with tropical species, as well as understanding the molecular mechanisms behind such tolerances.

RTS-19-30

Coral reef fish populations on the Padang Shelf Reef System, West Sumatra, Indonesia, 14 years after the extensive coral reef community die off in 1997

Norman John Quinn, Barbara Louise Kojis, Ofri Johan

Quantitative surveys of six coral reef communities on the coast West Sumatra began in the latter decade of the 20th century. Then, as many as 50% of the reefs were classified as degraded, primarily because of blast fishing and pollution. Some of the reefs surveyed were in an area that subsequently became the Marine Tourism Park Pieh Island. In 1997, reefs in the Padang Shelf Reef System experienced a massive die off associated with the Indian Ocean Dipole where an upwelling caused by unusually strong winds increased nutrient levels in the ocean and a decline in water temperature by >4^{o}C. Together with aeolian Fe^{++} from wildfires in Sumatra, oceanic nutrient levels were elevated to a point where a massive red tide event occurred and persisted for six months. Live coral cover (LLC) declined to 0% to a depth of at least 10-15m and many of the obligate coral reef fish populations were extirpated. In 2014, nearly 17 years after the die off, the reefs were resurveyed. All the surveyed reefs experienced increased live coral cover with some sites up to 70% LCC and a recovery of many of the fish populations with 28 families observed. Only four fish families were recorded at all eight sites: Chaetodontidae, Labridae, Lutjanidae and Pomacentridae. The most abundant family, the Pomacentridae, comprised 30.1% of the fish recorded. Species common in 1996, but not recorded in 2014 were *Heniochus moncerus* and *C. oxycephalus*. The most abundant Chaetodon in 1996, *C. trifascialis*, was ranked 10th in abundance in 2014. Three species with a ranking of >10 in 2014 were not recorded in 1996: *Chaetodon kleinii* – Rank 3, *Heniochus singularius* – Rank 4, *Forcipiger longirostrus* – Rank 6.

RTS-20-620

Responses of coral species-specific fatty acid profiles under eutrophication

Taihun Kim, David M. Baker, Jetty C.Y. Lee

In zooxanthellate corals, *Symbiodinium* supplies the host tissue with photosynthate from dissolved inorganic carbon (autotrophy). Simultaneously, corals ingest food, such as plankton, and inorganic and organic matter (heterotophy). These different energy sources have distinct fatty acid profiles, which thus differentiate corals utilizing either feeding mode. Thus, fatty acid profiles in coral tissues are being used as biomarker to evaluate the quality of nutrition to corals in the midst of environmental change. However, responses of coral species-specific fatty acid profiles under cultural eutrophication has not been investigated. To test the impact of eutrophication on fatty acid profiles, we collected 4 different genera (*Acropora* sp., *Favites* sp., *Platygyra* sp., *Turbinaria*sp.) in different sites, with each site showing distinctly different water quality. Gas Chromatography-Mass Spectrometry (GC-MS) and Gas Chromatography-Flame Ionization Detector (GC-FID) were performed to identify and quantify fatty acids. For the baseline, the 4 different genera of corals showed different concentrations of total lipid and fatty acid profiles due to their different diet. The key fatty acids were C18:3n3 (α-Linolenic acid), C18:3n6 (γ-Linolenic acid), C20:4n6 (Arachidonic acid), C20:5n3 (Eicosapentaenoic acid), C22:6n3 (Docosahexaenoic acid) and concentrations of these fatty acids were significantly lower in the most polluted site. Additionally, a biomarker for autotrophy (C20:5n3/ C22:6n3) showed a tendency to increase with water quality. These results suggest that we can apply fatty acid profiles as biomarkers to determine the level of eutrophication. It further provides information about suitable target species for successful restoration and conservation purpose.

RTS-21-170

Coral calcification and thermal stress histories from the Great Barrier Reef and Coral Sea over the past two centuries

Thomas M DeCarlo, Hugo B Harrison, Laura Gajdzik, Diego Alaguarda, Malcolm T McCulloch

In 2016, El Nino sparked coral bleaching across the tropical oceans, marking the 3rd global coral bleaching event. Australia's iconic Great Barrier Reef (GBR) and offshore counterparts in the Coral Sea were no exception, with bleaching in 2016 following two previous events observed on the GBR in 1998 and 2002. After El Nino had subsided in 2017, the GBR unexpectedly bleached again. This was the first known non-El Nino bleaching event on the GBR, raising concerns that global warming has surpassed the thermal thresholds of many hermatypic coral species. However, our knowledge of historical precedents for bleaching are limited by the relatively short time-span over which systematic observations have been made. In late 2017, we collected 57 skeletal cores from long-lived *Porites* corals in the northern GBR and the Coral Sea, with the longest cores (2.4 meters) extending back ~200 years. Ongoing computed tomography (CT) scanning of the cores enables (1) reconstruction of calcification rate histories from annual density banding, and (2) identification of past bleaching events from discrete high-density "stress bands". We will present the calcification and thermal stress histories from our cores, which together will depict coral responses to natural and man-made stressors in the GBR and Coral Sea over the past two centuries. This historical perspective will establish a baseline upon which to interpret the severity and uniqueness of bleaching events observed during the past few years.

RTS-22-263

Effects of water quality and temperatures stress on the demography of corals

Adriana Humanes

To improve understanding of the effects of early life history stages on coral population dynamics, a size-based model considering all life history stages (i.e. from gametes to adult colonies) was built for *Acropora tenuis*. The model was constructed based on empirical published data of the demography of juveniles and adult coral colonies from inshore reefs of the Great Barrier Reef, together with the experimental information of early life history stages (gamete fertilization, larval survivorship and settlement success) were used to construct the model. Impacts of contrasting water quality (i.e., nutrient enrichment and suspended sediments) and stress-inducing high temperatures were modelled during the period of coral spawning, to examine their potential effects on the annual population growth rates. This theoretical exercise provides new insight into the effects of local (i.e. water quality) and global (i.e. temperature) stressors during the development of early life history stages on coral population dynamics. Results highlight the importance of considering early life history stages in demographic analyses aimed at understanding how coral cover is likely to change when spawning events are affected by local and global stressors.

RTS-23-458

Using a Bayesian Belief Network to prioritise management actions on coral reefs threatened by multiple stressors.

Abdi Tunggal Priyanto, Nils C Krueck, Nicholas Wolff, Yves-Marie Bozec, Peter J Mumby

Coral reefs worldwide are threatened by both local (e.g. overfishing and outbreaks of coral predators) and global (e.g. cyclone and bleaching) pressures, which reduce biodiversity, compromise ecosystem functioning and jeopardise ecosystem services. However, very little is known about how natural and human-induced pressures interact and affect coral reefs, specifically under the influence of climate change. Here, we capture predictions from a validated ecological model of coral reef functioning in a Bayesian Belief Network (BBN) to investigate the response of coral communities to multiple stressors under alternative climate scenarios. We use Indonesian coral reefs as an example, parameterising our ecological model with empirical information on, for example, grazing rates and Crown-Of-Thorns-Starfish (COTS) outbreaks. We then simulate coral reefs futures under climate scenarios RCP85 (business-as-usual), RCP45 (stable) and RCP26 (mitigation). Based on coral cover trajectories over the next 50 years, the BBN predicted relatively stable coral reef futures (25 % cover) under all three RCPs over the next 20 years, regardless of whether coral reefs are situated in exceptionally cool or hot regions. Over the next thirty to fifty years, in contrast, projections for hot regions indicated pronounced declines in coral cover (approximately 30% of initial cover) for all three RCP scenarios. In cool regions, coral reefs were also predicted to decline, but these declines were less pronounced (approximately 50% of initial cover) for RCP45 and RCP26 than for RCP85 (30% of initial cover). Our results demonstrate that a BBN and associated predictions of coral reef futures under climate scenarios provide researchers and managers with an opportunity to analyse reef responses and prioritise management actions even if ecological information is strictly limited.

RTS-24-265

Strengthening catchment to sea connections through improved linkages between terrestrial input and process-based measurements

Mia Comeros

Declining water quality is one of the greatest threats to the health of coral reefs, and the goods and services they provide. Despite the potential importance of water quality in shaping coral reef ecosystems, the effects of declining water quality on the population dynamics of reef fishes are poorly understood. Parrotfishes and surgeonfishes are critical in the maintenance of reef health but are negatively affected by a suite of threats from habitat degradation and overfishing. These fishes are dominant components of coral reef herbivorous fish assemblages across the Indo-Pacific. Importantly, these fishes are also economically and culturally valued fishes across much of their distribution. As increasing rates of land modification and pollution continue to pose a threat to coral reef health, a mechanistic understanding of the links of land-based pollution sources to the biological responses of these key functional groups is needed. We will use American Samoa, a high vegetated island in the South Pacific, to explore the dynamics of nutrient delivery and food webs in nearshore coral reef and measure biological responses of these fishes to increased turbidity and suspended sediment concentrations and enriched nutrients. This approach can enable better understanding of the process-based responses of species to the cumulative impacts of pollution stressors. By directly documenting the link between terrestrial run-off to reef fish populations, enhanced understanding of the important regulatory factors affecting coral reef population dynamics can be used to inform and support coral reef conservation and management.

RTS-25-82

Coral bleaching impact to the decline of *Chaetodon* Fish (butterflyfish) Abundance in Karimunjawa National Park, Central Java, Indonesia

Fakhrizal Setiawan, Efin Muttaqin

This study showing temporal variation in the abundance of *Chaetodon* fishes in Karimunjawa National Park, from 2012 to 2016. Using 2012 and 2013 data to show good condition before bleaching impact in the end year of 2015 until middle year of 2016. In general, coral bleaching in 2015-2016 caused 27% coral white, 49% bleach, 12% died and 12 % are not affected. This phenomenon has implications to declines coral cover significantly ($P_{(23,330)}$ = 6.25e^{-06},p <0,001) and also abundance of *Chaetodon* fishes ($P_{(78,033)}$ = 1.41e^{-13},p <0,001). Survey in 2016 showed decrease significantly (p<0,05) in the abundance of obligate corallivores (*Chaetodon baronessa, Chaetodon lunula, Chaetodon octofasciatus, Chaetodon lunulatus, Chaetodon Triangulum, Chaetodon speculum)* and non coral feeders (*Chaetodon vagabundus*) but not for *Chaetodon ephippium, Chaetodon melannotus, Chaetodon trifascialis, Chaetodon occellicaudus (obligate corallivores), Chaetodon adiergastos, Chaetodon decussatus, Chaetodon lineolatus, Chaetodon oxycephalus, Chaetodon wiebeli* (facultative corallivores) and *Chaetodon auriga* (non coral feeders). Not so clearly impact coral bleaching to some obligate corallivores spesies because the abundance in Karimunjawa NP is very small (less than 2 individu per species per transect) and species that are facultative corralivores mostly not declined because the ability to change their diet to another source.

RTS-26-579

Tejakula Local Marine Management Area of Bali, A living example on strengthen coral reef resilience

Sila Kartika Sari, Nyoman Sugiarta, Ayub Ayub, I Made Jaya Ratha, Derta Purwita Dhine Prabuning

Tejakula Subdistrict on Bali's northern coast provides an example of how Local Marine Management can improve reef resilience and help corals withstand major stresses, including mass bleaching events. The Tejakula Local Marine Management Area (LMMA) was established in 2008 with strong involvement of local stakeholders. Reef Check Indonesia, a coral conservation nonprofit, has maintained semiannual monitoring of the reef's substrate, anthropogenic impacts on coral, fish community, and invertebrates with the cooperation of local fishermen and stakeholders trained in data collection. Twice since its creation, in 2010 and 2016, Tejakula LMMA has been impacted by severe coral bleaching events. The baseline monitoring program allowed Reef Check to analyze the impacts of the bleaching events on the reef. The 2010 bleaching event caused serious degradation to the Tejakula LMMA coral reef, with a 25-44% decrease in live hard coral at our two sites of four. Ecosystem recovery began within a year, and our 2011 post-bleaching-event survey showed that hard live coral had regained 4-36% of its losses through the dual processes of zooxanthellae return (tolerance) and recruitment (recovery). The resilience of Tejakula's coral reef was proved again by the 2016 bleaching event. In May 2016, Bali experienced the highest Degree Heating Week (DWH) on record. NOAA announced a DHW of 18°C, indicating extreme thermal stress and predicting high coral mortality. To enhance reef resilience, Reef Check worked with local stakeholders to reduce dive pressure on some popular sites with intact yet vulnerable reefs by concentrating tourists on alternative dive sites. Reef Check is currently completing a post-bleaching-event assessment to understand the lasting impacts. Tejakula LMMA is expected to be a model for understanding how local investment in management can improve the resilience of a marine ecosystem to unprecedented anthropogenic stress.

RTS-27-465

Impact of the 2016 mass bleaching event on Singapore's coral communities

Tai Chong Toh, Teck Wei Wee, Chin Soon Lionel Ng, Wan Ting Sim, Shu Qin Sam, Yuichi Preslie Kikuzawa, Loke Ming Chou

Thermal warming events exert tremendous stress on natural ecosystems and are predicted to increase in intensity and frequency. In 2016, anomalous sea temperatures triggered mass coral bleaching on numerous reefs, making it one of the most severe episodes in history. In Singapore, four sites were surveyed during this period and over 40% of the coral colonies recorded were bleached. We compared the benthic and coral communities at these sites before (2015), during (2016) and after (2017) the mass bleaching event. The results indicated that there were no significant change in scleractinian coral cover and generic diversity. However, the benthic and coral communities changed significantly over the duration of the study. These results highlighted that mass bleaching can alter benthic assemblages that could have cascading impacts on community dynamics.

RTS-28-309

Back-to-back thermal stress events cause failure in coral settlement in Talim Bay, Philippines

Miledel Christine Carino Quibilan, Wilfredo Ybanez Licuanan, Porfirio Miel Aliño

The 2014-2017 Third Global Bleaching event is considered to be the longest, most widespread, and possibly most destructive ever recorded. For the Philippines, widespread coral bleaching was observed in 2016 and 2017 based on the 400+ incident reports submitted via the Philippine Coral Bleaching Watch (PCBW) on-line survey. However, it appears the impact of recent bleaching events on coral reef condition was less severe compared to that of the 2010 event. To determine the potential impact of thermal stress events on coral larval supply, coral settlement patterns were studied in seven reef sites in Talim Bay, Philippines from January 2016 to January 2018. Thirty (30) fiber-cement tiles were deployed and retrieved every four months for the two-year period. Coral settler abundances and composition on tiles were derived for each reef site. Findings reveal that annual coral settlement rates in 2016 and 2017 were significantly lower compared to 2010 baselines. In terms of coral settler composition, there was also greater diversity of coral settlers on tiles immersed from May to August 2010 compared to the 2016 and 2017 data for the same period. Previous studies have shown that elevated SSTs can lower coral fecundity, increase larval mortality, and shift the timing of coral spawning events. This study documents a significant reduction in coral settlement rates as a consequence of the recent thermal stress events.

RTS-29-399

Effects of ocean acidification and warming on the early life stages of the reef coral *Acropora intermedia*

Youfang Sun, Hui Huang, Lei Jiang, Yuyang Zhang, Xinming Lei, Jiansheng Lian

Ocean warming and acidification constitute the most serious threats to the recruitment success of reef corals. This study investigated the impacts of ocean acidification(pH ~7.75) and warming(~30.5 °C) on the symbiosis establishment and early growth of the reef coral *Acropora intermedia* from Luhuitou fringing reef, Sanya, Hainan island. Newly settled recruits were reared in flow-through aquaria and maintained at a full cross design of two temperatures (~30.5, 28.0 °C) and pH(~8.02, 7.75) for 33 days. Results showed that neither temperature, pH nor their combination affected the lateral growth and survival of coral recruits. Moreover, skeletal weight was only depressed by reduced pH treatment at ambient temperature, although there was no significant main effect of temperature, pH and their interaction on calcification. In contrast, higher temperature totally arrested the successful *Symbiodinium* infection while reduced pH exerted minor effects. Furthermore, an exponential relationship exists between symbiont infection and budding rates ($y=0.0004e^{6.43x}$, $R=0.72$, $p<0.0001$), highlighting the importance of symbiosis in promoting asexual budding in juvenile corals. Interestingly, there were more corals exhibiting green fluorescent tissue at higher temperatures, possibly suggesting a role of fluorescent proteins in responses to thermal stress. These results suggest that rising temperature affects the early life stages of coral *Acropora intermedia* more than ocean acidification.

RTS-30-188

Post-bleaching stressors to the corals of Gulf of Mannar, Southeast India

K Diraviya Raj, G Mathews, J K Patterson Edward

Gulf of Mannar (GoM) in southeast coast of India has been known for its rich coral reefs and the associated biodiversity. Corals in GoM have been influenced by various natural and human-induced stressors such as coral bleaching, disease outbreaks, bio-invasion, coral mining, destructive fishing methods, and pollution. In line with the third global coral bleaching event, corals in GoM faced a huge mortality (16.2%) during the summer of 2016. Fast growing species of Acropora, Montipora and Pocillopora were the most affected by this bleaching event. Branching acroporans, in particular, were reduced to 3.91% from 7.59% during the bleaching. After the mortality, a slight increase (1.1%) in the live coral cover was observed in 2017. But the recovery is significantly disturbed by the space competitors such as macroalgae, sponges and ascidians. Macroalgae, in particular Lobophora variegata, have taken up most of the dead space available and are growing towards the live tissue. Sponges, such as Cliona spp. and Terpios hoshinota, have capitalized on the stressed corals and are making a phase-shift in favour of sponges. Ascidian species such as Didemnum sp. have also taken advantage of the dead coral space to compete with live corals. Effective management measures focused on reduction of fishing pressure, controlling the pollution levels especially by way of addressing domestic sewage disposal, and regular monitoring of physicochemical parameters have become imperative to keep the recovering corals stress-free. Focused coral rehabilitation with the native resilient species is also warranted to help increasing the coral cover.

RTS-31-98

Different coral calcification and photosynthesis in two contrasting coral reef waters of the South China Sea

Xiangcheng Yuan, Hui Huang, Weihua Zhou

As many reef systems in China are subject to the varying degrees of anthropogenic influences, it is crucial to compare the growth and metabolism of in situ reef systems in different regions. In this study, carbonate parameters and coral calcification were measured in two contrasting reef waters: a coastal fringing reef of Sanya and an offshore reef of Xisha islands. In the reef water of Sanya, nitrate concentrations were high (3.2 μmol L^{-1}), and the average organismal coral calcification (OCC) and diurnal net community calcification (NCC) was low (~2 mmol m^{-2} h^{-1}). In contrast, the average diurnal NCC rate was higher (6.6 mmol m^{-2} h^{-1}) on the reef flats of Xisha islands, due to receiving less anthropogenic influence. Despite of lower NCC, the net community photosynthesis (NCP) were much more dynamic in Sanya water (-98 to 170 mmol m^{-2} h^{-1}) than Xisha islands (-20 to 12 mmol m^{-2} h^{-1}). With such dynamic NCP, photosynthetic organisms can exert more modulating effects on pH, which was more obvious when seawater buffer capacity is lower in responses to future acidification in Sanya waters. Therefore, the seawater of Sanya and Xisha would exhibit different susceptibility to future ocean acidification due to different NCC and NCP.

RTS-32-499

Treated sewage discharge effect on the coral *Porites cylindrica* at Malakal Bay, Palau

Evelyn Ikelau Otto, Chuki Hongo, Izumi Mimura, Haruko Kurihara

Excessive nutrients and particulate matter in the marine habitat could have a detrimental effect on the delicate balance of coral reef ecosystems. Especially in small developing island nations, the natural environment is at risk for pollutants and/or contamination if infrastructure is ill-equipped to handle the increased demand of growing population. This study is geared towards examining the effect of treated sewage dispersal on the coral reef ecosystem surrounding the sewage disposal pipe in Malakal bay, Palau. Nutrient levels and light intensity was measured, and sediment traps were used to examine the dispersal of sedimentation as a result of the sewage outflow. Based on a dispersal patterns showing nutrient concentration and sedimentation flow in the north-northeast direction towards the harbor, a coral transplant experiment was conducted in the same direction to examine the potential effect of the treated sewage using *Porites cylindrica*. Corals were sampled from four stations, sewage outflow, 75m north-northeast, 150m north-northeast, and a control (1000m south). A three-month reciprocal transplant experiment was conducted to evaluate the effect of treated sewer on the coral physiology. Light intensity at the control station was significantly higher compared to the other three stations along the gradient. Results indicated a decrease of zooxanthellae density while coral growth increased as samples were transplanted furthest from the outflow (150m and control), regardless of the origin. Gross rate of photosynthesis:respiration (P_G/R) of all corals significantly decreased when transplanted at the outflow, except for the corals originating from 75m north-northeast station. Results show that although outflow does not induce nutrient concentration beyond excessive conditions, sewage negatively impact the corals by inhibiting coral growth and decreasing P_G/R rates. Suggesting that corals are affected not solely by nutrient elevation, rather combination of multiple stress factors such as decreased light intensity, increased sedimentation, and/or particulate matter.

RTS-33-563

Submarine groundwater discharge and nutrients input at tourist hotspot island, Pulau Redang, Malaysia

Li Yin Siow, Kimiko K Hamilton, Chun Hong Tan, Seng Chee Poh

Located on the east coast of Peninsular Malaysia, Pulau Redang is one of the 13 islands gazetted as Marine Park in Terengganu State. The number of visitor to Terengganu marine parks has increased two-folds since last 10 years. Environmental evaluation activities are conducted regularly within the marine parks to monitor the marine resources but the evaluation of submarine groundwater discharge (SGD) as an alternative nutrients enrichment pathway in coastal water have never been examined. In this study, a time series sampling was conducted at two potential SGD sites (Pasir Panjang Beach and Tigi Bay) of Pulau Redang. Water samples were collected hourly (12 – 14 hours) to capture a complete tidal cycle. The natural occurring of radon-222 isotope (SGD tracer) and associated ammonia, nitrate and phosphate in seawater were measured. At Pasir Panjang Beach the concentration (in range) of measured parameters were: radon (0.08 - 0.2 Bq/L), ammonia (2x10-4 - 7x10-4 mg/L), nitrate (2x10-4 - 0.068 mg/L) and phosphate (0.003-0.012 mg/L). For Tigi Bay, the measurements were 0.033 -0.18 Bq/L (radon), 0.002 - 0.059 mg/L (ammonia), 2.005 - 4.233 mg/L (nitrate) and 0.062-0.766 mg/L (phosphate). Results from Tigi Bay shows stronger relationship between radon and nitrogen (r2=0.55) and phosphorus (r2=0.39) when compare to the other sampling site. This suggested that the SGD maybe one of the nutrient sources contributed to the coastal water of Pulau Redang especially for Tigi Bay area.

RTS-34-532

Sediment-rejection efficiency of nine scleractinian coral species in Singapore

Hui En Pang, Ding Lun Lee, Aaron Teo, Peter Alan Todd

Sediment deposition on corals interferes with their feeding and photosynthesis. Land reclamation and dredging actives can result in increased sedimentation and previous studies have described how reefs under stress may become populated by hardy species. Sediment-rejection rates of nine coral species were studied *in situ* on the western reefs of Pulau Hantu, Singapore. To elucidate the mechanical effect of sedimentation on hard corals, inert silicon carbide powder was used so that contaminants associated with natural sediments could be controlled for. Various grit sizes of the silicon carbide powder were mixed to mimic the natural sedimentation profile found at P. Hantu and corals were subjected to two sediment loads: low (100 mg cm^{-2}) and high (200 mg cm^{-2}). The artificial sediments were deposited on horizontal surfaces of colonies in 50 mm circular patches using a specially fabricated device. Photographs of target corals and controls were taken immediately upon artificial sediment deposition and after three hours. Images were compared using ImageJ to determine the percentage area of sediments removed from the 50 mm circle. Rejection efficiency differed significantly between loads and among species. No specimens of any species were able to clear all of the sediments within three hours regardless of load. *Podabacia crustacea* was the most efficient at rejecting sediments at high (200 g mg cm^{-2}) loads whereas *Diploastrea heliopora* was the most efficient at rejecting sediments at low (100 g mg cm^{-2}) loads. Meanwhile, *Favites sp.* was the least efficient at rejecting sediments. Our results provide an insight into the rejection efficiency of nine relatively common coral species on Singapore's reefs. These data can be used to predict shifts in coral species dominance and potentially help with future conservation management efforts.

RTS-35-349

Growth trends of a massive coral in the subtropical reef environment of Hong Kong

James Xie, Jian-Wen Qiu, Yip Hung Yeung, Nathalie Goodkin, Hiu Yan Yu, Clement Dumont

Skeletal extension and calcification of *Porites* corals have been used as proxies of environmental conditions of coral reefs. This study examined the skeletal linear extension rate and calcification rate of *Porites lutea* across 10 sites in subtropical Hong Kong. Eight environmental factors were measured to determine the environmental drivers of coral growth. It was found that both the linear extension and calcification rates were much lower when compared with similar studies done on the same species in tropical areas. The linear extension rate and calcification rate of *P. lutea* were both negatively correlated with sedimentation rate. In addition, *P. lutea* displayed reduced growth in six of the ten study sites in the past decades. These results indicate that Hong Kong is a marginal environment for *P. lutea*, and sedimentation in western part of local waters can also act as a stressor for the growth of this massive coral.

RTS-36-582

Assessment of the potential sedimentation of nearby watershed of NIPAS sites caused by a storm event

Merced Mylanie Viceral Panganiban, Lovely Joy Villarin, Aldwin Torres Almo, Gay Jane Perez Perez, Laura Tenmatay David

Sedimentation is one of the major stressors in the reef system. Several impacts of sedimentation to coastal and marine ecosystem includes suffocation, increase in eutrophication, and worst are degradation as well as mortality. Thus, the assessment of the potential severity and extent of sedimentation is important especially in managing areas under the National Integrated Protected Areas System (NIPAS) act. It is also important to identify the factors that influencing the sedimentation to properly address the management measures. However, large-scale sedimentation monitoring is often resource-intensive. It is also difficult to identify the location that are potentially highly vulnerable to sedimentation and the factors that are influencing it. To address this issue, a simulation model using a modified form of MUSLE was created to assess the sedimentation intensity contributed by a nearby sub-watershed that can impact the NIPAS sites. The simulation aims to assess a worst-case scenario where the present land use/land cover of nearby sub-watershed of NIPAS sites were exposed to the rainfall intensity of the strongest historical typhoon. The strongest historical typhoon/storm in terms of precipitation that passed the NIPAS area within its 200km radius was used together with the present land use/land cover derived from satellite imageries and/or secondary data. The study also identified which of the attributed factors (e.g. run-off factor, soil erodibility factor, topographic factors, and cover factor) influence the sediment loss to provide potential decision support for soil erosion and land use management practice.

RTS-37-267

Response of reef fishes assemblages on silted coral reef in Tubay, Agusan del Norte, Philippines

Romell Seronay

Mining is aggressively pursued in the Philippines to boost the country's economy, reduce foreign debt, and increase employment. However mining may affect the biodiversity by changing the species composition, species structure and community structure of the living organism inhabited in the area. Mining introduced sediment in the coastal waters. Reef fishes, the most vital resources in coral reefs would be affected negatively if coral reef conditions have heavily impacted on land- based sediments. This study aims to determine the temporal response of reef fish assemblages on silted coral reef condition attributed by the construction of causeway in La Fraternidad, Tubay, Agusan del Norte, Caraga, Philippines. Caraga Region, which lies in the Pacific side of the Philippine Archipelago, has the richest mineral deposits in the country. Day time fish visual census was done in the four permanent monitoring stations across eight monitoring periods. Reef fish composition, richness, abundance and biomass were measured quarterly in the four monitoring stations. Result reveals that the number of reef species and biomass in the silted station (Pier 5) did not differ significantly with other non-silted monitoring stations. This indicate that the reef fish richness and biomass in silted station were able to recover but not the fish abundance. The lower sedimentation rate value in Pier 5 (ranges from 2 to 9 mg/cm2/d) probably contributed for the recovery of fish biomass and species richness. Temporal pattern on the assemblages of herbivores and corallivores species were also discussed.

RTS-38-163

Demography of a scleractinian - octocoral community shift: *Eunicea flexuosa* and *Porites astreoides*.

Lorenzo Bramanti, Mimmo Iannelli, Howard R Lasker, Georgios Tsounis, Peter J Edmunds

All ecosystems experience changes in community structure and composition, but changes over the last 100 years have been occurred at an unprecedented rate. When changes are irreversible, even after cessation of the disturbance, a regime shift can occur. In marine ecosystems, attention has focused on large and rapid shifts in community structure, yet not all regime shifts have rapid dynamics. Changes in benthic community structure involving increases in octocoral density and decreases in scleractinian cover have been recently observed and described as "cryptic regime shift". The objective of this study is to explore the mechanistic basis of a scleractinian-octocoral shift using a time-structured demographic model based on transition matrices to project the population dynamics of a scleractinian (*Porites astreoides*) and an octocoral (*Eunicea flexuosa*) under stable and under recurrent disturbance scenarios. The model is used to test the hypothesis that a phase change could be caused by recurrent disturbances (e.g., hurricanes) acting on two species characterized by different population dynamics. Simulations showed that disturbances recurring every 11 y have differing long-term effects, with the density of *E. flexuosa* remaining stable while the density of *P. astreoides* declines. These results can be generalised to species having life-history traits similar to those of our study species, with *E. flexuosa* characterizing octocoral dynamics (fast growth and positive density dependent recruitment) and *P. astreoides* characterizing scleractinian dynamics (slow growth and density regulated recruitment).

RTS-39-454

Detecting coral reefs recovery from the natural disturbances: The importance of marine protected areas (MPAs)

Melchor R Deocadez, Fleurdeliz Panga, Renmar Martinez, Ethel Wagas, Michael P Atrigenio, Roquelito Mancao, Porfirio M Aliño

Coral reefs around the world have been subjected to several natural disturbances such as typhoon, coral bleaching and *Acanthaster planci* outbreaks as well as anthropogenic disturbances. Coral reef resilience depends on the degree of the stressors and the role of herbivorous fishes in promoting coral reef recovery. The Philippines being a global marine biodiversity hotspot and found along the typhoon belt of the Pacific is an ideal study site to test coral resilience via recovery mechanisms after disturbance. This study will determine the recovery of coral assemblages in two sites with marine protected areas (MPAs) after being hit by tropical cyclone (Typhoon Bopah) in December 2012. Line intercept transect and fish visual census techniques were employed both in the protected and non-protected reefs in pre-Bopha (2011, 2012) and post-Bopah (2013, 2014, 2015, 2016 and 2017) periods. Coral assemblages detected significant decrease in live coral cover and increase in dead coral cover and rubble after the typhoon. There was a good sign of coral recovery in protected reefs (inside MPAs) while no signs of recovery were detected in non-protected reefs (outside MPAs). In addition, herbivore abundance and biomass were higher in the protected reefs in both sites. The patterns of recovery across these reefs were possibly due to influence of some factors such as herbivore biomass, wave exposure, degree of disturbance and type coral assemblages were also observed. These results support the hypothesis that herbivory is the major factor influencing reef recovery. Other important factors such as interaction between human-induced and natural disturbances remain to be investigated. This interaction is essential for coral reef resilience and conservationpriorities, management, and associated activities will differ among reefs from a disturbance, susceptibility to climate change and capacity of human communities to cope with and adapt to change.

RTS-40-533

Allelopathic effects of different macroalgae on survival and settlement of *Pocillopora acuta* larvae

Zi Wei Lim, Jenny Fong, Andrew Geoffrey Bauman, Zack Chen, Suresh Valiyaveettil, Peter Alan Todd

The survival and successful settlement of coral larvae are fundamental to the maintenance and recovery of degraded coral reefs, including those that are dominated by macroalgae. Allelopathy has been suggested as one mechanism by which macroalgae may outcompete corals. To investigate the allelopathic effects of macroalgae on the survival and settlement of coral larvae, we exposed *Pocillopora acuta* larvae to varying concentrations of crude extracts of four common macroalgae in Singapore (*Bryopsis*, *Endosiphonia*, *Hypnea*, and *Lobophora*). We also examined whether the presence of crustose coralline algae (CCA), that is known to give positive settlement cues, would help mediate the detrimental effects of macroalgae on coral early life-history stages. Crude extracts of *Bryopsis*, *Endosiphonia*, and *Lobophora* at concentrations of 0.05 and 0.1 mg ml^{-1}were found to increase the rate of partial metamorphosis, but also caused greater mortality than *Hypnea* and the control. At lower concentrations (0.01 mg ml^{-1}) survival and settlement rates were comparable between the different algal extracts and controls. Larval survival and settlement rates in the presence of CCA were higher in *Bryopsis* treatments but not in *Lobophora*treatments, suggesting that CCA has a limited ability to alleviate the deleterious effect of specific allelochemicals. Overall, our results show that macroalgae can kill *Pocillopora acuta* larvae and/or inhibit their settlement through allelopathy, and that there exists interspecific variation for the potency of allelochemicals. Based on existing literature, the concentrations tested in our study are below those found in natural reef environments, hence there is a real possibility that macroalgal allelochemicals are impacting coral recruitment and the ability of reefs to resist algal dominance.

RTS-41-70

Macroalgae alleopathic affect foraging of reef fish

Chen-Lu Lee, Shao-Lun Liu, Hsing-Juh Lin

Due to the human disturbance, coral reef ecosystem has underwent the phase shift from coral- to macroalgae-domanant system in many regions. Furthermore, some macrolage contain secondary metabolites that would repel the grazing behaviores of herbivorous reef fish, thereby slowing down the recovery of a health coral ecosystem. However, it remains unexplored if these chemical-rich macroalge have different repellent effects on different hebivore fish. In this study, we test the repllent effect of a chemical-rich macroalga, *Galaxaura divaricata*, on the foraging efficiency of different fish using tank experiments. This species are overgrowthing and occupied benthic substrates on many reef around Dongsha atoll, South China Sea. Our results showed that *G. divaricata* can have a great impact on the foraging efficiency for many herbivore fish by decreasing about 60% grazing amount. Over all, most fish species (except some Siganidae species) show the avoidance behavior in contect with food treatments subjecting to *G. divaricata*. This study revealed that the chemical-rich seaweed like *G. Divaricata* can affect the herbivourous fish, implying that the overgrowth of the chemical-rich seaweed might have adverse impacts on the benthic environment in the coral reef ecosystem.

RTS-42-442

Macroalgal density and predation risk interact to alter macroalgal removal on coral reefs

Jovena Chun Ling Seah, Andrew G. Bauman, Jenny Fong, Peter A. Todd

Coral reefs are declining worldwide, with some reef systems undergoing phase shifts to an alternate, macroalgal-dominated degraded state. A critical process in preventing and potentially reversing macroalgal dominance, thus promoting coral dominance, is the removal of macroalgae by herbivorous fishes. Previous studies indicate that high macroalgal density can negatively affect foraging behaviour and removal rates of herbivores, which may lead to the growth and persistence of macroalgal stands. Predator-mediated risk has been proposed as a potential mechanism for reductions in removal rates within macroalgal stands. However, this phenomenon has not been formally tested, and the degree to which increased predation risk influences removal rates remains unclear. To examine whether predation risk affects herbivore foraging behaviours, we created habitat patches using *Sargassum ilicifolium* thalli of varying densities: 5 (low), 15 (medium) and 25 (high) and simulated predation risk using predator fish models (grouper *Plectropomus leopardus*). We quantified how predation risk alters removal rates within different habitat patches over time (24 hours) and mass-standardised bite rates (3.5 hrs) for four non-consecutive days. Our results revealed the presence of model predators outside medium- and high-density macroalgal stands led to substantially lower removal rates of *S. ilicifolium* biomass (daily mean 6.15 ± 0.52 g 24 h^{-1} and 4.01 ± 0.38 g 24 h^{-1}respectively) with consumption rates 2- to 3-fold lower than on low density patches (13.64 ± 1.65 g 24 h^{-1}). Remote video cameras also revealed substantially higher feeding rates (mean 114.52 ms-bites 3.5 h^{-1}) on low density patches compared to medium- and high-density patches (mean 53.73 and 75.32 ms-bites respectively). Collectively, these findings provide evidence for predators altering herbivore foraging behaviours and macroalgal removal rates, and suggest that density thresholds of macroalgae beyond which production exceeds consumption is likely lower, enhancing positive feedbacks that may increase stability of macroalgal-dominated states.

RTS-43-292

Dynamics of coral-macroalgal interactions on Singapore's highly impacted reef systems

Jenny Fong, Andrew Geoffrey Bauman, Peter Alan Todd

Competitive interactions between corals and macroalgae (or seaweed) are increasingly common on many coral reefs, yet the processes and mechanisms affecting the dynamics of these interactions are poorly understood. To assess coral–macroalgal interactions, we quantified the frequency of coral colonies in close proximity (<1 cm apart) to macroalgae on three shallow reefs in Singapore (Pulau Satumu, Pulau Hantu, and Kusu Island) every two months for one year. Among reefs, there were marked differences in benthic community composition and competitive interactions between pairs of corals and macroalgae. On Pulau Hantu and Kusu Island, >60% of the coral colonies were recorded interacting with macroalgae whereas <30% of coral colonies on Pulau Satumu interacted with macroalgae. We also found that the frequency of coral–macroalgal interactions remained relatively consistent throughout the year across reefs (5–7 interactions m^{-2}), yet the macroalgal genera in contact with the coral colonies varied considerably due to seasonal fluctuations in abundance. Corticated red algae *Hypnea* and brown leathery algae *Sargassum* had the greatest frequency of interactions with corals. Two coral genera, *Echinopora* and *Goniastrea*, interacted most frequently with macroalgae compared to *Fungia* and *Platygyra* corals, suggesting that some coral genera may possess specific traits (e.g., growth form, growth rate, colony size) that make them more likely to contact with competing macroalgae. Overall, our results add to a growing body of evidence that competitive interactions between corals and macroalgae are highly dependent on the pairs of interactors involved. Considering trait-based life-history strategies may provide new insights on mechanisms regulating competition between corals and macroalgae.

RTS-44-339

Competition between macro algae and the coral reefs of the Thousand Islands, Indonesia

Atika Rahmah, Kyra Bestari Wicaksono, Joost Soomers, Louis Stolper, Nicole J de Voogd

Competitive interactions between corals and macro algae has been recorded in several waters, and it affects the community structure of coral reefs. Human activities that lead to nutrient enrichment and overfishing of algae grazers contributes to this shifting community. To determine the competitive interaction between macro algae and corals, and if the coral reef community was shifting into a macro algae state in the waters of the Thousand Islands, we recorded the occurrence and effects of the macro algae and coral interactions on different coral life forms. The data was collected from the southeast and northwest of Pramuka Island, and northwest of Air Island. Methods used in this research are the line intercept transect and belt transect. We used three transect lines parallel to the shore at each sites, with 15 meters apart from each other. The result shows that the coral lifeform diversity increased along the distance from the shore. The most common lifeform of all sites are branching, encrusting, and submassive, respectively. The northwest of Pramuka Island has the most abundant macro algae on the coral reef among all sites. The first transect is dominated by branching lifeform which also a fast growing lifeform, whereas the second transect is dominated by algae assemblage, and gradually changing into mostly slow growing lifeforms, such as encrusting on the third transect. The lifeform that has the most interaction with macro algae is the submassive. However, the interaction is most likely that macro algae outcompeted submassive corals. We also found that the encrusting corals have more resistance and 'wins' against algae while the submassive is the opposite. Moreover, the condition of the corals at the northwest of Pramuka Island is more severe than the other two sites, which indicates the impact of sedimentation to the health of the coral reefs.

RTS-45-516

Reclamation of shallow lagoons and reef for urban and tourism development

Hussein Zahir, Abdulla Naseer, Rifath Naeem

Maldives as fast developing archipelagic nation where land is small compared to reef and and lagoons is moving to increase land areas through reclamation of shallow reef areas for urban and tourism development. The total land area of Maldives geopolitically referenced as $299x10^4$ ha has been increased significantly by anthropogenic means. Habitat loss and alteration and subsequent biological, ecological and fisheries impact on important marine sources resulting form such activities are documented little. This paper looks at the extent of recent reclamation and its environmental and socio economic impacts. Current practice of environmental screening and approval for such projects is also reviewed.

RTS-46-61

Exposure of substrate to fish farm environment reduces the settlement of *Pocillopora damicornis* larvae

Timothy Joseph Rama Quimpo, Patrick C Cabaitan, Dana Manogan, Charlon Ligson, Ritzelle Albelda, Cecilia Conaco

Mariculture has increased in scale and intensity in the last few decades to meet human food demands. Untreated waste waters from mariculture activities are detrimental to nearby marine environments, such as coral reef ecosystems. In the Bolinao-Anda Reef Complex, coral cover has been reported to decrease with proximity to mariculture areas. However, the processes that caused these differences in coral cover at these sites are not well understood. In this study, we tested the settlement of *Pocillopora damicornis* larvae on substrates that were exposed to reef environments at different distances from mariculture areas. We found that the settlement of *P. damicornis* larvae was higher on substrates that were exposed to environments farther away from mariculture activities. The biofilm on these substrates included crustose coralline algae and a diverse microbial community. On the other hand, settlement on substrates exposed to sites near the mariculture farms were overgrown with turf algae, which may have impeded larval settlement. This study suggests that changes in environmental conditions due to effluent from mariculture farms can affect reef substrate conditions, thus rendering them unsuitable for coral settlement. This may have a downstream effect on the recruitment and recovery of coral communities at these sites.

SC-1-377

The role of evolutionary history in the spatial distribution of coral species abundance: an example from coral populations in Australia

Sun W. Kim, Brigitte Sommer, John M. Pandolfi

Spatial distributions of species abundance provide insights into fundamental questions in ecology and evolution, including population connectivity and range dynamics. The abundance centre hypothesis, which postulates that species are most abundant at their range centres, has long been considered to be the general rule across taxon groups. Whilst many species flourish at their range centres, empirical evidence suggests that the abundance centre hypothesis oversimplifies the mechanisms that drive complex ecological, evolutionary, and environmental patterns. For corals, the spatial distribution of species abundance has been attributed to life history traits and species interactions, yet the role of evolutionary history in the spatial distribution of coral species abundance remains unexplored. Here we focus on coral populations along a tropical-to-temperate gradient on the east coast of Australia. We demonstrate that the association between coral species abundance and the distance to species range centres varies widely among species. Coral species abundance scales exponentially with the distance to species range centres for taxa abundant at high-latitudes. In contrast, taxa abundant in the tropics show mixed patterns; some follow the abundance centre hypothesis, whereas others exhibit no apparent patterns. The variability in species abundance patterns is influenced by a positive association between the degree to which species abundance scales with the distance to species range centres, and diversification rates of taxa. This association leads to higher per capita diversification rates for high-latitude coral communities. Together, these patterns highlight that the spatial patterns in coral species abundance are more complex than simply explained by the abundance centre hypothesis, and show that evolutionary history of coral species contributes to the composite of factors that shape the spatial distribution of coral species abundance.

SC-2-631

Morphogenetic of *Clavularia inflata* (Soft Coral: Stolonifera) in Coral Triangle

Beginer Subhan, Dietriech Bengen, Sebastian Ferse, Dondy Arafat, Prakas Santoso, Nurlita Anggraini, Luzmi Malia Izza, Hawis Madduppa

Indonesia is a center of marine biodiversity, especially coral reefs and its associated biota. Taxonomic studies in this area are still quite minimal, especially morphology and genetic. The purpose of this study was to describe soft coral stolonifera Clavulatia inflata derived from coral triangle both morphologically and genetically. A total of 62 samples taken from the Nine locations of Pulau Panjang (Java Sea), Tanjung lesung (Sunda Strait, Natuna Island (Natuna Sea), Madura, Gili Lontar, Gili Sulat, Selaru Island, North Maluku and South west Maluku were observed in morphology and genetic use of CO1 marks.The results clearly confirm that all samples in either genetic morphology are clavularia inflata.

SC-3-654

Evaluation of octocoral adaptive strategies using individual trait-based approach

Ching Wei Bill Wang, Qi Chen, Vianney Denis

Strangled by natural and human disturbances, scleractinian corals have been substituted by alternative taxa in most of the reefs around the world. In these conditions, octocorallians could become more abundant in tomorrow's reefs because of their higher physiological plasticity to environmental conditions. As previously identified for hard corals, octocorallians may however not be all equal facing these changes. Therefore, there is an urgent need to evaluate possible differences among soft coral species and the consequences of these contrasted ecological strategies on the reef communities. Using a trait-based approach, this study proposes to set up a framework for delineating soft coral ecological niche on the base of intra-species variations in key morphological and physiological parameters. We selected five common and taxonomically well-defined species in the benthic assemblage from the north of Taiwan. There, soft corals are abundant and relatively diversified. In addition, they are exposed to large seasonal variations in environmental conditions, which increase the susceptibility to identify contrasted phenotypes along the year. Individuals were compared on the base of the similarity in the characteristics they exhibit using Gower matrix. Species niches were delineated using convex hull and examined across species for their volume and divergence. To our knowledge, this study is the first to address adaptive strategies within soft coral species with a consideration of individual variability. It also constitutes the first step toward an extension of our approach to all soft coral species around Taiwan, and a better understanding of the ecological shift happening in the coral reef communities worldwide.

SC-4-419

Eating your Greens: Selective consumption of sacoglossan sea slugs by scleractinian corals

Rahul Mehrotra, Chad M. Scott, Coline Monchanin, Suchana Chavanich, Voranop Viyakarn, Manuel Caballer, Bert W. Hoeksema

In recent years, our understanding of viable prey items for some scleractinian corals has expanded to include many that challenge the idea of a predominantly microscopic prey scale. Observations of larger planktonic organisms such as salps and jellyfish being consumed by numerous free-living corals has allowed for an improved understanding of the role of heterotrophy in many such corals. The observation of a benthic sea slug, the sacoglossan *Plakobranchus cf. ocellatus*, being ingested by a free-living mushroom coral further pushed the boundaries of predatory capacity of these corals, however active consumption of the prey item was never confirmed. To investigate the role of sacoglossan sea slugs as possible prey items of scleractinian corals, feeding trials were carried out using six sacoglossan species (*Plakobranchus cf. ocellatus*, *P. cf. papua*, *Elysia pusilla*, *E. japonica*, *Costasiella cf. kuroshimae* and *C. usagi*) and four free-living solitary corals (*Fungia fungites*, *Danafungia scruposa*, *Pleuractis paumotensis* and *Heteropsammia cochlea*). Trials were carried under both in-situ and ex-situ conditions with the aim to observe ingestion and assess signs of prey consumption based on tissue loss of prey items over time. Significant differences were observed in both ingestion time and consumption state of prey between prey items, with both *Costasiella* species and *E. pusilla* being ingested more rapidly and preferentially consumed over the other species. Additionally, prey size was found to be a significant factor with larger prey (>12mm) being ingested more slowly and rarely than smaller prey items. Consumption capability between predators showed no significant difference with all coral species showing similar preferences for prey items. Under changing climatic conditions and increasing occurrences of mass coral bleaching events, the improved understanding of heterotrophy in corals may be particularly important for zooxanthellate species which may increasingly rely on predation to survive such events.

SC-5-227

Acropora and merulinid corals use different mechanisms to regulate the spawning day

Che-Hung Lin, Yoko Nozawa

Synchronous spawning is a common phenomenon in corals and has been described in many regions of the world over the last three decades. Moonlight, tide, and temperature have long been suggested as primary factors in determining coral spawning time. However, their actual influence is not well understood. Here, we examined the influence of no moonlight, no tidal change, and low temperature on the spawning day of the coral, *Acropora hyacinthus* and two merulinid corals, *Dipsastraea speciosa* and *Favites pentagona* in a field experiment (*A. hyacinthus*) and tank experiments (all spp.). In the field experiment, all fragments of *A. hyacinthus* spawned synchronously, irrespective of the presence or absence of moonlight and tidal change. In the tank experiments, *A. hyacinthus* and merulinid corals showed different spawning behaviors among experimental conditions. In the control condition (presence of moonlight, 28°C), both *A. hyacinthus* and two merulinid corals spawned. In the no moonlight condition (absence of moonlight, 28°C), *A. hyacinthus* did not spawn, whereas most fragments of the two merulinid corals spawned 3–4 days earlier than those in the control condition. In the low temperature condition (presence of moonlight, 26°C), most *A. hyacinthus* fragments did not spawned, but fragments of the two merulinid corals spawned 0–1 day later than those in the control condition. When spawned, *A. hyacinthus* fragments kept in the same tank mostly spawned synchronously. The different spawning behaviors between *A. hyacinthus* and the two merulinid corals suggested different spawning mechanisms. The synchronous spawning of *A. hyacinthus* fragments in the field experiment and in the individual tanks implied the use of chemical signals to synchronize spawning time.

SC-6-708

Investigating dynamics in spawning timing and early life stages of *Acropora* corals at Sattahip in the upper Gulf of Thailand

Suppakarn Jandang, Suchana Chavanich, Voranop Viyakarn, Pataporn Kuanui, Se Songploy, Sanit Piyapattanakorn, Akira Iguchi

The corals of the genus *Acropora* are widely accepted to be among the most threatened of reef building scleractinia, highlighting the importance of monitoring their reproductive strategies and development under the changing climatic conditions seen in recent decades. Data was collected on spawning time and duration for *Acropora* spp. at Sattahip, Chonburi province in Thailand between the years 2006-2017, with all spawning occurring during January and February months. To assess the role of *Acropora* corals as symbionts to zooxanthellae during early life stages, numerous techniques were employed on *A. millepora* corals reared under ex-situ conditions. Fluoresence Microscopy was used to investigate the presence of *Symbiodinium* in egg bundles pre-fertilization, embryos at 8 hours, 24 hours, 4 days and embryos 10 days post fertilization. The results indicated absence of symbiodinium at each stage, and these were verified by use of Transmission Electron Microscopy (TEM) of 3 replicates at each stage, and by molecular methods which failed to amplify *Symbiodinium* genes via the polymerase chain reaction. Molecular analysis taken from 2 months up till 2 years post fertilization verified presence of clade D *Symbiodinium* in *A. millepora* colonies in the hatchery.

SC-7-634

Characteristics and distribution of reef associated communities in Taiwan

Yu Ting Vicky Lin, Vianney Denis

Diversity from tropical shallow water reefs (TSWR) is now in imminent collapse, and deeper areas or regions at the edge of their distributions are now examined as possible lifeboats for its persistence. However, it remains unclear if these marginal habitats represent the continuity of TSWR or alternatively if they could form distinctive biological communities self-functioning. Taiwan is located on the edge of the continental shelf, and spans the transition between tropical and temperate latitudes. Several locations offer conditions where temperature and light levels departed significantly from optimum for reef organisms. In the present study, Taiwanese benthic assemblages were surveyed along regions (North, East, South) and depths (10 and 40m) using 89 photo-transects. We used a functional categorization based on the morpho-type of living organisms, and identified using unsupervised *learning* algorithms (K-means clustering) biological communities across these contrasted habitats. We further tested the relevance of region and depth factors in discriminating those benthic assemblages, and categorize individual transect to the biological communities where it belongs. We identified seven unique and well-supported biological communities. Benthic assemblages were better differentiated by region than depth suggesting a partial functional overlap among depths across regions. Eventually, we demonstrated that complementarity to ensure a representativeness of each biological communities could only be achieved by considering all regions and depths in an objective of conservation.

SC-8-120

Coral reef benthic communities at Panwa Cape, Phuket, Thailand

Pathompong Pramneechote, Sutinee Sinutok, Koraon Wongkamhaeng, Ponlachart Chotikarn

This study aims to assess coral diversity in southeast reef of Phuket Island using Photo belt-transect method in June 2017. 100 meters line transects were laid parallel to the coast in both reef flat and reef slope and the photo was taken every 50 cm. Coral Point Count with Excel extensions (CPCe) program was used to overlay 4x4 point on the image and substrate underlying the point was identified. The results showed a total of 9 families and 17 genera on reef flats and 12 families and 25 genera on reef slope. On the reef flat, mean percentage cover of live coral, dead corals, sand and sponge were 43.93%, 51.64%, 4.36% and 0.06%, respectively. The dominant species were presented by *Porites* sp. (31.38%), followed by *Favites* sp. (4.80%) and *Goniastrea* sp. (3.35%). On reef slope, the mean percentage cover of live coral, dead corals, sand and sponge were 21.65%, 62.53%, 15.44% and 0.38%, respectively. The dominant species were presented by *Porites* sp. (5.05%), followed by *Acropora*sp. (2.84%) and *Goniastrea* sp. (2.49%). Shannon's diversity indexes of reef flat and reef slope were 1.13 and 2.67, respectively suggesting that reef slope had more coral diversity than reef flat due to physical parameters such as sediment accumulation rate, light availability and depth. This study suggested that coral diversity was due to sediment accumulation, depth and other physical and chemical factors.

SC-9-545

Effect of no take zone on reef fishes biodiversity and biomass within marine protected areas in Raja Ampat, Indonesia

Fakhrizal Setiawan, Austin Humphries, Beginer Subhan, Regitri Darmawan, Mufti Afrizan, Paul Carvalho, Luky Adrianto, Alan Koropitan, Chris Paight, Hawis Madduppa

Indonesia's coral reefs are the most biodiverse in the world but are under threat from overfishing and other stressors. However, overfishing plagues many coral reef fisheries, compromising food from the sea and self-sufficiency of coastal communities. Raja Ampat Islands included in bird's head Peninsula have the worlds most diverse coral reef fishes and ranked the highest priority of biodiversity conservation in Indonesia. This study was conducted to assess the fish diversity between zones (core, tourism, and open access). A total of 42,312 individuals from 354 species in 41 coral fish families were recorded from three management type (core, tourism and open access), conducted from 14-22 January 2018 around the Dampier Strait. Corals cover showed significant different (P<0,05) between no take zone (core and tourism) and take zone (open access) but corals cover between tourism and core zone no significant different (P>0,05). Tourism zone have highest biomass and abundance but no significant different (P<0,05) with core zone and open access. Shanon-weinner diversity, similarity and dominance (basis ln) of reef fishes didn't showed significant different between management type. Habitat complexity showed positive relationship with fish abundance but negative relationship with fish biomass. Tourism zone have same function as core zone and establish before management zonation declared by government. Some area from open access (Ruvas and Piaynemo) also become spot diving and have good quality of corals cover and reef fishes (biomass and abundance). No significant different between three management type showed the low fisheries activity mainly destructive fishing in this area and protection system in this area works properly.

SC-10-359

Decline in coral reef cover in East and Southeast Asia over the last 32 years

Yong Kit Samuel Chan, Loke Ming Chou, Put Jr Ang, Allen Chaolun Chen, Chao-Yang Kuo, Vivian YY Lam, Nguyen Van Long, Cleto L Nañola, Karenne Tun, Thamasak Yeemin, Tadashi Kimura, Danwei Huang

Coral reefs are a major ecosystem in the tropical oceans, encompassing both large areas of habitat and providing many ecosystem functions and services to a greater variety of organisms. Yet, these reefs are increasingly being threatened by natural and anthropogenic threats at an increasing rate. We explored the temporal change in scleractinian coral and macroalgal cover from seven countries in East and Southeast Asia by examining over 10,000 transects surveyed across from 1986 to 2017. From these surveys, we modeled the change in proportion cover of coral and algae, identifying a constant decline in coral cover throughout the years, despite much greater variation among countries, sites and time periods. This is in contrast to other long-term studies identifying greater losses within different time periods in regions such as within the Caribbean and the Great Barrier Reefs in Australia. Despite this decline, the macroalgal cover does not appear to be increasing in proportion to the loss in coral cover, contrary to the general thought model of alternate stable states between coral- and algae-dominated reefs. Lastly, while we know the current trajectory of coral cover loss, we warn that cover does not completely represent community assemblage and health, with even small losses in cover potentially hiding greater underlying loss in both function and evolutionary history. To address this gap in knowledge, more long-term species- or genus-level studies should be attempted to give greater resolution through current surveys to elucidate change in function and evolutionary history through time.

SC-11-348

Coral reef benthic habitat mapping using Unmanned Aerial Vehicle (UAV) Imagery: Case study at Labuan Marine Park, Malaysia

Chong Wei Sheng, Idham Khalil, Aidy M Muslim, Khaira Ismail, Zainudin Bachok, Mohd Safuan Che Din, Azizi Ali

Repeatable and replicable coral reef benthic habitat mapping is required for understanding coral reef ecology and supporting management decisions. For shallow (<5m) reef habitats, baseline maps can be produced by integrating fine resolution remote sensing imagery with field survey data, and it is more practical compared to acoustic surveys in shallow waters. Unmanned Aerial Vehicles (UAVs) or drones are the latest remote sensing platforms combined with UAV imaging sensors can generate fine resolution imagery. Here, we demonstrated a technique using a lightweight (<5kg) drone and mounted with consumer grade cameras to produce fine resolution (~8cm/pixel; 120m altitude) orthomosaics for shallow reef benthic habitat mapping in Labuan Marine Park, Malaysia. Standard photogrammetric workflow and image processing were applied to generate orthomosaics. In the field, georeferenced videos of the reef habitats collected within the drone flight tracks via snorkelling. Videos were analysed for abiotic and biotic components and then used as validation data to map shallow water reefs. We trialled two classification approaches of varying complexity to investigate and illustrate the differing performance and capabilities of each. Our results show that supervised classifications perform better than unsupervised to classify coral reef habitat cover. The mosaicking procedure of water area in drone imageries does affect the classification accuracy due to the presence of 'image artefacts' in orthomosaics. Hence, potential challenges and issues in image acquisition and processing highlighted. This study demonstrated that the UAV-based remote sensing is good at indicating the extent of habitats; field survey identifies the habitat composition, and the digital image processing extends the field survey coverage to the whole area of management interest. UAV data collection is more consistent, repeatable and cost-effective for coastal managers. Thus, we posited that further advance of UAV technology justified for the coral reef habitats monitoring in ongoing management programmes.

SC-12-63

Quantification of reefs benthos for coral health assessment in southern South China Sea, Malaysia using coral video transect technique

Che Din Mohd Safuan, Raveena Kim Lai, Putri Asma Megat Yusof, Mohamad Azlani Mohamad Amin, Khaira Ismail, Idham Khalil, Azizi Ali, Siti Nur Tahirah Jaafar, Wei Sheng Chong, Zainudin Bachok

A broad range assessment of coral reef in Malaysia can provide a good opportunity to examine the trend of coral health status in the region. In this study, a coral assessment was carried out in five distinctive islands in the southern South China Sea (SCS), Malaysia utilizing an optimized method called Coral Video Transect (CVT). The output of this study revealed the trend in coral condition has been decline from 'good' to 'fair' condition over the past two decades. Together with the current published data, we analysed coral condition on 118 sites in west and east Malaysia and data were compared with an earlier coral assessment in 1994. The output of the survey found that the reefs rated as 'excellent' condition were declined up to 4-folds and 2-folds decline of the reefs with 'good' condition. Furthermore, almost 4-fold increase of 'poor' reef sites suggests an extensive coral degradation in Malaysia. Overall, the coral communities in Malaysia were relatively in a healthy state but slowly degraded due to natural and anthropogenic disturbances. Sedimentation, nutrient enrichment, coral bleaching, predation, and disease, as well as physical damage by human activities, were the main threats to the reefs in the study area. Based on outputs of the survey, we proposed a simple strategic map for sustainable use of biological resources of the coral reefs in Malaysia. The reefs can be classified under three zonations (Critical Zone, Open Zone and Buffer Zone) in which can be classified based on the IUCN protected area management category.Even though the classification is simply base on the baseline data, we hoped that this can help the coral reef manager especially Marine Parks to strengthen their management in protecting and conserving the coral reefs in Malaysia.

SC-13-638

An evaluation of sample processing methods for stable isotope analyses of scleractinian corals

Chien Hsun Eric Hsieh, Nicloas Sturaro, Ling Wen Liu, Pei Ling Wang, Vianney Denis

Most scleractinian corals are mixotrophic but are commonly believe to mainly rely on energy uptake by their symbiotic algae, the zooxanthellae. Several species challenge this belief, and have demonstrated remarkable abilities to compensate decline in autotrophic feeding in stressful conditions or in order to colonize marginal habitats. Since, coral diets have raised as a critical trait to apprehend coral's survival facing climate changes. Unfortunately, but because of practical reason, their assessment has often been reduced to untested proxy at species level (*e.g.* corallite diameter) which does not allow to pinpoint their plasticity. Stable isotopes (SI) offer a compelling means to study nutrition and trophic positions of corals. The SI analysis of carbon and nitrogen in both animal tissues and zooxanthellae has been successfully applied to track shift toward heterotrophic feeding in several coral species. However, despite the power of this type of approach, a variety of sample treatments are applied on the sample material before analytical determination of isotope ratios, which might influence the SI measurements. Currently no well-established standard protocol is available for SI measurements in zooxanthellate corals. Here, we tested the potential effects of different sample treatments on the $d^{13}C$ and $d^{15}N$ values of two species of scleractinian corals, namely *Stylophora pistillata* and *Porites* sp. The treatments were applied on the algal and the animal tissues, and correspond to the most common methods used in the literature: acidification (direct addition of HCl and indirect HCl vapors), sample rinsing, lipid extraction and dehydration. Overall, our study provides a comprehensive and adequate protocol to be used in the application of SI analysis to coral science, including the assessment of trophic plasticity of corals. The use of a standard protocol is of paramount importance for a better accuracy of data and better comparability of studies using SI analysis in coral science.

SC-14-307

Population ecology for a three-dimensional world: The case of *Pocillopora verrucosa* in Taiwan

Aziz Mulla, Yoko Nozawa, Takefumi Nakazawa

The ability to make predictions concerning environmental change depends on our understanding of basic ecological patterns and processes. Demographic studies have led to estimations in population dynamics that have been essential in highlighting both local and global change. However, many of the traditional studies regarding coral reefs are restricted to either a one (1D diameter) or two-dimensional (2D projected area) body size. The absence of a third-dimension (3D) severely underestimates size-specific functions such as growth, mortality and fecundity. Here, we aim to conduct one of the first demographic studies to utilize a 3D approach, able to quantify overall performance (growth, mortality, fecundity) of dominant species, *Pocillopora verrucosa*, in Taiwan. We estimated a relationship index for 34 colonies based on their 2D measurements, using a wax coating method to obtain 3D values. This index was then applied to compare changes in populations from permanent photo-quadrat data over a 6-year period (2012-2017). The relationship index and field data was then used to model any significant differences between 2D and 3D resolutions, whilst developing a separate model to predict patterns of growth, mortality and fecundity, under various climate and disturbance scenarios. Compared to previous studies, our analysis provides a more robust and realistic predictive power that can be used with relation to coral reef management and conservation.

SC-15-52

Socio-ecological model for sustainable management of Kenting National Park (Taiwan) in the context of climate change

Lauriane Ribas-Deulofeu, Pierre-Alexandre Château, Vianney Denis, Chun-Hung Lee, Yun-Ju Chen, Pei-Jie Meng, Yu-Wen Chiu, Yang Chi Chang, Chaolun Allen Chen

Kenting National Park (KNP) was created in 1985 to enforce conservation of terrestrial and marine diversity in Southern Taiwan. Despite the implementation of MPAs, many reefs within KNP are now severely degraded under increasing natural and anthropogenic disturbances. Conciliating growing socio-economic demands with ecological conservation represents a challenge to durably sustain coral reefs. Here, we developed a transdisciplinary approach using socio-ecological surveys and ecosystem modelling to identify keys levers and their impacts on the reefs of the KNP. Benthic and fish communities were surveyed over a 5-year period, with seasonal surveys in 2015-2017 to assess the effects of punctual disturbances such as typhoons and bleaching events. State and response of communities were related to water quality surveys including watersheds to identify origins of land-based pollution. Eventually, stakeholders were interviewed about their acceptance of different management strategies. Socio-ecological data were then integrated into our model to explore several management strategies.

Following major typhoons in 2016, KNP showed an important shift toward macro-algae dominated states. Between 2015 and 2017, macro-algae coverage increased from 5.2% to 21.1% and hard coral decreased from 29% to 23.8%. Stress-tolerant corals such as encrusting and massive species constituted 61.3% (2015) to 68.3% (2017) of the coral coverage and critical species for reef growth and complexity (branching, foliose and tabulate species) contribution decreased from 25.9% to 18.3%. Fish biomasses in KNP (8.6t/km^2) are similar to over-fished reefs in Philippines (6.8t/km^2). Water quality surveys reveal localized nutrient and sedimentation inputs, mostly related to cropland. Interviews showed that younger and higher educated classes have stronger willingness to pay for policy reinforcements, capacity control regulations, and establishment of park entrance fees than older generations. Current work is integrating those results in different climate change and management scenarios for a sustainable governance of the reefs in the regions.

SC-16-363

Evaluating the effects of MPAs and fishing pressure on fish parasitic gnathiid isopods in the central Philippines

Mary Oluremi Shodipo, Paul Carl Sikkel, Rene Aberin Abesamis

Coral reefs harbor more biodiversity per unit area than any other ecosystem. While larger organisms such as reef fishes and larger reef invertebrates including corals, receive most attention, parasitic organisms dominate biodiversity on coral reefs and have significant impacts on community dynamics. The effects of fishing pressure and loss of live coral due to anthropogenic and climate-induced stressors on larger reef organisms have been well studied. However, the impacts and responses of parasites that inhabit reefs have been largely ignored. Gnathiid isopods are the most common external parasites of coral reef fishes. These highly mobile "micropredators" are similar to ticks and fleas on land, emerging from the bottom, mostly at night, to feed on the blood of host fishes before returning to the bottom. Thus, they depend heavily on both benthic habitat and fish hosts and can have significant impacts on the latter. Our goal was to compare the abundance of gnathiid isopods in marine protected areas (MPAs) and heavily fished areas in Negros and Siquijor islands in the central Philippines. Analysis of our data thus far indicate that 1) the density of live coral and cleaner wrasses, both known predators of gnathiids, are greater within than outside MPAs; 2) while the density of host fish is similar between MPAs and fished areas, the size and thus biomass of host fish is greater inside MPAs; and 3) while the density of gnathiids overall is not significantly different between MPAs and fished areas, the ratio of gnathiid density to fish biomass is overall higher outside MPAs. These data suggest that while human-induced stressors may reduce both predators of gnathiids and host biomass, the reduction is not sufficient to reduce the impacts of gnathiids on the remaining fish hosts, constituting a secondary effect on fish populations in fished areas.

SC-17-9

What does global change mean for decomposition in human-impacted coral communities?

Archana Anand

Microbial decomposition of organic matter in coastal marine sediments is a critical ecosystem function that helps regulate atmospheric CO_2 levels. Excessive anthropogenic nutrient inputs can have detrimental effects on organic matter breakdown by favoring some microbial community interactions and processes over others.. We recorded marine sediment decomposition rates using commercially available green and rooibos tea bags in four sites characterized by a nutrient pollution gradient in one of the most urbanized cities on Earth, Hong Kong. Sites with elevated nutrient concentrations recorded higher decomposition rates and sequestered lesser carbon. Strikingly, carbon cycling microbes were more abundant in habitats characterized by high decomposition rates. This study presents the first use of a simple and standardized technique to measure carbon breakdown in combination with high throughput sequencing technologies that link microbial contributions to geochemical cycling in human-impacted coral reefs.

SC-18-79

Transcriptome analysis of the reef-building octocoral, *Heliopora coerulea*

Christine Guzman, Chuya Shinzato, Tsai-Ming Lu, Cecilia Conaco

The blue coral, *Heliopora coerulea*, is a reef-building octocoral that prefers shallow water and exhibits optimal growth at a temperature close to that which causes bleaching in scleractinian corals. To better understand molecular mechanisms that may contribute to its temperature tolerance and its reef-building capacity, we generated a reference transcriptome for *H. coerulea* using next-generation sequencing. Analysis of the blue coral transcriptome revealed enrichment of genes involved in stress response, including heat-shock proteins and antioxidants, as well as genes participating in signal transduction and stimulus response. Its tissues host *Symbiodinium* related to the thermotolerant C3-Gulf ITS2 type, known from the Persian Gulf. These features suggest a basis for the reported tolerance of *H. coerulea* to elevated temperature. Furthermore, the blue coral possesses homologs of biomineralization genes found in other corals and may use a biomineralization strategy similar to that of scleractinians to build its massive aragonite skeleton. These findings thus offer insights into the ecology of *H. coerulea* and suggest gene networks that may govern its interactions with its environment.

SC-19-484

Toward an integration of intraspecific variability in the definition of coral adaptive strategies

Qi Chen, Vianney Denis

Intraspecific variability offers a ground for natural selection to operate and species to adapt. It represents a key factor for species survival. In corals, four adaptive strategies were previously defined on the base of average trait values, which overlooked intraspecific variability in their response to different environmental conditions. Here, we used a trait-based approach to characterize intraspecific variation and identify the main drivers of this differentiation under contrasting light and temperature conditions. Ten physiological traits characterizing the input and output of energy were examined in six coral species sampled in 4 habitats at 2 seasons. More than 200 individuals were compared for their trait similarity using Gower distance and visualized into a functional space using a Principal Coordinates Analysis. Intraspecific variation was compared at habitat-season level, as well as across habitats and seasons. Eventually, it was characterized for each species by the volume of the convex hull delineating all individuals. Species divergence was further examined by the distance among species centroid and degree of niche overlap. Our results showed distinctive patterns where some species can occupy a large proportion of our functional space while others do not. We further concluded on the possible existence of generalists and specialists in scleractinians. The later may further be divided in several strategies that remain to identify. Overall, this study constitutes a first step toward an integration of intraspecific variation and species niche into a re-evaluation of coral adaptive strategies.

SC-20-565

Coral community demographics: A predictive framework for the long-term viability of corals at high latitudes

James Cant

Tropical coral communities are among the most vulnerable to the rapidly intensifying effects of climate change, with many populations now at risk of recurrent bleaching across much of their core range. It has been suggested that under future conditions of increased sea surface temperatures, marginal subtropical coral communities may act as potential refuges for these tropical populations. However, high latitude environments are far more stressful and variable compared to their tropical counterparts. With climate change projected to only increase the novelty of environmental conditions in these locations; this subsequently raises questions regarding the capacity of subtropical communities to support tropical coral communities, and the ability of tropical corals to establish viable populations at higher latitudes. The viability of any population is underpinned by the underlying vital rate schedules of growth, survival and reproduction in its individuals. Therefore demographic assessments quantifying how corals allocate resources between their vital rates as conditions change, offer insights into the status and structuring of coral populations, and the mechanistic factors promoting their success or failure within novel and changing environments. This presentation will discuss the conceptual framework and early progress of work designed to investigate how demographic traits vary with contrasting stress regimes, and how any variation influences viability within the tropical and subtropical coral communities of southern Japan and eastern Australia. Preliminary work within the Solitary Islands Marine Park suggests that despite intense environmental filtering at higher latitudes, *Acropora* and *Turbinaria* populations allocate resources differently in order to enhance their success within this stochastic subtropical environment. This highlights the immense potential of demographic modelling techniques for uncovering the causal factors governing the persistence of coral populations across latitudinal scales, and will aid in the investigation of whether high latitudes can actually support increased coral biodiversity.

SC-21-22

The high turbidity reduced mortality of coral bleaching in Kabira Bay, Ishigaki Island, Okinawa

Kotaro Yashiro, Koichi Kinjo, Koichiro Kamio, Yoshiyuki Nakamura

We investigated mechanisms by which high turbidity of inner bay reduced mortality of coral bleaching, in Kabira Bay.

In the late 1970s, branch-formed and bottle wash brush-formed Acroporidae were the dominant species of the east side of the bay. Recently, most of the species died, however, some corals survived in a layer of 2-6 m depth of the inner part of the bay.

We examined factors of coral death by several data sets (water temperature, aerial photograph, monitoring data of corals in adjacent area, and local information) and concluded that the most probable cause was the coral bleaching in 2007. During the period, high temperature condition should have prevailed in whole area of the bay, but some corals in the inner part of the bay survived. There should be some reasons why some corals survived ever under high temperature.

Turbidity in the inner part was generally higher. Light penetration at 5 m depth in the inner part was estimated to be lower than those in the central part (2.7% and 6.5% of surface irradiance, respectively). Therefore, reducing radiation due to high turbidity was estimated to be responsible for the reduced mortality in the inner part of the bay.

Results of spectrum analysis of turbidity and tide level showed that the turbidity of the inner part of the bay had tendency to increase during low tide. This phenomenon was attributed to resuspension of sediment, which was formerly deposited on tidal flats. Red soil, the main component of the sediment, was flushed to the bay by heavy rainfall and was stocked nearby tidal flat area. The deposited soil was resuspended and then gradually transported to around the inner part of the bay by tidal motion. This mechanism can create suitable conditions for maintaining higher turbidity and lower mortality of coral bleaching.

SC-22-29

Structure of juvenile coral communities at euphotic and mesophotic depths in Apo Reef Natural Park, Philippines

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Coral ecosystems especially at shallow depths are continuously threatened by natural and anthropogenic factors. For this reason, various studies are beginning to explore the role of coral ecosystems at mesophotic depths (30 to 150m) as potential refuge to marine life. To date, our knowledge about mesophotic biodiversity especially in the center of marine biodiversity, the Philippines, remains scanty. Here we provide a preliminary study of the structure of juvenile scleractinian corals in the euphotic (<30m depth) and upper mesophotic (30 to 40m) depths in Apo Reef Natural Park (ARNP) in the Philippines. Specifically, we assessed the variability in the richness and abundance of juvenile corals (≤50 mm maximum length) between depths and the association between juvenile coral and benthic community structure. We identified a total of 13 and 17 genera at euphotic and mesophotic depths, respectively, in three fringing reef sites in ARNP. In general, branching corals dominated the euphotic zone with *Seriatopora* spp. being the most abundant genus; while encrusting corals dominated the mesophotic zone with *Favia* and *Porites* spp. as the most abundant genera. Overall, coral recruitment was more prevalent in the mesophotic depth (86 individuals per transect) than in the euphotic depth (42). This may be caused by the difference in their benthic community structure, i.e., euphotic depths were either fully covered by live adult corals or with unstable substrate such as dead coral/rubble/rock/sand, while the mesophotic depths had a relatively more available stable substrate. Results provide insights into the coral community that could potentially thrive at euphotic and mesophotic depths and the influence of the benthic communities on juvenile corals. As ARNP is one of the remaining pristine coral ecosystems in the Philippines, results will serve as a benchmark for future studies on recovery of degraded coral communities in the country and region.

SC-23-135

Isolation of alkylquinolines and a nucleoside from a sponge-associated bacterium *Achromobacter xylosoxidans* strain ISP2-B-142-O-2-A

Miguel Aunario Azcuna

The coral triangle located in the Indo-Pacific is home to the most diverse sponge-assemblages in the world. Sponges are sessile filter feeders that provide thebenthic framework of the coral reef ecosystem. They can host horizontally or vertically-acquired microorganisms in their tissues, which comprise 40-60% of the biomass of the sponge. Marine microorganisms have become significant players inthe field of drug discovery, and this group currently ranks third in terms of the number of new compounds isolated, next to sponges and cnidarians. The aim of this study is to explore secondary metabolite production in a sponge-associated microorganism and evaluate its antimicrobial or antiviral activity. Achromobacter xylosoxidans strain ISP2-B-142-O-2-A isolated from a Haliclona sp. sponge was found to produce two known alkylquinolines and a known nucleoside. The alkylquinolines heptylquinolinol and nonylquinolinol were purified from the crude extract ofthe bacterium and showed Staphylococcus aureus activity. The nucleoside 5'-deoxyadenosine was also purified from the crude extract. It showed HIV cytoprotection and no significant cytotoxic activity to normal mammalian cells at the same effective doses. This is the first report of these natural products occurring in A. xylosoxidans, and it is proposed that they have distinct roles for the bacterium to persist as a sponge-associated microorganism

SC-24-213

Revelation of a hidden species in *Fungia fungites*

Yutaro Oku, Kenji iwao, Naoko Dewa, Hironobu Fukami

The coral genus *Fungia* in the family Fungiidae is a monotypic genus with a single species, *F. fungites*. *Fungia fungites* is a common species and live in the tropical and subtropical regions in the Indo-Pacific. This species is known to have two morpho-types, such as free-living (including type specimens) and attached types at the adult stage. Nishihira and Veron (1995) considered the attached type as a different species, *F.* sp. (Sessile). On the other hand, Hoeksema and Yeemin (2011) reported large attached *F. fungites*, so it is thought simply intra-specific morphological variation. In usual, the attached type lives on the shallow rocky zone (around less than 5 m), and there are no free-living types around. In contrast, free-living type occurs at the deeper zone such as the bottom of reef slopes. This habitat difference suggests these two types having different niche and ecologically independent species each other. In this study, we focused on the two morpho-types of *F. fungites* to clarify their phylogenetic relationships and to confirm whether the attached type is intra-specific morphological variation or separate species. We collected a total of 37 specimens of the two types of *F. fungites* from the Ryukyu Archipelago, Japan, and performed molecular phylogenetic analyses using two markers (mitochondrial cytochrome oxidase I and the nuclear ribosomal internal transcribed spacers), together with published DNA sequences. Our data revealed that the free-living and attached types were genetically distant from each other. Moreover, we found that these two types had the significant morphological differences at thickness of corallites and septal dentation. These results indicate that *F. fungites* is restricted to free-living type, and the attached type is a distinct and undescribed species of *Fungia*.

SC-25-17

A newly designed primer revealed high phylogenetic diversity of Endozoicomonas in coral and higher diversity in seawater

Jia-Ho Shiu

Endozoicomonas bacteria are commonly regarded as having a potentially symbiotic relationship with their coral hosts. However, their diversity and phylogeny in samples collected from various sources has not been clearly elucidated. Therefore, we designed an *Endozoicomonas*-specific primer paired with a bacterial universal primer to detect 16S ribosomal RNA (rRNA) genes of this taxon and conducted an in-depth investigation of the *Endozoicomonas* community structure in reef-building corals. The primer had high specificity in the V3-V4 region (95.6%) and its sensitivity was high, especially when *Endozoicomonas* was rare in samples (e.g. in seawater, which had higher alpha diversity of *Endozoicomonas* than corals). Our study is the first to report a high level of *Endozoicomonas* diversity in seawater. In coral samples, predominant V3-V4 ribotypes had greater divergence than predominant V1-V2 ribotypes, and were grouped into at least 9 novel clades in a phylogenetic tree, indicating *Endozoicomonas*had high phylogenetic diversity. In that regard, divergence within this genus was potentially higher than that among 7 outgroup genera, based on phylogenetic distances of partial 16S rDNA sequences, suggesting that taxonomy of this genus should be revised. In conclusion, dominant *Endozoicomonas* populations had variable phylogeny; furthermore, the newly designed primers may be useful molecular tools for reliable detection of *Endozoicomonas* community in marine environments.

SC-26-320

Phylogenomics of corals: Transcriptome-based target hybrid enrichment in Scleractinia

Randolph Zheng Bin Quek, Sudhanshi Jain, Mei Lin Neo, Danwei Huang

Our understanding of the evolutionary history of stony corals (Cnidaria: Anthozoa: Scleractinia) has been hampered by high levels of intraspecific morphological variation and plasticity, as well as difficulty in finding homologous traits among species of Scleractinia. In the last two decades, the molecular revolution has unlocked a treasure trove of information about their phylogeny, shedding light on evolutionary relationships. However, much uncertainty still shrouds their phylogeny due to scant and uneven coverage of sequencing in the few genetic markers used for coral phylogenetic analyses. The application of high-throughput sequencing for phylogenomics in Scleractinia is still fairly limited, and therefore, we resolved to use target-hybrid capture to reconstruct the scleractinian phylogeny. We first sequenced the transcriptomes of 16 coral species collected from Singapore. We assembled and cleaned the transcriptomes of Symbiodinium transcripts, included 28 publicly available transcriptomes of corals, and searched for single-copy orthologs across 44 different transcriptomes. We designed a total of 25,562 120-bp baits from 2741 genes, including two barcoding genes for species verification (COI and histone H3). We tested target-hybrid capture across the same 16 coral species, with 2 corallimorph taxa as outgroups. Here, we present the efficacy of the probes for target-hybrid enrichment, and their utility in phylogenomic reconstruction. Our work paves the way for an easy and affordable pipeline for coral phylogenomics to advance our understanding of scleractinian evolution, with wide-reaching impacts on various fields such as divergence dating and conservation.

SC-27-306

Biogeography, species boundaries, and invasive potential of the coral reef annelid species complex, *Chaetopterus longipes*

Jenna M Moore, Nancy Prentiss, Gustav Paulay

Chaetopterus longipes is an epifaunal suspension feeding annelid, occurring commonly in coral reef environments in the Indo-Pacific. The species was formerly synonymized under the putatively cosmopolitan species *Chaetopterus variopedatus*, however, it occupies an unusual habitat compared to most *Chaetopterus* species. *C. longipes* was described from the Maldive Archipelago, and has been reported in Japan, Easter Island, and the Galapagos Islands, spanning the Indo-Pacific basin. Despite its apparent wide range, genetic confirmation of the range of this species has not yet been undertaken. Here, we investigated whether cryptic species exist within this widely distributed species using genetics, and discuss its potential as a biological invader through observation of reproductive modes, habit, and range. Specimens of *C. longipes* were observed and collected from several localities spanning the Indo-Pacific and Caribbean, including the type locality. Additional specimens were examined from collections at the Florida Museum of Natural History and National Museum of Natural History. Genetic sequence data from COI mtDNA, 18S rRNA and histone H3 were obtained to screen for cryptic diversity and to establish the extent of the geographic range of *C. longipes*. Our findings suggest that *C. longipes* is composed of two broadly distributed, sympatric cryptic species. Some populations in both species exhibit both asexual and sexual reproductive modes. *Chaetopterus longipes* is likely to have strong potential for biological invasion, owing to its broad distribution in two ocean basins, capacity to colonize hard substrata in large numbers, and flexible reproductive mode.

SC-28-141

Diversity of zoantharians (Cnidaria: Anthozoa: Hexacorallia) in Palau

Hiroki Kise, Lori J Bell, Patrick L Colin, James Davis Reimer

Palau is known to harborthe highest marine biodiversity in Micronesia because of its combination of highly diverse habitats and location just outside of the Coral Triangle. Understanding the Palauan marine fauna is important to better understand how Palau acts as a link between the Coral Triangle and the rest of the Micronesian islands. However, taxonomy and diversity studies of many marine faunal groups are generally lacking, with the exception of some such as fishes and hard corals. In this study we examine one undocumented taxon, the order Zoantharia (Cnidaria: Anthozoa: Hexacorallia), which are characterized by forming clonal colonies without hard structures such as skeletons, and having polyps with two rows of tentacles.

In Palau, 4 genera and 8 species have previously been recorded from shallow coral reefs (Colin 2009; Reimer et al. 2013). We subsequently conducted collections of zoantharians from numerous sites (> 40 sites) across Palau, including diverse environments and examined photographic records. Our studies revealed that at least 11 genera and 24 species, including undescribed species, exist in Palau from intertidal zone to deep sea.

Although Palau has a relatively small area (over 1,000 km^2), its zoantharian diversity is comparable to other region; South China Sea (= 22 spp.), central Indo-Pacific (= 24 spp.), and southern Japan (= 28 spp.). All these areas are still understudied and very likely to also harbor additional species. Based on our study, we suggest that more research effort is needed on understudied environments such as deep waters (>200 m), deeper inner lagoons, and marine caves to better understand zoantharian species diversity and distributions.

SC-29-154

Distribution and population structure of two giant clam species (Cardiidae: Tridacna) of Perhentian Islands Marine Park, Malaysia

Li Keat Lee, Po Teen Lim, Mei Lin Neo, Zhen Fei Lim, Kieng Soon Hii, Hong Chang Lim, Chui Pin Leaw, Haifeng Gu

Giant clams are one of the key reef species contributing to overall reef biodiversity and functionality. Their ecological niche are significant where they act as caches of calcium carbonates for coral reef, contribute productivity to overall marine food webs and excellent holobiont host. Unfortunately, global warming and human-mediated threats have accelerated the loss of giant clams across the Indo-Pacific while they are in pressing need of conservation action. This study aimed to evaluate the diversity and distribution of giant clams around the Perhentian Islands Marine Park, and fill information gaps of population genetic connectivity between select *Tridacna* species of Perhentian Islands and other populations in the South China Sea. In our field surveys, two species of *Tridacna* were observed in Perhentian Islands: *Tridacna maxima* and *Tridacna squamosa*. The total abundance of *T. maxima* (401 individuals) was doubled of *T. squamosa* (195 individuals) across 13 sites; the highest clam density observed in the area was 17.4 individuals per 100 m^2. For juvenile clams (<5 cm in shell length), *T. squamosa* recruits were rare, while *T. maxima* juveniles were more abundant with 67 individuals recorded. This observation may clue in on the recruitment constraints in *T. squamosa* populations, but lesser for *T. maxima*. Molecular characterization of the samples collected is currently undergoing. Evidence of recent recruitment of giant clams in the survey sites was reassuring, as it stands for healthy and replenishing tridacnine populations in Perhentian Islands Marine Park.

SC-30-375

Differential effects of coral-giant clam assemblages on biofouling production

Isis Aline Guibert, Isabelle Bonnard, Xavier Pochon, Mayalen Zubia, Christine Sidobre, Gaël Lecellier, Véronique Berteaux-Lecellier

Benthic sessile communities are under direct and constant pressure of their surrounding environment. Therefore, many species have developed various mechanisms such as direct and indirect biotic interactions to maximize their survival. Most studies on host-environment interactions and associated production of bioactive compounds have focused on single species responses. Additionally, there exist very limited data on the effect of multiple interactive species on biofouling formation or their ability to minimize the dramatic impact that uncontrolled biofouling expansions may have on coral reef ecosystems. In this study, we combined cytological, metagenomics and metabolomics approaches to explore the interactive effect of multiple benthic species assemblages on the biofouling appearance and composition under normal or thermal stress conditions. Two common Indo-Pacific scleractinian coral species, *Pocillopora damicornis* and *Acropora cytherea*, and a filter-feeding organism, the giant clams *Tridacna maxima* were placed in 24 aquariums under varying assemblage combinations and heat stress conditions, and the influence of each assemblage on the algal biofouling formation was investigated. Biofouling communities were characterised using cytological and metabarcoding analyses. Our results revealed the formation of a unique biofouling community composition specifically derived from each interactive assemblage. Furthermore, a taxonomy-based profiling of bacterial function yielded distinct functional patterns with each assemblage. Finally, biofouling formation was significantly reduced when the three species co-occurred. Metabolomics' analysis suggested that this inhibition results from the production of a mixture of metabolites rather than a novel or particular metabolite in isolation. The possible effect of absorbed or released secondary metabolites on biofouling establishment will be discussed and the impact of interspecific assemblages on coral reef ecosystem will be highlighted.

SC-31-402

The role of sea urchins on coral resilience in Taiwan

Viet Do Hung Dang, Yoko Nozawa

Sea urchins play an important role in coral reef ecosystems. Via grazing algae, sea urchins create open space for coral settlement and facilitate coral recovery. There are many studies documented on the relationship between sea urchins, algae, and corals in the Caribbean and Great Barrier Reef. However, few such studies have been conducted in Southeast Asia. Accordingly, in this project, we investigated the quantative relationship between sea urchins, algae, and corals (including both adult and juvenile stages) at 45 sites in four representative coral reefs in Taiwan from 2016 to 2017; 10 sites in Green Island, 11 sites in Orchid Island, 9 sites in Kenting, and 15 sites in southern Penghu Islands. Structural complexity at three size scales (centimeter, decimeter, meter) of reef substrata was also measured as a key abiological factor influencing the relationship. Results indicated that large-sized sea urchins, *Echinothrix spp.* and *Diadema spp.* prevailed over herbivorous fishes and gastropods in many reef sites. We also found a positive correlation between densities of sea urchins and coral juveniles in Orchid Island and Kengting. By contrast, this pattern did not occur in Green Island and Penghu. For structural complexity, sea urchin abundance was positively influenced by reef complexity on a meter scale, along with coral juveniles on a centimeter scale. Because coral juvenile is a proximate indicator of coral resilience, our finding demonstrated that the large-sized sea urchins facilitate coral resilience in some reefs in Taiwan. Given widespread overfishing of herbivore fishes, this may occur not only in Taiwan but also in neighboring countries of Southeast Asia.

SC-32-179

Can Crabs' preying behaviors on sea urchins reduce corallivory and coral bioerosion?

Yip Hung Yeung, Jian-wen Qiu, James Yang Xie, Vincent Chi-sing Lai

Outbreak of the long-spined sea urchin *Diadema setosum* has been considered to be responsible for the local damage of coral communities in Hong Kong, as the urchin not only grazes on fouling algae grown on dead coral skeleton but also feeds on live coral tissues. A lack of predation by fish due to overfishing has been suggested to be the cause of the outbreak of the urchin populations. In this study we conducted caging experiments to quantify the predatory effect of the sea urchin on *Platygyra carnosa*, a structure forming coral species in northern South China Sea, and explored how such predatory effect on the coral could be reduced by *Thalamita prymna*, a common portunid crab in local coral communities. Our results showed that corallivory and coral bioerosion of *D. setosum* were density-dependent, with higher densities of urchins causing more live tissue loss and higher weight reduction. Introducing *T. pyrmna* into the cages resulted in the death of at least some of the urchins, reducing the coral tissue damage and bioerosion. These results suggest that limiting fish trapping in coral areas, which may result in crab bycatch, can be considered as a method to tackle the problem of urchin-caused coral damage.

SC-33-433

DNA barcoding of sharks species landed at Muara Baru, Jakarta based on mitochondrial DNA

Kevina Rizkikamila, Noviar Andayani, Djumadi Parluhutan, Budi Raharjo, Nurmila Anwar, Fitrian Dwi Cahyo, Dani Dasa Permana, Yunita Yunita, Effin Muttaqin, Benaya Meitasari Simeon, Muhammad Ichsan, Beginer Subhan, Hawis Madduppa

Exploitation of shark fisheries is caused by the high demand for shark products. Many local fishery companyin Indonesia export kinds of shark products to several countries. Products include dried fins, dried skin, frozen meat, which are sometimes illegal or mislabeled. Species Identification is almost impossible to be done since the sharks are mostly found with some key diagnostic features removed, or in an already preserved condition. This study aims to identify the species of sharks landed at Muara Baru using molecular approaches. DNA from the samples were amplified using CO1 target (Cytochrome Oxidase 1) mitochondria. Amongst the 37 samples sequenced, a total of 16 species were able to be identified and classified into 4 families including Carcharhinidae, Alopiidae, Sphyrnidae, and Hemigaleidae. Based on The World Conservation Union (IUCN) red list status of all 16 species, there are 7 near threatened species, 4 vulnerable species, an endangered species, a least concern species, and 3 unrated species. It is suggested that mitochondrial-based DNA barcoding can be used for shark species identification in order to assist in fisheries management and shark conservation.

SC-34-330

Energy pathways of coral reef-fish in the Maldives

Yiou Zhu, Nicholas Polunin, William Reid, Steven Newman

Coral reef-fish food webs are supported by multiple local and pelagic production sources. Interestingly some of those dietarily-strictly-categorized fish can utilize more than one production sources to supplement their nutritional and energetic intakes (e.g. scarinids, acanthurids). Preliminary data indicated that about 80% of the total biomass in the surveyed area were strictly or partially relying on zooplankton or zooplankton derived food items (e.g. faeces). Thus, roles of pelagic production sources in such food webs might be grossly underestimated. To understand food source compositions of coral reef-fish and re-evaluate the importance of pelagic sources into such food webs, six categorical primary consumers (*Acanthurus leucosternon*, *Ctenochaetus striatus*, *Chaetodon meyeri*, *Pygoplites diacanthus*, *Myripristis violacea*, *Caesio* spp) and production sources (*Halimeda* spp, *Pearsonothuria graeffei*, *Acropora* spp, *Hyritos erecta*, nocturnal plankton, *Copepoda* spp) representing six major energy pathways were sampled from inside- and outside-atoll coral reefs of North Malé Atoll, the Maldives to 1) discriminate isotopic signatures (bulk $\delta^{13}C$, $\delta^{15}N$) among production sources, 2) analyse isotopic compositions of these sources in consumers' white muscle tissues using Bayesian mixing model, and 3) detect spatial pattern of these two locations. Results improved our understandings on feeding strategies and resilience of some coral reef-fish, and signified the importance of pelagic production sources integrated into coral reef-fish food webs.

SC-35-451

Population biology of the coral trout, *Plectropomus leopardus* in two Live-Reef-Fish-for-Food-Trade sites in the Philippines

Robert Bryan Casauay, Rodulf Balisco, Zayda Halun, Samuel Mamauag, Porfirio Aliño, Hazel Arceo

Previous centers of the Live-Reef-Fish-for-Food-Trade-(LRFFT) in the Philippines have been reported to collapse due to its concomitant high fishing pressure levels. Stock assessments of target species, which are vital for LRFFT management programs, are rare in the Philippines, and are usually done only in response to already declining stocks. This study 1) provides baseline information on the most sought-after grouper species in the LRFFT, *Plectropomus leopardus,* in the town of Bongao, Tawi-Tawi, an emerging LRFT site in the Philippines located in southern Philippines; and 2) reevaluates the status of the species in Taytay, Palawan, the country's current center of LRFFT in the northeastern part of Palawan island. Results revealed that the Bongao population still has large and old individuals (SL_{mean} = 33 cm; age_{mean} = 9 yrs old). At least 80% of samples were above the minimum market weight of 500g ($weight_{mean}$ =1067g). Sex ratio was 4.85:1 while size and age at maturity were 27 cm and 4.2 years, respectively. In contrast, Taytay had significantly smaller and younger individuals (SL_{mean} =25 cm; age_{mean} = 7 yrs old) with 67% of the samples already falling below the minimum market weight ($weight_{mean}$ =492g). The 19.2:1 sex ratio indicates shortage of males in the population. Immature individuals comprised 20% of the samples, size and age at maturity were 19 cm and 3 years, respectively, and growth rate coefficient where higher (K=0.15) compared to Bongao (K=0.09). These suggest Taytay's population to be undergoing growth and biological overfishing and may have an altered growth rate as compensatory mechanism to deteriorating stocks. Therefore, existing LRFFT management programs such as the closed fishing season for the species must be strictly enforced in Taytay. On the other hand, the development of management programs for the Bongao LRFFT must be initiated soon to maintain the integrity of its grouper population. This study may serve as baseline data for future monitoring efforts and inputs to develop relevant management strategies for the live grouper trade in the Philippines.

SC-36-614

Variation between giant barrel sponges in the Pacific

Thomas Swierts, Nicole de Voogd

Giant barrel sponges in the Pacific have long been considered one species; *Xestospongia testudinaria*. The species occurs in a wide range of colours and morphologies. This variability is also present in the giant barrel sponge species from the Caribbean, *Xestospongia muta*, and it is practically impossible to differentiate between them without knowledge of their origin. Recently, it was shown that part of the morphological variation in *Xestospongia testudinaria* is related to mitochondrial and nuclear DNA markers. The existence of similar patterns in independent markers is very indicative for the existence of multiple (cryptic) species. Here we present the results of multiple studies seeking to map the variation between giant barrel sponges in the Pacific and their relationships to populations in other regions. We used different approaches, including phylogenetics, taxonomy and demography. Our efforts revealed three main genetically isolated groups often living in sympatry. One of these genetic groups is thought to be *Xestospongia bergquistia*, a giant barrel sponge species described in 1991 and previously considered to be restricted to Australia, but according to our data has a much wider distribution. Furthermore, we found that specimens in the Pacific can be genetically more closely related to a giant barrel sponge in the Caribbean, than to a sympatric individual on the same reef. The complex and intertwined nature of the phylogenetic tree of giant barrel sponge species suggests a long evolutionary history, that can potentially be related to major oceanic and geological events of the last hundred million years.

SC-37-195

Impact of artificial barriers on coral reefs biodiversity in Okinawa, Japan

Giovanni Diego Masucci, Piera Biondi, James Davis Reimer

Coral reefs in Okinawa, Japan, have been undergoing degradation for at least 80 years, mostly because of direct local human pressure, aggravated by global change. Their economic benefit has been estimated as 1.6 billion USD/year. Artificial barriers, like seawalls and concrete tetrapods, can lead to beach narrowing or loss, and exacerbate erosion, by increasing the intensity of longshore currents and preventing the exchange of sand between dunes and beaches. Despite this, artificial barriers have been massively deployed over the years in Okinawa, resulting in potential negative impacts on the surrounding coral reef ecosystem. Given how prevalent coastal construction is in Japan, it is important to clearly understand the effects and potential downsides that such large-scale deployments may cause. This study is the first in the Ryukyu Archipelago to compare demersal reef communities between natural and artificial coastlines. We compared diversity between 6 paired artificial and adjacent natural locations. The fauna within coral rubble was used as a diversity proxy, as rubble can host a variety of benthic taxa, including worms, crustaceans, molluscs, echinoderms, and fish. Each demersal animal, living inside or over the sampled rubble, was individually collected, photographed and preserved in ethanol. At high taxonomic levels (Phylum, Class), a reduction of biodiversity was seen from artificial sites, with trends towards a higher dominance and lower numbers of animals and taxa on rubble. Ongoing genetic analyses will allow to compare the two environmental situations at the species level. As global climate change will bring a rise of sea levels that will likely lead to an increase in the deployment of artificial barriers, the importance of this issue reaches far beyond Okinawa and Japan.

SC-38-771

Resort runoff threatens coral reefs: A novel isotopic assessment to test the ecosystem impact of sewage around Pulau Redang, Peninsular Malaysia

Liam Lachs, Le Quang Dung, Zainudin Bachok, Marc Kochzius, Kotaro Shirai

To maintain resilience, coral reef ecosystems rely on a site-specific combination of controlling mechanisms. Two well-documented processes, bottom-up nutrient availability and top-down herbivory, control the competitive ability of macroalgae to affect coral ontogenesis. The marine park status of the Terengganu islands, Peninsular Malaysia, has fostered a good condition of herbivorous fish communities. However, development of island tourism has increased the annual number of visitors by an order of magnitude in the past two decades (270,000 in 2016), contributing to enhanced nutrient-rich sewage pollution that may present an ecosystem scale threat to coral reefs around these islands. Using stable isotopic techniques combined with reef community composition data, we assess the spatial extent of sewage-derived nitrogen uptake in reef organisms and test the relationship between sewage influence and coral reef state around Pulau Redang (Redang Island). Considering the differential rates of isotopic fractionation between competitive macroalgae *Lobophora* spp. (days), corallivorous gastropods *Drupella* spp. (weeks), and branching coral *Acropora* spp. (months) we aim to identify the most suitable functional group as a bio-indicator. Preliminary results show significantly higher enrichment of $\delta 15N$ in *Acropora* spp. near sewage outflows and resorts on the eastern side of Redang (3.85 ± 0.18SE ‰) than at more pristine reefs on the uninhabited northern and western sides (3.02 ± 0.04SE ‰). In the literature, these levels are comparable to coral tissue from moderately sewage-influenced areas. Pristine sites may provide an isotopic baseline for monitoring in the light of new resort development plans. In Terengganu there is a need for better cooperation between state and marine park authorities to ensure that tourism-related nutrient enrichment does not cause reef degradation. Determining the ecological impact caused by nutrient enrichment is an important first step in the long term sustainable development of tourism on the now-booming Terengganu islands.

TBE-1-51

Species diversity and distribution of octocorals at Dongsha atoll in the South China Sea

Chang-feng Dai, Chi-Shiang Chin

The species diversity and distribution of cctocorals at Dongsha Atoll in northern South China Sea were studied in 2016-2017. A total of 119 species of octocorals belonging to 2 orders, 11 families and 31 genera were identified based on morphological characters. The octocoral fauna was dominated by soft corals of Subclass Alcyoniina (102 species), while the diversity of gorgonians (including subclasses Scleroxonia, Holoxonia, and Calcaxonia) was low (only 16 species). For the distribution and community structure of octocorals, a total of 30 video-transects (each 50 m long) covering all sectors of Dongsha Atoll were analyzed. Thirty images were randomly selected from each transect and the cover of octocorals as well as other benthos was quantified by CPCe (Coral Point Count with Excel extensions) software. The results showed that living cover of octocoral at Dongsha Atoll was highly heterogeneous and ranged from 0.22% to 73.67%. The highest octocoral cover were found on the outer reef slopes in northern, eastern and southern sectors of the atoll where octocorals occupy more than 30% of the substrate and become dominant in benthic communities, except that on the shallow reef front (<5 m depth) in eastern sector. Octocoral cover was low on western sector as well as the north and south channels. Very few octocorals were found in the lagoon where the coral communities were dominated by hard corals. The results of cluster analysis and nonmetric multidimensional scaling (nMDS) showed that the reef areas with high octocoral cover were homogeneous with similar composition of alcyonacean genera including *Sinularia*, *Lobophytum*, *Sarcophyton* and *Cladiella*. While, the reef areas with lower octocoral cover were grouped into several small clusters based on the dominant alcyonacean genera. The composition of octocoral fauna is not uniform, which may be related to the remote island and the species dispersal, and the distribution of octocoral communities is not homogeneous, which may be influenced by internal wave, current and sediments.

TBE-2-490

The shallow water soft corals (Octocorallia: Alcyonacea) off the eastern part of Mactan Island, Cebu, Philippines

Aubrey Jacklynn Abadiano, Filipina Boroy Sotto

The shallow waters of the Indo-Philippine-New Guinea archipelagos are considered to hold the most diverse number of soft coral species, however, the Philippine soft coral taxonomy remains poorly known today. Thus, the main purpose of this paper is to identify the soft corals (Octocorallia: Alcyonacea) off the eastern coast of Mactan Island, Cebu, Philippines. The octocorals were collected using SCUBA diving from three sampling sites: Brgy. Maribago, Brgy. Soong and Brgy. Punta Engaño. Two 5-cm fragment samples were collected per colony and were subjected to morphological and molecular examinations. For the morphological examination, the samples were anaesthetized, fixed, and preserved to get high-quality preserved materials, whereas for the molecular analysis, samples were directly preserved using 96-100% ethanol and were stored in 45-mL Falcon tubes. The 40 samples collected in this study yielded 26 morphologically distinct species under the families Tubiporidae, Alcyoniidae, Nephtheidae, Nidaliidae, Xeniidae, Briareidae, Melithaeidae, Acanthogorgiidae, Plexauridae, and Ellisellidae. With the use of 28S nDNA, ten out of the 26 morphologically distinct species were validated through molecular techniques. This paper is the first study that utilized an integrated approach in identifying the soft corals in Mactan Island, Cebu, Philippines.

TBE-3-219

Evaluating the Indo-Pacific genus *Cespitularia* and descriptions of new genera of the family Xeniidae (Octocorallia)

Yehuda Benayahu, Leen P van Ofwegen, Catherine S McFadden

Several species of the family Xeniidae, previously assigned to the genus *Cespitularia*, are revised. Based on the problematical identity and status of the type of this genus, it became apparent that the literature has introduced misperceptions concerning its diagnosis. A consequent examination of the type colonies of *Cespitularia coerulea* May, 1898 has led to the establishment of the new genus, *Conglomeratusclera* gen. n.; and similarly of *Cespitularia simplex* Thomson & Dean, 1931 to the new genus *Caementabunda* gen. n. Both genera are described and depicted and both genera feature unique sclerite morphology, further highlighting the importance of sclerite microstructure for generic assignment among Xeniidae. Freshly collected material was subjected to molecular phylogenetic analysis whose results have substantiated the taxonomic assignment of the new genera, as well as to synonymies of several others. As currently circumscribed, the new genera and in particular the respective species occur over a wide geographic range from the southwestern Indian Ocean (Madagascar) to Japan.

TBE-4-47

Using colony life-form to predict the health condition of *Tubipora musica* (Stolonifera)

Oktiyas Muzaky Luthfi

About six sites has been surveyed in Lirang Island, Southwest Maluku (Moluccas), Indonesia that was a remote area. Belt transects 1x100 m was lied down on each site and then counted and recorded the condition of *T. musica* as health (H), broken colony less 50% (B1), broken colony more 50% of colony area (B2) and death (D). The life form of *T. musica* also divided into two categories: massive (OM) and thick encrusting (OTE). The monitoring was conducted throughout of April 2016. The result showed the total about 379 colonies of *T. musica* was monitored which OM was dominated form (328 colonies) than OTE (51 colonies). And the total health (H) of *T. musica* was 87.33%, broken 1 (B1) was 2.63%, broken 2 (B2) was 6.33% and death (D) was 3.69%. In this monitoring, the etiology of disease in colony *T. musica* might not cause by micro bacteria, but more attention in other causalities, such as mechanical lesions or sedimentation. Various caused by mechanical lesions, such as: invading invertebrate, fish bite, algal competitor and physical causes (wave, a current of anthropogenic, sediment).

TBE-5-324

Mapping octocoral research in India and identifying challenges and needs for improved knowledge

Ramvilas Ghosh, Rajeev Raghavan, Ranjeet K

The tropical Indo-West Pacific, known for its remarkably high diversity and endemism of corals is however a region (especially Eastern Pacific and Indian Ocean) of data-deficiency in the case of octocorals, due to the largely opportunistic and sporadic nature of studies and biased sampling efforts. Though India is known for its distinctive tectonic history, paleogeographic position and unique biodiversity; there exists a huge knowledge gap in case of octocorals from Indian waters. Of the 174 online primary publications relating to octocorals from Indian waters, a considerable magnitude of work has been focused on diversity and bioactivity studies. Despite several publications on diversity and distribution, the taxonomic ambiguities and probable misidentifications have obliterated the actual octocoral diversity data of the Indian waters. The lacuna in studies related to ecology, threats and conservation are also evident. There is also a regional inclination in representation of octocoral studies where several regions, especially on the northern coasts, have been ignored. A significant number of non-peer reviewed publications (including predatory journals), inaccessible types, and obscure and in most cases erroneous records of species diversity have challenged the progress of octocoral research and science in India. The situation clearly indicates the need for increased taxonomic expertise and research initiatives in India to contemplate the 'biodiversity shortfalls'. Integrative taxonomy integrating morphology, molecular biology, ecology and biogeography serves to be the best way to overcome prevailing diversity and taxonomic ambiguities in this context. Besides improved publications, comprehensive and collaborative research projects, and standardizing museum facilities and allowing access would help improving the standard of octocoral research and receive global recognition. Future research should also focus on 'deep-sea octocorals' of the Central Indian Ocean and other diversity rich areas in this region (e.g. Lakshadweep and Gulf of Kutchh).

TBE-6-175

Annual gametogenesis pattern in two scleractinian corals, *Alveopora japonica* and *Oulastrea crispata* from high-latitude Jeju Island, South Korea

Jin-Soo Park, Shashank Keshavmurthy, Thatchaneshkanth , Hyun-Ki Hong, Sang-Rul Park, Kwang-Sik Albert Choi

Populations of high-latitude scrlactinian corals *Alveopora japonica* and *Oulastrea crispata* have been increasing recently in Jeju Island off the southwest coast of Korea, while no studies have investigated their reproductive physiology. We first examined the annual gametogenesis of those two species in Jeju Island. Coral colonies were collected monthly from the north and the south coast during 2015. Surface sea water temperature (SST) at the north site ranged from 13.72 to 24.01°C, and 14.70 to 25.02 °C at the south, annually. Histology revealed that the gonial cells (i.e., oogonia and spermatogonia) of *A. japonica* developed in separate mesenterial filaments of the polyps, while the cells of *O. crispata* develop in same mesenterial filaments. Histology demonstrated that the oogonia of *A. japonica* developed during September and October, a short period after the spawning. Mature eggs of *A. japonica* in the mesenterial filaments could be seen as early as in April, although most of the polyps contained the mature eggs or planula larvae in late August. During September and October, mesenteries of *O. crispata* were filled with fully mature eggs, suggested that this species spawn in late September and October, a month after as *A. japonica* spawned. Massive spawning of *A. japonica* and *O. crispata* in the southern Jeju Island were also observed by local SCUBA divers. Histology suggested that *A. japonica* and *O. crispata* have one spawning peak in Jeju Island, and seasonal changes in SST may govern the observed annual gametogenesis.

TBE-7-28

Gametogenesis and reproductive pattern of the reef-building coral *Acropora millepora* in northwestern Philippines

Elizabeth Jordan Gomez, Emmeline Jamodiong, Elizaldy Maboloc, Ronald Villanueva, Patrick Cabaitan

Coral reef populations continue to decline due to natural and anthropogenic disturbances. The persistence of coral populations mainly relies on natural recruitment through coral reproduction. However, studies on the reproduction of many important reef-building coral species in the center of marine biodiversity, the Philippines, are very limited. Here, we investigated the reproductive biology of the coral *Acropora millepora* in Bolinao-Anda reef complex, northwestern Philippines from February 2014 to March 2015, through in situ observation of gamete maturity and histological examinations of coral tissues for gamete development. Results showed an annual gametogenic cycle, with oogenesis and spermatogenesis occurring eight and three months, respectively, before broadcast spawning. Abundance and size of eggs in *A. millepora* were greatest during the months nearest to the spawning period. Broadcast spawning occurred around the months of February to April, which suggests an extended spawning pattern in periods when there is a rapid increase of sea surface temperature. This study provides additional information on coral reproduction in the region and reveals the potential of this species in providing coral propagules for the replenishment and recovery of degraded coral communities.

TBE-8-67

Timing of coral spawning and light signaling in the era of increasing ecological light pollution

Yaeli Rosenberg

Marine organisms live in a complex environment, governed by geophysical oscillations, influenced principally by the daily light/dark and monthly lunar cycles. Predicting such oscillations is important for any organism survival terrestrial or marine. Coral reefs are known to exhibit monthly cycles of spawning or planulation that correspond to nocturnal lunar light cycles. Timing of spawning may have significant impacts on reproductive success and larval survival. Sexual reproduction in corals is possibly the most important ecological process for the replenishment of degraded reefs and maintenance of the coral population and supports evolutionary processes, which may enhance fitness. To determine whether the endogenous clock is implicated in the regulation of reproductive behavior in corals, we characterized the transcriptome of *Acropora digitifera* colonies at twelve time points over a 2-month period of full and new moons, starting with the day of spawning in June 2014. We identified 608 transcripts with differential expression only on the spawning night during the coral setting phase and gamete release. Our data revealed an upregulation of light-sensing molecules and rhodopsin-like receptors that initiate different signaling cascades that all together lead to gamete release.

After finding this novel pathway that includes light sensing cascades we were interested in exploring the landscape of gene expression in coral reefs in the era of light pollution. The rapid industrialization and urbanization causing ecological light pollution to be widespread disturb many time based biological processes and cause a-synchronized outputs. We started with a mid-term "light pollution" experiment exposing *Acropora eurystoma* colonies to four months of artificial light. Our results indicate that corals under un-natural light cycles (i.e. light pollution) exhibit an extreme shift in gene expression and showed an elevated number of differentially express genes that are involved in many pathways controlling cell cycle, tumor suppression and reproductive failure.

TBE-9-370

Sex determination and planulation of caryophyllid coral, *Euphyllia glabrescens* in the central Philippines

Antonio Narollo Ayop, Filipina Boroy Sotto, Ethel Cabatinga Wagas, Mario V Aragon

The benthic marine invertebrates play an important role in timing of larval release to insure reproductive success and larval dispersal. Larval release is influenced by environmental factors that trigger the reproductive biology and ecology of organisms. Five mature brooding colonies of *Euphyllia glabrescens* with a colony diameter ranging from 7.5-20 cm at a depth range of 5-15 m were collected three (3) days before the commencement of planulation which usually occurred on the full moon week. One sacrificial colony was used for dissection and histological examination. A daily planulation monitoring of mature gravid colonies were done every eight (8) hours from 08:00 in the morning, 04:00 in the afternoon and 12:00 midnight. Released planulae were immediately collected and filtered using a nylon screen with 215µm mesh size. Result of this study concretely determined that *E. glabrescens* is a simultaneous hermaphrodite wherein testes and oocytes were developed in the same mesentery. The reproductive strategies of *E. glabrescens* were attributed by several factors such as time of the day, lunar period, temperature and season. Release of planulae in response to time of the day had usually two (2) peaks; major peak occurs in the evening and minor peak occurs early in the morning. The planulation was synchronized by lunar phases, planulation starts on full moon or third quarter and peak of planulation occurs 2 days before and after new moon. *E. glabrescens* require optimum temperature for major peak released of planulae ranges from 26.5°C to 28.47°C and highest planulation rate occurred during warm-wet season from June 2015 to October 2015. This study provides vital information on the early life history of reef building coral *E. glabrescens* for coral restoration and coral culture purposes. The unique strategy of larval release profound successful recruitment in the natal environment.

TBE-10-494

Comparison of spatial and temporal patterns of coral recruitment in the northwestern Philippines using three tile types

Dexter W dela Cruz, Ronald D Villanueva, Peter L Harrison

The success of coral larvae surviving and growing into adult corals is critical to the health of coral reef ecosystems. Successful coral recruitment is a key driver of coral reef recovery and resilience. Coral recruitment has been studied from low to high latitude reefs and most studies have quantified recruitment from recruitment tiles temporarily deployed on reefs. The wide range of methods and tile types used in studies potentially influences recruitment patterns thereby hindering accurate comparisons among reef areas. To examine the influence of different tile types on the spatial and temporal patterns of recruitment in three reef sites in Bolinao-Anda Reef Complex (BARC), Philippines, three tile types (natural, terracotta and fibre-cement tiles) were deployed and retrieved quarterly for 15 months. In contrast to previous studies, the density and composition of recruits were consistent among tile types. Recruit densities varied spatially and were highest in Caniogan Reef, followed by Cory Reef and Lucero Reef suggesting that coral recruitment in BARC is influenced to some degree by existing coral cover and distance from the major eutrophication source. The results of this study contrast sharply with some previous reports that indicate that coral recruitment patterns are strongly influenced by tile surface contour and structure. Development of a standardized recruitment tile with appropriate three-dimensional design features to facilitate recruitment by different types of coral larvae could be achieved using a range of different materials provided that the tiles are appropriately biologically conditioned prior to deployment on the reef.

TBE-11-301

Simulating the effects of colony density and intercolonial distance on fertilisation success in broadcast spawning scleractinian corals

Aaron Teo, Peter Alan Todd

As fertilisation success in broadcast spawning scleractinian corals is limited by sperm dilution and colony density, broadcast spawning corals are predicted to be vulnerable to the Allee effect. In situ studies are hindered by infrequent spawning events, lack of colony spatial distribution data, and difficulties in manipulating coral colony density. In this study, numerical simulations of broadcast spawning events were used so that colony density, size, position and current flow speed could be controlled. The number of gametes released by each colony of a given size were estimated by multiplying the means of polyp density, number of egg-sperm bundles released per polyp and number of gametes per egg-sperm bundle. The simulated gametes were released at fixed positions and dispersed in 3D at rates dependent on the flow speed while a fertilisation kinetics model estimated the number of cross-fertilisations per second. The simulations were used to investigate fertilisation success at various colony densities and the scale of distance at which reproductive contact between colonies became unlikely (critical intercolonial distance). Fertilisation success exhibited a logarithmic relationship as colony density increased, with low fertilisation success at densities similar to post-disturbance populations. Fertilisation events also rarely occurred between colonies that were more than 30 to 40 m apart due to low sperm concentrations and poor mixing between gametes from different colonies. Higher flow speeds improved gamete mixing between distant colonies but generally resulted in low fertilisation success while larger colonies reduced the impact of dilution due to increased reproductive output. The results support existing evidence for multiple spatially restricted breeding groups instead of homogeneous populations across a coral reef as well as the potential for strong component Allee effects due to broadcast spawning. Low density coral populations should be monitored for strong Allee effects, but this requires accurate measurements of spatial distribution.

TBE-12-649

Coral reef condition and corals recruitment potential in Bunaken Marine Park, North Sulawesi, Indonesia

Kakaskasen Andreas Roeroe, Minlee Yap

Current information on the condition of coral reefs is very important to know and to be used as one of the guidelines for management and utilization of coral reef resources. Indonesia is a country with the largest coral reefs in the world and the highest biodiversity of corals. This makes coral reef ecosystem economicaly important for our country especially for marine tourism. Especially for marine tourism industry in North Sulawesi is very dependent of healthy or unhealthy coral reefs it selfs. Bunaken National Park which is one of the popular marine tourism destinations in North Sulawesi and Indonesia. Information of coral reef condition and recruitment potential of corals in Bunaken Marine Park, will be observed for 3 years (start in September 2017) base on information of coral reef condition from permanent transect and settlement of recruits corals to coral settlement devices (CSD). New material and shape of CSD have been used in this study, which was designed easy to use by local and unskilled people. Coral reef condition will be observed continuously by setting up permanent transect and 3.000 CSD in total used to observed corals recruitment potential.Data collection for the 1st year has been successfully completed and will be performed at this symposium, and also we would like to show the current progress of the project

TBE-13-56

The role of biological clocks in the life coral reef and the timing of spawning

Oren Levy

The geophysical cycles in our planet Earth are mirrored in evolving endogenous clocks allowing organisms to anticipate daily and seasonal rhythms and to adjust their biochemical, physiological and behavioral processes accordingly. Many corals participate in a yearly cycle known as the mass-spawning event. This reproductive event is one of earth's most prominent examples of synchronized behavior and coral reproductive success is vital to the persistence of coral reef ecosystems. Although several environmental cues have been implicated in the timing of mass spawning, the specific sensory cues that function together with endogenous clock mechanisms to ensure accurate timing of gamete release are largely unknown. During the last few years we have characterized the cascade of spawning using transcriptomes analysis mainly on two *Acropora* coral species by sampling colonies at different timelines; before, during and post spawning. Our finding show that moonlight is an important external stimulus for mass spawning synchrony and describe the potential mechanisms for the signaling cascades that ultimately result in gamete release. We identify transcripts that vary only on the spawning night, with upregulation of light-sensing molecules and rhodopsin-like receptors that initiate different signaling cascades such as the glutamate pathway, SMAD signaling pathway, WNT signaling pathway, neuroactive ligand-receptor interaction and calcium signaling, which together, lead to gamete release. We also manage to identify RNA-editing, for the first time in the *Acropora* corals during spawning event. We found that the coral editome resembles the mammalian one: it contains more than 500,000 sites, virtually all of which are clustered in non-coding regions that are enriched for predicted dsRNA structures. RNA editing levels were increased during spawning and increased further still in newly released gametes. This may suggest that editing plays a role in introducing variability in coral gametes and implying on epigenetic intensifying during spawning.

TBE-14-403

Transcriptomic characterizations of the stony coral *Euphyllia glabrescens* illustrates the diel rhythmicity and higher responsiveness of host cells during the endosymbiosis

Hung-Kai Chen, Li-Hsueh Wang, Sabrina L. Rosset, Wan-Nan U. Chen, Chii-Shiarng Chen

Few mechanisms of the coral-*Symbiodinium* endosymbiosis have been elucidated despite decades of study. Based on the dynamic lipid body (LB) formation in coral gastrodermal cells, recent studies have shown that this symbiosis is diel-regulated and highlighted the active role of the coral host in symbiosis regulation. To investigate the diel-rhythmicity of gene expression related to LB formation, *de novo* next generation sequencing was performed in the scleractinian *Euphyllia glabrescens*. We examined the percentage and expression patterns of (*i*) differentially expressed genes (DEGs) in accordance to the diel cycle, and (*ii*) LB-related genes, in both host and symbionts. Results showed that the percentage of DEGs (log2 FPKM ratio >1 or <-1) in coral hosts is significantly higher than in symbionts (43.6% versus 16.6%). DEGs clustered into five distinct expression patterns in both hosts and symbionts. Statistics using coefficient of variation (CV) indicated that the number of genes with highly fluctuating expression patterns (CV, 0.917-1.009) is significantly higher in hosts than in symbionts (11.2% versus 1.8%). Although the mechanism of LB biogenesis is not elucidated yet, analyses of the expression of related genes should provide information to further confirm the rhythmicity and examine the role of host and symbionts in this process. Three functional categories were chosen for analyses, including Endoplasmic Reticulum (ER)-, Membrane Trafficking (MT)- and Lipogenesis (LG)-related. Percentages of these categories are similar between hosts and symbionts (ER, 3.8% versus 3.3%; MT, 7.1% versus 7.0%; LG, 3.7% versus 4.0%). However, expression patterns in hosts are more fluctuating than in symbionts (CV 0.18-0.203 versus 0.15-0.157). The present study, for the first time, provides genetic characterization to understand the diel-rhythmicity of the coral-*Symbiodinium* endosymbiosis. It suggests that the coral host is more responsive to the diel cycle than the symbionts and implies a superior role of hosts in regulating this symbiotic association.

TBE-15-459

Elucidating the mechanism of diel lipid body formation in the coral-*Symbiodinium* endosymbiosis

Sabrina Rosset, HK Chen, LH Wang, WNU Chen, CS Chen

Coral reefs are of immense global value and under considerable threat, yet we still lack a comprehensive understanding of how the coral-*Symbiodinium* endosymbiosis functions. Several studies comparing symbiotic to aposymbiotic cnidarians identified that lipid metabolism is central to the symbiosis with multiple genes being upregulated in the symbiotic state. Correspondingly, a cellular process that underpins the symbiotic state is the biosynthesis of lipid bodies (LBs) within the host gastroderm. LB formation depends directly on light irradiation and is subject to a diurnal rhythm, with LB size and abundance increasing during the course of the day and then diminishing to baseline at night. In order to further understand the mechanism of LB formation and its significance to the functioning of the symbiosis we aimed to elucidate the transcriptional regulation of the LB life cycle using next generation sequencing. We performed RNA-Seq analyses of our model species *Euphyllia glabrescence* at four time points during the course of one diel cycle. Assessment of the temporal expression fluctuation of host genes involved in lipid metabolism showed a prevailing up-regulation of genes involved in acyl chain remodeling, de novo fatty acid- and glycerolipid biosynthesis and lipid storage from sunrise to noon. Of particular interest are homologues of genes known to be key players in LB biosynthesis and catabolism in other organisms, including DGAT, Seipin-, Perilipin, FIT2- and ATGL-like genes. Validating the involvement of these genes in the coral LB life cycle will provide evidence for the host endoplasmic reticulum being the localization of LB biogenesis. Understanding the mechanism and localization of diel LB formation and catabolism will provide new insight into the coordination of lipid metabolism between the coral host and its algal symbionts and advance our understanding of the diel rhythmicity and functioning of this endosymbiosis.

TBE-16-313

Rarity of the 'common' coral *Pocillopora damicornis* in the western Philippine archipelago

Andrew Torres, Rachel Ravago Gotanco

Phenotypic plasticity and intraspecific variability have often led to the misidentification of the cauliflower coral *Pocillopora damicornis*, a species complex of several mitochondrial lineages that has been recently formally delineated into five species. With the recent revision of species boundaries, this study surveyed species of *Pocillopora damicornis sensu lato* (Veron and Pichon 1976) occurring throughout the Philippines. Employing a rapid PCR-RFLP assay using the mitochondrial control region and in combination with morphological characters, this study characterized the genetic diversity of *P. damicornis s.l.* from 13 locations along the western Philippine region, to identify potentially unrecognized species. Of the 694 colonies assayed, 75.7% (n=525) were reclassified as *P. acuta*. No *P. damicornis sensu stricto* (Schmidt-Roach *et al.* 2014) was detected among the samples. Sequencing the mitochondrial open region frame for a subset of the samples (n=152) corroborates these findings and further reveals the presence of at least three *Pocillopora* species (*P. verrucosa*, *P. meandrina*, and *P. brevicornis*) among the samples unresolved by the PCR-RFLP assay. Results confirm the occurrence of *P. acuta* populations in the Philippines and reveal the rarity of *P. damicornis s.s.*, calling for a redefinition of the distributional limits of these species. This study highlights the need to revisit this extensively studied and widely distributed scleractinian species complex and the necessity of complementing morphological identification with genetic validation.

TBE-17-342

Shallow-water Indo-Pacific black corals (Anthozoa: Hexacorallia: Antipatharia) from the eastern part of Mactan Island, Cebu, Central Philippines

Kurt Bryant Balinario Bacharo, Filipina Boroy Sotto, Antonio Narollo Ayop, Clyde Kristoffer Ceniza, Nico Brian Bautista Uy, Pierre Anthony Gwen Ilano Abella

Order Antipatharia (Milne Edwards and Haime, 1857) belonging to the anthozoan Subclass Hexacoralllia is composed of 7 families, 43 genera and over a 235 species that can be whip or branch-like in morphology. It is characterized by its spiny proteinaceous skeleton that can range from black to brown in color. In the Philippines, hardly is known about black corals since there have been few published works on Philippine black corals whether ecology or taxonomy. But even with this dearth on studies of Philippines black corals, million pesos worth of black coral harvest were reported in the country, hence the significance of this study. With permission from the local government of Lapu-Lapu City and Municipality of Cordova sample collections were carried out off the reefs of the eastern part of Mactan Island by means of SCUBA within a depth range of 5-35m during the periods of August 2016-Febraury 2017. Collection sites were characterized by having a vertical wall, rocky, and strong currents. Black corals were photodocumented *in situ* and colony height was measured before an inch of black coral were taken from the colony. Immediately in the laboratory the live unfixed samples were photodocumented using Moticam10 that is attached to Motic SMZ-17 stereoscope afterwhich samples were divided into three portions and was fixed in (1) 10% formaldehyde in seawater, (2) 90% ethanol, and a processed proteinaceous skeleton in (3) 90% ethanol. Spine morphology were photodocumented using AmScope Microscope Digital Camera attached to ASA-168206 stereoscope. Species identification followed that of Wagner (2011) and was based on the following morphological features: morphology of the colony, morphology of the polyps, and morphology of the spines. A total of 30 black coral species have been examined and identified belonging to two families (Myriopathidae and Antipathidae), four genera (*Antipathes*, *Cirrhipathes, Stichopathes, Myriopathes*) and 14 distinct species.

TBE-18-486

Revisiting the threatened Scleractinia in the Calamian Islands, Palawan, Philippines

Katrina S. Luzon, Wilfredo Y. Licuanan

The Philippines is a biodiversity hotspot for scleractinian corals. However, there is a dearth of information on the history of occurrence and current distribution of these corals within the country, hindering the determination of their conservation status. One of the most extensive species inventories of Scleractinia in the Philippines was made two decades ago in the Calamian Islands, Palawan. Taxonomic surveys were made in 23 sampling stations in 2015 and 2016 to update this inventory and assess the extinction risk of the corals in these islands. In each of the stations, sweep dives were made from the reef edge to the reef flat and all unique coral colonies that were encountered were photographed. The corals in the photographs were then identified to species-level in the laboratory. About half of the coral species that were classified as Endangered, Vulnerable, and Near Threatened in the IUCN global Red List had significant reductions in their frequency of occurrence and area of occupancy in the Calamian Islands. Some species are potentially locally extinct. These findings bear on the possible uplisting of extinction risks of several coral species in the region. Elevated extinction risks of corals in one of the most diverse regions for Scleractinia in the country indicate the necessity for a national evaluation of such risk in the rest of the Philippines.

TBE-19-269

Distribution and abundance of the non-indigenous invasive coral species, *Carijoa riisei*, at Pulau Payar Marine Park

Normah Said, Yuek-Ming Ho, Nizam Bin Ismail

The presence of the non-indigenous invasive coral species, *Carijoa riisei* in Pulau Payar Marine Park waters was identified after the species invaded one of the most popular dive sites in this waters, namely, Coral Garden. As *C. riisei* is an alien species that has high reproduction features and able to dominate its new habitat successfully, basic data concerning the distribution pattern and abundance of *C. riisei* invasion within Pulau Payar Marine Park waters was very important to enable effective remedial actions to be taken in controlling the overgrowth of this invasive species. The photo quadrat method is used to assess the *C.riisei*'s condition in the study sites and the Coral Point Count with Excel extensions (CPCe) v.4.1 software was used to analyse the photo quadrat digital images taken from the survey. From the preliminary survey, the *C.riisei* was found abundant at the depths of within 10 to 20 metres at each of the study sites. The analysis of variance showed the distribution of the *C. riisei* was no statistically significant difference while the diversity and evenness of this species has a greater value compared to the native species in all of the study sites. The presence of a suitable substrate and environmental factors encouraged this species to spread widely in this waters. Specific studies on the native species that have been affected by the invasion of *C. riisei* should be done to prevent the loss of marine biodiversity in future.

TBE-20-707

IOC/WESTPAC Coral Reef Conservation Project

Suchana Chavanich, Somkiat Khokiattiwong, Wenxi Zhu

UNESCO IOC Sub-Commission for the Western Pacific (IOC-WESTPAC) has been promoting international cooperation and coordinating programs in marine research including capacity building. One of the projects which is high priority interest among member states is Coral Reef Conservation. Originally, the program was under Coastal Marine Biodiversity and Conservation, which was approved during the Seventh Intergovernmental Session of the IOC Sub-Commission for the Western Pacific in Malaysia in 2008 as a contribution to the High Level Objective of UNESCO/IOC in safeguarding the health of ocean ecosystems. The project focuses and covers 3 study areas 1) biodiversity and taxonomy of coral reef organisms, 2) effect of disturbance and current stressors on coral reef biodiversity, and 3) restoration and rehabilitation of coral ecosystems. Currently, there are several activities being conducted including organizing workshops related to coral reefs, synthesizing data for further management in local, country, and regional levels, and raising awareness of coral reef conservation among youths and locals. In addition, collaborations within IOC/WESTPAC projects and other international organizations have been emphasized. More details of activities will be showed.

TBO-1-350

On the neglected diversity of crustacean copepods living on stony corals (Lizard Island, Great Barrier Reef)

Viatcheslav Ivanenko, Mikhail Nikitin, Sofya Mudrova, James Reimer, Michael Berumen

Copepods are a large group of microcrustaceans filling an enormous number of ecological niches. Currently more than 360 species are known to live symbiotically with more than 150 species of hermatypic corals (primarily Order Scleractinia); 46 species of copepods are found living on hermatypic corals of the Great Barrier Reef (GBR). The biology of these copepods and their significance for corals remain unexplored despite the fact that copepods are found (i) in large aggregations (up to tens of thousands of specimens of ten species of copepods) in one colony of coral, and (ii) in almost every coral colony inspected. In this study, we developed original approaches that allow us to conduct a complete study of the diversity of copepods living on corals, and also to estimate their specificity to the host species. The study was based on (i) the use of an original and inexpensive protocol to extract DNA from each copepod specimen that still leaves the exoskeleton intact for morphological study, and (ii) analyses of both molecular and morphological data of each of collected coral host. 26 coral colonies representing 25 species in 17 genera (*Acropora, Astreopora, Ctenactis, Echinopora, Fungia, Galaxea, Herpolitha, Lobophyllia, Merulina, Montipora, Pectinia, Platygyra, Polyphyllia, Porites, Seriatopora, Stylophora, Tubastraea*) were collected in 2010 near Lizard Island on the GBR, and all copepods were removed from them. Analyses of three fragments of nuclear and mitochondrial DNA (18S, ITS2, COI) of only the most abundant copepod morphotypes (=190 specimens) representing about 1/3 of the found morphotypes, revealed nearly 70 potential species (MOTUs), most of which were found only on one coral host. The data clearly show the effectiveness of our approach but also indicate that there is significant diversity of microsymbionts present in corals that require further investigation. Comparative differences in copepod assemblages in corals under both regular and stressed conditions remains to be conducted, but given the recent bleaching on the GBR, many of these microsymbionts may be under threat alongside their coral hosts.

TBO-2-153

How many species? Documenting hermit crab diversity in the Philippines

Maria Celia (Machel) D. Malay

Crustaceans are a large and diverse group, and comprise a major source of marine biological diversity in megadiverse regions such as the Philippines. In a recent paper we described a new species of diogenid hermit crab, Dardanus balhibuon Malay, Rahayu, & Chan, 2018; resurrected another species D. sanguinolentus (Quoy & Gaimard, 1824); and compiled all known valid records of Philippine hermit crabs, for a total of 153 species. This is likely an underestimate of the true levels of hermit crab diversity given that only 64 species have been reported from the family Diogenidae, which is known to be particularly species-rich. In this study hermit crab species richness will be compared across the Indo-West Pacific by compiling records from well-studied localities. Patterns of diversity appear to vary by genus. Ongoing intensive surveys in the Western Visayas have already resulted in over 500 crustacean specimens, all of which are vouchered, photographed, and tissue-subsampled. Thus far at least two crustacean species represent new records for the country, and it is expected that many more will be found.

TBO-3-300

Preliminary study on the morphological variations in selected populations of *Scarus niger* (Scaridae) in the Philippines

Estephen B Fortela, Victor S Ticzon

Morphological analysis has been established as a tool to discriminate populations in reef fish. However, few studies have utilized this method to analyze geographically separated populations of scarids in the Philippines. The study aims to determine the pattern of morphological variations among the selected populations of *Scarus niger* in Batangas, Romblon, and Zambales using linear measurements (size) and landmark-based geometric morphometric analysis (body shape). Morphometric characters were measured in each individual using ImageJ software. For the body shape analysis, landmark points were laid on each photograph of fish samples through tpsDig software and generated thin-plate splines of each populations were analyzed using MorphoJ program. Sizes and body shape of each population were analyzed using Linear Discriminant Analysis (LDA) and Canonical Variate Analysis (CVA), respectively. Discriminant analysis showed variations on the morphometrics of the three populations. Most of the individuals in Batangas population exhibited compression of the ventral body region, and elongation of the caudal peduncle and head length compared to the samples collected in Zambales and Romblon populations (DF1 = 72.35% variance). DF2 (16.82% variance) explains the elongation of the body size (i.e., increased standard length and dorsal fin base length) and increase in body depth in both Romblon and Batangas populations. In contrast, CVA showed significant variations in the body shape of the three populations (CV1=72.3% variance) ($p<0.001$ Mahalanobis Distance). Both Romblon and Zambales populations exhibited expansion of the ventral and dorsal body regions, and compression of the head and caudal peduncle. While the Batangas population showed expansion of the dorsal region of the head and compression of the caudal peduncle.

TBO-4-45

Fish diversity as a function of depth and body size

Klaus M. Stiefel, Timothy Joseph R. Quimpo

We analyze the number of marine fish species as a function of fish body size and occurrence depth. For this purpose, we analyze the FishBase database. We compare these data to predictions of fish species numbers derived from the neutral theory of biodiversity combined with well-established ecological scaling laws, and measured oceanic biomass data. We consider several variants of these scaling laws, and we find that more large fish species exist compared to the prediction, which is especially true for elasmobranchs, possibly due to their overwhelmingly predatory niches. We find species numbers decreasing with occurrence depth somewhat quicker than our predictions based on the decrease of the number of individuals with depth indicates. This is especially true for the elasmobranchs. This is unsurprising, since the individuals versus depth data did not specifically determine elasmobranch biomass, and since sharks are known to be limited to depths < 3,000 m. Finally, we discuss how a reduced rate of speciation in larger animals could explain why large species are rare, in spite of the advantages of large body sizes outlined in Cope's rule.

TBO-5-338

Nocturnal and tidal rhythmicity in the movement of pacific sugar limpets, *Patelloida saccharina* in Samal Island, Davao Gulf

Eliza Ysabelle Zapanta, Maybelle Fortaleza, Merlene Elumba, Reena Cyndi Uy, Cleto Nañola, Jr.

Most marine gastropods exhibit nocturnal activity and are highly influenced by circatidal rhythms. The activity of Pacific sugar limpets, *Patelloida saccharina* in relation to time of the day and tidal cycle was investigated along the rocky intertidal shores of Samal Island, Davao Gulf. A coordinate system was devised and used to observe their diel movement where changes in position and corresponding tidal height were recorded. In situ observations revealed that *P. saccharina* movement commenced as soon as it is dark and when they are partially submerged in the water, as a result of the incoming of the tide. Limpet activity was continuous with increasing tidal height and this was uniformly observed across all lunar phases. Limpets were observed returning to their home scars as the tide recedes, at 2:30 AM during the neap tide and at 5:30 AM during the spring tide. No significant activity was observed throughout the daylight hours, regardless of the incoming or outgoing of the tide. The absence of daylight and submersion to water during the flowing of the tide are key requirements for *P. saccharina* limpets to move whereas cessation of limpet movement is influenced by presence of daylight. Moreover, strong wave action during unfavourable weather conditions was also seen as a limiting factor to their movement despite the long hours of darkness and total submersion in the water. This study posits that hours of darkness and tidal regime are coupled drivers of movement in *P. saccharina* limpets and that strong wave action and presence of daylight are identified as exogenous factors that impede their activity. The inactivity of *P. saccharina* during daylight hours indicates an adaptive mechanism to avoid predation and desiccation.

TBO-6-43

Diel pattern activity and prey preference of *Cassis cornuta* (Helmet Shell)

Lala Grace Edis Calle, Patrick Cabaitan, Sherry-Lyn Sayco, Cecilia Conaco

The horned helmet shell, *Cassis cornuta*, is one of the largest gastropods and a known predator of echinoderms. However, because of their large size, they are vulnerable to overexploitation mainly for food and the decorative shell trade. To aid in conservation of *C. cornuta*, there is a need to better understand its feeding behavior and preferences, as an initial step towards developing culture methods for the replenishment of the stocks of this species. In this study, we examined the diel pattern activity and prey preference of *C. cornuta* on different species of sea urchins. Hourly visual observations were conducted for 96 hours to record the diel activity pattern of the gastropod. Laboratory choice experiments were conducted by providing *C. cornuta* with combinations of different species of sea urchins, including (1) *Salmacis sphaeroides*, (2) *Tripneustes gratilla*, (3) *Diadema setosum*, and (4) *Echinothrix diadema*. Most *C. cornuta* individuals remained burrowed during day time and were more active at night. The animals fed on both *S. sphaeroides* and *T. gratilla*, but preferred the former. They can consume an average of one sea urchin every two days. Consumption of long-spined species of sea urchins, such as *D. setosum* and *E. diadema*, were rarely observed. These results provide information on the diel activity pattern and prey preference of *C. cornuta*, which are essential for the development of culture and rearing techniques necessary to support future helmet shell conservation efforts.

TBO-7-275

Shell use, population structure, and reproductive pattern of two species of *Clibanarius* hermit crabs from Taklong Island National Marine Reserve, Western Visayas, Philippines

Dina Mae Llido Ranises, Maria Celia D. Malay

Hermit crabs constitute a significant portion of the macrobenthic assemblage in intertidal habitats, where their abundance and distribution are primarily influenced by competition for available gastropod shells. Despite their ubiquitous presence, the population ecology of intertidal *Clibanarius* species from the Indo-Malay region is less studied. This study is being conducted in order to understand how a common resource, the gastropod shell, influences the population structure of closely-related species. The abundance of the two most abundant *Clibanarius* species, *C. merguiensis* and *C. virescens*, in a rocky intertidal area is assessed once a month during low tide. Collected samples are identified to species, measured, sexed, and the reproductive condition of females is noted. Their shell use and shell condition are also determined, as were the relationship between crab and shell size. The site's temperature, salinity and sediment organic matter content are also assessed to examine the relationship of species assemblages with these environmental factors. Results of this preliminary study will contribute to the scarce ecological studies of hermit crabs in this region and could provide baseline ecological information from a fragile and increasingly-threatened nearshore habitat.

TBO-8-544

The reproductive characteristics of coral-killing sponge, *Terpios hoshinota* (Rutzler and Muzik, 1993) in Pulau Redang, Malaysia, South China Sea

Nurzahirah Kamarudin, Chun Hong Tan, Zainudin Bachok, Muhammad Hafiz Borkhanudin

Terpios hoshinota (Rützler & Muzik, 1993) is an encrusting, cyanobacteria sponge that is currently one of the threats to coral reefs. It can overgrow on live and dead corals, and any hard substrates available including living shells. During outbreaks, *T. hoshinota* had cause 30% to 80% of coral loss throughout the western Pacific. However, the information about*T. hoshinota* in South China Sea especially on reproductive aspects remained scarce. This study examined the reproductive structures of *T. hoshinota* and aimed to understand its' reproduction pattern in Malaysia. Fifteen colonies from three different sites at Pulau Redang, Terengganu were first selected randomly. Tissue samples were collected then processed via histological technique for gonads observation. Sampling was conducted monthly from April to October 2016, each within three days of the full moon period. *T. hoshinota* is hermaphrodite and viviparous sponge. Overall, at least 87% of active gonads were recorded at all sites from April to September. In October, the percent active gonad reduced to half (43%) compare to previous months. From the histological slides, reproductive structures such as spermatic cysts, oocyte, blastomere, early embryo, cell mass and pre-larva were observed. Spermatic cysts and oocytes were present in all months. Meanwhile, pre-larvae were not found in July and September. Active gonads observed every month showed that *T. hoshinota* reproduce continuously. Then, reproductive activity may reduced during the monsoon (November to February). However, data collection during monsoon was not feasible due to safety reason.

TBO-9-435

Feeding preferences of the crown-of-thorns sea star (*Acanthaster* sp.) on the coral reefs of Koh Tao, Thailand

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Increased tourism and rapid development has dramatically altered the environment and economy of the island of Koh Tao, Thailand, over the last 3 decades. This study used various data sets collected between 2006-2017 to investigate prey preferences, size class distribution and population dynamics of the corallivorous Crown of Thorns sea star, *Acanthaster* sp. The study found that of 619 *Acanthaster* collected, 77% were actively feeding during the day time, with the majority feeding on *Fungiidae* (19.1%), followed by *Acropora* (13.7%), *Porites* (9.1%), *Pavona* (9.1%) and *Favites* (7.9%). Substrate surveys conducted across 11 different key locations around the island 2006-2017, showed that *Porites* (8.4%), *Pavona* (8.1%), *Acropora* (7.9%), and *Diploastrea* (6.0%) make up the 4 most dominant coral genera on the island (respectively), with *Fungia* making up only 3.9% of the reef substrata despite being the most preferred prey species of *Acanthaster*. Furthermore, large aggregations of the sea star are regularly observed in reefs dominated by mushroom corals, and so far have not been observed in any other reef types around the island. This change in prey preferences and feeding behavior may be indicative of other changes occurring on the reef, and the causes and potential effects of this shift warrant further investigation. Regular collections of *Acanthaster* were conducted over the course of the study to mitigate the rates of coral mortality being observed around the island, but *Acanthaster* populations were not significantly altered by these activities. The results of this study suggest a continued need for regular coral predator collections, and the refinement of population management strategies, particularly for the coral genera that are under the greatest threat of *Acanthaster* predation would help mitigate further threats to the reefs of Koh Tao.

TBO-10-86

Differential consumption of scleractinian broadcast spawning and non-scleractinian brooding coral larvae by planktivorous damselfishes

Timothy Joseph Rama Quimpo, Patrick Cabaitan, Andrew Hoey

Many species of planktivorous fishes are known to opportunistically consume coral larvae. However, few studies have investigated the consumption rate of fishes on coral larvae, how this varies among fish species, coral reproductive strategy and developmental stage, as well as, the functional response of the fishes. Here, we offered larvae of a broadcast spawning scleractinian coral (*Acropora hyacinthus*) and a brooding non-scleractinian coral (*Heliopora coerulea*) to two species of planktivorous damselfishes, *Amblyglyphidodon sexfasciatus* and *Abudefduf curacao*, and recorded their rates of consumption. *A. sexfasciatus* had a consumption rate of 44 to 99%, while *A. curacao* had a rate of 43 to 67%. There were no differences in consumption rates between the two fish species and between a 2 day and a 5 day old *A. hyacinthus*larvae. For both fish species, consumption rate was significantly lower on *H. coerulea* compared to *A. hyacinthus* larvae. The functional response varied between the two planktivorous fishes. *A. sexfasciatus* exhibited a decelerating intake rate (type II) on 2 day *A. hyacinthus* and *H. coerulea*, and a sigmoidal intake rate (type III) on 5 d *A. hyacinthus*; whereas, *A. curacao* showed a linear intake rate (type I). Planktivorous fishes are generally visual predators and should have consumed more of the larger brooding coral larvae than the smaller broadcast spawning coral larvae. This observation suggests that other factors such as coral larvae behavior may have contributed to the differences in consumption. Most of the brooding coral larvae tended to use the lower part of the water column, while broadcast spawning coral larvae tend to use the whole water column, which may have made them more visible and vulnerable to planktivorous fishes. Further, the functional responses exhibited by the planktivorous fishes suggest that susceptibility of coral larvae is dependent on the both the composition of predators and prey, and the densities of coral larvae prey.

TBO-11-72

Effect of competition on the territorial behaviour of *Plectroglyphidodon lacrymatus*

Laurence Evangelista Robles, Patrick C Cabaitan, Maria Eleanor B Aurellado

Farmer damselfish establish territories on the reef where they cultivate algal turfs. Some farmer damselfish species are solitary while others form colonies and cooperate in cultivating and defending their farms. However, the effect of competition with other farmers on the territorial behaviour of farmer damselfishes is poorly understood. *Plectroglyphidodon lacrymatus* territories are proliferating in the degraded reefs of the Bolinao-Anda Reef Complex, northwestern Philippines, which made the examination of this species essential. In this study, we examined the territorial behaviour of a solitary farmer damselfish, *P. lacrymatus*, in the presence of adjacent territories of conspecific and heterospecific individuals. Sizes of the territories, i.e., the extent of the area the farmer damselfish swims from their individual turf algal patches, were measured in the field through the underwater video recordings. The territorial aggression towards adjacent farmers was also quantified. *P. lacrymatus* territories were smaller (~60%) in the presence of an adjacent conspecific farmer, whereas an adjacent heterospecific farmer has no significant effect on the territory size. Aggression towards conspecific farmers was also higher (~90%) as compared to heterospecific farmers (~30%). Although farming activities were not quantified, the higher aggression exhibited by *P. lacrymatus* towards conspecifics suggests that more time was probably allocated to defence, which consequently decreased the territory sizes. Results of the study provide baseline information for the assessment of long term influence of the dynamics of damselfish territoriality on the recovery of degraded coral communities.

TBO-12-430

Predator avoidance influences herbivore foraging behavior

Andrew G. Bauman, Glenn Dunshea, Jenny Fong, Peter A. Todd, Andrew S. Hoey

Non-consumptive effects occur when prey modify their behaviour and habitat use patterns to avoid large predators. Recent studies on coral reefs indicate that feeding by macroalgal browsers are reduced when in close proximity to large predators or stationary predator models, which in turn can influence benthic community dynamics. However, predator avoidance is not a uniform process across seascapes or prey species, and is also dependent on ecological context (e.g. habitat complexity, predator diversity, prey behavior and predator and/or prey density). Group feeding has been hypothesized as a strategy to reduce non-consumptive effects, but little is known about how predator presence affects group foraging behaviours among browsing fishes. To address this, we investigated how predator avoidance affects the foraging behavior of macroalgal browsers on Singaporean coral reefs by simulating predator risk using fiberglass model predators (grouper *Plectropomus leopardus*). We quantified how predator avoidance alters the consumption of assays of *Sargassum ilicifolium* across space (distance from predator) and foraging group size to examine how browsers reconcile the conflicting demands of avoiding predation vs. foraging. We found that browsing fishes took longer (~23–37 mins) to begin foraging on assays closest to the predator and consumed considerably less macroalgae (1.7–2.3 g 4 h^{-1}) at lower rates (~6.4 ms-bites h^{-1}) than browsers that fed on assays at greater distances. Proximity to the predator also strongly influenced the number of individuals foraging, with larger groups feeding (>4 individuals) more frequently on assays furthest from the predator. Collectively, these findings emphasize the importance of considering the spatial context of predator-prey interactions that structure macroalgal communities, and suggests that predator density and distribution, in addition to group foraging behavior, are important factors for explaining spatial variability in macroalgal removal on coral reefs.

TBO-13-573

Assessing the trophic role of copepod in coral reef ecosystem

Simin Hu, Sheng Liu, Xianzhi Lin, Tao Li, Hui Huang

As main group of mesozooplankton, copepod play a significant role in trophodynamics of coral reef ecosystem, serving as food sources for many coral fish and some reef-building coral. They usually have high density in coral waters while the biomass of phytoplankton in coral reef ecosystem is low. To explore this dichotomy between the limited primary production and relatively high zooplankton stock, we collected both benthic and planktonic copepods from coral ecosystem of Sanya Bay and analyzed the in situ diet of dominant species by molecular methods. Various prey items were detected for different copepod species, including microalgae, protozoan, metazoan, land plants and fungi. Benthic copepods, such as *Harpacticus*sp. and *Oithona* sp., fed mostly on benthic diatoms (e.g., *Bacillaria*, *Cylindrotheca*, *Navicula*) accounting for approximately 60-80% of total diet composition, indicating that the primary production from benthic algae could be transferred upward by copepod. While for planktonic copepods, such as *Temora* and *Subeucalanus*, organic detritus originated from land plant and metazoan was predominant food. Predation on these detritus can not only subsidize zooplankton production in coral waters where phytoplankton biomass is limited, but can also accelerate the biogeochemical cycles of carbon along the food chain in coral reef ecosystem. These results demonstrated that copepod play important role in the recycling of particulate organic matters in the coral reef ecosystem.

TBO-14-587

Influence of substrate covers of a branching sponge *Callyspongia samarensis* on the interactions of reef associated predator and prey fish species

Eena Nuevas, Patrick Cabaitan, Maud Ferrari, Gaëtan Vallet, Sherry-Lyn Sayco, Ronald Olivades

Anthropogenic and natural disturbances have negatively impacted coral reef benthic communities and substrate complexity that consequently reduce local biodiversity and productivity. Shifts from domination of corals to sponges brought about by these disturbances have been documented on many coral reefs. However, few have assessed the influence of shifts to high sponge cover on the interactions of reef associated predator and prey fish species. *Callyspongia samarensis*, a branching sponge, are proliferating on many degraded coral reefs in the northwestern Philippines. We examined whether *C. samarensis* can provide shelter for juvenile reef fish, *Chromis viridis*, from predation by a grouper, *Epinephelus merra*. To test the hypothesis that higher substrate covers of branching sponges are more effective in protecting juvenile reef fishes from predation, a hatchery experiment was conducted by providing the juveniles with shelters of different amounts of sponges. Visual and video observations were employed to quantify the survivorship of juveniles from predation and to examine the behaviors and interactions of the juvenile and predator fishes. Interestingly, *C. viridis* with no sponge shelter (control treatment) had the highest survivorship. Without shelter, *C. viridis* constantly swam and were able to escape from *E. merra* when being pursued. On the other hand, *C. viridis* experienced high mortality when provided with high cover of sponge. *C. viridis* hid into the branches of the sponge when being attacked by *E. merra*, but the predator can easily penetrate into the sponge. *E. merra* had higher successful strikes on the juvenile fish in setups with higher cover of sponge. Hence, the branching *C. samarensis* sponge could not provide the structural characteristics to efficiently protect the juveniles from predation. Results imply that proliferation of the branching *C. samarensis* sponge on degraded coral reefs have potential consequential effects on the population structure of juvenile reef fishes.

TBO-15-527

The diversity and distribution of Holothuroidea on the reef flat of Panwa Cape Phuket, Phuket province

Rachakorn Sirijarukul, Ponlachart Chotikarn, Koraon Wongkamhaeng

Panwa Cape, Phuket province, contain a large patch of coral reef covering an area of 323.200 m^2 and has been established as Marine Protected Area (MPA) in 2016, after major coral bleaching event in the Andaman Sea. One of an important organism found here is Holothuroidea which play a role as a decomposer. In this study, the diversity and distribution of Holothuroidea on the reef flat of Panwa Cape was investigated from July to December 2017 using systematic belt transect technique. The animals were counted and noted during snorkeling along the transects. The identification was done based on external morphological and confirmed with morphological Ossicles. Two species of Holothuroidea belonging to one order and one families were found in this study. The only dominant family was Holothuriidae which included *Holothuria (Halodeima) atra* and *Holothuria leucospilota*. The highest abundance species of Holothuridea was found on the living coral substrate following by sandy substrate. The highest total number of individual was found June (162 individuals). During the study, only one individual of *H. leucopilota* was found. This study indicated that the population of sea cucumber in this area has declined.

TBO-16-218

The community structure of snappers (*Lutjanus* spp.) at Lankayan Reefs, Sugud Islands Marine Conservation Area, Sabah, Malaysia

Davies Austin Spiji, B. Mabel Manjaji-Matsumoto, Zarinah Waheed

The population dynamics of snappers (*Lutjanus* spp.), a prized fish group were investigated at three patch reefs, within Sugud Islands Marine Conservation Area. Underwater fish censuses were carried out at these patch reefs, while assessing the association of the snappers with reef substrates and ocean current.

Throughout the surveys, a total of 12 species of *Lutjanus* were found. The species *L. fulviflamma* had the highest mean abundance at 52.73 individuals/100m2 (SD = 23.88) and the highest mean estimated biomass at 5.66 kg/100m2 (SD = 2.53), as they occurred in large schools in all sites. There were significant relationships between monsoon seasons (Southwest monsoon vs. Northeast monsoon) and species abundance for the species *L. argentimaculatus* and *L. lutjanus* at one site, respectively, and for the species *L. russelli* at two sites ($P<0.05$). The relationship between tidal variations (spring tide vs. neap tide) and species abundance showed significance in the species *L. russelli* at one site ($P<0.05$).

The schooling of *L. quinquelineatus* and *L. russelli* were frequently found around sub-massive corals and large rocks, respectively, as they appeared to seek shelter in these substrates. In contrast to the schools of *L. lutjanus*, *L. quinquelineatus, L. russelli* and*L. vitta* that were typically found at the same side of the reef or around the same dominant substrates, the schools of *L. argentimaculatus* were always found at the side of the reef where the current was facing. The findings from this study provide new insights to support effective management of the wild stock of *Lutjanus* spp.

TBO-17-407

Density, size class and distribution of Napoleon Wrasse in Tubbataha Reef Natural Park, Philippines

Cleto Nañola Jr, Angelique Songco, Mae Angelie Paradela, Retch Paglinawon, Rowel Alarcon

Napoleon Wrasse, *Cheilinus undulatus* locally known as *Mameng* has been classified as endangered species in 2004. This prompted the need for assessment of this particular species. Tubbataha Reefs Natural Park (TRNP), being a protected reef has high sightings of *Mameng* but has never been extensively surveyed in terms of its density, size class range, and distribution. A thorough survey was conducted in May 2017 using fish visual census. More than 19km of stretches of reefs were surveyed both in the south and north atolls. Total count obtained was 641 individuals or between 6 to 7 individuals/ha. Global records showed that density does not exceed more than 10 individuals/ha. Density comparison Using Mann-Whitney U test showed no significant difference between north (6.1 individuals/ha) and south (9.8 individuals/ha) atolls. However, significant difference was observed between the eastern (4.7 individuals/ha) and western (9.5 individuals/ha) sides. This suggests that *Mameng* thrives in relatively sheltered environment. Size frequency distribution yielded higher density from 40 cm to 80 cm total length (TL) numbering more than 400 individuals. Largest individuals observed were between the size class range from 130 cm to 150 cm TL. Juveniles were also seen inside the lagoon of the north atoll. These findings clearly illustrate the importance of TRNP for the supply of *Mameng* in the Sulu Sea and adjacent seas.

TBO-18-304

Community structure of butterflyfishes (Chaetodontidae) in coral reefs exposed to different ocean-climate typologies in the Philippines: Preliminary findings

Marion Michael Bacabac, Victor Ticzon, Alvin Nowell Simon, Jerome Benedict Cabansag, Cleto Nañola Jr, Laura David

Patterns of distribution in reef fish assemblages are influenced by biological and environmental variables operating on both local and regional scales. For chaetodontids, it is already established that species richness and abundance were found to be positively correlated with hard coral cover. In a scenario of a rapidly changing climate, investigating patterns in community structure of indicator species, such as butterflyfishes, in an ocean-climate typology perspective has increased in importance but remains unstudied. The objective of the study is to examine patterns in chaetodontid community structure across different ocean-climate typologies in the Philippines. Butterflyfishes were surveyed in replicated 50 m x 10 m belt transects, across nine (9) locations in the country. In general, using Analysis of Similarities (ANOSIM), the results showed a relatively weak dissimilarity (Global $R = 0.246$, $p < 0.01$) across typology clusters. However, pairwise comparisons revealed that there is a strong dissimilarity ($R = 0.546$, $p < 0.01$) in chaetodontid community structure between extremely different ocean-climate typologies (Cluster II and Cluster XI). Preliminary results showed that in areas where ocean-climate typologies were highly different, modest changes in butterflyfish community structure were observed. The difference was primarily attributed to the abundance of obligate corallivores such as *Chaetodon baronessa* and *Chaetodon lunulatus* in the cluster that is least susceptible to rapid changes in air-sea climate exposure. Understanding how the distribution patterns of chaetodontids vary across typologies is important in modelling changes in reef fish community structure through time.

TBO-19-200

Response of coral reef fishes to small-scale habitat enhancement on tropical seawalls

Daisuke Taira, Elizabeth C Heery, Lynette HL Loke, Andrew G Bauman, Peter A Todd

Coastal defences (e.g. breakwaters, seawalls and jetties) are widely used to protect shorelines and coastal developments from erosion, wave action and sea level rise. However, these structures typically support lower species diversity than the habitats they replace. In Singapore, seawalls constitute >60% of the coastline and are often constructed adjacent to coral reefs. Recent studies have shown that species richness on local granite rip-rap seawalls can be increased by attaching moulded concrete tiles that enhance structural complexity, but there is limited information as to whether these enhancements also affect reef fish assemblages on and near seawalls. In this study, we quantified and compared fish community structure and fish behaviour between study plots (2.4 m x 2.4 m) on the seawall with and without habitat enhancement tiles using stationary underwater video cameras. Video footage revealed more than 30 fish species, including Pomacentridae (seven species), Labridae (six species), and Chaetodontidae (two species). Two fish species, *Scarus rivulatus* and *Chelmon rostoratus*, took more bites on the biota (e.g. turf algae, molluscs) colonizing enhancement tiles than on the bare seawall plots. Some gobiids and juveniles of *Choerodon anchorago* and *Dischistodus fasciatus* were observed using the tiles as shelter. Our results suggest that enhanced food availability and structural complexity derived from small-scale habitat enhancement may increase the exploitation of shallow seawall habitats by some fish species. Based on our findings, we will discuss the potential for eco-engineering to mitigate the impact of coastal development on fish diversity in heavily urbanised coastal reef systems.

TBO-20-409

Variation of trophic structure in response to habitat degradation in a tropical coral reef ecosystem

Sheng Liu, Simin Hu, Xianzhi Lin, Lingli Wang, Tao Li, Hui Huang

Trophic interactions between different functional organisms is of great importance for coral reef ecosystems to maintain their ecological functions as well as to resist disturbance. To explore the trophic structure of coral reef ecosystem and its response to habitat degradation, various organisms from different trophic levels were collected from coral reef ecosystems with varying degrees of degradation mainly based on the coverage of living corals. The species diversity and biomass of different groups were compared from different habitat conditions, and their diets were identified using high-throughput sequencing technology. The results showed that the total biomass of organisms in areas with high coral coverage (> 30%) was approximately 30% higher than in areas with low coral coverage (<10%), but the species diversity was similar. The diet compositions of different organisms varied significantly with the coral coverage, and a wider food spectrum with no predominate prey groups were found in reefs with lower coral coverage. Copepods switched from feeding on phytoplankton to benthic animals and chaetognaths switched from feeding on copepods to polychaetes with the decrease of coral coverage. In area with high coral coverage, herbivorous/omnivorous fish mainly fed on brown algae and arthropod, while in heavily degraded area, green algae occupied the niche of coral and became the main food sources of reef fish. In conclusion, coral reef ecosystem showed a high degree of plasticity and adaptive capacity as different functional organisms could maintain survival in short term by increasing food sources and adjusting food intake when the habitat degraded, but the trophic structure was vulnerable. These results, combined with model analysis, demonstrated that coral, macroalgae and other organisms were key species in maintaining the stability and health of the coral reef ecosystem.

TBO-21-207

Linking nutrition and bioerosion in parrotfishes on coral reefs

Kendall David Clements, Brett Taylor, John Howard Choat

The maintenance and restoration of parrotfish populations is widely seen as a major priority for the management and restoration of coral reef ecosystems. This is largely because these fishes are thought to be major agents in the removal of turfing algae and macroalgae, thus preventing reef phase shifts to algal-dominated states. Rapid feeding and oral jaws designed to excavate reef surfaces also identify parrotfishes as ecosystem engineers: they are key agents of bioerosion that contribute significantly to the production of reef sediment. But what is the connection between these two distinct ecosystem roles, i.e. removal of macroscopic algae and bioerosion of reef substrata? We examined stable isotope and fatty acid data from a sample of 18 species of herbivorous and detritivorous fishes collected from Lizard Island on the Great Barrier Reef, Australia. While conventional gut content analysis had reliably characterized the diets of browsing members of this assemblage, the nutritional targets of grazing species, especially parrotfishes, were poorly resolved. Our stable isotope and fatty acid data demonstrate that the use of generalized categories such as turf algae, detritus and even macroalgae fail to capture the complexity of resource partitioning in these fishes. Our data challenge the established view that parrotfishes feed on macroscopic algae, but rather indicate that they target microscopic phototrophs, especially the euendolithic flora, i.e. highly productive microscopic algae and cyanobacteria that bore into the upper layer of calcareous substrata. By linking parrotfish nutrition to microbial phototrophs living in the reef substratum and sediments, i.e. the euendolithic flora, this novel hypothesis explains why parrotfishes are central to reef carbonate budgets, especially since euendoliths themselves are major agents of carbonate bioerosion. These unrecognised interactions between parrotfishes and euendolithic communities may be key to determining how carbonate budgets on coral reefs respond in the future to natural and anthropogenic stressors.

TBO-22-428

Trophic role of herbivorous fish *Ctenochaetus striatus* in coral reefs with different habitat conditions

Xianzhi Lin, Simin Hu, Sheng Liu, Hui Huang

Herbivorous fish is an important functional group in the coral reef ecosystem, which is of great significance for maintaining the balance and stability of the ecosystem. In this study, nine sites suffered different degrees of disturbance were selected in the southern of South China Sea, and classified into different degrees of reef habitat conditions (relative good, generally and poor) mainly based on coral coverage. The diets of dominated herbivorous fish *Ctenochaetus striatus* from these sites were analyzed by high-throughput sequencing, to investigate their trophic role as well as responses to habitat degradation. A total of 36 prey categories were identified, mostly consisting of macroalgae (green algae, red algae, brown algae), and other organisms, such as arthropods, flatworms, and molluscs. The dietary composition of *C. striatus* varied significantly with coral coverage. In general, *C. striatus* showed a wider food spectrum with the decrease of coral coverage, with 19 food categories detected in good coral conditions but almost 30 groups in generally and poor conditions. Furthermore, dominant prey groups of *C. striatus* differed under different coral conditions, with brown algae accounting for 52.0 ~ 57.8% when coral coverage was more than 30% while green algae being main food source in areas with poor coral condition. The widen food spectrum and variation of food sources of *C. striatus* under different reef habitats indicated that degeneration of coral reef would significantly affect the food sources of herbivorous fish. While they could change their feeding strategies flexibly according to the habitats changes and thus play different roles.

TBO-23-376

The safety net role of coral reef fisheries

Louise Teh, Lydia Teh

Social safety nets help the poor and vulnerable stay out of extreme poverty by providing a source of income and food support in times of need and crises. In this context, reef fisheries are crucial safety nets for some of the most marginalized and vulnerable people in developing countries. At the same time, coral reefs are highly vulnerable to anthropogenic threats and climate change. The uncertainty of coral reefs' capacity to act as safety nets in the future puts the social-economic wellbeing of millions of coastal people at risk. However, to date there is no baseline information about what constitutes safety net contribution from reef fisheries, and what the global magnitude of this contribution is. To fill this gap, our study objective is to first, define what constitutes 'safety net' contribution, and second, to quantify the contribution reef fisheries need to generate in order to provide 'safety net' support for reef fishing communities. We draw upon databases on fisheries, social welfare, economics, and food consumption to 1) estimate the food and income components of reef fisheries' safety net contribution; 2) assess whether this contribution meets current food and income requirements for reef fishing communities worldwide. Preliminary results indicate that reef fisheries could potentially provide a 'safety net' income to people most dependent on reef fisheries. However, this is not distributed equally among the world's reef countries. Further, global subsistence reef fish catch of approximately 3 million t in 2014 was sufficient for meeting the daily fish consumption needs of reef dependent people. Our results suggest that currently, most reef fisheries worldwide are capable of serving as a safety net. By quantifying the prominent social welfare contribution of reef fisheries, this study provides a social argument for improved coral reef and fisheries management such that policies support future human well-being.

TBO-24-378

An economic approach to marine conservation: the case of marine turtles in the Semporna Priority Conservation Area, Sabah, Malaysia

Lydia Teh, Louise Teh, Gavin Jolis

The Semporna Priority Conservation Area (PCA) is situated in the Sulu-Sulawesi Sea of Sabah, Malaysia. Part of the Coral Triangle, this region's rich marine biodiversity is under pressure from fishing, seaweed farming, marine tourism, and coastal development. Combined with the uncertainties of climate change, the future sustainability of Semporna's marine ecosystem is at stake. Successful conservation not only has to protect biodiversity, but also generate benefits for coastal households who depend on the sea. Balancing trade-offs can be achieved by applying an economic approach to ecosystem management. We demonstrate this by quantifying the Total Economic Value (TEV) of marine turtles in the Semporna PCA. We then discuss how these results have been used to support marine spatial planning for conservation. Marine turtles epitomise the socio-ecological dynamics at play in this region. They are a threatened species and valued by local communities who consume their eggs, as well as by tour operators for whom marine turtles are a major attraction for visitors. Marine turtle TEV was based on field interviews with marine resource users and managers in 2014, and was estimated to range from USD 21-25 million per year. The combined non-consumptive and non-use values (from tourism and conservation investment) of marine turtles far outweighed the consumptive use (from turtle egg consumption and sale) value portion of the estimated TEV. This is a clear message for protecting marine biodiversity, and has been used by local environmental organisations to help stakeholders understand where conservation trade-offs occur. Doing so can promote stakeholder buy-in and acceptance of conservation, and contribute towards the design of more equitable outcomes.

mini symposium

MS1-1-765

What are we set to lose?

Filipina Sotto

Beyond the super typhoons and the extreme weather events, the many and varied impacts of climate change are becoming more and more tangible and real. Recent studies on the Philippines' oceans and coral reefs reveal that our marine ecosystem absorb an underestimated brunt of these impacts. This discussion aims to present the recent studies conducted on the Philippines' oceans, its previous state, the visible impacts of climate change, and the importance of convergence to halt climate change. Conclusions of the recent studies, particularly on the fact that the Philippines has lost all excellent reef cover amidst climate change, will likewise be presented. In essence, the presentation aims to ask the question: As regards our oceans, what have we lost, and what more are we set to lose?

MS1-2-766

Why is a global campaign for healthy oceans a long-term solution to climate change?

Vince Cinches

The Philippines as the epicenter of marine biodiversity, as part of the global south, with low historical CO_2 emission, is in a unique position to lead the global initiatives on climate change and oceans. Despite this, the global climate discourse on oceans is very weak, and only looks at ocean as victims and not as a solution. It is also essential that the role of Philippines should be backed by strong ocean science, movement of people to extract accountability from carbon majors, and be located within the global effort to address climate change. Before the impacts of climate change, the world's ocean is already being ravaged by overfishing, unsustainable land utilization e.g. reclamation, power plants, and mining, and pollution. The current practice if not reversed will hasten climate change. This discussion will briefly present elements of global campaigns led by various Greenpeace across the planet for a healthy ocean as a climate strategy which includes accountability from carbon majors, development of global agreements, country policies, public engagement e.g. non-violent direct actions, mobilizations, and communications, including consumer engagement. The uptake of CO_2 from the atmosphere by the oceans has far exceeded sustainable limits affecting marine life and people. Further, the ocean's "blue carbon" capacity is at stake, which has serious ramifications for the climate. Any notion, that the climate crisis can be fixed by continued ocean CO_2 uptake is not only wrong, it is also very dangerous, as it underestimates the CO_2 cuts needed to keep our planet – and our ocean – safe and livable. Key recommendation at the end of the presentation will focus on the facilitation of a national discussion that will lead to the formulation of a national agenda for oceans using the lens of climate justice that will form part of a country position at the UNFCCC negotiations.

MS1-3-767

What are the coastal policies and realities?

Avril De Torres

The Philippines is an archipelagic state with more than half of its population situated in coastal areas. Ironically, instead of healthy, thriving, and sustainable coastal communities, our coastal communities are exposed to numerous vulnerabilities. Our fisherfolk, which comprises 60 percent of the total Filipino population, remain among the most marginalized sectors or the "poorest of the poor". Some of these fisherfolk are still addressing issues of harmful and unsustainable fishing and coastal practices, such as illegal fishing, dynamite fishing, reclamations, and many more. Moreover, as discussed in the earlier presentations, the impacts of climate change are gradually being felt by coastal communities, as they adversely affect their livelihoods and food security, among others. This discussion aims to surface another circumstance which exacerbates the existing vulnerabilities of coastal communities—the presence of fossil fuel power plants and mining sites in the coasts. Taking stock of existing policies and laws on oceans, coastal communities, fossil fuels, and extractives; environmental performance reports and management plans; roundtable discussions; and interviews; the discussion aims to provide a holistic assessment of current policies on the coast, juxtaposed with current realities. The presentation will end with legal and policy recommendations on oceans and coastal communities.

MS1-4-768

Voices from the Coast: The Case of Manicani, Eastern Samar

Marcial Samooc

Manicani, a small island off mainland Guiuan, Eastern Samar, hogged both local and national news when protests erupted anew against the recent endorsement by the local governments of the renewal of large-scale mining on the island. October 27, 2017 should have marked the end of mining in Manicani with the mineral production sharing agreement (MPSA) granted to Hinatuan Mining Corporation (HMC) expiring, thus, ending a quarter of a century of mining operations that have caused deep divisions in the community and man-made environmental destruction. To the dismay of anti-mining groups and residents, the local government units (LGUs) in Manicani and the legislative bodies of the Municipality of Guiuan and the Province of Eastern Samar issued separate resolutions supporting HMC's application to renew its MPSA covering Manicani. This incident led to a series of protests, a 36-day camp outside of the Department of Environment and Natural Resources (DENR), and a victorious return to Manicani after an assurance from DENR Secretary Roy A. Cimatu that mining operations in Manicani will no longer be renewed. This discussion aims to share a story of a fisherfolk from the small island of Manicani. The story centers around the adverse impacts experienced by their coastal community caused by climate change, which are exacerbated by mining operations. These experiences led them not only to speak against mining operations, but to ensure that their voices are heard.

MS2-1-95

Evolutionary traits and biogeographic species richness patterns of mushroom corals

Bert Willem Hoeksema

Phylogeny reconstructions are not only useful for taxonomy but can also be applied in evolutionary studies concerning ecological traits, life histories, and biogeographic ranges among closely related species. The Indo-Pacific family of mushroom corals (Scleractinia: Fungiidae) is an ideal model group for such studies in relation to species richness patterns. Most mushroom coral species show widespread Indo-West Pacific ranges, while a few occur in smaller areas, such as the Coral Triangle (CT) and the Red Sea. From a biogeographic perspective, the CT appears to have relatively many species that prefer offshore reef slopes in clear water where they migrated up and downward with shifting sea levels stands. From an evolutionary point of view, these are not the youngest species, implying that the CT represents a centre of survival instead of speciation. Hence, offshore reef slopes appear to be predominantly ancestral habitats in clear oceanic water, common in the West Pacific, whereas onshore reefs, reef flats and reef bases seem to be derived. Examples of evolutionary traits are habitat preference, maximum growth size, free-living vs. attached mode of life, and the capacity to form secondary mouths.. A loss of the ability to become free-living appears to have evolved independently as reversals in various separate clades. The evolution of secondary mouths from a single mouth has also occurred several times. Polystomatous species (free-living or attached) are able to grow larger than their monostomatous relatives, whereas encrusting species appear to be size-constrained. Species with large maximum sizes, secondary mouths and those that remain attached are widespread in the Indo-Pacific but are lacking in some marginal regions such as the East Pacific and the Arabian/Persian Gulf. Perhaps phyloecological models can be applied to predict and conserve future habitat availability and species richness patterns.

MS2-2-761

More Merulinidae mysteries unveiled: Systematics and biogeography of the hard coral genus *Favites*

Francesca Benzoni, Roberto Arrigoni, Tullia I. Terraneo, Claude Payri, Michael L. Berumen, Danwei Huang

Advances in our understanding of phylogenetic relationships among hard coral taxa, species boundaries and their geographic distribution are possible thanks to genetic analyses of material from multiple locations spanning the Indo-Pacific and to the reassessment of its morphological features. The scleractinian family Merulinidae is one of the most affected by the last two decades of discoveries in systematics and subsequent taxonomic changes, and several taxa within it are still being addressed. Although the merulinid genus *Favites* has been recently reassessed and twenty nominal species are currently recognised, eight of these have never been included in molecular analyses so far. In this study, over 190 corals identified as Favites from various localities in the Red Sea, Indian and Pacific Ocean were sampled and analysed, including species yet to be examined genetically and material of four morpho-species not matching any of the known nominal species. Robust phylogenies using DNA sequence data across five loci of mitochondrial (COI) and nuclear (histone H3, Pax-C, calmodulin, and ITS) origins were obtained. Colony and corallite morphological features were studied. The examined material were placed in five distinct genus level clades: the Favites clade including two undescribed taxa, one sister to the genus type species; the Dipsastraea clade, where three species previously ascribed to *Favites* were recovered including *F. melicerum*; the Paramontastraea clade, including *F. monticularis*; the Paragoniastrea clade where *F. stylifera* was retrieved as closely related to and genetically indistinguishable from *Paragoniastrea russelli* despite significant differences in corallite diameter and number of septa; and a fifth clade, for which we resurrected the genus name *Aphrastrea*, more closely related to *Astrea* and Paragoniastrea than to *Favites*, including *F. pentagona* and *F. micropentagonus* plus a new species. Our results call for more formal taxonomic revisions in the Merulinidae and point out, once more, to the importance of large collections of material from multiple localities for coral systematics and biogeography.

MS2-3-356

How fossils help reveal the murky origins of Coral Triangle biodiversity

Kenneth Johnson, Nadia Santodomingo

Coral reefs throughout the tropics are severely impacted by anthropogenic environmental change, and therefore active research initiatives are under way to document the response of reef systems to a variety of stressors to help develop priorities for management, mitigation and adaptation. One urgent research priority is the identification of potential ecological refugia. Deep mesophotic reefs have been identified as one such potential refugia, but recent work suggests that shallow turbid mesophotic habitats may play a similar critical role. However, contemporary ecological studies lack the necessary data to assess species resilience and shifts in such refugia locations because of the timescales over which ecological processes operate. To address this temporal data vacuum and to quantify the viability of shallow water turbid habitats as long-term environmental refugia, we have conducted pioneer study on the long-term history of turbid reef habitats in the Coral Triangle (CT) region of SE Asia. In this talk, we will present our preliminary compilation of new data on the ecology, and evolution of reef corals and the environments in which they have lived under the shallow mesophotic conditions that characterised sites within this region during the past 30 million years. This will allow us to assess the potential for these habitats to serve as refugia and to do so within the only region globally that has suitable well-preserved palaeontological records. Our integrative approach includes data from modern and ancient assemblages and apply newly developed tools from biostratigraphy, geochemistry, and phylogenetics.

MS2-4-150

Biogeography without binomials: molecular operational taxonomic units reveal patterns of community assembly and regional endemicity in octocorals

Catherine S McFadden, Yehuda Benayahu, Merrick Ekins

Octocorallia is a species-rich sub-class of anthozoan cnidarians that includes many of the most prominent, ecologically dominant, and structurally important sessile macro-organisms found in both shallow tropical reef and deep sea environments. The inadequacy of early taxonomic descriptions, a dearth of modern taxonomic work on the group, and poorly understood, environmentally plastic morphological traits make species-level identification extremely challenging for most of the >3000 described taxa of octocorals. In the absence of a stable taxonomy, names cannot be assigned to species belonging to most of the common genera of octocorals found on Indo-Pacific reefs, a situation that has prohibited understanding of the most fundamental aspects of their biology, including species diversity, geographical ranges and community interactions. These problems are exemplified by the family Xeniidae, a group of opportunistic and potentially invasive soft corals that are emerging as important competitors of scleractinians in disturbed and marginal reef habitats. The near impossibility of identifying xeniids to species based on their morphology presents a major impediment to increased understanding of their ecology. We used a multilocus molecular barcode to assign xeniid octocorals to molecular operational taxonomic units (MOTUs) as proxies of species. Comprehensive biodiversity surveys at 13 sites spanning the Indo-Pacific revealed high species richness of xeniids accompanied by high turnover (ß-diversity) among sites. Few MOTUs were shared among sites, suggesting high levels of regional endemism by species with narrow geographic ranges. Although individual species occupied narrow geographic ranges, representatives of most major phylogenetic clades were found at each site, suggesting that closely related species replace one another within communities spanning the Indo-Pacific. This pattern contrasts with that seen in other octocoral families such as Melithaeidae and Gorgoniidae, in which molecular phylogenetic analyses suggest that major clades have restricted biogeographic distributions.

MS2-5-564

Utilization of eDNA metabarcoding to assess coral reef health in Okinawa, Japan

James Davis Reimer, Joseph DiBattista, Piera Biondi, Giovanni Masucci, Michael Stat, Michael Bunce

Environmental DNA (eDNA) metabarcoding has great potential in assessing comparative total biodiversity, and facilitating robust comparisons across a wide variety of sites and taxa. In particular, eDNA combined with next-generation sequencing can help address the huge critical data gaps in our understanding of marine biodiversity, especially in regions with high levels of understudied diversity such as the coral reefs of the Indo-Pacific region. Within this region, Okinawa is known for its high levels of marine biodiversity and endemicity, and also for the threats shallow coral reef ecosystems face from a variety of stressors including local-scale coastal development and over-exploitation to global scale threats such as climate change. In this study, we generated eDNA metabarcoding sequences from sediment and seawater samples from various reefs in Okinawa, Japan. At the same time, we developed a simple methodology to assess the relative health of these reefs based on anthropogenic and natural stressors. We discuss our eDNA results in comparison to coral reef health, identify potential bioindicator taxa, and explore the relative biodiversity of coral reef communities across sites. Our results indicate that taxa asides from the corals (Scleractinia) can provide robust information on coral reef health.

MS2-6-739

Nutritional musings on coral evolution

David Michael Baker

Since the 1970s it's been debated that coral colony and polyp morphology are related to corals' trophic position. Larger polyps and massive skeletons are considered traits common to heterotrophic corals, whereas small polyps and branching morphologies are attributed to autotrophy. Moreover, heterotrophic corals appear more resilient in the face of climate change with observations of bleaching resistance attributed to provisioning via heterotrophy. In this talk, I will argue that morphology and nutrition share a common phylogenetic history, and that polyp and skeletal surface area:volume are optimized for autotrophy in fast-growing and highly competitive species. Yet, times are changing. The oceans are warmer and more eutrophic than ever before. In this Anthropocene, autotrophic corals are succumbing to starvation and disease as their over-investment in autotrophy becomes their 'Achilles' heel'.

MS3-1-760

Amidst the science of coral reefs: why talk about financing?

Annabelle Cruz-Trinidad

Challenges confronting coral reefs are compounding in time. Modest gains in protection measures and informed policies are negated by climate change and emerging and worrisome patterns of utilization such as reclamation and land development. Thus, the economic and financial losses surpass the value of ecosystem services of coral reefs at USD 9.9 trillion. This has serious implications for at least 500 million people who rely on coral reefs for food, coastal protection, and livelihoods (Wilkinson 2004).

Why talk about financing? First, the agenda for research alone is enormous as evidenced by this symposium. Second, significant funding is required to address threats posed by illegal fishing, reclamation, pollution, harvesting of corals and associated species, etc. Third, due to the severe rate of destruction, coral restoration procedures will cost more, in fact, more than what it would cost to prevent the destruction. Relevant discussions on financing are not focused solely on raising revenues or ensuring more funding but includes cost avoidance, delivering better, and realigning expenditures, all befitting coral reef management.

BIOFIN promotes a methodology, applicable at both national and sub-national levels, that emphasizes how policies and institutions promote or suppress economic drivers impacting on coral reefs, estimates expenditure patterns to detect policy alignment, and determines the major costs associated with coral reef management. Application of the methodology in several countries in the Asia Pacific region show emergent finance solutions. The Philippines is working on increasing public sector budgets, accessing earmarked funds, and localization of the BIOFIN process, while Thailand is applying island visitation fees and establishment of a trust fund in Koh Tao Island. Lastly, Indonesia is looking at how the practice of Islamic giving can be harnessed for coral reef management.

MS3-2-759

Mobilizing Resources for the Philippine Biodiversity Strategy and Action Plan

Anabelle Plantilla

As a signatory to the Convention on Biological Diversity (CBD), parties are committed to prepare and implement their National Biodiversity Strategy and Action Plans. This is a significant contribution to the Philippines' efforts towards implementing the CBD Strategic Plan 2011-2020 at the national level and integrating biodiversity conservation into national and local plans. The Philippine Biodiversity Strategy and Action Plan (PBSAP) is the country's roadmap to conserve its biodiversity and achieve its vision - "By 2028, biodiversity is restored and rehabilitated, valued, effectively managed and secured, maintaining ecosystem services to sustain healthy, resilient Filipino communities and delivering benefits to all." While the estimated cost of PBSAP implementation within the given time frame of 2015-2028 is PhP24B/year, a public and private expenditure review revealed that current government (including local governments) spending on biodiversity is only PhP5B/year which leaves a financing gap of PhP19B/year to fully implement the PBSAP. To mobilize resources for the implementation of the PBSAP, the Biodiversity Finance Initiative (BIOFIN) will contribute to closing the financing gap by identifying, accessing, combining and sequencing sources of biodiversity funding to meet national needs.

The project is implementing the following finance solutions to increase biodiversity investments in the country:

- Increasing access of local government units (LGUs) to earmarked funds i.e., Energy Regulation (ER) 1-94, Malampaya Fund, Integrated Protected Areas Fund (IPAF) and the People's Survival Fund;
- Increasing funding for national agencies through increased public sector budgets by mainstreaming biodiversity conservation into national, regional and local plans; and
- Engaging and enhancing partnership with private sector through public-private partnerships and corporate social responsibility.
- BIOFIN will also test other finance mechanisms such as crowdfunding, diaspora, use of mandated funds (mining sector) for biodiversity conservation, enterprise challenge funds and social impact investments.

MS3-3-751

From national to local: BIOFIN applied to Mindoro

Lorenzo Cordova

The Biodiversity Finance Initiative (BIOFIN) is a global partnership that aims to address finance challenges to implement National Biodiversity Strategy and Action Plans (NBSAP). Guided by the BIOFIN Workbook coupled with localized approach, the 8 pilot municipalities in Mindoro Island Philippines undergone the following: 1) Policy and Institutional Review (PIR); 2) Public and Private Biodiversity Expenditure Review (PPBER); and 3) Financial Needs Assessment (FNA) of Local PBSAP Programs. The development of Biodiversity Finance Plan, however, was only made possible for the LGU Sablayan given the availability of data.

As one of the eight pilot LGUs, Sablayan was able to develop conservation and revenue-generating programs to be implemented until 2022 with estimated total cost of PhP2.42 billion. These are: 1) Sablayan Sustainable Ecotourism Development Program (SSEDP); and 2) Sablayan Integrated Ridge to Reef Development Program (SIRRDP).

The program components complement and support these priority sectors: Tourism, Infrastructure, Urban ecosystem, Forest ecosystem, Freshwater ecosystem, Coastal and Marine Ecosystem, and Disaster resilience. These are also aligned with regional and national development agenda. This provides rationale to mobilize resources (technical, financial, services) from internal and external sources to maintain optimum ecosystem services.

The FNA showed that the financing gap range from PhP1 billion to PhP2.25 billion. This necessitate the LGU to design resource mobilization strategy and determine finance solutions that will guide them to raise 96% of the annual cost requirement or approximately PhP463 million.

The combined result of PIR, PPBER, and FNA informed the crafting of the Biodiversity Finance Plan (BFP) for Sablayan. The Plan envisions to attain sufficient financing for the identified programs in the next five years through the following finance solutions: Maximizing Locally Available Funds; Accessing National Government Agencies; Fostering Partnership and Assistance from CSOs and Research Institutions; Catalyze Biodiversity Investments through Private Sector Engagement/ Partnership; and Tapping Earmarked Funds.

MS3-4-752

What Will it Take to Make Payment for Ecosystems Service Work? A Case of a Small Island Called Koh Tao

Niran Nirannoot

As with many island destinations, the success of nature-based tourism is also the major cause of all the symptoms of environmental ills such as degraded coral reefs, polluted coastal waters, and marine debris. Technical assistance has been coming in from all directions. Public agencies have invested in artificial reefs and alternative dive sites to reduce the pressure on natural reefs. In addition to a number of CSR investments, academics have been providing inputs from their respective fields such as marine biology, social and political sciences, environmental economics. These technical and financial assistance however, resembled pieces of jigsaws that never quite fit together. Moreover, there are no guarantees for continuity, or the assurance that they will be sufficient for the scale and level of intensity of conservation efforts required.

This paper presents Biodiversity Finance Initiatives—BIOFIN Thailand's efforts to consolidate the pieces of jigsaw by linking stakeholders who benefit from recreational services from the islands' coral reefs and the partners on the supply side who are involved in coral reefs' protection and restoration. Taking off from two earlier studies, BIOFIN Thailand aims to advocate the principle of collecting island visitation fees to finance (i) coral reefs restoration, (ii) comprehensive marine turtle conservation program, (iii) strengthening marine ecosystems' resilience and (iv) measures which aim at reducing sources of land-based pollution and thus preventing any potential harm or damages to coastal resources. Our aim is to demonstrate that the right mix of financial solutions will be contingent upon the measurable and tangible results of these conservation efforts.

The research analysis is being conducted by BIOFIN Team in UNDP Thailand: Ms. Orapan Nabangchang PhD, Chief Technical Advisor and Mr. Ricardo Marchant, Research Associate.

MS3-5-753

A blended finance approach for MPAs in Sulawesi, Indonesia: seeking solutions beyond traditional funding sources

Abdul Wahib Situmorang

The Financial Needs Assessment (FNA) of the Biodiversity Finance Initiative in Indonesia conducted an analysis of six (out of twenty-two) national targets found within the Indonesia Biodiversity Strategy and Action Plan. The targets analyzed are under the areas of responsibility of the Ministry of Environment and Forestry and the Ministry of Marine Affairs and Fisheries. The FNA resulted in an estimated budget need of IDR 336,6 trillion to achieve the six national targets based on activities supporting realization of the targets and their associated costs for both ministries.

Biodiversity is crucially important to the Indonesian economy. Marine Protected Areas play an important role in marine biodiversity protection as well as providing potential sources of revenue through ecotourism development. However, Indonesia's MPAs often suffer from budgetary shortfalls resulting in poor management. Several financial solutions for the development of ecotourism attractions and improved MPA management have been proposed. Unfortunately, the revenue potential of several sites is limited by strict government regulation on visitation fees and/or the willingness to pay of visitors for a tourism experience, given the current level of services on offer, creating a bit of a financial vicious circle.

Zakat, Infaq, Shadaqah, and Wakaf (ZISWAF) and its principles of charity, equity, productivity, and fairness create an emerging financial solution through support to microfinance institutions supporting underprivileged communities around ecotourism areas. ZISWAF is a proactive approach to optimizing the use of private sector funds as well as from the community-at-large, and can supplement biodiversity funding from government. The potential of ZISWAF is very high in Indonesia, not only because of the high population of Moslems (the contributors to Zakat), but also because of the interest of BAZNAS, a national organization tasked to manage funds donated to charities, to allocate part of the ZISWAF for conservation-related activities.

MS3-6-762

BIOFIN opportunity for non-BIOFIN countries

Jessica Alvsilver

Besides offering and assisting in the implementation of a structured and stepwise methodology to assess and identify solutions that can assist countries in achieving their biodiversity related objectives, BIOFIN also supports countries that have not yet carried out the BIOFIN steps and approaches. This so called regional node activity, is a demand driven support mechanism that offers technical advice and support in a range of biodiversity finance related areas including the development of knowledge products tailored to the country needs and ongoing country processes, the development of an inventory of existing finance solutions and the analysis of potential future solutions in the country and the identification of the best opportunities to support resource mobilisation strategies. Countries becoming regional node countries have access to a global network of biodiversity finance experts and can participate in webinars about biodiversity finance solutions and the BIOFIN methodology as well as engage in regional knowledge sharing platforms and events with other countries implementing the BIOFIN methodology. The intention of this presentation is to brief non-BIOFIN countries in the region of this opportunity to receive biodiversity finance related advice and support.

MS4-1-740

Coral reef sentinels of the new normal ecosystem services and impacts of climate change and anthropogenic disturbance

Porfirio M Aliño

Coral reefs are often referred to as the rainforests of our seas. Due to the exemplary richness in the biodiversity of coral reefs the broad range of ecosystem services especially found in the coral triangle. The changing states of reefs and its capacity to cope with the rapidly changing concerns of climate change and human impacts has been made the subject of scientific investigations. Whether human society and/or coral reefs are able to survive these challenges is not already the question but how to meet these to attain resiliency. We present our indicators of whether there is hope through the design of Marine Protected Areas (MPA) network of critical habitats in the six marine biogeographic regions nested within the ten climatological typologies of David et al. These sentinel sites offer seeds of hope as the Philippine contribution to the establishment of the global "Noah's" arc in our planet. These sparks of hope is envisioned to provide a representative set of sentinel reefs that tests its STEWARDS Program through the monitoring of its resiliency to the warming and to share the learnings derived from the experiences in the changing normal e.g. in terms of the severity and frequency of storms. Together with an arsenal of knowledge tools, sentinel sites for adaptive management and governance of socio-ecological adaptation measures the MPA Support Network (MSN) can offer interconnected and coordinated Hubs of People and Ecosystems (HoPE) in the Philippine Anthropocene.

MS4-2-741

Recent use of habitat service value for tourism of and impacts to coral reefs in the target destinations in South Vietnam

Si Tuan Vo

Coral reef - based tourism has developed quickly in South Vietnam, taking into account of the target locations namely Cu Lao Cham islands, Nha Trang bay, and Phu Quoc islands during last decade. Among them, Nha Trang bay had longer history of marine tourism, starting with inshore development and expanding to islands in and around the bay. Tourist activities in Cu Lao Cham islands was developed in linkages with MPA development and management. Meanwhile, Phu Quoc had become a new destination and drawn huge investments for extensive development of tourism in the islands. Economic value which was brought from use of coral reefs for tourism has increased significantly. For example, the economic value was estimated around 500K in 2007 up to 2 million USD in 2010 in Phu Quoc islands and the payment of entry fee to Cu Lao Cham MPA has quickly increased year by year, reaching approximately 700K USD in 2017. Reclamation for infrastructure building on inshore land and islands was considered as a serious impact, resulting in loss of terrestrial and underwater habitats (e.g. loss of Melaleuca forest in Phu Quoc islands or seagrass beds and coral reefs in Nha Trang bay) and increased sediment loading to coral reefs. Overexploitation of living resources for high food and souvenir demands occurred at all areas, leading to modification of communities, poorness and uncertainty for resource recruitment. Among these tree areas, Phu Quoc waters are the most vulnerable to coral bleaching due to increased surface temperature with records of mass bleaching in 2010 and 2016. Although MPAs existed in all three study areas, role of conservationists in developing coral reef tourism was significantly considered only in Cu Lao Cham case but poorly in others. Local managers and businesses should pay more attention to sustainability in order to ensure not only coral reef conservation but also long-term benefits of local communities and tourist sector itself.

MS4-3-763

Dispersal range of *Acropora* larvae in Okinawa: estimate by ecological method

Kazuhiko Sakai

Coral communities in Okinawa Island were declined by the coral bleaching event occurred in 1998. Although the mortality of corals by the bleaching was much lower in Kerama islands than in Okinawa I., the communities were declined by predation of COTs of which outbreak started in early 2000s there. In both areas, *Acropora* corals, which were major components of the communities, were decreased much since they were "losers" in bleaching event and were preferred by COTs. After these disturbances, the communities had recovered in 10 to 15 years in these areas. To estimate the larval source of *Acropora*corals for the recovery in these areas, we measured coral spats on settlement panels and conducted survey of the communities on reefs at, from north, Motobu (MT; 4 sites), Onna-North (ON; 3 sites), Onna-South (OS; 4 sites) in Okinawa I., and at Zamami Is. (ZM; 8 sites) in Kerama Is since 2002. The study sites were within 5, 5, 10 and 8 km in MT, ON, OS and ZM, respectively. The distance between the areas was 13, 4 and 50 km between MT-ON, ON-OS and OS-ZM, respectively.

We deployed 10 to 50 sets of coral settlement panels (10 × 10 × 0.5 cm) at each site (depth at high tide, 2 to 5 m) at least 3 days before predicted time of mass spawning of *Acropora*corals at June full moon. We retrieved the panels 1 to 2 months after the mass spawning and conducted survey of communities by taking digital images. Coral spats on the retrieved panels were identified to the family level (Acroporidae, Poritidae, Pocilloporidae and others) and counted. Percent cover of corals and size of individual *Acropora* colonies were measured on the images by grouping *Acropora*colonies into arborescent, corymbose, digitata and tabular forms. We assumed that the spats of Acroporidae were mostly *Acropora*, which are major components of the family.

The recovery of the communities had proceeded in MB by 2011, and spats of Acroporidae increased on the panels as *Acropora* colonies of matured size (> 10 cm in diameter) increased. The recovery had proceeded in OS by 2013, and the spats increased in ON as the colonies matured sized increased in OS. The recovery in ZM had proceeded by 2015 and the spats increased as in the other areas. These results indicate that the dispersal range of *Acropora* larvae was mostly within 20 km. This suggests that, when the MPAs are designed to support matured coral colonies as larval source to other areas in Okinawa Islands, the distance among the MPAs should be at most 20 km.

MS4-4-764

The current status and stressors affecting of coral reef distribution of Langkawi Archipelago

Sau Pinn Woo

The Langkawi Archipelago is a group islands situated at the northeast of the Straits of Malacca. The islands have seen rapid coastal development, land-use and various other anthropogenic activities due to the increasing tourism activities on the island. These activities have negatively impacted the coral reef distribution around the islands. A study into the distribution of corals in Langkawi is done. Teluk Datai which is situated in the northwest of the main island, has the largest contiguous reef among all sites although it is subjected to various environmental and anthropogenic stressors. The reefs in Langkawi can act as a model study area due to their resilience towards multiple environmental and anthropogenic stressors.

MS4-5-742

Estimating ecosystem service of coral reefs in Thailand: A fisheries perspective

Wichin Suebpala, Thamasak Yeemin, Makamas Sutthacheep

Coral reef fisheries provide a crucial contribution to human food security, livelihoods and national economy. Yet, the fishing also generates negative impacts on coral reefs. Maintaining ecological functions of the coral reefs are significant to sustain the quality of their goods and services, especially the fish abundance. The value of ecosystem services is, however, unclear and unable to reflect its importance to society. In this study, we analyzes the ecosystem services of coral reefs by focusing on the services of fisheries using Thailand as a case illustration. Different fishing gears are applied in coral reef to catch fish such as traps and pots, gillnets, hook and lines, bottom longlines etc. Fish traps and hook and lines seems to be mostly found. Fish trap are generally found in Thai waters and mostly deployed near coral reefs and pinnacle targeting high economic fish such as groupers and snappers. The CPUEs of fish traps in Trat Province varied geographically and seasonally ranging from 0 – 2.56 kg/trap/day with its mean of 1.49 kg/trap/day. By tabulating the 2016 landing data, fish trap fisheries yielded about 6,867 tons with the total value of 15 million USD. The estimated value reflects a direct use, provided by coral reefs, which may be also underestimated due to that one fishing gear was only considered while the data of other gears and recreational fishing are still scarce. This study highlights the importance of coral reefs and the needs for the valuation of other indirect uses especially the importance of spawning, nursery, breeding and feeding areas for various organisms still exists.

MS4-6-743

Value added and community based coral reef management for sustainable use

Thamasak Yeemin, Makamas Sutthacheep, Wichin Suebpala, Wanlaya Klinthong, Watchara Samsuvan

Coral reefs generate goods and services with a significant economic value for Thailand and other ASEAN countries. The socio-ecological importance of coral reefs for human is obviously recognized as a large number of population in the Asia-Pacific region depend on healthy coral reef ecosystems. Anthropogenic disturbances on coastal areas are causing habitat degradation, particularly coral reefs. The studies in the Gulf of Thailand and the Andaman Sea showed that several human activities have severe negative impacts on many reef sites, decreasing the socio-economic benefits provided to local communities. Maintaining local community activities that rely on coral reefs while preserving the ecological function of the coral reef ecosystems is a management challenge. Management of coral reef ecosystems require scientifically based knowledge, because of the high complexity of the ecological processes. Our results showed the significant value added for good and services provided by coral reef ecosystems, particularly from tourism and bioactive compounds. Management strategies for sustainable use of coral reef ecosystems in Thai waters were proposed. Several neglected coral communities on the pinnacles and the new discovered offshore coral communities were highlighted and collaboratively managed by government agencies and local stakeholders with scientifically based knowledge supported by academic institutions. The ecological and socio-economic linkages that underpin the sustainable use of coral reefs can be projected. The effective integration of science with management is significant to improve coastal policies for both environmental management and economic development in Thai waters. A project on promotion and development of ecotourism sites for snorkeling and SCUBA diving in Chumphon Province, the Gulf of Thailand highlights the importance of tourism carrying capacity assessment, socio-economic conditions and community based ecotourism management.

MS5-1-755

Home is where the reef is: People and coral reef tourism

Maarten De Brauwer

The growing tourism sector is often heralded as a sustainable source of income for coastal communities in developing countries. However, the effects of climate change, overfishing, and impacts caused by tourism might change this. A wide body of research investigates these impacts and how they affect coral reefs, fish stocks, or tourism revenue. But in its core, tourism is not about the ocean, reefs, or fish. Tourism is first and foremost about people, people visiting locations, people doing activities, visiting sites, etc. Importantly, tourism is also about people welcoming visitors, people guiding tours, cooking food, building resorts… More often than not, tourism is about people meeting people, rather than people going places. This talk explores the different roles coral reefs play for people, and the roles people can play for coral reefs. By discussing studies that investigate the value of marine resources, aspects that attracts tourists, diver behaviour and impacts, I will try to address some of the crucial questions regarding the continued sustainability of coral reef tourism.

MS5-2-749

Oslob Whale Sharks: A bright spot in community based dive tourism

Judi Lowe

Dive tourism is often cited for its capacity to provide livelihoods forintegrated coastal management. There is however, insufficientevidence of the effectiveness of livelihoods from dive tourism inreducing reliance on coral reefs. No studies have quantified thecontribution of livelihoods from community based dive tourism orexplored whether they can reduce fishing intensity. Using thesustainable livelihoods framework, we study Oslob Whale Sharks, abright spot in community based dive tourism, located on the island of Cebu, in the Philippines. We found that Oslob Whale Sharks broughtsignificant income to fishers and their community in the five yearsfrom 2012 to 2016, creating alternate livelihoods for fishers and their families and diversifying the livelihoods of other residents of Tan-awan and Oslob. Livelihood outcomes include improvements in wellbeing, food security, empowerment and social inclusion for both communities. Importantly, the combination of livelihoods that ripplethroughout the communities and increased on-water law enforcementby the Bantay Dagat, lead to collective engagement in sustainableintegrated coastal management by fishers and their communities. As aresult, destructive fishing is reduced, whale sharks are protected fromillegal fishing and fishing effort is reduced when fishers changelivelihood strategies away from fishing.

MS5-3-748

To feed or not to feed? Artificial bread feeding and its effect on coral reef fishes and perception of stakeholders in the Aitutaki Lagoon, Cook Islands

Natalie Prinz, Sebastian C. A. Ferse, Richard Story, Stephen Lyon, Sonia Bejarano

Feeding wild animals is a regular habit in ecotourism worldwide, with poorly known consequences forecosystem function. This study synthesises for the first time 1) how effective is artificial feeding at attractingcoral reef fishes in the South Pacific, 2) which feeding guilds are most attracted, and 3) how are naturallevels of omnivory and grazing-detritivory affected and 4) how is this practice perceived by localstakeholders. Within the Aitutaki Lagoon (Cook Islands), data were collected in sites where fish are regularlyfed bread by snorkelers, and adjacent experimental sites, where bread was only provided for this study. The fish community was censused and feeding rates (bread vs. natural food) of two model species (*Chaetodon auriga*, *Ctenochaetus striatus*) were quantified. 24% of 71 species observed across sites wereeffectively attracted by bread, largely piscivore-invertivore and omnivore feeders. Mean fish biomass andabundance was significantly higher in tourism feeding sites than experimental sites. Taxonomic richnessdecreased during bread feeding, compared to one hour before and after across sites. Favouringopportunistic feeders, such as omnivores, may pose consequences to the ecosystem function through ashift in functional feeding groups and dominance over the long term. The effect of artificial feeding onnatural foraging rates varied between species. *C. auriga* fed significantly more on bread in tourism feedingsites versus experimental sites, *C. striatus* fed less on the benthos during feeding events, suggesting anindirect effect of bread feeding on foraging behaviour. Stakeholder interviews revealed that localstakeholders favour artificial feeding to improve tourist satisfaction, whereas tourists appreciatesnorkelling regardless of artificial feeding. Finding ways for humans to appreciate wildlife closely whilecausing minimal disruptions is crucial to balance awareness raising and conservation. Future research onfish metabolism and cascading effects on the reef benthos may reveal further impacts of artificial feeding.

MS5-4-750

Alternative or Additional? Stakeholder perceptions of tourism as an alternative for destructive fishing practices in Malapascua Island, Daan Bantayan, Cebu, Philippines

Julian Engel, Judith Almonacid, Anette Breckwoldt, Filipina Sotto, Marie Fujitani

As part of the coral triangle, the Philippines harbor large biodiverse small island ecosystems. However, destructive fishing practices, e.g. shark and dynamite fishing, have decreased ecosystem functions and services. On the Philippine Island of Malapascua thresher shark tourism generates significantly higher revenue, than the exploitation and therefore offers the potential for an alternative livelihood. In this study fuzzy-logic cognitive mapping, a type of participation modeling was used to analyze the perception of different stakeholder groups involved in marine resource management. A total of 51 (N = 100) interviews and 100 maps (N =300) were conducted. Our findings suggest that the local community is still highly dependent on fishing, but are also benefiting from the tourism. While marine resources slowly seem to recover from past typhoons and destructive fishing, land resources, especially the natural water reservoir, are overexploited and increasing pollution threatens the marine life and island population. Temporary migration (e.g. fishing) or permanent migration (e.g. occupation) to Malapascua Island seems to be a threat leading to additional pressure on the natural resource system. Tourism will not be a solution to overuse and resource depletion, but rather compensates, as it can reduce destructive fishing practices and creates an economical interest to resource conservation. The use of marine resources becomes more diverse and enforcement to ensure long-term management, rather than short term gain becomes more abundant. Conclusively, stakeholder participation, community based management regimens and stronger enforcement are needed to insure sustainable livelihoods on Malapascua Island.

poster presentations

AAC-159

Local acclimatization of *Symbiodinium* hosted by the coral *Galaxea fascicularis* at Hainan Island, northwestern South China Sea

Guowei Zhou, Hui Huang

The success of coral reef ecosystems largely depends on mutualistic symbiosis between scleractinian corals and the dinoflagellate photosymbiont *Symbiodinium* spp.. However, the flexibility of coral-algae associations in response to environmental changes is poorly known. In this study, we applied high-throughput internal transcribed spacer 2 amplicon sequencing to explore diversity and flexibility of *Symbiodinium* associated with *Galaxea fascicularis*, an ecologically important scleractinian coral species collected at five locations around Hainan Island, South China Sea. The results revealed a high diversity of *Symbiodinium* subclades with C2r and D17 being dominant in *G. fascicularis*. Clade D *Symbiodinium* occurred most frequently in habitats where the annual average sea surface temperatures are highest, suggesting that temperature is an important factor in determining *Symbiodinium* D compositions in *G. fascicularis*. The distribution of coral-*Symbiodinium* associations are possibly mediated by trade-off mechanisms which change the relative abundance of *Symbiodinium* clades under different environmental conditions. These findings may indicate that reef-building corals such as *G. fascicularis* can shuffle their symbionts to cope with environmental changes, and have implications for our understanding of the ecology of flexible coral-algal symbiosis.

AAC-461

Bacterial community shifts and biomarker enzymes in tourism-influenced corals

Sharon N. Nunal, Nino Dan G. Posadas, Jant Cres C. Caigoy

Multiple environmental and anthropogenic stressors are major threats to the Philippine coral reefs. One major factor affecting the functioning and immunity of coral is its microbial assemblage symbiont. Bacterial community which is a part of the coral-associated microbiome is known to contribute to the metabolic processes and adaptation of the corals to environmental changes. Bacterial community composition and biomarker enzyme activities of healthy and bleached *Acropora*, *Seriatopora* and *Porites* samples collected from two identified coral reef sites that are pristine (Unisan, Guimaras) and tourism-influenced (Boracay Is., Aklan) within Panay Island, Philippines were evaluated. DGGE profiles revealed shifts in the bacterial community composition of the holobiont among samples between sampling sites suggesting that shifts are linked and influenced by coral morphology and genus. Furthermore, biomarker enzymes involved in the innate immune mechanisms such as the melanin synthesis pathway and free radical scavenging were investigated to determine susceptibility of the corals to diseases induced by pathogens and to understand the limits of resilience of the reef ecosystem. Crude enzyme extracts of coral samples from tourism-influenced site generally showed significantly higher activities than those collected from the pristine environment. The results also suggest that tourism-related stressors may induce the correlation between melanin synthesis associated enzymes such as peroxidase and various phenoloxidases.

AAC-329

Seasonal dynamics of the *Symbiodinium* subtypes in *Lecptoria phrygia*

Ya-Yi Huang, Rodrigo Carballo-Bolaños, Shashank Keshavmurthy, Allen Chen

In response to environmental stress, corals can either physiologically acclimatize or genetically adapt to surrounding circumstances. Symbiotic associations between scleractinian corals and dinoflagellates (*Symbiodinium*) are considered an acclimatization in response to sea surface temperature (SST) fluctuations. The *Symbiodinium* comprises genetically diverse clades. A case study of *Isopora palifera* in southern Taiwan demonstrated the shuffling between thermal-tolerant *Symbiodinium* type D1a and thermal-sensitive type C3. Another study of *Platygyra verweyi* showed that this species is particularly abundant at the outlet of a nuclear power plant where the average SST is 2~3°C higher than other reef sites and its associated *Symbiodinium* is type D1a. However, the *Symbiodinium* becomes type C3 when it grows at cooler areas. In this study we explore *Symbiodinium* dynamics of another coral species *Leptoria phrygia* using Illumina MiSeq paired-end sequencing. Samples were collected repeatedly at different seasons from five colonies each in Wanlitong and the Outlet. Our sequencing of 80 amplicons resulted in 111,898 ITS2 sequences, representing 142 C subtypes and 14 D subtypes. Three colonies from the Outlet are consistently D dominant without significant seasonal fluctuation, even after they were translocated to Wanlitong. The remaining two colonies host relatively higher ratio of the C subtypes and seasonal ebb and flow is more dramatic. Of the four colonies from Wanlitong, the ratio of the C subtypes increased and become stabilized through time in three of the colonies, which become consistently D dominant after being translocated to the Outlet. Samples of the 4th colony had significant ebb and flow of the C subtypes through time and eventually become dominated, a scenario found in translocated samples of one colony from the Outlet to Wanlitong. In addition to seasonal fluctuation and environmental effect, there is also within colony variations, which have been observed from samples collected from Wanlitong and the Outlet.

AAC-518

Symbiont diversity in *Heliopora coerulea* from the Bolinao reef complex in northwestern Philippines

Vanessa Joy Fano Diamante, Rubie Ibanez Esmolo, Cecilia Conaco, Patrick Cabaitan

A major driver of the distribution and diversity of coral reefs is the symbiotic relationship between corals and the dinoflagellates of genus *Symbiodinium* in their tissues. The types of symbionts hosted by a coral influence its ability to tolerate and thrive under certain environmental conditions. In the Bolinao Reef Complex in northern Philippines, the blue coral, *Heliopora coerulea*, has emerged as one of the most dominant species in recent years. Whether the blue coral hosts different communities of symbionts compared to scleractinian corals, is not yet known. In this study, colonies of *H. coerulea* were collected from different sites in the Bolinao-Anda reef complex and from different depths. The coral colonies did not exhibit site or depth-specific differences in symbiont density. However, distinct symbiont types were identified in some blue coral colonies from different reef environments. These differences may correlate with unique physiologies of the symbionts that, along with intrinsic adaptability of the host, may play a role in the ecological success of the blue coral in areas that experience highly variable environmental conditions.

AAC-672

Influence of terrestrial runoff on a coastal coral reef documented from century-long coral skeleton-bound nitrogen isotope (CS-δ15N) records

Taihun Kim, Nicolas Duprey, Dae-Won Lee, Heung-Sik Park, David M. Baker

Population along the world's coastlines is rising and exerts an increasing pressure on coral reefs. Excess nutrient, in particular nitrogen (N), is one of the major concerns, and it has been associated with biodiversity loss and decrease in coral cover. Thus, identifying natural and anthropogenic N-sources in a coral reef ecosystem is crucial to implement efficient mitigation policies. The influence of N point-sources, such as sewage effluent can be identified relatively easily. However, defining inputs of N nonpoint-sources on coral reefs, such as terrestrial runoff, remains challenging. Coral skeleton stable N isotope ratios record the $\delta^{15}N$ of the N sources in the ecosystem, and therefore can be used as tracer of runoff-derived N. Moreover, historical fluctuations in the CS-$\delta^{15}N$ record may bring invaluable information on land-use changes (e.g. deforestation, reclamation and agriculture). Here we produced two CS-$\delta^{15}N$ records from 77 and 128 years old *Porites*cores in Chuuk lagoon, Federated States of Micronesia. Chuuk has a long-history of land deforestation that started during WWII with the invasion of the Japanese forces and the subsequent heavy bombing of Operation Hailstone in 1944 by the US Navy. This historical context provides an interesting ground to assess the potential of CS-$\delta^{15}N$ records to track runoff-N in the ecosystem.

AAC-722

Comparative Evaluation of Five Protocols for Protein Extraction from Stony Corals (Scleractinia) for Proteomics

Huamin Cheng, Hongwei Zhao, Tinghan Yang, Sunlan Ruan, Nan Xiang, Hailong Zhou, Qing X Li, Xiaoping Diao

Corals especially the reef-building species are very important to marine ecosystems. Proteomics has been used for researches on coral diseases, bleaching and responses to the environment change. However, a comparative evaluation of different protein extraction protocols is still not available for proteomic analysis of stony corals. In the present study, five protocols were compared for protein extraction from stony corals. The five protocols were TRIzol, phenol-based extraction (PBE), trichloroacetic acid (TCA)-acetone, glass bead-assisted extraction (GBAE) and a commercially available kit. PBE, TRIzol and the commercial kit were more robust for extracting proteins from stony corals. The protein extraction efficiency and repeatability, two dimensional electrophoresis (2-DE) and matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF-MS) were employed to evaluate the protocols. The results indicated that PBE protocol had the better protein extraction efficiency than the others. Protein extraction coverage varied among the procedures. Each protocol favored for certain proteins. Therefore, it is very important for coral proteomic analysis to select a suitable protein protocol upon the experimental design. By using PBE protocol and iTRAQ quantitative proteomics, we have performed a protein expression comparison between bleaching and unbleaching corals (*Acropora muricata*), more than 1800 proteins were found to have a significant expression difference between them.

AMC-185

Distribution and abundance of intertidal sponge (Porifera) communities in coral reefs of Singapore

Shu Feng Lim, Lik Tong Tan, Jasmine JieLin Tong, Beverly Pi Lee Goh

Given the functional roles of sponges in the coral reef community, few studies have looked at sponge community assemblages in Singapore. This survey was conducted to study the sponge diversity, species richness and abundance of intertidal sponge communities in Singapore's coral reefs, namely, P. Hantu, Tanjong Rimau, Labrador Park and P. Subar Laut. Belt transects measuring 10 m by 1 m were established to survey sponge communities at these reef sites. Sponges were identified based on their morphology. A total of 28 morphospecies belonging to eight different sponge orders (Chondrillida, Clionaida, Dictyoceratida, Haplosclerida, Poecilosclerida, Suberitida, Tetractinellida and Verongiida) was identified. Univariate statistical analyses revealed that sponge diversity, species richness and abundance at P. Hantu site 2 was significantly higher than in Labrador Park. In addition, multivariate statistical analyses showed that in terms of community structures, there were three distinct clusters (P. Hantu site 2, Labrador Park and P. Subar Laut). These clusters may be sponge species specific or due to environmental factors. The preliminary data presented in this study could serve as the baseline data for future studies on sponges in Singapore for their ecological, biopharmaceutical and commercial roles.

AMC-365

The coral reefs at Kenting National park, Taiwan, refused to die

Chao-yang Kuo, Ming-Jay Ho, Yie-Jia Chen, Ai-Chi Chung, Pei-Jie Meng, Ping-Ho Ho, Jih-Terng Wang, Jeng-Ping Chen, Yuh-Wen Chiu, Hsing-Juh Lin, Yang-Chi Chang, Tung-Yung Fan, Chaolun Allen Chen

In the era of Anthropocene, the temporal change of coral assemblage compositions under multiple disturbances, in particular, human-induced chronic disturbances, are important studies for understanding the mechanism and to predict the shift of coral assemblages in the future. In this study, a 13-years long-term monitoring research was used to document the change of coral assemblage compositions in the tiny but high diverse coral reefs at Kenting National Park (KNP), Taiwan, the connective Stepping-stone in the Kuroshio Current, under repeated disturbances. More importantly, other than natural disturbances such as bleaching events and typhoons, the reefs at KNP are also suffering from the stress induced by millions of tourists annually. Our result suggested the reefs at KNP showed high ability to recover from major disturbances, even under severely anthropologic stress. In the six years since severely damaged by Typhoon Morakot in 2009, coral increased in biomass and became the dominated benthic taxa from the algae dominated status until severely damaged again by Typhoon Nepartak and Typhoon Meranti in June 2016. The recovery was contributed by the consistency of high density of juvenile corals recruited on the reef. However, the recovery patterns of coral cover among sites were varied across KNP. Coral assemblages in areas protected from typhoon-induced disturbances recover faster than coral assemblages at areas exposed. More interesting, the recovery was contributed by tabular and corymbose *Acropora* instead of open-branching *Acropora* or foliaceous *Montipora*, the dominant taxa before the typhoon. Out result highlighted the ability to recover after repeated disturbances in the tiny but high diverse anthozoan assemblages. However, reassembly might take longer or shift toward a new shape of assemblage composition in KNP.

AMC-423

Reef fish diversity and nursery function of a patch reef in Zhaoshu island of Xisha islands

Yang JianHui

In a field survey of coral reefs in the Xisha Islands in June 2016, we found one patch reef, in the south of Zhaoshu Island, which had unusually high species richness and densities of reef fishes. By comparison, records of 5-8 years from other sites on the same island show much lower species richness and densities. Within an area of 250 square meters, this patch reef had about 5,000 fishes belonging to 24 families, 52 genera and 89 species, and mean density of 17.86 individuals/m^2. In particular, this patch reef had 30 species of juvenile fishes present, predominantly omnivorous or carnivorous species, and including small-scale aggregations of juveniles of 4 species, *Caesio tere, Lutjanus kasmira*, *Pterocaesio tile* and *Monotaxis grandoculis,* which are commercially fished in the Xisha Islands. These aggregations were not observed at other sites. We suggest that this patch reef may serve as a nursery habitat and refuge for juvenile reef fishes, which will colonize adjacent reef areas as they grow.

AMC-520

Assessment of the benthic community of the Bolinao Marine Laboratory intertidal zone

Rubie Ibanez Esmolo, Vanessa Joy Diamante, Cecilia Gastardo Conaco

Human activities, such as mariculture and coastal development, cause changes to the coastal environment with unexpected effects on marine ecosystems, especially on the less appreciated benthic fauna. Benthic fauna includes animals, such as molluscs, crustaceans, worms, corals, and others, that live on the sea floor or in sediments. These organisms play a vital role in the functioning of coastal ecosystems but are vulnerable to changes in the environment. The site of the Bolinao Marine Laboratory in Bolinao, northwestern Philippines, is one such area affected by intense fish farming, coastal reclamation, and the building of more roads and houses near the coast. These activities have resulted in visible changes to the quality of water and sediment, yet their effect on marine biodiversity in the area remain unknown. In this study, the benthic faunal species in the rocky intertidal zone adjacent to the Bolinao Marine Laboratory was surveyed. Benthic cover along the intertidal zone area was dominated by the seagrasses, *Cymodocea* and *Thalassia*. Diverse epifaunal species of economically valuable gastropods and bivalves, including cone snails and the invasive blue mussel, were commonly observed. Initial findings indicate that the rocky intertidal area in Bolinao remains productive and diverse. This emphasizes the importance of conducting regular monitoring in the area to track shifts in the benthic community so as to guide effective strategies for the management of human impacts. Importantly, this diversity assessment activity involved participation of local highschool students, providing an ideal opportunity to spread awareness on the consequences of coastal development and to inspire an appreciation for hidden marine biodiversity in members of the local community.

AMC-557

Preliminary analysis of reef fish species composition in the Andaman Sea and Gulf of Thailand

Felipe Monteiro Gomes de Mattos, Thamasak Yeemin

Thailand's coastal systems are considered to be within the influence zone from the coral triangle biogeographic region, covering both the Andaman Sea and Gulf of Thailand. For it's shallow waters (suitable for the growth of coral reefs) land barriers and intern currents, these ecosystems present some of the highest diversity and endemism rates among Asian continental margins. The aim of this study is to present initial data regarding the reef fish composition of five Islands systems in the Andaman Sea and Gulf of Thailand. The study sites comprised two archipelagos in the Andaman Sea: Similan Islands and Surin Islands; and three more in the Gulf of Thailand: Sichang Islands, Samet Islands and Lan Islands. The method used for data survey was UVC, with depths between 3 and 6 meters. Since the data herein presented is preliminary, and the collection method varied among some sites due to environment conditions, we do not present density data here. Between the two ecosystems a total of 233 Actinopterygii species were identified, belonging to 42 different families, and one Ellasmobranchi (*Dasyastis kuhlli*). In the Andaman sea we were able to identify 168 species not present in the Gulf, while 48 were registered for this last one and only 18 were common to both ecosystems. The five families with highest species numbers are Pomacentridae (46), Labridae (43, being 9 inside Scarinae), Chaetodontidae (20), Acanthuridae (14) and Epinephelidae (11). From the 18 species in common above cited, 8 belong to Pomacentridae, and the other 10 are distributed in 8 more families. It is interesting to notice that no Acanthuridae or Scarinae was registered for the Gulf of Thailand, while only 1 labrid species was common between both systems. The on going studies might result in more clarifying data, allowing further discussions and trustworthy conclusions.

AMC-626

Health assessment of coral reef ecosystem

Tao Li, Cuimei Liu, Jing Mo, Sheng Liu, Hui Huang

Coral reefs is one of the most productive and richest ecosystems on earth. And it is very important for marine ecological health, global economy and social development. In the last hundred years, the global coral reefs have been severely degraded affected by global changes and human activities. There are many islands in the South China Sea, and the coral reef ecosystem also tends to degenerate. However, it is still unclear how the health status of coral reef ecosystems is, and a set of scientific assessment standards for health has not been formed. This paper combines the domestic and foreign health assessment index system of coral reef ecosystems and other ecosystems. And then preliminary screening of major factors and related parameters for evaluating the health of coral reef ecosystem. It also stipulates the contents of evaluation index weight, assignment standard, related evaluation and calculation method and so on, and initially establishes the index system of health assessment. Its aim is to provide scientific basis for guiding the construction and utilization of coral reef engineering, and for the restoration, conservation and management of coral reef ecosystem in coral reef ecosystem.

AMC-658

Abundance and diversity of reef fishes and macroinvertebrates in Marudu Bay, Sabah, Malaysia

Mohd Firdaus Akmal Nooramli, Zarinah Waheed, Muhammad Ali Syed Hussein

Located between two peninsulas at the northernmost part of Sabah, Marudu Bay is a semi – enclosed bay shared between three districts: Kudat, Kota Marudu and Pitas. Part of the bay is also located within the Tun Mustapha Park, the largest marine protected area in Malaysia covering almost 900,000 hectares. Most of the reefs in Marudu Bay are fringing reefs with several patch reefs. Surveys were conducted in August 2015 to determine the abundance and diversity of reef fish and macroinvertebrates within the bay. A total of 14 sites were surveyed between 5 m and 10 m depth using a transect-based Roving Diver method. A 100 m transect line was deployed and the survey was conducted within 5 m width of the transect line. All reef fishes and macroinvertebrates within the 500m^2 area were noted and photographed. Identification was made to the lowest taxa possible, Relative abundance of reef fishes and macroinvertebrates were determined based on the number of individuals estimated in the photographs. For reef fishes, 9,557 individuals were recorded comprising of 236 species from 41 families while 823 macroinvertebrates were recorded comprising of 56 species from 36 families. For reef fishes, family Pomacentridae (Damselfishes) had the highest abundance (3,330 individuals) and diversity (48 species) while Caesionidae (Fusiliers) had the second highest abundance (1,981 individuals) from three different species. For reef macroinvertebrates, class Echinoidea had the highest abundance (316 individuals) from two species while class Gastropoda was the most diverse with 21 species.

AMC-645

Connectivity of marine habitats and reef fish species richness in Davao Gulf, Philippines

Cleto Jr. Lema Nanola, Mae Angelie Paradela, Ricky Biyo

Presence of various marine habitats are important to the life history traits of many reef fishes. In 2016 and 2017, a total of sixteen MPAs in Davao Gulf were surveyed during the southwest monsoon period from June to September. The benthic status and reef fish diversity of these MPAs were assessed using standard tools where sampling unit was a 50-m transect line. The benthos and reef fishes were assessed using photo quadrat and underwater fish visual census techniques, respectively. From a total of 123 transects, this study yielded a species diversity estimator using Jackknife of more than 400 species, just 150 less from the estimates obtained for the entire Celebes Sea Biogeographic Region. Moreover, historical data in Davao Gulf obtained in early 2000 yielded almost the same estimate. This simply suggest that species diversity in the area remained high suggesting good management efforts. Moreover recent publications revealed more new records and new species that further support Davao Gulf as a key marine biodiversity area in the southern part of the country.

AMC-735

Coral reef conservation efforts in the Emirate of Abu Dhabi

Hamad Al Jailani, Ibrahim Bugla

They are valued for their biodiversity and their unique ecosystem. Coral reefs play a significant role in providing habitats for important species of fish and invertebrates in Abu Dhabi. (Grandcourt E. M., 2017).

Similar to many ecosystems, coral reefs face massive threats from global climate change and deterioration due to anthropogenic activities. (Edwin Grandcourt, M. A., (2014). Coral reefs are one of the most critical marine habitats in Abu Dhabi. Hence, the Environment Agency – Abu Dhabi has implemented an annual monitoring program to ascertain the health status of coral reefs.

Three specific site have been chosen for analysis to represent the Ras Chanadah (eastern), Bu Tinah (central) and Delma (western) regions of the Emirate of Abu Dhabi.Cover analysis done using Coral Net, a web-based software which places 50 random points on an image to extract information on live coral and benthos coverage.

All three monitoring sites have the coral species *Porites*, the largest cover recorded is in Delma site (20.5%), following Bu Tinah (17.9%), then Ras Ghanada (9.4%).The highest coral cover diversity remains in Ras Ghanada site with a sum total of 50.8%, compared to Delma (31.2%) and Bu Tinah (19%).

The live coral coverage was highest in Ras Ghanadah at a percentage of 51%.This concludes with an overall increase in live coral cover across the three sites during the last three years. This increase shows that Abu Dhabi sites were not highly affected by the 2015-2016 bleaching event (NOAA, 2017) that affected other coral reefs in the indo-pacific region causing mass mortality.

BCC- 694

Bioactivity screening and chemical characterization of secondary metabolites from Philippine marine sponge

Shalice Susana, Zabrina Bernice Malto, Viviene Santiago, Lilibeth Salvador Reyes

Sponges continue to be a prolific source of bioactive compounds with therapeutic applications. In this study, we aim to screen secondary metabolites extracted from marine sponges collected in Pangasinan and Oriental Mindoro for their bioactivities and characterize the bioactive compounds through a bioassay-guided purification approach. A total of 48 sponges were extracted sequentially with hexane, 80:20 dichloromethane:methanol (DCM:MeOH), and MeOH. Crude extracts were screened for their antimicrobial activity against *Staphylococcus aureus, Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, antiproliferative activity against HCT116 and MCF-7 cancer cells and anti-inflammatory activity on lipopolysaccharide-stimulated RAW 264.7 cells. About 13% and 3% of the extracts inhibited the growth of *S. aureus* and *K. pneumoniae*, respectively at 50 µg/mL. Moreover, about 10% and 5% of the extracts exhibited antiproliferative activity against HCT116 and MCF-7, respectively at 5 µg/mL. Seven sponge crude extracts exhibited anti-inflammatory activity and were prioritized for further purification using solid-phase extraction-C18 (SPE-C18) followed by reversed-phase high performance liquid chromatography (RP-HPLC).

BEC- 193

Understanding the red reticulate *Goniobranchus*: Molecular and morphological investigations

Giun Yee Soong, James Davis Reimer

The taxonomy and diversity of many nudibranchs (Mollusca: Gastropoda: Nudibranchia) is relatively well studied, although molecular analyses have only been successfully completed for some groups. Within Nudibranchia, the genus *Goniobranchus*Pease, 1866 one such group that remains to be examined in detail. The genus is categorised into several different species-groups based on external colour, including the red-reticulate group. The red-reticulate group has been considered as a single variable species, but shows consistent differences between specimens based on geography, and may be a species complex. In this study, red reticulate nudibranchs were collected from different locations in Okinawa-jima Island and Iriomote-jima Island, Japan as well as from the Sunshine Coast, Australia. The external and internal morphology were closely examined, and molecular analyses were performed on all collected specimens. The specimens were analysed using mitochondrial cytochrome oxidase subunit I (COI), 16S ribosomal DNA, and nuclear Histone 3 (H3) sequences. A concatenized dataset's (COI+16S+H3) resulting maximum likelihood (ML) and Bayesian inference (BI) phylogenetic results demonstrated that all red reticulate specimens formed a monophyletic clade of their own separate from other *Goniobranchus* sequences. However, the red reticulate group included sequences of specimens of at least two described species; *Goniobranchus reticulatus* Quoy and Gaimard, 1832 and *Goniobranchus tinctorius* Rüppell and Leuckart, 1830, both with red reticulate patterns and white or yellow mantle borders based on original descriptions, that fell into one single clade. Other *Goniobranchus* red reticulate morphotypes formed other different phylogenetic clades, leading us to believe that undescribed species exist within this group. This study demonstrates that molecular phylogenetic analyses can further clarify the taxonomy of nudibranchs, particularly when paired with morphological analyses.

BEC-216

A preliminary results of soft coral barcoding in Dongsha Atoll

Chi Cheng, Chang-Feng Dai, Yehuda Benayahu, Shang-Yin Liu

Coral reef is one of the most important habitat to marine creatures, and almost half of them were comprised of soft corals (Cnidaria: Octocorallia). The identification of soft corals is always a challenging task to marine biologist because their colony shape and sclerites are sometimes flexible. Recently, with the combination of both morphological and phylogenetic approaches which provides a better resolution to understand their evolutionary relationship. Dongsha Atoll, which located in the northern South China Sea, has great coverage of hard coral as well as soft coral. In present study, 86 specimens were collected and identified as 50 species (10 genera) in Alcyoniina. We used the mitochondrial protein-coding gene *msh1* as genetic barcode, 86 specimens were sequenced and a maximum likelihood tree was constructed with reference sequences downloaded from Genebank. Our results showed highly support at the genus level. *Dendronepthya*, *Litophyton* and *Stereonepthya* formed a reciprocal monophyletic clade in Nephtheidae. The genus Sinularia formed a monophyletic group. Additionally, *Sarcophyton* was polyphyletic, and *Lobophytum* was embedded within *Sarcophyton*. The results showed that *msh1* can only identified 2 out of 8 species in *Sarcophyton*. Since there are not many reference sequences of several genera (i.e. *Klyxum*, *Cladiella*), the resolution of *msh1* on these genera was unable to detect. Our result suggested that using the mitochondrial protein-coding gene *msh1* as a single barcoding gene is not enough to resolve species level taxonomy. In the future,we are going to combine more genetic markers such as COI and 28S rDNA to perform multilocus barcoding analyses.

BEC-245

Reconstruction of the phylogenetic and diversification patterns of the circumtropical macroalgae *Sargassum*

Zhi Ting Yip, Randolph Zheng Bin Quek, Danwei Huang

The highly diverse brown macroalgae *Sargassum* is a cosmopolitan genus spanning three ocean basins, Atlantic, Pacific and Indian Oceans, dominating both subtropical and tropical habitats. *Sargassum* was believed to have originated in the Oligocene epoch approximately 30 Ma ago according to Silberfeld et al. (2010), but its diversification to become one of the most species rich and widespread macroalgal genera remains unclear. We present a Bayesian molecular clock study which included data from the Fuculean order of the Brown Algae Crown Radiation (BACR) group to reconstruct the phylogeny. The analysis included a total of 120 taxa with 99 *Sargassum* species sampled for three genes – *ITS-2*, *cox3* and *rbc*-LS – as well as an unambiguous Sargassaceae fossil for calibration. The reconstruction revealed a much earlier origin of *Sargassum* estimated at 4 Ma which diversified only at 2.8 Ma. The time tree mapped with current geographic data was then applied in model-based stochastic analyses to estimate range-dependent (Atlantic and Pacific [including Indian Ocean] regions) rates of speciation, extinction and dispersal. High diversity in the Pacific Ocean is attributed to faster range expansion of Atlantic species into the Pacific, while dispersal of Atlantic species into the Pacific and subsequent extinction lead to low species richness in the Atlantic Ocean. Diversification patterns are inconclusive due to low species number represented in the Atlantic region resulting in diversification rate heterogeneity. However, ancestral range reconstruction using Dispersal-Extinction-Cladogenesis (DEC) model posits an origination in the Pacific region. Analyses of these dynamic processes have potential, when fine tuned to a higher spatial resolution, to help identify evolutionary hotspots and provide insights into long-term dispersal patterns.

BEC-253

DNA barcoding of coral associated fishes of Saint Martin's Island of Bangladesh

Kazi Ahsan Habib, Amit Kumer Neogi, Najmun Nahar, Provakor Sarkar, Kabir Ikramul Haque

The current rate of species description using traditional keys is extremely slow and typically require specialized expertise which have severely limited the understanding of coral reef biodiversity. DNA barcoding is an advance tool to identify unique, cryptic and new species from marine ecosystems and reveals undisclosed biodiversity than previously estimated. Saint Martin's Island is the only coral island in Bangladesh. The island was declared an Ecologically Critical Area (ECA). There is lack of information on different biodiversity data such as a complete species inventory, recruitment process etc. for conservation and designing effective Marine Protected Area (MPA). Present study aims to assess the diversity and make an updated inventory of coral associated fishes of the island using DNA barcoding, and to build a reference library of DNA barcodes. From November to till date, 75 species of fish were collected from the reef environment of the Island. Collected samples were first identified by examining morphometric characteristics and then assessed by DNA barcoding. Until now, 50 fish species have been successfully barcoded. The study provided several new records of fish species in Bangladesh viz., *Valenciennea muralis* (Valenciennes, 1837), *Blenniella periophthalmus* (Valenciennes, 1836), *Leiognathus longispinis* (Valenciennes, 1835), *Johnius amblycephalus* (Bleeker, 1855), *Pomadasys guoraca* (Cuvier, 1829).

BEC-259

Phylogenomics of class Anthozoa (Cnidaria) using universal target-enrichment baits

Andrea M Quattrini, Brant C Faircloth, Estefania Rodriguez, Catherine S McFadden

The anthozoan cnidarians (e.g., corals, sea anemones) are an ecologically important and diverse group of marine metazoans that occur from shallow to deep waters worldwide, and include some of the ocean's most important ecosystem engineers. Our understanding of the evolutionary relationships among the ~7500 species within this class is, however, deeply flawed. Molecular phylogenetic studies have revealed widespread homoplasy in morphological characters and widespread polyphyly at the ordinal, family, and genus levels. Resolution of both deep and shallow nodes in the anthozoan phylogeny has been hindered by a lack of phylogenetically informative markers that can be sequenced reliably across taxa whose divergence may pre-date the Cambrian. While recent phylogenomic analyses have supported the reciprocal monophyly of sub-classes Octocorallia and Hexacorallia, resolution of the ordinal relationships within each clade requires more comprehensive taxon-sampling than can be achieved with transcriptomic approaches. Using all available anthozoan genomes and transcriptomes, we designed a set of 16,306 target-capture baits for enriching both ultraconserved elements (720 loci) and exons (1071 loci). Target enrichment was tested on 242 taxa representing all orders and a majority of the known families of Anthozoa. Illumina sequencing of enriched genomes recovered 1774 of 1791 targeted loci, with a mean of 638 ± 222 loci recovered per species. Maximum likelihood analyses of a 925-locus dataset with 50% taxon occupancy yielded highly resolved trees. In addition to answering long-standing questions about evolutionary relationships at the ordinal and family level, preliminary data suggest that this approach will also facilitate delimitation of species, offering a more versatile alternative to RAD-tag methods.

BEC-298

Examining temporal reproductive isolation between lineages of the reef-associated sea cucumber *Stichopus* cf. *horrens* in Northern Philippines

Rose Angeli Valeza Rioja, Maria Rachelle Gallmann, Rafael Junnar Dumalan, Apollo Marco Lizano, Marie Antonnette Juinio Meñez

Populations are continuously being broken down into smaller units through extrinsic barriers such as spatial and temporal reproductive isolation in the process of speciation. Previous studies have shown that *Stichopus* cf. *horrens*, a reef-associated broadcast-spawning invertebrate (Stichopidae), have two distinct mitochondrial lineages in certain parts of Northern Philippines, including Sta. Ana, Cagayan, and Anda, Pangasinan. The co-occurrence of these two clades (i.e. Clades A and B) in these areas indicates minimal spatial reproductive isolation and possible temporal isolation. To examine this potential temporal reproductive isolation, two approaches were carried out: (1) collection of two sets of broodstock (i.e. March and May 2017) from Sta. Ana, Cagayan, followed by molecular species identification and *ex situ* spawning observation at UP MSI Bolinao Marine Laboratory, and; (2) *in situ* spawning observation in Anda, Pangasinan, 3 to 4 nights after the 3rd lunar quarter followed by clade assignment of spawned individuals. Lineages were identified using Restriction Fragment Length Polymorphism (RFLP). For the March spawning batch, 2 out of 19 individuals were identified as clade A, while only 3 out of 32 for the May spawning batch. Results showed that Clade B individuals spawned 2-5 nights after new moon, a spawning timing similar to that documented in China. Moreover, clade A individuals spawned 2-5 nights after 3rdlunar quarter, concordant with the documented spawning events in other parts of Northern Philippines. In situ observations in Anda also revealed that individuals that have spawned 3-4 nights after 3rd quarter are all under Clade A. While the result of *in situ* observation supports that of *ex situ*, our observation may be due to the unequal abundance of clade B lineage in the Anda. *In situ* observation should also be conducted in Sta. Ana, Cagayan, where an equal abundance of clade A & clade B individuals are observed. Our preliminary experiment documented intra-species differences in spawning timing between *S.* cf. *horrens* lineages, which gives us an insight on the mechanism of temporal reproductive isolation among marine invertebrates.

BEC-315

Symbiodinium diversity in Philippine corals: Biogeographic variation in the Pocilloporidae

Andrew Torres, Rachel Ravago Gotanco

Identifying resilient coral populations and understanding determinants underlying resilience have important implications for coral reef restoration efforts. A key factor contributing to the resilience of corals is their obligate symbiotic relationship with photosynthetic single-celled dinoflagellates (zooxanthellae) predominantly belonging to the genus *Symbiodinium*. Zooxanthellae composition has been shown to be associated with coral survival in adverse environmental conditions. In this study, we employed PCR-DGGE fingerprinting of the zooxanthellae ITS2 gene region to characterize the subclade diversity of *Symbiodinium* in several coral species found in four of the biogeographic regions in the Philippines: West Philippine Sea (WPS), Bohol Sea (BOH), Sulu Sea (SUL), and Celebes Sea (CEL). Results show uniformity in dominant *Symbiodinium*subclades found in *Acropora* spp., *Porites cylindrica*, and *Heliopora coerulea* across all sites sampled. Species under Pocilloporidae (*Pocillopora damicornis sensu lato*, *Seriatopora* spp., and *Stylophora pistillata*), on the other hand, exhibited biogeographic variation in zooxanthellae composition. Pocilloporid coral communities in WPS and CEL were shown to harbor *Symbiodinium trenchii*, an endosymbiotic species hypothesized to be resistant to thermal stress, while communities in BOH and SUL were revealed to host a diverse array of *Symbiodinium* C subclades. Here we provide a snapshot of *Symbiodinium* diversity during the onset of 2014-2017 global bleaching event and speculate that differential levels of local stress and refugia among biogeographic regions was causal to this variability, which may provide insights on the adaptive capacity and resilience of coral communities in the face of increasing levels of environmental stressors in the years to come.

BEC-351

Microbiomes of gall-forming copepod crustaceans from the corals *Stylophora pistillata* (Scleractinia) and *Gorgonia ventalina* (Alcyonacea)

Pavel Shelyakin, Sofya Garushyants, Sofya Mudrova, Michael Berumen, Arjen Speksnijder, Bert Hoeksema, Mikhail Gelfand, Viatcheslav Ivanenko

Corals harbor complex and diverse microbial communities that have a great impact on host fitness and resistance to diseases, but these microbes themselves can be strongly influenced by stresses, like those caused by the presence of parasites. In addition to causing direct impacts on their host, parasites can serve as transmitters of pathogenic microbial communities. We analyzed two coral gall-forming copepod systems by using 16S rRNA metagenomic sequencing: (1) the sea fan Gorgonia ventalina with copepods of the family Lamippidae from the Caribbean and (2) the scleractinian coral Stylophora pistillata with copepods of the genus Spaniomolgus from the Saudi Arabian part of the Red Sea. We show that bacterial communities in these two systems were substantially different with Actinobacteria, Alphaproteobacteria, and Betaproteobacteria more prevalent in samples from the Caribbean, and Gammaproteobacteria, in the Red Sea. In the Red Sea scleractinian coral host, normal coral microbiomes were enriched with the common coral symbiont Endozoicomonas sp. and with some unclassified bacteria, while copepods and gall tissues microbiomes were highly enriched with ME2 group (Oceanospirillales) or Rhodobacteraceae. In the Caribbean gorgonian host, none bacterial group had significantly different prevalence in the normal coral tissues, copepods, and injured tissues. The total microbiome composition of polyps injured by copepods was different. In contrast with expectations, the alpha diversity in the normal and injured tissues was similar.

BEC-537

Genetic population structure of the blue seastar *Linckia laevigata* and the boring giant clam *Tridacna crocea* in Malaysia

Zarinah Waheed, Bastian T. Reijnen, Arthur R. Bos, Marc Kochzius, Bert W. Hoeksema

Studies on population genetics in the Indo-Pacific region have revealed phylogeographic patterns in marine species populations. Very few of these studies extend into Malaysia. In view of this, we investigated the genetic population structure and gene flow of the blue seastar *Linckia laeviata*, and the boring clam *Tridacna crocea* spanning across the Sulawesi Sea, Sulu Sea and South China Sea in four localities in Sabah, one locality each in Peninsular Malaysia and the Spratly Islands. Additional samples of *L. laevigata* were obtained from the Davao Gulf, the Philippines. *Tridacna crocea* was absent from two out of the five sampled localities (Kota Kinabalu and Pulau Tiga, Sabah) at the time of the sampling. The analyses were based on partial mitochondrial cytochrome oxidase I (COI) sequences of 233 individuals of *L. laevigata* (601 bp) and 98 individuals of *T. crocea* (439 bp). Populations of *L. laevigata* and *T. crocea* showed departure from neutrality, which could indicate population expansion. Lack of population structure in *L. laevigata* implies gene flow among the sampled reef sites. There was subtle genetic structuring in populations of *T. crocea* (Φ_{ST} = 0.031, P < 0.0001), but AMOVA did not detect any structure in the a priori groupings. These differing genetic population structures are most likely attributed to the life history traits of the two species, geological history and seasonal current patterns in the seas surrounding Malaysia.

BEC-606

Symbiont community and host genetic diversity of the galaxy coral, *Galaxea fasicicularis* (Scleractinia; Euphyllidae), across the Tropical of Cancer in Taiwan

Sung-Yin Yang, Chai-Hsia Gan, Hui-Wen Tung, Shashank Keshavmurthy, Chaolun Allen Chen

Sea surface temperature (SST) is the major factor contributing to coral bleaching, whose increased severity and frequency of occurrence are putting the survival of coral reef ecosystems worldwide at risk. However, the bleaching susceptibility is different among coral taxa, and depends on their associated *Symbiodinium*. During the global mass bleaching events in 1998, over 43% of ca. 4000 coral colonies from 45 genera were bleached in Great Barrier Reef, whereas less than 20% of *Galaxea fascicularis* showed signs of bleaching. Such patterns were associated with the different sensitivities of the *Symbiodinium* in response to thermal stress. Since *Galaxea fascicularis* is widely distributed in the Indo-Pacific areas dominating in inshore fringing reefs, it is a good model in the study of spatial variation of host and *Symbiodinium* due to the difference in climate zones. In this study, *G. fascicularis* and its *Symbiodinium* communities were examined around the coast of Taiwan and the surrounding islands including Green Island, Orchid Island, Penghu Island, and Dongsha Atoll. *G. fascicularis* were collected from two depths (3 m and 6 m) at 29 sites. The mitochondrial gene and microsatellite primers were used to analyze the population genetics of the host. The large subunit ribosomal DNA and ITS1 regions were analyzed for the *Symbiodinium* diversity. Results show a clear SST boundary line drawn from northeastern Taiwan to southern Penghu, where *G. fasicicularis* was dominantly associated with *Symbiodinium* D (*S. trenchi*) at southern Taiwan and Penghu, whereas at northern Taiwan and Penghu, a mixture of *Symbiodinium* C1 and D was dominant. The host populations also corroborate with this thermal boundary with a mixture of populations at the boundary of separation. It could be concluded that regional difference in the oceanic environment shaped both the *G. fascicularis* population and its*Symbiodinium* diversity.

BEC-618

Species diversity of molluscs in the Saint Martin's coral island of Bangladesh

Kazi Ahsan Habib, Kashfia Kabir, Amit Kumer Neogi, Najmun Nahar

Biodiversity study is essential for sustainable utilization of natural resources and to define biological entities for conservation and realizing the ecosystem structure. Saint Martin's Island is the only island in Bangladesh supporting coral reef ecosystem with coral associated floral and faunal diversity. This island is declared as an Ecologically Critical Area (ECA) by the government of Bangladesh. Mollusk is one the major dominant groups of this island. Previous studies on mollusk diversity of this island were not extensive and conducted based only on morphological characteristics. Unfortunately, the subtle morphological characters that differentiate species of this group are not easily discerned by non-specialists and sometimes misidentified. Present study aims to assess the diversity and make an updated inventory of mollusks of the island using morphomolecular approaches, and to build a reference library of DNA barcodes. This study has been started from August 2017 and continuing until now, and revealed a distribution of 60 Mollusks species belongs to 25 families based on morphological identification. Because DNA barcoding, the analysis of sequence diversity in the 5' region of the mitochondrial COI gene, has shown strong performance for identification of other taxonomic groups, we decided to test its capacity to identify most abundant species of mollusks found in Saint Martin's island. As a result, 40 individuals of 20 Mollusks species has been successfully barcoded. The study would be the database for the further ecological study and monitoring of coral reef mollusks in the Saint Martin's Island in future.

CRA-161

The common indicators of coral physiological ecology and its application

Huili Xu

Coral reefs, known as the "tropical rainforest in the ocean", are habitats for many marine animals. It is estimated that more than one quarter of marine fishes live in coral reefs. However, nowadays, human activities and the dramatic changes of natural environment have deteriorated coral reefs seriously. More and more scholars begin to study corals and theirs symbionts from the perspective of ecology, genomics and proteomics. Scleractinia corals are the main builders and frameworks of coral reef ecosystems. The study of coral physiological ecology can help to understand the stability, degradation and recovery process of coral reefs. The paper mainly sorts the common technique method indicators of physiological ecology, biochemistry and molecular for coral reef research, and to integrate, classify, compare and optimize them. Based on the introduction of observation methods, the biological implication and application of different indicators are discussed emphatically, which provides the basis for coral studies in the later period. These methods involve coral tissue biomass, calcification rate, respiratory metabolism, zooxanthellae density and photosynthetic physiological state of symbiotic algae in the coral, and other ecological indicators. Also the indexes of biochemical indicator (lipid content and fatty acid composition, antioxidant enzyme system) and the molecular level indicators (gene expression, the determination of housekeeping gene) were included. These results will promote the development of experimental marine biology methods and its application to the study of coral reefs ecosystem.

CRM1-101

Citizen science based marine pollution monitoring using ecotoxicological biomarkers in Singapore

Beverly PL Goh, Lik Tong Tan, Jasmine JL Tong, Karenne Tun, Linda Toh, Pei Rong Cheo, Henrietta Woo, Karen Lim

Ecotoxicological biomarkers have previously been developed at the molecular, biochemical, cellular and physiological levels to serve as early warning signals of environmental degradation using local green lipped mussels, *Perna viridis*, in Singapore. From 2016 to 2017, a citizen science biomonitoring programme involving schools, scientists and a government agency in Singapore was conducted. Over 90 pupils from 17 Secondary schools participated, contributing to data collection from two coastal locations in Singapore, namely, Sungei Buloh Wetlands Reserve and Punggol Jetty Point. The programme required organisms to be deployed in mesh bags at the monitoring sites and retrieved four days later. Levels of antioxidant in the blood of mussels were measured using the Ferric Reducing Antioxidant Power (FRAP) as a biochemical level assay, while a cellular assay examining lysosomal membrane stability was quantified using the Neutral Red Retention Test (NRRT). Physiological responses in the mussels were measured using clearance or feeding rate. Results showed higher antioxidant levels in organisms deployed at Punggol Jetty Point as compared to that at Sungei Buloh both in 2016 and 2017. In addition, an increase in lysosomal membrane stability and increase in clearance rate were observed at both sites in 2017, compared to 2016, indicating better environmental conditions prevailing in 2017. Results obtained from data collected over two years of the biomonitoring programme using these simple methods showed that these ecotoxicology techniques could be translated to citizen science activities that were relevant to, and applicable in environmental biomonitoring.

CRM1-117

Corals, kayaks, and citizen science

Otis Brunner, Shubham Deolka, Miles Desforges, Tim Keller, Darya Stepanenko, Connie Stemmer, Yazmin Zurita-Gutierrez, Satoshi Mitarai

Coral reef ecosystems across the globe are facing rapid decline due to anthropogenic stressors at a local and global scale. Corals in Okinawa have been subject to two severe bleaching events in the last 10 years that have affected over 90% of some reefs. Local disturbances such as poor farming or construction practices seriously mitigate coral's ability to recover from bleaching events and can often lead to the disappearance of local reefs. Citizen Science presents a method to actively engage local Okinawans in marine science while collecting baseline ecological data imperative to future conservation efforts. Innovative experimental procedures and customized equipment will facilitate the collection of high quality images of local fringing reefs using kayaks. A camera-frame system was designed to easily attach to a kayak while mitigating the effect the movement of the kayak has on image quality. Surveys were carried out in such a way that large areas of reefs can be captured in overlapping images, ensuring the replicability of the survey design so the reef can be monitored over time. Using 'Squidle' (open access image annotation repository), citizens identified organisms imaged from their local reefs. The open access nature of the annotation software means that there is no limit to the number of citizens involved in this project.

CRM1-243

Citizen science: A driver of community based marine conservation

Lucy Harding

People and the Sea (Pepsea) is a community-driven marine conservation NGO operating on Malapascua. Pepsea has two branches of operations; capacity-building community engagement initiatives and a volunteer based coral reef monitoring and biodiversity assessment programme. A commonly identified challenge in marine conservation continues to be a lack of manpower and finance to facilitate the necessary data collection (Bear, 2016; Cigliano *et* al., 2015; Cohn, 2008); In meeting this challenge, Pepsea has employed 'citizen science' at the core of their operations.

Prior to the establishment of Pepsea's monitoring programme in 2015 Malapascuas' reefs had not been subject to continuous, systematic biological monitoring. To bridge this gap, PepSea has set up 2 main surveys: a coral reef assessment and a roving diver fish survey. The first programme established 19 survey sites within the Municipality of Daanbantayan. Each site is surveyed annually to quantify anthropogenic and natural impacts, benthic composition, fish and invertebrate abundance and biodiversity, and coral recruitment rates. International volunteers specifically join PepSea to contribute to these surveys. The roving diver fish data is collected by members of the local community, trained by Pepsea's scientist and supported by dive centres. This survey specifically aims at monitoring the impact of enforcement of the Monad Shoal Sanctuary and is a great example of the value of citizen science as a tool for the education and engagement of local communities and stakeholders.

Such long-term programmes are only sustainable through the application of 'citizen science' and the establishment of a robust participatory programme. Visiting and local volunteers, who may not have a formal scientific background, undergo rigorous training (and testing) under the guidance of experienced marine scientists, allowing them to subsequently assist in the acquisition of reliable and accurate data to support local marine resources management efforts.

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CRM1-408

How to enable comprehensive tracking of coral bleaching across Indonesia Archipelagic

Derta Purwita Dhine Prabuning, Firdaus Agung, Permana Yudiarso, Hadi Yoga Dewanto, Beginer Subhan, Rizya Ardiwijaya, Muhammad Abrar

To monitor coral bleaching event and how the reef is impacted, timing is really important. However, tracking coral bleaching development in vast-scattered reef nations such as Indonesia is really challenging. Reef Check Network Indonesia (RCNI) and partners worked together in creating a coral bleaching network to cope with 2009-2010 coral bleaching event. An alert, based on NOAA Coral Bleaching Satellite Data, was distributed regularly to the network during the hot season. This is followed up by personal communication to certain members in bleaching alert areas. The network provided an in-situ coral bleaching early warning and rapid data. RCNI then distributed this information to its scientist members as well as reef manager so they can determined whether or not a more thorough coral bleaching data was needed. By 2010, the network gathered the most comprehensive coral bleaching data in Indonesia despite that there was no resources dedicated to this effort. The success lays behind RCNI structured. Started in 1997, the network rapidly grows comprising ranges of reef stakeholders from individual to institution, from fisherman to scientists, as well asa tourist to marine tourism provider. By 2016, national government led Indonesian Coral Bleaching Network that was designed to overcome data collecting challenging. Based on the 2016 rapid survey, 20 of 21 provinces reported bleaching occurs with various bleaching level; from <25% to >75% bleached. A headquarter coordinates the network and provides supports for both science capacity and organizational building. To minimize the costs, innovative coordination using various modes include social media. With the bleak prediction of future bleaching events, it is hoped that the Indonesian Coral Bleaching Network can be strengthened and expanded by using a more high tech and simpler information sharing system, as well as a data base.

CRM1-525

Community participation in coral reef conservation in the Tun Mustapha Park, Sabah, Malaysia

Sofia Johari, Ejria Saleh, Zarinah Waheed

Sabah is located within the highest marine biodiversity area known as the Coral Triangle (CT). The CT region transcends the Sulu-Sulawesi Marine Ecoregion (SSME) covering the seas of southern Philipines, eastern Indonesia and Sabah in East Malaysia as well as other seas in the Western Pacific region. One of the biggest initiative to manage the resources in this area is the establishment of the Tun Mustapha Park (TMP), a multiple-use protected area extending close to 900,000 hectares. More than 80,000 people live within this area, which makes the community an asset for the management of this Park. One of the activities initiated by the communities is coral planting as an effort towards reef restoration at Banggi Island, Simpang Mengayau and Bavang Jamal. The restoration areas are those that have been damaged by blast fishing and cyanide fishing. Different methods were used for different areas depending on the type of corals planted, environmental condition such as the water currents and the availability of materials. Scientists from Non-Governmental Organizations (NGOs) such as WWF-Malaysia and Kudat Turtle Conservation Society (KTCS), as well as Universiti Malaysia Sabah (UMS) are guiding the communities through Citizen Science programs in monitoring the coral growth. The efforts have shown positive results in terms of coral growth and survival as well as the level of awareness of the communities on the importance of protecting coral reef ecosystems.

CRM1-547

Philippine coral reefs: Efforts and challenges of local managers and the academe

Christine Cabañas Baran, Joana Andrea Maningas, Bella Sheila Albasin, Mark Lennon Marcelino, DJ Marie Palic, Hazel Arceo, Porfirio Aliño

Coral reefs in the Philippines ecologically support the marine fisheries production of the country. However, our knowledge of its current state and management lags behind, limiting the effective protection of the reefs. This study aimed to gather information on past or existing marine activities and initiatives, and the challenges in doing these programs in the Philippines. In 2017, a nationwide survey using a standard questionnaire was conducted on various academic, national and local government and non-government institutions with efforts on marine biodiversity research, conservation and management. Data from a total of 500 respondents from 232 institutions were analyzed. Results showed that almost 74% of the non-academic institutions (n=178) were involved in coral reef management and conservation activities, 35% of which focused on enhancement programs such as coral reef restoration, artificial reef establishment and monitoring, and re-seeding. On the other hand, only 24% of the academe (n=54) have been working on coral reef-related research and activities. Their efforts were often hampered by various challenges, such as a lack of technical capability among staff involved (which emerged as the top gap), limited funding, low political support and community acceptance. The survey also revealed that few institutions have collaborative activities with other groups, implying a relatively low level of partnership. The Biodiversity Resource Information Network Group (BRING) is currently being established to help address these gaps. The network is envisioned to enhance the capacity and collaboration among scientists, conservations, managers and decision-makers, and the general citizenry. Under the BRING, trainings on coral reef assessment, data analyses, science communications, and management have been conducted based on the skills gap identified by the respondents. . Besides capacity building, the BRING hopes to improve coordination and collaboration among the different key players in marine biodiversity research, conservation and management, thus paving a better convergence between science and management.

CRM1-651

Capturing expert opinion in a Bayesian Belief Network

Jose F de Leon

The ReefBayBe software is a computer application which uses experts' opinion to evaluate possible options in conserving Coral Reefs. In several workshops various experts evaluated the question "What would happen to a coral reef when certain events happen?". Fourteen events or factors were looked at and its effect on hard coral cover, phase shift and fish biomass were tabulated and given empirical odds score. These scores are then placed in a bayesian network (provided by the experts) to perform the probability predictions.

CRM2-33

The common thresher shark and the dive tourism industry of Malapascua Island, Republic of Philippines

Norman Quinn, Lanch Almaida

Malapascua Island in northern Cebu is about 45 minutes away from Monad Shoal seamount which is one of the few places in the world where pelagic thresher shark (*Alopias pelagicus*) sightings are almost a daily occurrence. At 25m around dawn the sharks approach the reef and are cleaned of parasites while about 100 divers using Enriched Air Nitrogen 32 observe the activity for about one hour. Prior to the opening of the first dive shop offering shark viewing in 1998, Malapascua Island was largely dependent upon artisanal fishing.

Owing the international interest in viewing Thresher Sharks the number of dive shops has increased to about 22 in 2017. While most of the dive shops are owned by foreign investors, many dive guides and instructors are Filipinos. The increase in revenue to the island provides meaningful employment in the service sectors. About 300-400 people are directly employed in the dive industry and about 30,000-40,000 divers each year dive the Monad Shoal.

Although the dive industry generates considerable employment and revenue for the island, pollution, shark fishing and bomb fishing threaten its sustainable existence. It is common for divers to hear explosions caused by fishers, some explosions are close enough to cause divers pain. Malapascua Island does not charge an environmental fee to support a local conservation organization.

Thresher sharks are opportunistic hunters and can be easily caught if feeding during the day. This behavior allows poachers easy access to the sharks, and can cause severe decline to populations. The fins are often sold for massive profits in the illegal shark finning trade. Fortunately, in October 2017, the Philippine Republic Act 10654 was enacted to protect all three thresher sharks species that are listed in Appendix II of CITES. The results of this important legal remain to be seen.

CRM2-197

Local craftsmen's understanding of imported varieties of black corals for Muslim prayer beads in Cairo, Egypt: Natural black coral from the Red Sea, and cultured black coral from Chinese islands

Hiroshi Nawata

Black coral is one of the most precious materials used for making traditional Muslim prayer beads. This paper examines local understanding of imported varieties of black corals for Muslim prayer beads, based on interviews with local craftsmen and storekeepers in Cairo, Egypt. This approach offers a new understanding of the technical, economic, and ethical aspects involved in crafting Muslim prayer beads, such as selecting and processing raw materials, in relation to origin and quality of the black coral source material.

CRM2-287

Production analysis of coastal fishes during amihan season in the municipality of Mabini, Compostela Valley, Southern Philippines

Queenie Lynly T Mendez, Leo Manuel Bastes Estana, Pedro IV A Alviola, Cleto Jr. L Nañola

As one of the top fish producing countries in the world, the Philippines' fisheries sector has been one of the main sources of food supply and income-generation for Filipinos. However over the years, a decrease in the fisheries production has been observed in the Philippines hence, there is a need to determine the significant inputs in fisheries production. This study aims to determine the inputs that have a significant effect on the fish catch output of the fishermen. Thus, we examined the factors affecting the fish catch ouput of the fishermen in the coastal barangays of the Municipality of Mabini, Compostela Valley. A survey was conducted during Amihan season in the fishermen households in the coastal barangays of the Municipality of Mabini. A Cobb-Douglas and Trans-Log stochastic production function will be estimated where fish catch output is a function of inputs such as gross register tonnage, effort days, bait, depreciation of capital inputs, fuel, and water consumption. This study also aims to assess the technical efficiency of the fishermen in the Municipality of Mabini. The years of formal education, age of household head, household size, years of fishing experience,, and training/ seminars attended will be utilized as factors of technical inefficiency.

CRM2-308

Review of scallop growout methods in tropical and marine waters

Ian Cris Raquinia Buban, Victor Salcedo Soliman

A review of the scallop grow-out techniques was undertaken using secondary data from published literatures. The search strategy includes the following terms: scallop, culture, suspended, bottom sowing, grow-out, method, growth, survival and production. The literature searches were conducted in December 2017 and early January 2018 using Google Scholar (*htttp.scholar.google.com*). From the 17 studies (10 on temperate species, and 7 on tropical species), 13 scallop species were identified, with 5 and 8 species of temperate and tropical scallops, respectively. The studies examing density-effects to growth and survival on temperate species contributed 21 (density x growth) and 13 (density x survival) data points. For the tropical species, the studies have contributed 13 (density x growth) and 7 (density x survival) data points. The dominant species with their corresponding number of litereatures examined were *Placopecten magellanicus* (3), and *Nodipecten subnodosus* (2) for both temperate and tropical species. Culture using lantern net/cage constitute majority (25%) of the method used. The means and standard deviations of selected variables for mariculture were 31.70 ±14.7 and 36.46 ± 6.1 mm (initial size), 39.51 ± 64.9 and 35.64 ± 18.6% (stock density), and 298 ± 183.5 and 297.25 ±245.13 days (culture period), for temperate and tropical waters, respectively. Growth of the temperate species is 0.10 ±0.004 mm day^{-1} and survival is 0.12 ± 0.07%. In tropical species, growth is 81.49 ± 21.36 mm day^{-1} and survival is 75.55 ±17.85%. In general, growth is faster and survival is higher among tropical species than temperate species under mariculture conditions.

CRM2-436

Length-weight relationships for three commercially important fish species in the Philippines

Janine Pornan Alfiler, Estephen Balais Fortela, Victor Sanchez Ticzon

Length-weight relationships (LWR) were calculated for three commercially important fish species under family Scaridae in several study sites under the Coral Reef Visualization and Assessment Project 3: Reef Fish Resiliency and Productivity. The samples were obtained monthly, from local wet markets and fish landing sites from May to December 2017. The species studied were *Chlorurus bowersi*, *Scarus schlegeli*, and *Scarus niger*. These species were the most abundant scards in the study sites located in Northern Verde Island Passage and Zambales, Northwestern Luzon. The parameters a and b for the length-weight relationship of the form $W=aL^b$ were estimated via linear regression of the log-transformed data. The b parameters computed were 1.8524±0.02188, 2.0745±0.02417, and 1.7367±0.01368 for *C. bowersi*, *S. niger*, and *S. schlegeli*, respectively. While the results showed a significant trend in the length-weight relationship for all species ($p<0.05$), the correlation between length and weight were moderate for *C. bowersi* ($r^2=0.5822$) and *S. schlegeli* ($r^2=0.5409$), and low for *S. niger*, ($r^2=0.2215$). The importance of parrotfishes in reducing algal biomass on coral reefs is regarded as a necessary contributor to maintaining coral reef resilience. By obtaining these parameters, the standing stock biomass of these scarids and the implementation of management strategies can be better evaluated. Maintaining sustainable populations of these scarids are crucial to the continued persistence of coral dominated reefs in the Philippines.

CRM2-576

Socio-economic impact of climate variability (extreme wather) on sardine fishery: Case of Bali Straight

Siti Hajar Suryawati, Maulana Firdaus

Sardine fishery contributes 60% of fish production from Bali Staight water coming from Pengambengan and Muncar Fishing Port. Sardine Fishery in Bali is predominantly fishers with vwssel size under of 30 GT. This study aims to identify fishers' adaptation pattern and to estimate the associated economic loss due to climate variability with respect to sardine fishery. We find a positive correlation between climate variablity and sardine fishery production in Bali Straight. The potential economic loss due to loss of sardine fishery in Bali Strait. Data collected during field survey in August-September 2017. Due to climate variability, some dominant adaptation strategies are: the fishermen weren't fishing for a certain periode (almost one year) and switching to other temporary job (not related to fisheries sector) in addition. The estimated economic loss due to climate variability ranges from IDR 24.461 million/year to IDR 242.691 million/year during period 2009 until 2016.

CRM2-686

Targeted fishing of herbivore parrot fishes disturbs the coral reefs of Gulf of Mannar, southeast India

G Mathews, K Diraviya Raj, R L Laju, J K Patterson Edward

Fishes are an integral part of coral reef ecosystems which provide many ecological functions to corals. Parrotfishes (*Scarus*spp.), in particular, help the corals by feeding on macroalgae, the main space-competitor to corals. Gulf of Mannar in southeast India has been known for its coral reefs and associated biodiversity. Various natural and human-induced factors have made Gulf of Mannar a depleted one. Fishing in the reef areas is one of the important factors that damage corals. The present study was carried out in three sites inside the Gulf of Mannar, Marine National Park (GoMMNP) and three sites outside the MPA and to assess the exploitation of Parrotfishes fishes during 2016. Benthic community structure and parrotfish population were also compared between the reefs inside and outside the MPA. Trap fishing, a traditional fishing method in Gulf of Mannar targets parrotfishes as they are commercially valuable. It was found that the density of parrotfishes was comparatively lower (91.33 60m^{-2}) than that of density (479.67 60m^{-2}) inside the MPA. The lower density of parrotfishes outside the MPA is related to the higher macroalgal cover (12.43%) as compared to the areas inside the MPA (5.4%). Coral-algal phase shifts have been reported from many reef regions around the world. The results of the present study prompt the management action to extend the boundary of MPA to include the reef areas outside the MPA. Further, a ban to trap fishing and larval ranching of parrotfishes are also recommended. Conservation of corals in Gulf of Mannar is vital to conserve the livelihood of dependant fisherfolk. Data can be useful to reef managers to ensure that functional herbivorous fish stocks are not overfished, so as to maximize resilience of corals.

CRM2-725

Anthropogenic activities and waste disposal practices in the ports and fish landing areas of Camotes Islands, Cebu, Philippines

Serapion N Tanduyan, Jonita V Literatus, Eva P Muana, Eddele M Condrillon, Jonar D Gonzales, Dharel Miro, Jocel Nagsuban, Homer Garciano, Jeziel Nudalo

Ports and fish landing areas are the busiest parts of the aquatic environments because of transportation services. Oil spills and other wastes can contribute to the pollution of the water including the land based activities. Hence, this study was conducted in terms to determine the anthropogenic activities waste disposal practices and perceived problems of the people in the ports and fish landing areas.

Actual interview of the respondents and actual field visits weremade using an interview guide to gather data at the municipalities of San Francisco, Poro,Tudela and Pilar.

Results shows that anthropogenic activities include fishing, fish vending, business like entrepreneurship (sari-sari store). San Francisco topped among the number of fishermen, fish vending and business activities followed by Poro, then Tudela and Pilar. In transportation services include motorcycle and multicab driving and stevedoring services. Then there is beauty and wellness. For the entertainment these include billiard, videoke , computer games , tour guiding and sports fishing .San Francisco, topped also among these activities followed by Poro, Tudela and Pilar Among all the activities, fishing and fish vending were the most common with the frequency 158 (94.04%) over other activities.

Proper waste segregation of solid and liquid waste was practiced in which San Francisco topped among all the municipalities(98%) ,followed by Poro (75%),Tudela (65%) and Pilar (62%). Plastics and bottles were the common solid wastes and the liquid waste from the offals of fishes which brings Camotes Sea clean and free from pollution.

Results further shows that most of the fish vendors are the fishermen themselves (60%) and real o vendors is (40%) in San Francisco. In Poro it is (40%) and (60%);Tudela is (55%) and (45%) and Pilar is (60%) and (40%) in that order.

Results finally shows that environmental problems like bad weather conditions ranked first followed by financial problem, social and technical problem the workers in the ports and fish landing areas.

CRM2-721

Subsistence fisheries profile of Sarangani Bay Protected Seascape

Joy Ologuin

Gleaning or subsistence fisheries is considered as an informal production sector (LeBlanc 1997) and not usually accounted for in mainstream capture fisheries production. As a result, it form part of the globally under-reported fisheries production that is still not being addressed in the Philippines. In Sarangani Bay Protected Seascape (SBPS), at least 20 percent of its coastal community is dependent on Gleaning fisheries for consumption and for livelihood. This leads to questions on what is the profile of the Gleaners? Is the method environmentally sound and sustainable? Does gleaning affect at least the income of this fishers? To answer such questions five sites in SBPS were identified and profiled during the wet and dry seasons. Gleaning areas were also assessed using Standard methods on assessing Mudflat areas. The results revealed that Gathering of mollusks ,sea urchins, crabs, fish and other edible animals is a daily activity during low tides in all sites usually done by women than men. Majority of the gleaners aged 21-60 years old, and the largest proportion of gleaners had been gathering edible invertebrates for 11-40 years. All those surveyed engage in reef gleaning either as full-time or part-time gleaners, and their daily catch is mostly for family consumption as food while a few sell their catch for supplemental family income. Fishing using multiple kinds of gear is the most common livelihood, despite low income, they are generally healthy. Each of the four sites surveyed are largely made up of sea grass beds and rocky intertidal area. Recommendation for this study include regulation gleaning effort and catches , reserving some areas as “no entry” zones, Implementation of “size limits”, comprehensive information, education and communication (IEC) and a regular inventory and catch assessment of gleaning harvest.

CRM3-167

SEAMANCORE: A user-friendly simulation model for assisting the local management of coral reefs

Sara Minarro

Community-based conservation has emerged as a promising alternative for management in places where overexploitation of marine resources in a decentralized manner make enforcement difficult. Involving marine resource users in the decision-making process is important, as is developing case specific management strategies. Computational models are important decision-support tools and can help improve our understanding of complex ecological feedbacks by mechanistically representing multiple ecological processes. We present such a spatially explicit model of coupled coral reef benthic and fish dynamics, with a user-friendly interface for managers to explore the possible outcomes of potential management scenarios at the local scale. Scenario settings such as depth profile, initial conditions and stressors can be customized, and the time series of benthic cover and fish abundances visualized in real time for each simulation. The effects of environmental stressors -i.e. eutrophication and bleaching events- on ecological processes such as benthic competition and trophic interactions can be simulated through changeable scenario settings. Fishery characteristics such as number of fishing units, gear selectivity or spatiotemporal restrictions can also be configured in the user menu.

To illustrate the model capabilities, we apply it to four neighbouring Indonesian coral reefs exposed to varying degrees of water quality and fishing pressure. The bathymetric profile, initial conditions of fish abundance and benthic cover at various depth strata, along with fishery characteristics were collected in-situ at each of the islands for model parameterization. Case-specific stressors were customized to explore how nutrients and fishing practices affect fish biomass, benthic cover and fishing yield.

CRM3-325

Potential benefits of partially protected marine areas: Size and design do matter

Renan Ugto Bobiles, Victor Salcedo Soliman

Partially protected marine areas in the Philippines known as marine reserves are promoted extensively for the conservation of reef fishery resources. Traditional regulated fishing is permitted in this type of marine protected area (MPA). Currently, ~90% of the total area of the MPAs in the Philippines is considered partially protected, but the potential benefits of conservation have received slight attention. Thus, potential benefits of partially protected areas were evaluated by comparing the species richness and abundance of commercially important fishes with those in fully protected and adjacent open fishing areas using underwater visual belt transect survey in four MPAs with diverse features (age, size, design, and fishing activity) in Lagonoy Gulf, northeastern Philippines. Local fishermen were interviewed to examine fishing activities in partially protected and open fishing areas in the four MPA sites. The species richness and abundance of commercially important target size fishes were significantly higher in fully protected areas compared with those in partially protected and open fishing areas in the four MPA sites. Similarly, species richness and abundance in partially protected areas were significantly higher than open fishing areas only in large and conventionally designed MPAs. The size of non-target fish did not differ significantly among the three zones in each MPA. There were also no significant differences in the fishing indices (e.g., fishing time and gears) for partially protected and open fishing areas in each MPA site, thereby suggesting that large MPAs with conventionally designed partially protected areas could reduce the fishing pressure and increase fish movements from the fully protected area. Moreover, older partially protected areas harbored higher numbers of large fishes than newer partially protected areas, which highlights the requirement for a longer period of management.

CRM3-420

Coral protection in the sea of Shenzhen and marine ecology public education

Shen Xiaoming

Our Federation is a marine NGO from Shenzhen China. The presentation introduces our NGO's work in Dapeng Peninsula. Under the sea, we cooperate with Marine Research Institutes to explore the ways of coral protection. On the shore, we promote public education on marine ecoloy in different groups, especially the lessons for primary and middle school students, which has received the Government and public recognition.

CRM3-492

Hidden MPA: Anyone?

Victor Soliman

With only about 1% of coral reefs in 1,600 Philippine marine protected areas (MPAs) under effective protection, this raises the question as to how best to proceed in managing them. In this paper, one case of an unorthodox marine reserve protection is presented. Due to the sensitive nature of the issues surrounding protective activities, it has been decided that the specific site, indicative description, people involved and survey dates would not be disclosed. The MPA referred to is called "Hidden MPA" which is a fitting name because the area is considerably hidden from popular view. Visit to the site is prohibited for most people particularly government officials for fear of armed reprisals between government personnel and the personnel of the MPA. In terms of operations, the MPA seems to be privately owned in the extreme sense because even barangay officials have to ask permission from the "owners" to welcome people wanting to visit the area. After thorough negotiations with the recognized protector, our research team was allowed to conduct coral reef assessment and reef fish survey because they considered us 'neutral' outsiders since we are researchers. Live coral cover was very good to excellent in many stations. Reef fish diversity and biomass were impressively high. We obtained very similar values on these metrics about a decade ago when we did our first assessment in the site. Armed men were guarding the area. Any intruder is ordered to be shot by the guards on site including fishing boat or fisher. Maintaining good coral cover and high fish biomass over a 10-year period in an MPA is definitely a result of good protective activities. Is this the way to go in protecting or managing an MPA? Could this regime become a new normal in protecting Philippine MPAs?

CRM3-685

Biophysical and management effectiveness status of selected marine protected areas in the Philippines

Remelyn Ibel de Ramos, Ethel C Wagas, Melchor Deocadez, Dana P Manogan, Michael Atrigenio, Porfirio Alino, Roquelito Mancao, May Blanco

Marine protected areas in the Philippines are growing in number as a result of proven positive effect on biodiversity conservation and fisheries. Most studies were able to report the coral cover, fish biomass, and fish abundance in MPA sites but a few were able to document the management effectiveness of each MPAs. Here we report the biophysical and management effectiveness status of selected MPAs and nonMPAs in the Philippines. Fish visual census and line intercept transect method were done in 21 municipalities in different biogeographic regions in the Philippines. Management effectiveness was assessed using the MPA Management Effectiveness Assessment Tool (MPA-MEAT). Results showed that most of the reefs assessed range from 25% to 49.9% (fair) and did not vary significantly between MPA and non-MPA sites. Sites in the Pacific side of the country were observed to have lower hard coral cover than those in the inner seas. Fish biomass, on the other hand, was significantly higher in MPA sites, with more than 50% (N=24) of the sites classified as very high (>41 mt/km^2). Majority of the nonMPA sites have 21 to 40 mt/km^2. Fish biomass in young, large MPAs were observed to be higher compared to older MPAs, highlighting the importance of size of protected areas. High hard coral cover does not translate to high fish biomass, as high levels of exploitation, reef rugosity and diversity may be among the important factors also affecting the reef ecosystem dynamics. Cumulative scores of management effectiveness showed 11 out of 16 sites with "Excellent" scores, however some of the MPAs was not able to reach the highest level for successfully managed MPAs. Successfully managed MPAs does not automatically produce the highest fish biomass but nevertheless aid in the continuous increase in biomass through time.

CRM3-690

Best management practices of locally-managed MPAs in the Philippines

Dane Erlo Cristobal Matorres, Diovanie De Jesus, Porfirio Aliño

About 1600 of over 1800 total marine protected areas (MPAs) in the Philippines are being managed by local government units (LGUs). The decentralized setup ideally gives authority to LGUs and its stakeholders to enact and implement marine policies fitting to their own contexts. Despite the varying capacities and resources of LGUs, MPA managers have come up with successful programs for effective management. By examining the case of 14 shortlisted locally-managed MPAs in the 2017 Para el MAR Awards and Recognition, this paper presents the best management practices of locally-managed MPAs. These finalists were selected among the 250 submissions based on their scores on the MPA Management Effectiveness Assessment Tool (MEAT) categorized from Level 0 to 4. Out of the 14 finalists, 10 of them are at Level 4 and the remaining all at Level 3. Results reveal that 1) budget allocation by the local government, 2) collaboration with non-government organizations and national government agencies, and 3) enforcement are key factors for effective local MPA management. Other major factors include 1) peoples organization managing the MPA, 2) incentive schemes for community participation through ecotourism and alternative livelihoods, and 3) IEC campaigns. The average core zone area which implements strictly no fishing activities is 64.52 hectares while average buffer zone area which sets condition for fishing activities is 46.90 hectares. Coral reef remains to be the primary habitat that is protected. Given these data, this study suggests 1) drafting of a legal framework for institutionalized MPA funding, 2) increasing area coverage for protection, 3) diversifying habitat for protection, and 4) exploring the cost and benefits of forming networks with adjacent LGUs for co-management. Venues such as Para el MAR which offers recognition and cash incentives have also encouraged LGUs to improve MPA management.

CRO-331

Correlating seagrass cover/species composition with sediment type and inorganic nutrient concentration at four coastal areas in southern Negros and Siquijor Island, Philippines

Miko Okada, Shoya Hirotsu, JB Tanangonan

Short et al. (2007) reported 14 seagrass species in the Philippines. Despite many studies documenting its critical role in the marine ecosystem, the distribution and diversity of seagrass beds are declining worldwide (Short et al., 2011). This study surveyed the seagrass cover and species diversity at 4 coastal areas in southern Negros and Siquijor, central Philippines, and analyzed the effect of sediment type and dissolved inorganic nutrients. The concentration of dissolved phosphate, ammonium, nitrate, and nitrite were measured with a portable spectrophotometer. Water temperature and light intensity were recorded using a data logger.

We identified 2 families and 7 species (*Cymodocea serrulata, C. rotundata, Enhalus acoroides, Halodule pinifolia, Halophila ovalis, Syringodium isoetifolium, Thalassia hemprichii*). *E. acoroides* and*H. pinifolia* are considered "decreasing" in the extinction risk assessment report of Short et al. (2011). The coast of Solangon in Siquijor has the highest average seagrass cover and species number (5). In Negros, we found 3 species in Agan-an and Bindoy, and 4 species in Bantayan. Phosphate concentration was found to exceed the oligotrophic limit in 3 coastal areas except Solangon, Siquijor. Ammonium concentration was 0.28 mg/l in Bantayan. The low seagrass cover in Bantayan (which has the highest population density among the 4 sites) could be the result of the high ammonium level indicating eutrophic conditions.

CRO-600

Mapping and change analysis of mangrove forests and aquaculture areas in Dumanquillas Bay Protected Landscape and Seascape, Philippines using landsat images

Jan Clarence Dy-Liacco, Josel Nathan Bernardino, Chisa Chiara Ching, Ariel Blanco

The decline in mangrove forest cover in Southeast Asia is driven primarily by the conversion of these areas to aquaculture ponds, which causes negative ecological and economic impacts (Primavera, 1997; Melana et al., 2005). Human-induced pressures such as encroachment and exploitation of resources have contributed to this decreasing trend as well. Efforts are being made to combat this decline through government initiatives such as the establishment of protected areas to conserve and protect land and aquatic ecosystems, including mangrove forests. This study looked at mangroves and aquaculture areas in Dumanquillas Bay Protected Landscape and Seascape, a NIPAS site in Zamboanga, by mapping Landsat images taken in 1996, 2005, 2015, and 2017 to determine their trends and changes. Landsat images were calibrated and atmospherically corrected using the FLAASH algorithm. Classification of the satellite images into land cover classes such as mangroves, aquaculture, built-up, water, and other land cover was done using SVM classification. Total area of mangroves and aquaculture per image were then computed. Results showed that the total area of mangroves continuously increased from 1996 (1,447.27 ha) to 2005 (1,616.78 ha), 2015 (2,289.58 ha) and until 2017 (2,501.45 ha). Conversely, aquaculture areas consistently decreased from 1996 (2,136.83 ha) to 2017 (1,400.24 ha). Assessment of the spatiotemporal trends in the total area of mangroves and aquaculture indicated that the increase in the total area of mangroves coincided with the decline in the total area of aquaculture. The generated land cover layers, which highlighted both mangrove forest cover and aquaculture extent, were used to detect areas where conversion/reversion occurred. Results of this study may serve as an important contribution in assessing the long-term impacts of land cover and land use changes, and can aid in better planning, conservation, and management of our mangrove forest and marine resources.

CRO-701

Assessment of the marine ecological habitats and coastal vulnerability of Libon, Oas, Ligao City, Pioduran, and Rapu-Rapu, Albay: A SCREMP- based Research Program

Ronnel Romano Dioneda, Sr.

This research was implemented in Bicol as part of the Sustainable Coral Reef Ecosystem Management Program (SCREMP) of the Department of Environment and Natural Resources. With the partnership between DENR RO V, Bicol University, and the provincial government of Albay, statuses of coastal habitats, the level of MPA governance, fisheries, total economic value and coastal vulnerability were assessed in five coastal municipalities of Albay.

Generally, the coastal habitats in the west coast of Albay are in poor to fair conditions while fair to good at Rapu-rapu on the East. The narrow reef systems in Albay West Coast are dominated by abiotic components. Despite the dismal coral health in the four west coast municipalities, coral reef fishes were very diverse and with fair fish biomass. Several seagrass and seaweed species are also present. Oas and Rapu-Rapu have the highest percentage of seagrass. True mangroves and eight associated species were equally diverse. Maonon harbours the most diverse assemblage at the entire west coast and a rare mangrove species was seen in Pioduran. Regenerative capacity was high in most of the mangrove areas and wide-ranging perturbations principally human-induced were noted. Fisheries is typically multi-species and multi-gear. Rapu-rapu dominated the 2015 estimated 1,311 MT production. The nine MPAs in the west coast are generally very small, poorly seated and weakly managed. MPA governance rating are low except for Ligao and Rapu-rapu. The estimated economic value of the ecological functions performed by the coastal habitats in the five selected municipalities ranges from Php112 to Php126 million per year. Projection of benefits when the present conditions of habitats were improved to good or excellent would show benefits of rehabilitative action or alternatively potential cost of inaction.

More than half of the barangays are highly vulnerable to impacts of climate change. Barangays with moderate vulnerabilities have marine habitats that, although in poor states, could become ecologically functional when properly protected. Recommendations along enhancements of policy and regulatory mechanisms, intensified IEC and advocacies, aggressive coastal zone rehabilitation and socio-economic interventions were forwarded.

CRR-59

Variability in production of corals through sexual propagation

Charlon A Ligson, Tracy Dofeliz Tabalanza, Ronald D Villanueva, Patrick C Cabaitan

Combined influence of natural and anthropogenic disturbances have caused significant decline to Philippine coral reefs. Addressing this environmental concern had led to the development of different rehabilitation efforts. One of the common active rehabilitation efforts is coral transplantation where coral individuals are transplanted on degraded reefs to initiate the increase of coral cover. However, this technique requires large numbers of transplant materials to rehabilitate large areas. Earlier efforts have used asexual propagation through fragmentation but it often causes increased collateral damage to donor reefs and results to poor genetic diversity of transplants. Here, we tested the feasibility of producing coral individuals through sexual propagation. More than 10 reef-building coral species had been successfully subjected to *ex situ* spawning, where thousands to millions of larvae were produced and settled. However, very few had reached 1-year old juvenile stage and at least two species, *Acropora millepora* and *A. verweyi*, produced >600 juveniles, which were used for transplantation studies. The overall low production percentage (highest at <0.03% for 1 year old *A. millepora*) poses caution for the use of sexual propagation of corals and need for further improved culture technologies, while new sexual approaches and techniques are tested to improve rehabilitation efforts.

CRR-148

Successfully reared coral juveniles from spawn slicks: potential source of coral propagules for reef restoration in the Philippines

Tracy D. Tabalanza, Emmeline A. Jamodiong, Leomir A. Diaz, Mikhael Clotilde S. Tanedo, Janice C. Leriorato, Ronald D. Villanueva, Patrick C. Cabaitan

In recent years, coral sexual propagation through ex situ spawning has been used in the Philippines as a means of providing coral materials for reef rehabilitation. Currently, we successfully demonstrated the potential of using coral spawn slicks for rearing coral larvae. This study aimed to assess the optimal methods for rearing sexually propagated scleractinian corals from spawn slicks. During a night assessment in March 2016, a coral mass spawning event occurred; and spawn slicks were collected and reared in the outdoor hatchery facility of the Bolinao Marine Laboratory of the Marine Science Institute. Some of the coral propagules exhibited relatively slower embryonic development. However, fertilization rate was 96% of the collected gametes, with high settlement rate of 92% at 120 h post-fertilization. Post-settlement survivorship after 4 months was 46%. Coral spats were then transplanted in six sites in Bolinao-Anda Reef Complex. Among sites, mean survival of coral spat was significantly higher at Cabungan (62.2% ± 2.2%) and Lucero (51.1% ± 9.7%) sites compared to Magsaysay (31.1% ± 2.2%), Cangaluyan (22.2% ± 2.2%), Caniogan (20% ± 3.8%) and RDG (11.1% ± 8%) sites after 6 months post-transplantation. Results indicate that rearing of coral larvae from collected spawn slicks is feasible, which provides an option for rehabilitating degraded coral communities.

CRR-194

Evaluation of the effect of coral reef restoration on demersal biodiversity in Okinawa, Japan

Piera Biondi, Giovanni Diego Masucci, James Davis Reimer

The world is facing global climate change, leading to damage and loss of coral reefs. In Japan, Okinawa Prefecture is working on coral reef restoration by outplanting sexually produced corals back to reefs after farming colonies within a coral lagoon. In this study we critically evaluated the ongoing coral reef restoration efforts on Kume Island and Okinawa Main Island by comparing outplanted areas with nearby locations with no restoration activity (=controls). We examined 3 sites each around Okinawa and Kume islands. Each site included an outplanted area and a control area. We used: 1) coral reef monitoring, including multi-taxa visual transects and tracking of hard coral demographics and bleaching; and 2) coral rubble sampling combined with DNA barcoding to evaluate and compare total biodiversity of demersal species and community structure, and thus examined total coral reef biodiversity. At higher taxonomic levels, biodiversity results were site specific in Okinawa Main Island. In other words, differences between different sites were more important than differences between the restored and natural reefs. Regarding rubble shape, we saw that this was also site specific. Sites more exposed on the outer reef with higher wave impact had smoother rubble in both restored and natural environments, while in more protected sites, rubble was more complex (e.g. branching) in shape and had higher rugosity. For this reason, we believe that different rubble shapes at different sites may be important in determining the different demersal communities living within the rubble.

CRR-225

Estimating the recreational benefits of coral restoration in Northwestern Philippines

Tara Alessandra Abrina, Jeff Bennett

In this paper, the recreational value of restoring corals reefs is estimated in the context of a site in Northwestern Philippines. The authors apply the travel cost method with a variation that integrates a contingent behavior question. This allows for the estimation of marginal benefits in the context of a change in recreational asset quality. The results show that the reef, in its damaged state, gives rise to average per visit benefits of around USD 62.00. In a restored state, that average value increases to approximately USD 108.00 per visit. Hence, the average marginal benefits associated with an investment in reef restoration for this case study site is in the order of USD 46.00 per visit, with a ninety-five percent confidence interval of USD 0.74 million to USD 2.43 million per year.

CRR-472

Are seawalls sufficient surrogates for natural reefs?

Yen-ling Lee, Samantha Qian Yi Lam, Dayna Su-en Hui, Yuichi Preslie Kikuzawa, Koh Siang Tan

Seawalls are prominent features of reclaimed reefs around the Southern Islands of Singapore. While serving as protective structures, those that extend between tidemarks support naturally recruited sessile organisms that form communities resembling natural coral reefs. The composition of biotic communities in the low intertidal zone between -0.2m and +0.8m chart datum (CD) of sloping seawalls on Lazarus Island was determined using random quadrats (each 50cm x 50cm in size; n=40). Turf algae emerged as a dominant group with a percentage cover of 60.9 ± 29.8%, followed by soft corals (9.9 ± 8.0%), cyanobacteria (7.2 ± 19.1%), hard corals (6.0 ± 9.3%), macroalgae (5.5 ± 8.4%), and zoanthids (5.5 ± 9.7%). Mean percentage cover of sponges, anemones, corallimorphs, and crustose coralline algae were equally distributed, ranging between 4 and 5 %. At the same time, moderate amounts of silt were recorded (21.7 ± 14.5%), reflecting the high sediment load in Singapore's waters. At +0.3m CD, the diversity of scleractinian corals was limited (Shannon-weiner index, H' = 1.50), where only six genera consisting of massive or encrusting forms were recorded, with *Leptastrea* as the dominant genus. Scleractinian corals were more speciose (H' = 2.47) at lower intertidal levels between -0.2m and +0.3m CD with 17 genera observed, encompassing additional plating, free-living and branching forms. The generic diversity of scleractinian coral is almost twice higher than those recorded from an adjacent intertidal reef on St John's Island.

CRR-714

Aggregation of Brownstripe red snapper (*Lujanus vitta*) in transplanted corals attached artificial substrates

Se Songploy, Aissara Srisuk, Janjira Kumdeegern, Suchana Chavanich, Onthip Kimkue, Voranop Viyakarn

Recently, efforts to raise coral eggs to 2- year-old-juvenile stage in a hatchery before being released to natural reefs have been accomplished in Thailand. 2-yeay-old-sexually reproduced corals were transplanted to artificial substrates laid in a natural reef in Sattahip District, Chon Buri Province, Thailand in February 2010. We monitored and compared the density of reef fish in the artificial substrate area (30 m X 30 m) to that in a nearby natural reef. Fish species and density were recorded by using fish visual census technique. The result showed that brownstripe red snapper (*Lujanus vitta*) was found higher numbers (4.6 individuals/100 m^2) in the artificial substrate area than that of in the natural reef (0.9 individuals/100 m^2). Other species of economically important reef fish, including bar-cheeked coral trout (*Plectropomus maculatus*), and pinkear emperor (*Lethrinus lentjan*) were also found in the artificial substrate area. Our study revealed that artificial substrates with transplanted corals can serve as preferred habitats of economically important reef fish.

DCC-234

Fine-scale population genomics of intertidal (*Stichodactyla haddoni*) and subtidal (*Entacmaea quadricolor*) sea anemone species

Rochelle Wan Wen Chan, Ywee Chieh Tay, Phyu Phyu Karenne Tun, Hui Ping Ang, Loke Ming Chou, Danwei Huang, Rudolf Meier

Habitat choice and reproductive strategies are some of the main biological drivers of population connectivity in sedentary marine animals. In particular, higher rates of population divergence have been detected across species in the high intertidal than subtidal zones — coupled with higher selective pressures, tidal regimes can further constrain dispersal across water bodies. Sea anemones can undergo both asexual (e.g. laceration and most commonly, longitudinal fission) and sexual (e.g. broadcast spawning, brooding) reproduction, the latter of which typically results in planktonic larvae that can be readily dispersed over long distances via water currents. Conversely, dispersal is often restricted in populations which adopt a clonal reproduction strategy. This study aims to examine the fine-scale population genomic patterns of two anemone species that occur in different regions of the tidal zone: *Stichodactyla haddoni* is primarily intertidal while *Entacmaea quadricolor* is primarily subtidal in Singapore. More than three thousand single-nucleotide polymorphism (SNP) markers were subsampled across their genomes and analysed using the double-digest RADseq (ddRADseq) method, to understand their population genomic patterns across Singapore. In Singapore, marine species with planktonic larval dispersal are predicted to be well-connected. A panmictic population would suggest a sexual mode of reproduction (planktonic larval dispersal). Population structure suggests other asexual reproductive modes, or the presence of physical dispersal barriers. The findings of this study will contribute to an ongoing documentation of the fine-scale phylogeography of several marine species with different reproductive modes. This will aid in our understanding of Singapore's highly connected waters and provide further insights to the preferred reproductive strategies for these two anemone species.

DCC-191

Deep-sea coral connectivity in the South China Sea

Shang-Yin Vanson Liu, Yu-Rong Cheng

Deep-sea scleractian corals are distributed from 50m to maximum 6000m depth. Under global environmental changes, deep-sea or cold-water stony coral assemblages are considered to suffer greatest risk because of the upward movement of the Aragonite Saturation Horizon (ASH) which makes deeper habitats no longer suitable for them to form calcified skeleton. Meanwhile, the biological and ecological studies of deep-sea corals are lacking due to the difficulties to explore compare to shallow reef habitats. Therefore, there is an urgent need to study their dispersal pattern thru genetic approaches which can indirectly infer the connectivity between populations. In present study, we developed and applied 9 novel microsatellite loci to reveal the connectivity of deep-sea coral *Deltocyathus magnificus* among 6 sites in the South China Sea. Our results indicated a genetic break between northern (~200m depth) and southern populations (~400m depth) which suggest either geographic distance (400km apart) or depth, or the combination of both may responsible for the genetic structure observed in present study. Results of this study provide not only insights of deep-sea coral dispersal patterns but also valuable info for future deep-sea coral conservation and management.

DCC-531

Species composition of pocilloporid recruitment in the southwestern coast of Shikoku Island, Japan: the first step for estimating local connectivity relationship

Satoru Sano, Yuichi Nakajima, Takuma Mezaki, Masako Nakamura

Recently, coral communities in both coral reefs and non-coral reefs have been diminished by several disturbances, e.g. thermal stresses, outbreaks of corallivorous predators. Larval dispersal and subsequent recruitment is a key process for recovery of coral communities following disturbance. Larval dispersal processes also play a role for structuring meta-populations and are essential for considering protection of the coral community.

The southwestern coast of Shikoku Island (32°N) is known that coral diversity is high in non-coral reefs, Japan. Previous studies have demonstrated that the major composers of the coral communities were acroporid corals while acroporid recruitment was barely observed for a decade. On the other hand, pocilloporids were sparse in the community but a large number of recruits were observed. Therefore, in this area acroporid coral populations could be maintained by survival and growth of existing corals. Large number of pocilloporid recruits could also be significant for future enlargement of pocilloporid populations. But, sources of pocilloporid recruits in this area has not been identified.

The main purpose of this study was to elucidate the connectivity among the pocilloporid populations in this area. We first investigated species composition of new recruits in the area to determine the major pocilloporid species in the recruits. We set 10 settlement plates per site at four sites in the area to collect pocilloporid juveniles. Pocilloporid juveniles were identified at the species level from the base sequences of mtORF. Furthermore, we will estimate the connectivity relationship among different sites for the major pocilloporid species and compare the relationship of recruits with surrounding adults using polymorphic microsatellite loci.

EEM-62

Multiple species of megafauna in the upper mesophotic coral ecosystems in Apo Reef Natural Park, Philippines: benchmark of a pristine reef

Timothy Joseph Rama Quimpo, Patrick Cabaitan, Ronald Olavides, Edwin Jr. Dumalagan, Jeffrey Munar, Fernando Siringan

Marine Protected Areas (MPAs) are established to arrest further degradation of coral reef ecosystems and to restore populations of marine organisms. Common indicators of restored coral reef ecosystems are the high abundance and diversity of reef fish communities, and the occurrence of large bodied animal populations such as marine megafauna. However, few studies have reported the enhancement of marine megafauna communities in MPAs. Timed underwater visual census (UVC) surveys were conducted to assess the spatial variability in the occurrence of megafauna in the euphotic and mesophotic zones, and in fringing and atoll reef systems in Apo Reef National Park (ARNP), Occidental Mindoro, Philippines. Multiple species of marine megafauna were observed at high abundance in Apo Reef. Remarkable species were *Bolbometopon muricatum* (bumphead parrotfish), *Cheilinus undulatus* (humphead wrasse), *Triaenodon obesus* (white tip reef shark), and *Eretmochelys imbricata* (hawksbill turtle). Megafauna community assemblage and abundance did not differ between the euphotic and mesophotic zones and between fringing and atoll reef types, which may be attributed to the high vagility of megafauna species that traverse across large areas, including different depth zones and habitats. These findings emphasize the importance of having large areas under long-term protection to safeguard marine biodiversity that may provide ecological and socioeconomic benefits. Moreover, MPAs located in fringing reefs should be extended to cover the mesophotic zone, and submerged reefs or shoals should also be considered in MPA site selection.

EEM-327

Examining the taxonomic and functional community composition of upper mesophotic coral reefs throughout the Philippines

Kevin Thomas Banal Go, Patrick Cabaitan, Timothy Joseph Quimpo, Edwin Dumalagan, Fernando Siringan

Describing variation in coral reef communities, and determining the spatial scales that best-explain this variation, represents a first step in uncovering the processes that shape these systems. For example, upper mesophotic coral reefs (i.e., reefs that occur at depths of 30 – 40 m) may harbor ecological communities that are distinct from adjacent shallow water reefs located geographically close by. Such patterns would suggest the strong influence of depth in explaining the composition of local communities. Alternatively, adjacent shallow- and deep-water reefs within a given locality may be more similar to each other than to reefs from other localities, suggesting geographical distance as a stronger influence on reef communities than depth. In the Philippines, research on mesophotic reefs is in its infancy, despite the potential taxonomic and functional richness of this reef system. In this study, we use ordination-based multivariate analyses to present patterns in taxonomic and functional community composition of reef fish and benthos in various mesophotic reef sites (and their respective adjacent shallow water reefs) throughout the Philippines. In addition, we highlight which taxonomic and functional groups characterize mesophotic reefs and adjacent shallow water reefs, and which groups are shared between the two depth zones.

GCL-38

Influence of elevated seawater temperatures on the embryonic and larval development in the true giant clam *Tridacna gigas* (Cardiidae: Tridacninae)

Odette Blanco Enricuso, Cecilia Conaco, Sherrylyn Sayco, Mei Lin Neo, Patrick Cabaitan

The response of marine bivalves to changing environmental conditions is well-studied. However, the response of tropical species, such as giant clams, remains less understood. Studies on giant clam early development will be critical in improving our understanding of their growth and survivorship under different abiotic conditions, such as fluctuating seawater temperatures. In this study, fertilization, development, and survivorship of *Tridacna gigas* larvae were observed at low (27°C), medium (30°C), and high (33°C) temperatures. Fertilization success was not significantly different at the temperatures tested. Progression of early development was similar at 30°C and 33°C, with the ciliated gastrula stage observed at nine hours post-fertilization (hpf) and trochophore larvae at 18 hpf. In contrast, at 27°C, ciliated gastrula appeared first at 12 hpf and trochophore larvae at 24 hpf. Veliger larvae were observed after 48 hours (hrs) at 27°C and 30°C. In addition, developmental aberrations appeared earlier and in greater frequency in embryos kept at 33°C compared to embryos at 27°C and 30°C. This resulted in lower larval survival at 33°C at the 12 and 24 hrs timepoints, although after 48 hrs, survival was not significantly different across treatments. Furthermore, post-settlement survival of 8 days post-fertilization (dpf) juveniles that had been subjected to different temperatures for 3 weeks was lowest at 33°C. Findings here reveal that higher temperatures may promote rapid progression through early development, but result in lower overall survival due to the higher occurrence of abnormal embryos and reduced post-settlement survival. This study thus provides information on the optimal conditions for mariculture of *T. gigas* and offers insights into the possible impacts of thermal stress on the larvae of the true giant clam.

GCL-99

Variation of zooxanthellae density and photosynthetic efficiency with age and mantle condition in the giant clam, *Tridacna gigas*

Kuselah Tayaban, Cecilia Conaco, Sherry-Lyn Sayco, Aubrey Tejada, Keana Dehnielle Tan, Patrick Cabaitan

The true giant clam, *Tridacna gigas*, has been successfully reared at the Bolinao Marine Laboratory of the Marine Science Institute in response to the need to enhance local stocks that had been depleted due to overexploitation. Similar to corals, giant clams harbor symbiotic dinoflagellates or zooxanthellae within their mantles and are vulnerable to bleaching induced by stressors, such as elevated temperature. At the Silaqui giant clam ocean nursery, instances of giant clam mantle bleaching have been observed, although the physiological state of the symbionts in these individuals is not known. In this study, zooxanthellae density, cell size, and photosynthetic efficiency were examined in *T. gigas* cohorts of different age and mantle condition. Density and photosynthetic efficiency, but not cell size, were significantly higher in older compared to younger clams. Bleached mantle areas showed a significant decrease in zooxanthellae density and photosynthetic efficiency relative to normal mantle tissue. These results suggest that these physiological parameters can be used as indicators of clam health and response to environmental stressors. It remains to be determined what type of symbionts are harbored in the clams at the Silaqui ocean nursery and whether age and stress affect zooxanthellae population in individual clams.

GCL-111

Fertilization success and early life development of the true giant clam, *Tridacna gigas* exposed to reduced salinities

Sherry Lyn Grajales Sayco, Cecilia Conaco, Mei Lin Neo, Patrick Cabaitan

Successful fertilization and early life development in marine bivalves are prerequisites for the maintenance of their population structure and to prevent extinction. Similar to most bivalves, giant clams exhibit a bipartite life cycle wherein fertilization and early larval development take place in the water column. Thus, giant clam early life stages are greatly influenced by fluctuating environmental water conditions. For instance, reduced salinity is now becoming common because of the increased in precipitation attributed to climate change and frequent anthropogenic inputs. Reduced salinity has been proven to negatively affect early life stages of some marine invertebrates. Therefore, in this experiment, we investigated the fertilization success and the survival and development of the early life stages of the true giant clam *Tridacna gigas*exposed to reduced salinities of 18 and 25 ppt, in comparison to normal seawater salinity of 35 ppt. Fertilization and cell division occurred at all salinity treatments but a higher percentage of disintegrated and irregularly cleaved eggs were observed at reduced salinities. A lower number of developing embryos were observed at 18 ppt compared to 25 and 35 ppt. Reduced salinity conditions also resulted in delayed embryonic development, as evidenced by the production of fewer trochophore and veliger larvae. Also, no larvae survived more than 6 days of exposure at either 18 or 25 ppt. This study confirms that reduced salinity is an ecological stressor for giant clams. Therefore, spawning in areas with lower salinities or even when gametes are drifted on these areas will result in decreased fertilization success, delayed development, and lower survival that would eventually limit recruitment of giant clams on reefs.

GCL-229

Diversity of *Symbiodinium* in two species of giant clams, *Tridacna maxima* and *Tridacna noae*, from Dongsha Atoll, northern South China Sea

Sherlyn Sher Qing Lim, Huang Danwei, Keryea Soong, Mei Lin Neo

Despite the importance of *Symbiodinium* in the ecology of giant clams, the symbiotic relationship between giant clams and their photosynthetic dinoflagellate remains relatively understudied. Tridacnines have shown to be able to host a variety of *Symbiodinium* subclades, which may affect the host's ability to adapt to environmental changes. Using metabarcoding of the nuclear ribosomal internal transcribed spacer 2 (ITS-2) marker, and Illumina MiSeq high-throughput sequencing, this study looks at the pattern of *Symbiodinium* diversity in two species of giant clams, *Tridacna maxima* and *Tridacna noae,* at Dongsha Atoll National Park, northern South China Sea. *Symbiodinium* DNA was extracted, amplified, and sequenced from 73 tridacnine individuals, where we detected the presence of major clades A, C and D in most *T. maxima* and *T. noae*specimens. For *T. noae*, *Symbiodinium* clades A and C were present in most individuals but clade D was absent in a few clams. Contrary, for *T. maxima*, clade C was present in most individuals but clade A was absent in <10 clams and clade D was absent in >10 clams. The proportion of different *Symbiodinium* clades within giant clams may affect the adaptability of the host to environmental changes, as previous studies have suggested that *Symbiodinium* clades C and D are more tolerant to temperature stress compared to clade A. The data obtained were also used to study the spatial and ecological partitioning of *Symbiodinium* in both species of clams. Understanding the symbiotic association between *Symbiodinium* and giant clams is necessary for predicting impacts of these species to rapid environmental change.

GCL-230

An interdisciplinary approach towards giant clam conservation

Keana Dehnielle Tan, Aubrey Joy Tejada, Sherry Lyn Sayco, Jeremiah Noelle Requilme, Ian de Guzman, Odette Enricuso, Krista Melgarejo, Kuselah Tayaban, Lala Grace Calle, Patrick Cabaitan, Cecilia Conaco

The application of advanced molecular technologies alongside traditional biological and ecological methods provides an innovative approach towards the conservation of vulnerable marine organisms, such as giant clams. Through the initiative of the Marine Science Institute of the University of the Philippines Diliman (UP MSI), populations of giant clams have been successfully replenished at multiple restocking sites around the Philippines. To build upon these efforts, UP MSI, with the support of the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology, is embarking on a program to assess the status of giant clams and advance culture techniques. Ecological studies under the program aim to quantify the effects of previous restocking efforts through field surveys to identify giant clam juvenile recruitment around established restocking sites and to determine the influence of giant clams on reef biodiversity. Studies to improve giant clam culture techniques include investigations on the effect of environmental stressors, such as elevated temperature and reduced salinity, on fertilization, early development, and larval survivorship. Sequences of selected stress marker genes have been determined and are used as tools to monitor giant clam responses to their environment. Molecular techniques are also being applied to assess differences in the population of symbionts associated with the tissues of giant clams restocked at different sites. Furthermore, the development of transcriptome resources for selected giant clam species through high-throughput sequencing is anticipated. This interdisciplinary approach combining field observations, laboratory experiments, and the development of molecular tools will allow researchers to obtain an integrated understanding of the ecology and biology of giant clams. The findings from this program will guide future efforts in giant clam mariculture and conservation policies.

GCL-355

Giant clam ocean nursery enhances the fish catch of artisanal fishers in Silaqui Island, northwestern Philippines

Patrick Cabaitan, Cecilia Conaco

Past restocking efforts have successfully brought back the populations of true giant clams, *Tridacna gigas*, in selected sites around the Philippines. Restocked clams contributed to the improvement of substrate complexity in degraded coral reef ecosystems and, consequently, to the enhancement of the abundance and diversity of fish communities. However, it is not known whether the increase in abundance of fish at restocking sites has had a positive effect on the fish catch of fisherfolk from adjacent coastal communities. In this study, fishers from Silaqiu Island, northwestern Philippines, were interviewed to determine their use of the Silaqui giant clam ocean nursery as a fishing ground. We also conducted experimental fishing within the giant clam ocean nursery and at two control sites farther away. Subsistence fishers report using the Silaqui giant clam ocean nursery as one of their fishing grounds. They employ different fishing methods in the area, including barrier nets, spear fishing, and fish traps. The fishers indicated that they capture more fish within the giant clam ocean nursery and they attribute this increase in fish catch to the presence of the giant clams. This observation was confirmed by the results of experimental fishing, wherein more fish were caught in fish traps placed inside the ocean nursery compared to the control sites after a few days of deployment. The fish traps caught fish from various trophic groups, including commercially important species, such as *Siganus* spp., *Lethrinus* sp., and *Epinephelus* spp. These results indicate that the long term impact of giant clam restocking efforts extend not only to the restoration of degraded populations in coral reef ecosystems but also to the enhancement of other ecosystem services.

GCL-616

Responses of juvenile fluted giant clams (*Tridacna squamosa*) to experimentally enhanced sedimentation

Ambert Chiam Foong Ang, Mei Lin Neo, Kareen Vicentuan, Peter Alan Todd

Compared to other marine benthic organisms, the impacts of sedimentation on giant clams are not well documented. To elucidate the mechanical effect of sedimentation on juvenile fluted giant clams (*Tridacna squamosa*), inert silicon carbide powder was used so that contaminants associated with natural sediments could b e controlled for. Both chronic and acute conditions were tested. The six week chronic experiment used three treatment types (control, shaded control and sediment-stressed) to identify possible morphological or behavioural responses in juvenile *T. squamosa*. The acute sedimentation experiment investigated whether different sizes of juvenile *T. squamosa* exhibited varying clearance rate and efficiency when subjected to different sediment sizes. Morphometrics and behaviour did not differ significantly under chronic sedimentation, however, higher mortality rates were observed in sediment-stressed and shaded treatments. Mortalities in the shaded treatment were mostly attributed to ectoparasites, while the energetic stress from sediment clearing likely caused the clam deaths in the sediment-stressed treatment. When subjected to acute sedimentation, all the clams were able to clear sediments at similar rates but, due to less accumulation, were more efficient in clearing the coarse sediments. It appears that giant clams are effective sediment clearers, but under chronic conditions and high concentrations of fine sediments, they remain vulnerable.

GCL-754

MPAs in Lyudao (Taiwan) failed to protect giant clam population

Wei Chen Tung, Yu-De Pei, Ching-Min Yang, Kao-Song Chen, Colin KC Wen

Giant clams (*Hippopus* and *Tridacna* species) have long been considered playing multiple roles in coral reef ecosystems. For example, the transplanted giant clams increase coral reef fish abundance in degraded reefs. Giant clams also provide shelters and serve as food resources to other coral reef creatures, but not clear for coral reef fishes. With increasing demands for food and aesthetic decoration, giant clams are facing greater fishing pressure than ever, and the conservation action is inurgent need. Four giant clam species (*Tridacna squamosa, T. maxima, T. noae,* and *T.crocea*) in Taiwan are also encountering above difficulties, and have been protectedby size-limited regulation and marine protected areas (MPAs) in Lyudao (Green Island) since 2014. To evaluate the efficacy of MPAs and size-limited regulation, the individual number and size of giant clam were surveyed in two protected area andtwo non-protected area (size-limited only) nearby from 2015 to 2017. The ecological function of giant clam to coral reef fishes was examined by recording the numbers of fishes using giant clam as shelters. Our results show that density of giant clam in MPA is higher than non-protected areas in one of two MPAs. The numbers of giant clam larger than 15 cm is higher in both MPAs than non-protected areas. As for the ecological function of giant clam, only 2 out of 263 giant clams were utilized as shelter by fish. In general, the number of giant clam are not always higher in MPAs, but large giant clam was found more in MPAs than in other areas. We suggest the improved enforcement are needed to increase the efficacy of MPAs.

OA-186

Characterization of calcareous sponges as model organisms for investigating the effects of coastal acidification

Niño Dan Guillen Posadas, Cecilia Conaco

The ocean is the largest sink of carbon dioxide next to the atmosphere. With the increase in carbon dioxide emissions since the industrial era, acidification of the oceans has accelerated and is aggravated by local anthropogenic perturbations, such as eutrophication in near-shore ecosystems. These changes in ocean chemistry have resulted in shifts in marine ecosystems, thus influencing the dynamics of entire food web. On the organismal level, the negative impacts of changing ocean chemistry are observed in biocalcifying marine invertebrates, including gastropods, corals, and sponges (Porifera). Although sponges exhibit a complex physiology and are associated with a diverse microbiome that contribute to their survival in varied habitats, it is likely that, similar to other calcifying organisms, calcareous sponges are vulnerable to elevated pCO_2. To develop model organisms for the study of coastal acidification effects on calcareous sponges, sponge samples from the reefs of Bolinao, Pangasinan, in northwestern Philippines, were collected, characterized, and cultured under controlled conditions. The identity of the sponges were determined using both morphological and molecular approaches. Sponge fragments were then subjected to different conditions to assess changes in morphology and to determine survival. Shifts in the bacterial community associated with the sponge tissues were elucidated using denaturing gradient gel electrophoresis, while the expression of selected stress-response-related genes were quantified by QPCR. These initial studies serve as a basis for deeper investigations into the response of calcareous sponges to conditions of coastal acidification.

OA-223

Ongoing activities on ocean acidification and its possible impacts to coral reefs in the coastal waters of Vietnam

Tuan Linh Tran Vo, Minh Quang Thai, Van Long Nguyen, Si Tuan Vo

Given the fact that ocean acidification (OA) is has been coming a hot issue over recent years, IOC/WESTPAC has organized a series of activities for information collection and exchange, human resources training, and deeper study the impact of OA on marine ecosystems; thence, towards the development of an OA research and monitoring network in the region. To date, many members such as Malaysia, Thailand, Philippines, South Korea, Indonesia, and China have been building OA monitoring / research systems. In that context, as an active member of IOC/WESTPAC, Viet Nam has been establishing our own system and integrate into the network. A project, approved and funded by the Government, has been carried out in the period of 2017 - 2020 in order to have basic knowledge about OA and its possible impacts to marine ecosystems and to enhance Vietnam's capacity in line with activities of IOC and IOC/WESTPAC. The studies relevant to OA include: (1) building a baseline data on indicator parameters such as pH, TA, pCO_2, DIC, calcium accretion, bioerrosion and reef status; (2) Intitial assessment potential impacts of OA to coral reef through the measurement of calcification of hard corals in different pH values *in situ*. The studies have been conducted at four study areas of Nha Trang bay, Ninh Hai coastal waters, and Phu Quy, Phu Quoc islands, all of which were registered to the regional network. Besides, researches on OA have been integrated into other projects implemented in Vietnamese waters to provide broader data and information.

OA-421

Response of coralline algae *Porolithon onkodes* to elevated temperature and reduced pH

Xinming Lei, Lei Jiang, Jiansheng Lian, Hui Huang

Coralline algae, a key primary calcifying producers present in coastal ecosystems, are considered one of the high sensitive organisms to marine environmental change. However, experimental analyses and investigations of coralline responses to elevated sea water temperature and reduced pH had documented either contradictory or opposite results. In this study we analyzed the growth and physiological responses of coralline algae to elevated temperature (30.8°C) and reduced pH (7.8). The aim of this analysis was to observe the direct and combined effects, while elucidating the growth and photosynthesis in this response. We demonstrate that the algae thallus growth rate and photosynthesis in reduced pH were higher than other experimental groups. The growth and photosynthesis of the thallus was reduced under elevated temperature, however, maintained in reduced pH. Coralline algae were considered one of the most sensitive organisms to OA because of their precipitate high Mg-calcite. We hypothesize that coralline algae could increase their calcification rate in order to counteract the effects of acidification. Accordingly, our results also support the conclusion that global warming is a stronger threat to algal performance than OA. Our findings suggest that coralline algae may be more resilient under OA than global warming.

OA-483

Variations of carbonate and water quality parameters in Autonomous Reef Monitoring Structures (ARMS) sites in the Philippines

Maria Lourdes San Diego-McGlone, Ma. Carmen Lagman, Marivene Manuel-Santos, Rachel Gotanco, Charissa Ferrera, Mary Chris Lagumen, Jane Abigail Santiago, Joseph Foronda

The decrease in pH of seawater, also known as ocean acidification (OA), is a global phenomenon primarily caused by dissolution of carbon dioxide (CO_2) from fossil fuel burning and land use change. However, local processes such as eutrophication may contribute to decreased pH and exacerbate the effects of OA by production of CO_2 from organic matter decomposition at a rate that is faster than air-sea equilibrium. To understand the response of coral reef organisms to OA, baseline information on carbonate and water quality parameters is necessary. ARMS or Autonomous Reef Monitoring Structures based on NOAA protocol, were deployed at five (5) national integrated protected areas in the Philippines. Each ARMS is a set of stacked polyvinyl chloride plates that act as "reef hotels" and attract colonizing invertebrates. They are deployed for one to three years, after which cryptic species are sorted and processed for taxonomic and molecular analysis. Within each protected area, ARMS were installed in sites with varying reef conditions (degraded reef, less degraded reef, least degraded/pristine reef). This study presents the spatial and temporal variation of carbonate parameters (pH, dissolved inorganic carbon, total alkalinity, aragonite saturation) and water quality parameters (nutrients, chlorophyll *a*, total suspended solids) in the study areas. These, together with hydrodynamic parameters such as temperature and dissolved oxygen, will be used as baseline conditions to help understand changes in biodiversity through the years as a result of environmental stressors such as proximity to CO_2 vents (Mabini, Batangas), thermal stress from a powerplant (Masinloc, Zambales), eutrophication associated with tourism (Palaui Island, Sta. Ana, Cagayan and Siargao Islands, Surigao del Norte), and possible effects of naturally-occurring bird droppings (Tubbataha Reefs, Palawan).

RTS-357

Influence of salinity and temperature on the survival and settlement of *Heliopora coerulea* larvae

Patrick Cabaitan, Cecilia Conaco

Global climate change has brought about recurrent thermal stress events and intensified precipitation that have altered environmental conditions on coral reefs. These conditions have resulted in a general decline in scleractinian coral populations. On the other hand, certain reef species, particularly octocorals, have been reported to thrive. Here we investigated the effects of salinity and temperature on survival and settlement of the larvae of the octocoral, *Heliopora coerulea*. Larvae were collected from *H. coerulea* colonies a few hours after release into the water column and subjected to controlled laboratory experiments. Larval survival was highest at 27 and 30°C and significantly lower at 24 and 33°C. Combination of temperature and salinity stresses revealed that temperature had greater influence on larval survival than salinity On the other hand, settlement of *H. coerulea* was highest at a temperature of 30°C and at salinities between 25-35 ppt. Extreme salinity levels affected larval morphology and buoyancy, which had a negative effect on viability and settlement. Larvae in 15-20 ppt seawater swelled up and sank whereas larvae in 40 ppt remained floating on the seawater surface and assumed a thin and worm-like form. These results suggest that *H. coerulea* larvae have broad salinity and temperature tolerance limits. However, early life stages are negatively impacted by high temperature and extreme changes in salinity. These effects may have an impact on the dynamics of *H. coerulea* and other corals in the face of environmental changes.

RTS-118

Vulnerability assessment of coastal resources in Carmen, Northern Cebu island

Raamah Concepcion Rosales, Oliver Semblante, Wennifel Porpetcho, Anthony Ilano

Mangroves, seagrass, and corals are under increasing pressure from climate change and anthropogenic stressors. Carmen, Cebu is a fishing community having a population of 51,325 in 2015 with an estimate of around 12% of the total households residing in six coastal barangays engaged in fishing. Using remote sensing, each of the said barangays was found to be nursing all three resources. Barangay Luyang appeared to have the most concentration of these resources while Puente is exactly the opposite in terms of resource extents. Buildups were mainly found in Barangays Cogon East, Poblacion, and Dawis Norte. Aquaculture was primarily concentrated in Luyang. Using the Vulnerability Assessment tool developed by the Philippine National LIDAR Program, a study on the coastal resources in six barangays of Carmen was conducted. Anthropogenic activities such as urban development and practice of aquaculture were identified as primary contributors to vulnerability of coastal resources. Results from focus group discussions and interviews further distinguished that lack of habitat restoration efforts, absence of marine protected area, and lack of community support and knowledge also contributed to the elevation of vulnerability of coastal resources in most barangays.

RTS-149

Coral size-frequency distributions at the Farasan Islands (Southern Red Sea): a valuable tool for reef monitoring

Diego Lozano-Cortes, Holger Anlauf, Saskia Kürten, Yasser Kattan, Susana Carvalho

The Farasan Islands represent the only declared Marine Protected Area in the Saudi Arabian Red Sea. Located in the southern region, they experience elevated nutrient concentrations and high primary productivity as a consequence of the intrusion of nutrient-rich waters from the Gulf of Aden. Turbidity is also high, particularly in the inner shelf. These distinctive environmental conditions are potential drivers of biodiversity and population genetics. Here, we investigate the coral colony size-frequency distribution patterns of the most abundant genera (*Porites*, *Acropora*, *Galaxea* and *Echinopora*) across a shelf transect. Size-frequency distributions have been used as a proxy for population responses to local environmental conditions and disturbances, with negatively skewed size-frequency distributions being associated with unfavorable conditions. Colony sizes surveyed from photo transects conducted at 11 reefs (seven nearshore; four offshore) were related to nutrient and chlorophyll *a* data to assess whether differences in coral size distributions were linked to environmental changes. Significant differences were detected for the size and density of the colonies between nearshore and offshore reefs. The size-frequency distribution varied among coral genera and only *Porites* showed negative values of skewness for the nearshore reefs. The negatively-skewed distribution seems associated with the poor environmental conditions in the inshore reefs (higher concentrations of nitrites and phosphates), in line with depressed reef diversity and higher macroalgal cover. These findings provide complementary data to standard reef assessment surveys aiming for a more comprehensive evaluation of the coral reef ecological status and a strong baseline for long-term monitoring in this sensitive area.

RTS-174

Coral-algal interactions: how do prokaryotic symbionts mediate the holobiont response?

Lindsey K. Deignan, Jenny Fong, Peter A. Todd, Diane McDougald

Coral reef ecosystems are experiencing significant declines worldwide. In response to anthropogenic stressors, many reefs are shifting from coral to algal-dominated systems. Increased algal abundance has led to increased competitive interactions between corals and algae. Corals respond variably to these interactions depending on the species involved; however in almost all cases, the coral is negatively affected. Corals host unique and abundant microbiomes, which are essential to the functioning of the organism and likely mediate the response of the holobiont to the competitive interactions with algae. In this study, we examined the response of the microbiomes of three corals (*Merulina ampliata*, *Montipora stellata*, and *Pocillopora acuta*) to manipulated interactions with two algae (*Lobophora variegata* and *Hypnea caespitosa)* in mesocosm experiments. Corals collected from reefs around Singapore were placed in aquaria in direct contact with algae, in close proximity to algae, or in the absence algae. 16S rRNA amplicon sequencing was used to assess prokaryotic community structure associated with both the coral and algal species at the start and end of the experimental period. Shifts in community structure where correlated with coral physiology, as well as coral tissue bleaching and loss. The port of Singapore is a highly degraded system with reefs often dominated by macroalgae, so understanding how corals from reefs within the port respond to algal interaction provides a unique opportunity to examine the adaptive ability of corals to respond to stressful environments and could provide a window for understanding the resilience of reefs to ever-increasing anthropogenic impacts.

RTS-195

Impact of artificial barriers on coral reefs biodiversity in Okinawa, Japan

Giovanni Diego Masucci, Piera Biondi, James Davis Reimer

Coral reefs in Okinawa, Japan, have been undergoing degradation for at least 80 years, mostly because of direct local human pressure, aggravated by global change. Their economic benefit has been estimated as 1.6 billion USD/year. Artificial barriers, like seawalls and concrete tetrapods, can lead to beach narrowing or loss, and exacerbate erosion, by increasing the intensity of longshore currents and preventing the exchange of sand between dunes and beaches. Despite this, artificial barriers have been massively deployed over the years in Okinawa, resulting in potential negative impacts on the surrounding coral reef ecosystem. Given how prevalent coastal construction is in Japan, it is important to clearly understand the effects and potential downsides that such large-scale deployments may cause. This study is the first in the Ryukyu Archipelago to compare demersal reef communities between natural and artificial coastlines. We compared diversity between 6 paired artificial and adjacent natural locations. The fauna within coral rubble was used as a diversity proxy, as rubble can host a variety of benthic taxa, including worms, crustaceans, molluscs, echinoderms, and fish. Each demersal animal, living inside or over the sampled rubble, was individually collected, photographed and preserved in ethanol. At high taxonomic levels (Phylum, Class), a reduction of biodiversity was seen from artificial sites, with trends towards a higher dominance and lower numbers of animals and taxa on rubble. Ongoing genetic analyses will allow to compare the two environmental situations at the species level. As global climate change will bring a rise of sea levels that will likely lead to an increase in the deployment of artificial barriers, the importance of this issue reaches far beyond Okinawa and Japan.

RTS-204

A survey on response of reef-building corals harbouring different *Symbiodinium* clades to changes in environmental condition of Larak Islands, Persian Gulf

Hamed Dehghani, Pargol Ghavam Mostafavi, Seyed Mohammad Reza Fatemi, Atoosa Noori Koupaei

Reef corals are hosts to a group of exceptionally diverse dinoflagellate symbiont in the genus *Symbiodinium* (commonly referred to as zooxanthellae). The genus *Symbiodinium* is currently classified into nine genetic clades (A–I). These clades have specific ecological and physiological features. Physiological variability among *Symbiodinium* clades plays an important role in survival of corals. In the Persian Gulf, coral reefs are subject to harsh environmental conditions including wide temperature fluctuations and high salinity. Since the survival of coral reefs is related to the resistance *Symbiodinium* clades, therefore identification of these symbionts is necessary. This study aims to identify different clades of in hospite *Symbiodinium* with different coral species in each season. For this purpose, nine and 12 coral species were collected between February 2012 and November 2013 off Larak island, respectively. Coral fragments were airbrushed with DNAB buffer, then DNA was extracted with CTAB (Cetyl Trimethylammonium Bromide) method. PCR amplification was performed using clade specific primers. The results showed that *Symbiodinium* clade D and C are dominant zooxanthellae clades in spring and winter while clade A was found as the dominant clade in summer and autumn. According to ABH hypothesis, such shifts may occur in corals with multiple types of algal symbionts as results of environmental change to create new ecospecies that differ in tolerances. Clade D was the second most dominant zooxanthellae clade in summer and autumn. Since, clade A are the most UV tolerant *Symbiodinium* clade, this might imply corals are more susceptible to light intensity in comparison to high temperature. It can be concluded that the reason of bleaching in summer is high light intensity in the first step and then high temperature.

RTS-251

The use of the common sea star, *Archaester typicus* as a biomarker of thermal and ocean acidification stress

Nursheena Parveen Katermeran, Jasmine JL Tong, Beverly PL Goh

Environmental biomarkers also known as early warning signals have increasingly become a subject of interest in environmental studies. The common sea star, *Archaester typicus,* found in shallow sandy habitats associated with coral reefs in Singapore, was utilised to study the effects of varying treatment conditions of temperature, salinity and pH. Treatment conditions were derived from predicted future scenarios of thermal and ocean acidification conditions. Experiments were conducted to determine physiological responses of sea stars subjected to treatments over 24h (acute) and 120h (chronic) exposures. Biomarker responses examined included righting behaviour (time taken to right after being overturned), burrowing time and feeding responses (time taken to close stomach) in experimental sea stars. To validate results of physiological biomarkers, two other biomarker responses were measured from coelomic fluid extracted from the experimental sea stars. These were the cellular lysosome integrity response (Neutral Red Retention time) and the biochemical Ferric Reducing Antioxidant Power (FRAP) assay. In acute exposure experiments, results indicated that sea stars exhibited normal physiological responses under various temperature treatments with the exception of the highest treatment of 34°C where all experimental sea stars died. Salinity and pH treatments did not result in significant impairment in behavioural responses. At chronic exposure regimes, treatment effects were more evident. Results from salinity treatments showed that physiological responses in sea stars were significantly impaired at treatments of 15 ‰ and 50 ‰. Significant temperature stress was observed at 32 °C, while a treatment pH of 7.2 resulted in total impairment of righting ability. Our results indicate that short-term exposure and the removal of the source of stress may result in a reversal of physiological impairments at the organismal level. Further studies could help us understand the effects of global warming on the physiology of organisms in various shallow water habitats.

RTS-256

Acute and chronic effects of temperature and ocean acidification stress on the azooxanthellate anemone, *Anthopleura handi* in Singapore

Hui Shan Lim, Jasmine JL Tong, Beverly PL Goh

Ocean acidification and ocean warming is occurring and predicted to accelerate as global production of greenhouse gases (GHG), namely carbon dioxide increases. In such a warming scenario, there is increasing concern for the health of both marine and tropical ecosystems. Sea anemones that are part of the marine benthic communities are at risk. Together with corals, they form the fundamental basis of whole reef ecosystems. Sea anemones are suitable cnidarian representatives for laboratory research. In this study the effects of lowered pH and various temperature regimes were assessed using the tropical sea anemone, *Anthopleura handi*. The organisms were subjected to three pH (7.4, 7.7 and 8.1) and five temperature (26°C, 28°C, 30°C, 32°C and 34°C) treatments under two exposure durations (24h and 120h). The levels of total antioxidants, glutathione and glycogen were measured using biochemical assays while lysosomal membrane stability was quantified using the Neutral Red Retention Test (NRRT). Results obtained demonstrated a general reduction of antioxidant properties, particularly glutathione, and impairment of cellular lysosomes under treatment conditions close to ambient conditions. Effects were seen at the pH levels of 7.7, and temperatures of 30°C. Lower glycogen reserves (during both short-term and long-term exposures) were observed for advanced conditions of pH 7.4, and temperatures of 32°C and 34°C. However, further investigation is needed to ascertain the mechanisms of energy usage. Whether these changes can be detected in other tropical cnidarians (e.g. corals), or eventually decrease or increase fitness in similar benthic communities are some of the questions that deserve further attention.

RTS-264

Ecological conditions of a conservation area in Palau influenced by chronic sedimentation

Dawnette Uly Olsudong, Marine Gouezo, Michelle Dochez, Randa Jonathan, Lincy Marino, Victor Nestor, Geory Mereb

Palau has a network of protected areas (PAN) that was established in 2003. The network consists of 14 marine protected areas. PICRC conducts ecological monitoring at these MPAs to follow the ecological conditions of different habitats and their effectiveness at protecting marine resources. This study was conducted at Medal Ngediull Conservation Area (CA) located in Airai state, and has been protected since 2005. The surveys consisted of recording the status of fish, macro-invertebrates, juvenile corals, seagrass cover and benthic cover within three stations in both the reef flat habitat the lagoon habitat, inside and outside the conservation area. Our findings demonstrate that inside the conservation area, fish and invertebrates were found in low abundance and biomass, the seagrass cover has been decreasing over the past five years and the coral cover has also decreased since the 2015 baseline surveys. We imply that the status of marine resources is Airai may be the result of chronic terrestrial run-off that is un-managed. PICRC recommends that Airai State and the national government take appropriate measures to control sediment loads from Ngerikiil watershed.

RTS-270

Impact of snorkelers on shallow coral reefs in the Rock Island Southern Lagoon, Republic of Palau

Victor Nestor

Pacific islands are popular travel destinations for tourists, especially for underwater excursions, and Palau is no exception. From 2010 to 2015, the total number of visitors to Palau nearly doubled, reaching approximately 160,000 visitors. Although this exponential growth may be good for the economy, information on the impact of tourists on shallow coral reefs in Palau is very limited. This study seeks to document the impact of snorkelers on snorkeling sites in the Rock Island Southern Lagoon (a UNESCO World Heritage Site). In 2015-2017, surveys were conducted at five popular snorkeling sites (visited sites) and 5 reference sites (non-visited sites) to quantify benthic cover including coral fragments density, fish density and biomass, and the number of visitors (boats and snorkelers). Our results illustrated that coral fragments at the non-visited sites was half of that found at visited sites. Benthic cover, including the percentage of live corals and rubble, was similar between visited and non-visited sites. Fish biomass was greater inside visited site (14 kg per 70m^3) than non-visited sites (8 kg per 70m^3). Our observations showed that on average 1 out of 5 groups of snorkelers were damaging live corals. Although regulations are in place, enforcement is required to help protect our reefs from the negative impacts of human activities, such as snorkeling.

RTS-305

High-resolution modeling of thermal thresholds and environmental influences on coral bleaching for local and regional reef management

Naoki H. Kumagai, Hiroya Yamano, Committee Sango-Map-Project

Coral bleaching may begin with rising sea temperatures, although the widely used threshold of 1 degree over the local climatological maximum sea temperature has been reconsidered. In this study, we refined thermal indices predicting coral bleaching at high spatial resolution (1 km) by statistically optimizing thermal thresholds, as well as considering other environmental influences on bleaching such as ultraviolet (UV) radiation, water turbidity, and cooling effects. We used a coral bleaching dataset derived from the web-based monitoring system Sango Map Project (*sango* means coral in Japanese), at scales appropriate for the local and regional conservation of Japanese coral reefs. We recorded coral bleaching events in the years 2004–2016 in Japan. We revealed the influence of multiple factors on the ability to predict coral bleaching, including selection of thermal indices, statistical optimization of thermal thresholds, quantification of multiple environmental influences, and use of multiple modeling methods (generalized linear models and random forests). After optimization, differences in predictive ability among thermal indices were negligible. Thermal index, UV radiation, water turbidity, and cooling effects were important predictors of the occurrence of coral bleaching. Predictions based on the best model revealed that coral reefs in Japan have experienced recent and widespread bleaching. A practical method to reduce bleaching frequency by screening UV radiation was also demonstrated in this study. Thus, our high-resolution models may provide a quantitative basis for the management of local reefs under current global and local stressors. The results of this study may be useful to other researchers for selecting a predictive method according to their needs or skills.

RTS-326

Exploring variation in coral partial mortality metrics across spatial scales

Kevin Thomas Banal Go, Patrick Cabaitan, Jiema Manaid, Ritzelle Albelda, Timothy Joseph Quimpo, Edwin Dumalagan, Fernando Siringan

Understanding the processes that affect coral size distributions is important because size distributions dictate the quality of functions corals provide, such as habitat provision, coastal protection, and primary production. In corals, colony partial mortality is an important demographic process affecting size distributions. Because coral partial mortality is often a response to local-scale stressors (e.g., pollution, predation, disease), observed levels of partial mortality in a given locality may predict coral size distributions in that locality. However, different metrics of partial mortality—such as partial mortality frequency, severity, and the shrinkage-size relationship (i.e., the probability of a colony experiencing partial mortality as a function of colony size)—may vary across spatial scales, and in their usefulness as predictors of coral size distributions. In this study, we use multilevel statistical models to determine what spatial scales best explain the variation in partial mortality across different study sites, and to what extent partial mortality can be used to predict shifts in coral size distributions. We include three locations of varying exposure to anthropogenic stressors in the Philippines: Apo Reef (Occidental Mindoro), Masinloc (Zambales), and Bolinao (Pangasinan), to better understand how partial mortality varies across disturbance levels.

RTS-328

Environmental drivers of depth-associated distribution of corals on sediment-stressed reefs

Gwendolyn Shi En Chow, Samuel Yong Kit Chan, Danwei Huang

In an era of rapid environmental change, understanding how reef corals vary spatially is key to predicting their future outcomes. Depth range has been identified as an important species trait in scleractinian corals, yet this remains to be quantified adequately among tropical reef species. Filling this knowledge gap is especially important under the threat of sea level rise, which is likely to affect the survivorship of coral species with different depth ranges. This study examines changes in coral diversity and community structure along a depth gradient in relation to environmental parameters, and quantifies the depth ranges of common coral species found in sediment-stressed reefs of Singapore. Using SCUBA, belt transect surveys of the benthos and environmental data collection were conducted along the reef profiles at two sites. Data obtained were used to model the relationships between environmental factors and the variation of coral species composition, abundance and total cover with depth. Few genera had an even distribution at all depths, while most genera and growth forms were dominant at different depths along the reef slope, indicative of varying biological responses to depth-associated environmental parameters. Regardless of site, light and temperature were negatively correlated with depth, while sedimentation had a slightly positive correlation with depth. Coral cover as a whole was mostly influenced by total light received. Coral cover at the deepest section of the reef was reduced to 2.7% of the cover at the shallow reef shallows, corresponding with a 92.4% reduction of the mean total light quantum received at 1-m depth. Understanding the zonation patterns observed along a depth gradient could give insight into the vulnerability of different species to environmental change and inform local conservation efforts, such as the selection of ideal conditions for reef transplantation, in the face of light limitation experienced by sedimented reefs.

RTS-439

Thermal tolerance of fish-parasitic gnathiid isopods in the central Philippines

Mary Oluremi Shodipo, Paul Carl Sikkel

Extreme warming events that result in coral bleaching are occurring with increasing regularity, and the effects of these events on coral reef biodiversity have received considerable recent attention. However, as with other studies on coral reef ecology, parasite-host interactions are typically ignored. Extreme warming events can have significant effects on host-parasite interactions through their effects on mortality and performance. Gnathiid isopods are common external parasites of coral reef fishes that feed only during the juvenile stage. Like terrestrial mosquitoes and ticks, they are highly mobile blood-feeders that associate only temporarily with hosts, and thus may be considered "micropredators". The goal of this study was to examine the effects of simulated bleaching conditions on survivorship of gnathiid isopod juveniles. Gnathiids were collected using light traps set on shallow fringing coral reefs (<10m) of Cangmating, Agan-an and Bantayan in Negoros Oriental in the central Philippines, and sorted by size into two size classes (< 2mm, and > 2 mm). Individuals were then allowed to feed on host fish (Labridae and Pomacentridae), and assigned to one of five temperature conditions, ranging from ambient (28 C) to 36 C in the first trial, and 30 to 35 C in the second. Containers were heated gradually over a 10 hour period to their desired temperature, and inspected daily for molting and mortality until all gnathiids were dead or until 21 days. For both size classes, rapid mortality occurred above 34 C, and mortality rates increased significantly above 30 C. These data suggest that, as with their fish hosts, coral reef gnathiids cannot tolerate extreme warming events and are also negatively impacted at moderately above-normal temperatures. Further studies are needed to examine effects on behavior and reproductive performance and at other localities to determine the generality of these findings.

RTS-468

Effects of pH, temperature and salinity shift on the behavior and settlement of *Pocillopora damicornis* planulae

Adrian Jovin Hara Cocjin

Physico-chemical changes in seawater associated with climate change may affect the long-term health of coral reefs by influencing the recruitment of coral larvae. Although previous studies have addressed these factors, none has focused on special attributes of coral larvae, in particular their motility and their capacity to transform into viable coral polyps. This study gives the effects of a suite of altered seawater properties, including pH, and salinity on newly released planulae of the scleractinian coral Pocillopora damicornis in controlled laboratory conditions. pH values ranged from 7.8, 7.5, 7.0, 6.5, 6.0 while salinity values ranged from 34ppt, 33ppt, 32 ppt, 31 ppt, 30ppt. Planulae were observed regarding their motility movement and transformation change from planula to polyp in fifteen-minute intervals for a total of 2 hours. Results indicate 100% survival for planulae in all the pH treatments, with similar high survival values for the salinity treatment at 100% - 34ppt; 100% - 33ppt; 100% -32ppt; 90% - 31 ppt; 80% -30 ppt. In terms of planular motility, no significant difference was observed in the performance of planulae in all treatments ($X = 0.9936$, $p = 0.6034$), while differential performance was observed between planulae exposed to the different salinity treatments: Motility slowed down with decreasing salinity levels with the control = 33 ppt = 32 ppt> 31 ppt = 30 ppt; $X^2 = 31.7$, $p = 2.345^{-07}$. Correlation analysis revealed that planulae movement in different pH treatment has a moderate correlation with r value of -0.576 for pH and high correlation for salinity with r value of 0.917. Regression analysis was done to show how the causal relationship of the variables. The F value for pH = 0.309 > 0.05 which reveals that there is no causal relationship between pH and movement. While the F value for salinity = 0.028 < 0.05 which reveals that salinity and movement is related to each other. In terms of transformation into polyps, 100% transformation was observed in all pH treatments. They were varied but similarly high transformation levels were observed in planulae in the various salinity treatments at 100% - 34ppt; 100% - 33ppt; 60% -32 ppt; 70%-31ppt; 90% - 30ppt. In terms of planulae polyp transformation there is no significant difference between pH ($X = 3.778$, $p = 0.077$) and salinity ($X = 5.584$, $p = 0.051$) treatments.Correlation analysis revealed that planulae movement in different pH treatment has a moderate correlation with r value of -0.576 for pH and high correlation for salinity with r value of 0.917. Regression analysis was done to show how the causal relationship of the variables. The F value for pH = 0.309 > 0.05 which reveals that there is no causal relationship between pH and movement. While the F value for salinity = 0.028 < 0.05 which reveals that salinity and movement is related to each other. The results of this study shows that altered seawater state may negatively impact coral reef health by affecting the larval motility and transformation potential.

RTS-501

Histological observation of white syndrome effects on *Porites* corals

Mathinee Yucharoen

Environmental and anthropogenic disturbances are not only excessive coral mortality, but also influence to increasing of susceptibility to coral diseases. More attention on coral diseases has been interested by many research communities in Thailand. However, there were only quantitative data of baseline survey on presence and distribution of coral diseases in Thai Waters, which were established without etiology and comprehension. The present histological study on *Porites* corals was conducted in order to investigate effects on coral cell structure. Coral specimens manifesting white syndrome (WS) were collected from Thian Island, Trat, the Eastern Gulf of Thailand during February 2017. All samples were treated, decalcified and done histological protocol by staining of hematoxylin and eosin. The results showed that *Porites* tissues affecting by WS were disintegrated tissues, fractionated melanin packages and detached zooxanthellae. The necrotic cells were observed in all parts of inflamed tissue. In contrast, all layers of healthy tissues showed orderly-connected and well-structured. The components were held by cell membranes inside tissue layers (epidermis and gastrodermis). This examination could serve as an additional indicator of coral health and understanding in coral disease research in Thailand. Their modifications and gametogenesis will be required to better demonstrate the long-term effects on coral host.

RTS-528

Effects of inorganic nutrient enrichment on the physiology of scleractinian coral *Pocillopora damicornis* larvae

Fang Zhang, Lei Jiang

This study tested the isolated effects of ammonia nitrogen (NH_3/NH_4^+) and orthophosphate (PO_4^{3-}) enrichment and their combined effects on physiology of brooded Pocillopora damicornis larvae from Luhuitou fringing reef, Sanya, China. Results showed that NH_4^+ or PO_4^{3-} enrichment did not influence larval survivorship and maximum quantum yield (Fv/Fm). Although larval settlement was unaffected by the individual effects of NH_4^+ or PO_4^{3-}, it tended to be reduced at the combined treatments. Furthermore, the combined effects of ammonia nitrogen (NH_4^+) and orthophosphate (PO_4^{3-}) enrichment on larval net photosynthesis were concentration dependent, in a positive manner under 50μmol×L-1 NP and in a negative manner under 100μmol×L-1 NP. These results suggest that the joint exposure to NH_4^+ and PO_4^{3-} (NP) enrichment is likely to be more detrimental for coral larval performance than single stressor.

RTS-569

Effect of thermal stress on survivorship and substrate selection of *Acropora tenuis* and *Heliopora coerulea* larvae

Jeric Da-Anoy, Patrick Cabaitan, Cecilia Conaco

Substrate selection plays an important role in larval recruitment and the development of coral reefs. Chemical cues emitted by other members of the benthic community can affect the process of substrate selection and settlement. Yet, the influence of changing ocean temperature regimes on this event and the differences in the response of larvae from diverse species of corals remain to be elucidated. In this study, we examined the effect of coral-derived crude extracts and thermal stress on survivorship and substrate selection of larvae from *Acropora tenuis* and *Heliopora coerulea*. Larvae were provided with substrates containing different coral extracts and were allowed to settle under various temperature regimes. *H. coerulea*larvae remained viable even at high concentrations of heterospecific coral extracts. On the other hand, *A. tenuis* larvae exhibited mortality at high concentrations of extracts from heterospecific corals, including *H. coerulea*. Both *H. coerulea* and *A. tenuis* larvae had greater preference for substrate containing the extract from crustose coralline algae. *A. tenuis* larvae also settled on substrate containing acroporid coral extracts while very few settled on substrate with *H. coerulea* extracts. Exposure to 27°C and 30°C did not affect larval substrate selection and settlement. These results highlight the importance of further studies on the potential effects of thermal stress and chemical cues emitted by heterospecific corals on the settlement of coral larvae.

RTS-625

Long-term change of dead coral substrates after the 2010 coral bleaching event at Mu Koh Surin, the Andaman Sea, Thailand

Sittiporn Pengsakun, Thamasak Yeemin, Makamas Sutthacheep, Wanlaya Klinthong, Prarop Plangngan

The widespread coral bleaching in the Andaman Sea has been reported in summer of 2010 due to anomaly elevated seawater temperature. More than 50% of coral mortality was reported while most *Acropora* and *Pocilloporacolonies* were affected at all sites and their mortality rates were very high (>90%). In this study, we conducted field surveys at ten study sites at Mu Ko Surin National Park in January 2018 to examine the long term change of dead corals resulted from the 2010 bleaching event. Overall, increased live coral covers were observed at all study sites. In terms of the dead corals, about 90% of dead table coral colonies observed were collapsed while about 70% of dead massive coral colonies were settled by other juvenile corals. Almost of all the dead branching coral colonies investigated (about 90%) were covered with algae, zooanthids, and corallimorphs. Low recruitment of juvenile corals was also found on the dead branching coral colonies making it difficult to recover. Since the coral reef at the study sites were most covered by branching corals, any measures that enhance coral recruitment should be established in order to promote coral recovery in Mu Ko Surin area. Besides, tourism management plan for protection of these coral communities is urgently needed in order to minimize anthropogenic stressors and to ensure the sources of coral larvae for coral recovery in the Andaman Sea.

RTS-650

Marine debris stresses on coral communities in the Gulf of Thailand

Makamas Sutthacheep

A problem of marine debris pollution is one of major perceived threats to the conservation of marine biodiversity in the Southeast Asian countries. With limited knowledge of the impacts on coral communities, in the present study, we surveyed at three underwater pinnacles in the Gulf of Thailand in order to investigate abundance of marine debris and its impacts on coral communities. The results revealed that the highest density of marine debris was found at Hin Chalam, the Inner Gulf of Thailand, with an average of 18.83 ±4.07 items/100m^2 while the lowest one was recorded at Hin Lak Ngam, the Western Gulf of Thailand, with an average density of 7.83 ±2.08 items/100m^2. Most marine debris was parts of fishing gears. Higher percentages of coral mortality and syndromes were found at Hin Chalam. We found some partial mortality in tissues of corals, including *Porites lutea*, *P. rus*, *Pocillopora damicornis*, *Acropora divaricata*, *A. millepora*, *A. hyacinthus*, *A. valenciennesi* and *Pavona decussata*, *Platygyra sinensis*. We also observed that the higher percentage of corals with syndromes (*P. lutea*, *P. sinensis*) was recorded at Hin Chalam compared to those observed at Hin Lak Ngam and Ko Losin. These impacts could be linked to the higher density of marine debris found at Hin Chalam. The marine debris also contributes to impacts on marine life as ghost fishing. This study provides scientific data for establishing effective policies to mitigate impacts of marine debris on coral reef ecosystems.

RTS-630

A link between human activities and coral diseases in the Gulf of Thailand

Watchara Samsuvan, Thamasak Yeemin, Makamas Sutthacheep, Wiphawan Aunkhongthong

In this study, we investigated the influence of human activities on coral health by conducting the field surveys at fourteen study sites in the Gulf of Thailand in during 2016. The main patterns of coral diseases at the study sites consisted of pigmentation responses, white syndromes, growth anomalies, and unusual bleaching patterns. Twelve species of corals with the diseases and signs of compromised health included *Acropora muricata, Astreopora mileopora, Plerogyra sinuosa, Pavona decussata, Fungia fungites, Platygyra sinensis, Favia speciosa, Favites halicora, Goniastrea aspera, Porites lutea* and *Goniopora lobata.* The highest prevalence of the diseases and signs of compromised health was found with *P. lutea* (83% of total colonies observed). Of which, more than 50% was pigmentation response, followed by white syndromes accounting for 23%. The results show that the highest prevalence was found at the study sites located close to big cities including northern and eastern of Ko Khang Khao (A), Ko Khang Khao (C), Ko Thai Ta Muen. High prevalence was also observed at the study site influenced by the tourism activities such as Ao Phrao, Ao Platom, Ko Samed, Ko Taiplao. The prevalence of coral diseases may link with poor water quality, especially with high nutrients and organic carbon derived from human activities along the coasts. This study provides baseline data to support that higher coral disease prevalence is linked to anthropogenic disturbances on coral communities.

RTS-653

Impacts of natural disturbances on the population dynamics of sea urchin *Diadema setosum* in coral reefs at Ko Khang Khao, the Upper Gulf of Thailand

Charrnmee Chamchoy

A Sea urchin, *Diadema setosum*, is a dominant marine invertebrate animals found in coral community in the Upper Gulf Thailand. The *D. setosum* lives on hard substrates and feeds on algae living in corals, dead or live sessile invertebrates etc., resulting in bioerosion of coral reefs. This research aims to study the population dynamics of the sea urchin *D. setosum* and the change of bioerosion rates at Ko Khang Khao, Chonburi Province, the Upper Gulf of Thailand. Field surveys were conducted during 1998 - 2016 using belt transect method (50m x 1m). The results revealed the population densities of *D. setosum* varied among years (One-way ANOVA, $p<0.05$). The highest density was found in 2009 (11.34 ind.m^{-2}), followed by 2010 (10.97 ind.m^{-2}), and 2012 (8.77 ind.m^{-2}) while the lowest density was detected in 2011 (4.02 ind.m^{-2}) because of the impact from heavy flooding. The average bioerosion rates observed in 1998 (1.03 kg $CaCO_3$ /m^2/year) was significantly lower than that observed in 2016 (2.64 kg $CaCO_3$ /m^2/year) (t-test, $p<0.01$) reflecting that the higher bioerosion rate is related to the increased number of sea urchin population. This study provides a baseline data on population dynamics of the sea urchin in relation to reef bioerosion for the management of coral reef ecosytems.

RTS-652

Will recurring coral bleaching promote shifting and stablising symbiont community towards the thermal-tolerant clade/ types? A case study of scleractinian corals in the lagoon of the Dongsha Atoll (Pratas), South China Sea

Nai-Syuan Yang

Coral bleaching, a stress response of symbiotic relationship breakdown between coral hosts and their associated *Symbiodinium*, has been suggested as a mechanism for corals to shift symbionts from thermal-sensitive clades/ types towards the thermal-tolerant ones. However, multi-year, seasonal phylotypic surveys of symbionts reveal a prevalent stability or post-bleaching reversion in Caribbean and Indo-Pacific scleractinians. However, the frequencies and severity of recurring bleaching becomes a common feature of coral reefs due to climate change in the recent years (e. g., 2015-2016 in the Great Barrier Reef), it is expected that shifting symbiont community towards thermal-tolerant clade/ types would become a common pattern and, as the consequence, losing the capability of post-bleaching reversion. In this study, we examined the symbiont community of scleractinian corals from two sampling times, 2009-2010 and 2016-2017, both involved intensive bleachings between consecutive years. Among 20 genera (n=928) surveyed in 2009-2010, and 28 genera (n=1474) in 2016-2017 by the RFLPs and DDGE of ribosomal DNA markers, we discovered over 25% post-bleaching increase of *Symbiodinum* clade Dx (D1/D1a/D17) in both sampling periods, and a significant higher proportion of clade Dx in 2016-2017 than that in 2009-2010. Our results highlighted that recurring severe coral bleaching could promote shifting and stablising symbiont community towards the thermal-tolerant clade/ types. Losing the capability of post-bleaching reversion to *Symbiodinium* clade Cx, a better partner, acquiring, assimilating and transferring more photosynthetic resources to the host than Dx, might explain, at least partially, the long-standing and unable to recover of scleractinian community in the lagoon of the Dongsha Atoll.

RTS-661

Assessing microplastic ingestion by reef fishes in the Gulf of Thailand

Thamasak Yeemin

Microplastics are plastic fragments, <5 mm in diameter, which are a widespread form of pollution in marine and coastal ecosystems worldwide. Near-shore coral reefs, are at risk to be heavily impacted by microplastics because the plastic pollutants can enter the coastal environment through fragmentation of larger plastic items from land-based sources. Previous studies have reported on plastic ingestion by sea turtles, seabirds and marine mammals but much less are known about the consumption of microplastics by reef fishes, especially in Thai waters. This study examined the abundance of microplastics in gut contents of reef fishes in the Gulf of Thailand. The reef fishes were collected using fish traps during January - October 2016. The stomachs of the fishes were removed, opened and then the contents were rinsed into vials. The abundance of microplastics in the fish was examined by hydrogen peroxide and floatation- filtration with saline (NaCl) solution treatments. A total of 17 reef fish species were collected. The dominant fishes were *Siganus canaliculatu*, *Myripristis hexagona* and *Lutjanus fulviflamma*. The microplastic sizes ranged between 500 and 4,000 µm. High abundance of microplastics was found in *Siganus canaliculatu* while low abundant levels were observed in *Myripristis hexagona* and *Lutjanus fulviflamma*. Our results revealed that fish feeding habit is an important factor controlling microplastic ingestion by reef fishes. This study also highlights the importance of public awareness regarding microplastic pollution in coastal and marine ecosystems in the Gulf of Thailand.

RTS-664

Assessing long-term impacts of oil spill incident on meiofaunal communities from coral reefs at Ko Samet, the Eastern Gulf of Thailand

Laongdow Jungrak

Studies on meiofaunal communities in coral reef ecosystems in the Indo-Pacific region are limited although meiofauna are important for marine ecosystem contributing to marine food web, particularly being as a food source for the juveniles of various marine economic species. This study examined long-term changes of meiofauna density in coral communities at Ao Prao Nua, Ao Prao Tai and Ao Platom in Ko Samet during 2014 – 2017 after the oil spill incident. Based on our surveys, the mean density of meiofauna observed at Ao Prao Nua observed in 2014 was higher than that observed in 2017. In both surveyed periods, a total of 14 taxa were found including Ciliates, Foraminifera, Bryozoa Turbellaria, Nemertina, Nematoda, Polychaeta, Nauplius larva, Ostracoda, Copepoda, Sea mite, Gastropoda, Bivalvia and Cephalopoda. Increased densities of some taxa, i.e. Ciliates, Bryozoa, Nemertina, Nauplius larva, Sea mite and Cephalopoda were found in 2017. At Ao Prao Tai, the mean density of meiofauna observed in 2014 was less than that observed in 2017. In both surveyed periods, a total of 10 taxa were found including Foraminifera, Turbellaria, Nemertina, Nematoda, Polychaeta, Ostracoda, Copepoda, Amphipoda, Gastropoda, and Bivalvia. Densities of Turbellaria and Amphipoda were increased in 2017. At Ao Platom, the mean density of meiofauna observed in 2014 was less than that observed in 2017. The densities of Turbellaria, Nemertina, Nauplius larva, Crustacea and Gastropoda increased in 2017. The mean total density of meiofauna observed in 2017 was significantly greater than that observed in 2016 (t-test, $p<0.05$). The density of meiofauna observed at Ao Platom was significantly higher than those observed at other study sites (two-way ANOVA, $F=14.63$, $p<0.01$). This study provides useful information for monitoring changes of meiofauna in coral reefs impacted from the 2013 oil spill incident which affected certain reef sites of Ko Samet and its vicinity.

RTS-668

Long-term monitoring of juvenile coral communities at the offshore island of southern Thailand after coral bleaching

Juthamart Putthayakool, Prarop Plangngan, Thamasak Yeemin, Makamas Sutthacheep, Watchara Samsuvan, Charrnmee Chamchoy

Understanding on density of juvenile corals can improve the ability to forecast the coral recovery rates after coral bleaching events and explaining variation of coral community structure. The aim of this study was to examine long-term changes of juvenile coral densities and composition during 2015 – 2017 at 6 study sites in Mu Ko Surin National Park, the Andaman Sea following the 2010 coral bleaching event. The random sampling was conducted with quadrat (16x16 cm^2) to detect juvenile coral colonies on available substrates using SCUBA diving. Based on the surveys, we found that eleven families of juvenile corals were observed at all study site where Fungiidae, Poritidae, Acroporidae and Agariciidae were dominant. The mean total densities observed in 2015 – 2017 were 23.38±9.94, 18.08±4.18, 15.85±4.15 colonies.m^{-2}, respectively. The highest density of juvenile corals was observed at Ao Suthep in 2015 (38.31±7.28 colonies.m^{-2}) while the lowest one was found at Torinla Island in 2017 (10.21±1.94 colonies.m^{-2}). The most dominant juvenile coral found in 2015 and 2016 was the family Fungiidae while Poritidae was a dominant in 2017. A decreasing trend of juvenile coral density during sampling periods may be influenced by various factors. This research supports important information for further research in order to determine the dynamics and coral recovery after the natural disturbances.

RTS-671

Status of coral reef in the Gulf of Thailand after the 2010 coral bleaching event

Chainarong Ruangthong

In this research, we illustrated the status of coral reefs at four national parks in the Gulf of Thailand. Based on our surveys, after the 2010 bleaching event, coral reefs at Mu Ko Ang Thong National Park and Khao Laem Ya-Mu Ko Samet National Park were severely affected while the coral reef at Mu Ko Chang National Park and Mu Ko Chumphon National Park had relatively low impacts. The monitoring on coral recovery at four national parks showed that spatial variation of live coral covers across the national parks were detected. The highest live coral cover was found at Mu Ko Chumphon National park with the percent cover of 77.2%, followed by Khao Laem Ya-Mu Ko Samet National Park (71.73%), Mu Ko Chang National Park (60.16%), and Mu Ko Chumphon National Park (50.68%). This study highlights the importance and management guidelines for enhancing reef resilience and natural recovery.

RTS-682

Status of coral communities after the 2010 coral bleaching event at Mu Ko Similan Island National Park, Andaman Sea, Thailand

Prarop Plangngan, Songtham Suksawang, Nok Malaidang, Thamasak Yeemin

We assessed the status of coral reef after the 2010 bleaching event using the photo-belt transect at six study sites in Mu Ko Similan Island National Park, Andaman Sea, Thailand. On reef flat, Ao Numchai (15.66±0.48%) had the highest live coral cover while East of Eden exhibited the lowest live coral cover (6.46±2.41%). The coral reefs in this areas were severely impacted. The dominant corals included *Porites lutea*, *Heliopora coerulea*, *Montipora* sp. Conversely, the highest liver coral cover found on reef slope was recorded at East of Eden (38.19±5.98%) while the lowest one was found at Ao Khonkae (8.82±5.34%). The dominant corals were *Montipora* sp., *Porites lutea*, *Porites rus*, *Diploastrea heliopora*, and *Pavona* sp. Reef fish, monitored using the fishes visual census method, consisted of 175 species in 31 families in which Labridae was a dominant family. The highest density of reef fish was recorded at Ko Hok (3,610.33 ind. 300 m^{-2}). Based on the visual estimation, soft corals were abundant at Hin Muan Diaw. However, a decrease in the density of soft coral *Dendronephthya* spp. was also found. Twenty seven species of juvenile corals were found in the study sites with the density rage of 1.79±0.34 - 16.74±3.18 colonies.m^{-2}. The dominant juvenile corals included *Pavona* spp. and *Porites* spp. The West of Eden also showed the most abundance of benthic invertebrates accounting for about 2.52 ind.m^{-2}. This information serves as a background data which can be beneficial for conservation and sustainable uses of coral reefs in the national park.

RTS-693

Anthropogenic threats to coral reefs: insights from small scale fishery in the Philippines

Ma. Czarmayne Victoria Jude Tejada Escoro, Jesse Jan Galera, Mary Joyce P. Velos, Jemelyn Grace P. Baldisimo, Maryjune M. Cabiguin, Jerome Genilan, Joseph Benedict Tion Garcia, Ariel Loja, Robert Bryan Casauay, D.J. Marie Palic, Ma Celina Anonuevo- Arcega, Denmark Bagsican Recamara, Hazel Ouano Arceo

Philippine coral reefs are among the highly diverse and productive ecosystem in the globe. However, it is threatened by natural stressors and intensified by anthropogenic activities. Actual assessment and monitoring of anthropogenic threats are difficult to conduct because most are illegal and destructive in nature. Using fishers' perceptions, researchers determined the prevalence and history of common coastal anthropogenic threats (i.e. dynamite fishing, poison fishing, commercial fishing, and pollution). A total of 5,666 respondents in 371 coastal barangays in 55 coastal towns in the Philippines were surveyed using semi-structured interviews. In addition, actual observations of threats were noted during underwater surveys in 77 coastal towns. Preliminary analysis of 26 coastal towns show that reported type of threats and its prevalence vary across marine biogeographical locations. Dynamite fishing was highest in the South Philippine Sea region and mostly in island localities. Poison fishing incidents were relatively dominant in the North Philippine Sea while encroachment was found to be highest in the Visayan and Celebes Sea (particularly in Davao Gulf) regions. In addition, actual observation of dynamite fishing was noted in 16 localities. The study highlights the importance of local knowledge as a source of information to enhance our understanding on the threats affecting coral reefs, especially since there is limited information on the distribution and magnitude of these threats across the country despite their widespread incidence; thus hindering more effective conservation, enforcement and management efforts.

RTS-692

Influence of different environmental conditions on coral communities in Bolinao, Pangasinan, Philippines

Ma. Czarmayne Victoria Jude Tejada Escoro, Jue Alef Avanzado Lalas, Melchor R Jacinto, Janine Bobadilla, Maria Vanessa Baria-Rodriguez

Coral reefs are among the most biologically diverse ecosystem globally, providing various ecosystem services. It is formed from the carbonate deposition by reef building corals, hence, corals are fundamental for the coral reef dynamics and functioning. However, coral populations are threatened by global and exacerbated by local disturbances. This study was carried out to assess the impacts of local disturbances, siltation and eutrophication primarily caused by mariculture activity, on coral communities (e.g. cover, composition, diversity) in Bolinao, Pangasinan, Philippines. Mariculture activities in Bolinao is one of the major source nutrients transported to coral reefs in the area. Three (3) stations, Trenchera, Lucero and Malilnep, at 3-5 m depth were surveyed using phototransect method while water samples were collected for water quality analyses (i.e. total suspended solids, pH, total alkalinity, SiO_3, NO_2–, NH_4+). Initial results show that benthic cover, composition, and water quality varied across sites. Hard coral cover and generic diversity are relatively higher in Lucero and lowest in Trenchera. Reduced diversity can be attributed to the relatively high turbidity and high amount of NO_2. Thus, siltation and eutrophication pose negative effects to coral communities by reducing coral cover and diversity. This study will provide information on which species thrives and or more tolerant in a more turbid and eutrophic reefs.

RTS-733

Occurrence and distribution of Polycyclic Aromatic Hydrocarbons (PAHs) in seawater, sediments and corals from Hainan Island and Xisha Islands, China

Tinghan Yang

Surface water, sediments and corals from coral reefs of Hainan Island and Xisha Islands were analyzed in 2016 and 2017 for occurrence of polycyclic aromatic hydrocarbons (PAHs) using gas chromatography-mass spectrometry (GC/MS). Concentrations of the 16 US EPA priority PAHs of surface seawater and sediments respectively, but were the markedly ($P<0.01$) highest in corals demonstrating the bio-accumulation mechanisms of PAHs in corals. There are ability discrepancies of PAH accumulation in different species of coral, ΣPAHs in *Porites sp.* cleanly ($P<0.01$) higher than that in *Acropora sp*. The potential sources analysis showed extremely similar sources of PAHs in corals and seawater, whereas PAHs in sediments were from different origin. This demonstrated that in corals distribution and origins of PAHs contaminations cloud be mainly affected by surface seawater, and revealed the main approach of the organic pollutant being absorbed via directly feeding aquatic organisms from the surrounding seawater.

RTS-772

Can latitudinal migration save coral reefs in the South China Sea

Weihua Zhou, Xiangcheng Yuan, Hui Huang

High temperatures caused by global warming may limit coral growth in tropical areas, and subtropical areas might therefore act as coral refugium habitats. Our culture experiments showed that coral species failed to survive fromhigh temperature of 33 °C within 5 days, suggesting that the summer high temperature (>33 °C) could result in coral disappear at the end of century in tropical waters. The annual sea surface temperature was ~3 °C lower in subtropical waters than in tropical waters in the South China Sea, suggesting that subtropical areas could be potential refugia from ocean warming. In contrast to the decline of coral cover in most of reef systems, coral cover increased from 39% to 63–71% after it was made a protected marine park in 2001 in the subtropical area off Hong Kong. This suggested that reefs in subtropical waters should be well-protected as potential refugia. However, pH decreased at a rate of 0.012–0.014/ yearin both Sanya and Hong Kong waters; this decrease was four-fold higher than the global average value (~0.003/year). Our culture experiments showed that the lower temperature in subtropical waters can save some acidic resistant coral species at the end of this century, and subtropical coral reefs can potentially serve as coral refugia.

SC-80

Elevated temperature promotes spreading growth of the blue coral, *Heliopora coerulea*

Christine Guzman, Michael P Atrigenio, Chuya Shinzato, Porfirio Miel Alino, Cecilia Gastardo Conaco

Heliopora coerulea, the blue coral, is a reef building octocoral that is reported to have a higher temperature optimum for growth compared to scleractinian corals. It is rare within its range yet *H. coerulea* has been reported to have the ability to grow over scleractinians and can dominate certain reefs. The molecular mechanisms underlying the ability of *H. coerulea* to compete for space on the reef are yet unknown. In this study, we subjected *H. coerulea* colonies to 26°C, 28°C, and 31°C for three weeks. We found that the margins of the colony spread faster at 28°C and 31°C. Transcriptome profiling of the soft tissue at the growing margin revealed enrichment for genes with translation-related functions. In contrast, the calcified encrusting section of the colony was enriched for genes that function in energy-generating metabolic processes and transport. The digitate parts of the colony exhibited the most diverse gene expression profile, with enrichment for genes that function in metabolism, ATP generation, and calcification. Under conditions of thermal stress, biomineralization-related genes were downregulated, suggesting that the coral may be investing more energy towards spreading growth to take up more space on the reef.

SC-217

Dispersal mechanisms of the *Halophila ovalis* population in the Northwestern Pacific: A preliminary study

Chi-Hsuan Hsu, Shang-Yin Vanson Liu

In recent years, climate change, coastal development and marine pollution are causing dramatic decline of marine ecosystems, especially seagrass ecosystem which locates exclusively in subtidal zone. To understand their dispersal mechanisms and connectivity are very important for restoration, conservation and management of seagrasses. *Halophila ovalis* (R. Br.) Hook. *f.* is a wildly distributed species in the Indo-Pacific. Around Taiwanese water, it can be found in Taiwan, Penghu Islands and Dongsha atoll. Previous literature indicated their fruits and seeds which digested by birds were have a much higher germination rate. Therefore, the biotic vector such as migratory birds may play an important role on their long distance dispersal. If the migratory shore birds are responsible for carrying new recruits from different geographic populations (countries), a temporal genetic structure shift could be expected. In present study, we performed the sampling for two consecutive years in Penghu (7 sites), Qigu (3 sites) and Dongsha atoll (4 sites) to reveal a possible temporal population structure shift to test the biotic dispersal hypothesis. ITS and hyper-variable microsatellite loci were used to barcode and reveal the population structure, respectively. The results of ITS analyses showed that all haplotypes were clustered with reference ITS sequences of***H. ovalis*** downloaded from GenBank which excluded the possibility of mis-identification. Meanwhile, the genotyping is currently processing.

SC-221

Preliminary species identification and diversity of marine derived fungi isolated from selected hard corals of Perhentian Islands, Malaysia.

Lee Li Chuen, Mohammed Rizman Idid, Siti Aisyah Alias, Zhu Hua Luo, Kishneth Palaniveloo

Hard corals (Scleractinia) are organisms comprising of polyp colonies that harbor an assemblage of microbes, known collectively as coral holobionts that may comprise of algae, bacteria, viruses, fungi and archaea. Marine fungi have commonly been isolated from marine invertebrates such as sponges and soft corals, but rarely from hard corals. This preliminary study investigates the diversity of marine fungi associated with selected hard corals of Perhentian Islands, Malaysia. A total of 12 hard coral species were collected, photographed and identified based on morphology and COI sequences. A total of 39 marine derived fungal isolates were successfully obtained from the coral tissue samples and cultured on CMA plating media. Marine derived fungi were isolated according to their morphotypes (colony color and texture, border type and radial growth rate, branching patterns of mycelia, diffusible pigments). The scleractinian coral species and number of fungal isolates were as follows: *Acropora hyacinthus* (4), *Pocillopora darmiconis* (4), *Fungia* sp. (4), *Pavona* sp. (4), *Porites lutea* (5), *Galaxea* sp. (3), *Tubastrea coccinea* (3), *Lobophyllia* sp. (2), *Platygyra* sp. (4), *Diplostrea* sp. (3), *Hydnophora* sp. (1) and *Turbinaria* sp. (2). DNA sequencing of the ITS gene revealedthat some of the fungal isolates were tentatively identified as *Aspergillus sydowii* and *Penicillium chrysogenum*, that been isolated from most of the hard corals species. Through preliminary micro-morphology characteristic examination of these isolates, *Penicillium* and *Aspergillus* were the dominant fungi that can be found across most samples. Despite the terrestrial origin of these two species *Aspergillus sydowii* and *Penicillium chrysogenum*, they are well adapted to marine environment.

SC-233

Ongoing activities on ocean acidification and its possible impacts to coral reefs in the coastal waters of Vietnam

Tuan Linh Tran Vo, Minh Quang Thai, Long Van Nguyen, Si Tuan Vo

Given the fact that ocean acidification (OA) is has been coming a hot issue over recent years, IOC/WESTPAC has organized a series of activities for information collection and exchange, human resources training, and deeper study the impact of OA on marine ecosystems; thence, towards the development of an OA research and monitoring network in the region. To date, many members such as Malaysia, Thailand, Philippines, South Korea, Indonesia, and China have been building OA monitoring / research systems. In that context, as an active member of IOC/WESTPAC, Viet Nam has been establishing our own system and integrate into the network. A project, approved and funded by the Government, has been carried out in the period of 2017 - 2020 in order to have basic knowledge about OA and its possible impacts to marine ecosystems and to enhance Vietnam's capacity in line with activities of IOC and IOC/WESTPAC. The studies relevant to OA include: (1) building a baseline data on indicator parameters such as pH, TA, pCO_2, DIC, calcium accretion, bioerrosion and reef status; (2) Intitial assessment potential impacts of OA to coral reef through the measurement of calcification of hard corals in different pH values *in situ*. The studies have been conducted at four study areas of Nha Trang bay, Ninh Hai coastal waters, and Phu Quy, Phu Quoc islands, all of which were registered to the regional network. Besides, researches on OA have been integrated into other projects implemented in Vietnamese waters to provide broader data and information.

SC-260

Strategic or Opportunistic? Subtidal seagrass use by dugongs in the Sibu-Tinggi Archipelago, Johor, Malaysia

Wei Khang Heng, Jillian Lean-Sim Ooi, Louisa Shobhini Ponnampalam

In Peninsular Malaysia, endangered dugongs (*Dugong dugon*) are localized around the Sibu-Tinggi Archipelago (South China Sea) owing to the presence of extensive seagrass meadows. Field surveys were conducted in 2016 and 2017 to comprehensively study the distribution of seagrass meadows and the dugongs' interactions with their seagrass habitat in the subtidal tropical environment of the archipelago. We examined the spatial distribution patterns of the dugong feeding trails across different seasons using towed underwater video and ascertained whether dugong feeding patterns in subtidal meadows were related to seagrass diversity, biomass, nutrient composition, water depth and/or substrate. Sixteen feeding trails were sampled by SCUBA diving for seagrasses and sediment. Feeding trails were on average 2.9 ± 1.0 cm deep, and were dominated by small and fast-growing species, *Halophila ovalis* (mean shoot density 1077.63 ± 503.68 m^{-2}) and *Halodule uninervis* (mean shoot density 1066.47 ± 903.85 m^{-2}) while *Cymodocea serrulata* (mean shoot density 171.39 ± 118.34 m^{-2}) and *Syringodium isoetifolium* (mean shoot density 605.05 ± 8.26 m^{-2}) were less abundant. Most of these feeding trails occurred in the mid to southern part of the meadow. The distribution of intensive feeding areas across the seasons suggested a practice of regular dugong grazing of sectional swards, called "feeding hotspots". Such regular, non-random feeding patterns imply the dugongs utilize the meadows in a strategic way, driven by the vegetative and physical habitat factors measured in this study. By identifying the most influential drivers, this study provides a seagrass-explicit rationale for designing better protected areas for dugongs.

SC-274

Population Genetic Structure of *Acropora solitaryensis* and *A. cf. glauca*, Including the Northernmost Colonies Settled Recently

Akifumi Shimura, Hiroaki Aizawa, Takashi Nakamura, Takehisa Yamakita, Yuko F Kitano, Akira Iguchi, Hiroya Yamano, Masato Kiyomoto, Satoshi Nagai, Nina Yasuda

In Japanese coastal areas, northward migration of stony corals has been reported along with rising sea temperatures in the last 80 years. To effectively manage and conserve coral populations, knowledge of genetic diversity and meta-population structure of temperate corals are essential; corals have pelagic larval duration that may contribute to the maintenance of connectivities among populations. Genetic diversity is also an important indicator for evaluating the vulnerability against environmental change especially in the recently colonized northernmost populations that may have lower genetic diversities. In this study, we collected a total of 284 *Acropora solitaryensis* and *Acropora* cf. *glauca* that have been regarded as a single species from 9 temperate sites and the distribution of these species has been expanding toward north since the 1930s. We conducted the population genetic analysis using nuclear microsatellites and a recently developed method for population genetic study (MIG-seq). We used 5 microsatellite loci and obtained in total 73 and 144 MIG-seq loci for *A. solitatyensis* and *A. glauca, respectively*. Both the microsatellite and the MIG-seq analyses indicated that the gene flow of *A. solitaryensis* was higher than that of *A.* cf. *glauca* among site implying more limited larval dispersal in *A.* cf. *glauca* than *A. solitaryensis*. The genetic diversity of *A. solitaryensis* was comparable among different sites including recently colonized populations while in *A.* cf.*glauca*, genetic diversity of Tateyama, the northernmost habitat showed significantly lower values than other populations. In summary, genetic diversities in most of the recently colonized populations was higher in both species except for Tateyama. Contrary to our expectations, the data suggests recently colonized temperate populations of *A.* cf. *glauca* and *A. solitaryensis* are not necessarily vulnerable to environmental changes in terms of genetic diversity, implying potential usability of these temperate coral resources for tourism and other sustainable activities.

SC-413

A population genetic study of the Japanese temperate coral species, *Acropora pruinosa*

Sota Ishizu, Hiroyuki Yokochi, Nina Yasuda, Hironobu Fukami

In Japan, a coral species, *A. pruinosa*, lives widely through the temperate region of Japan, and it is one of the main species to form the coral communities. This species, however, exhibit wide morphological variations at the length and thickness of branches, suggesting that a cryptic species may be included. In this study, to examine existence of the cryptic species of *A.pruinosa*, we performed the population genetic study for them. We collected the samples by scuba or snorkeling from wide ranges (17 sites) in Japan. Seven nuclear microsatellite markers and a mitochondrial non-coding region were used for the analysis. To investigate the population structure, we used STRUCTURE software for microsatellite data. The result showed that *A. pruinosa* was divided into two main groups (K=2). Two groups were clearly separated into eastern and western sides at Kochi, where is a middle part of the distribution range of this species in Japan. This data suggests that genetic connectivity between two groups is very limited. On the other hand, the phylogenetic tree based on a mitocondlrial markar showed that this species were divided into five clades without any geographic relationships. In addition, we could not find any morphological characteristics of each two groups based on STRUCTURE data. Thus, this species would be a single species, but might be dividing to two species.

SC-444

Effects of sea surface temperature (SST) and cyclone Winston on *Pocillopora damicornis* and the associated *Symbiodinium*

Shubha Shalini Singh, Susanna Piovano, Ciro Rico

Coral reefs in the tropical Pacific region are exposed to periodic regular cycles of changes in sea water temperature due to El Niño Southern Oscillation (ENSO). Coral reefs are also systematically exposed to the effects of cyclones which produce strong currents and a sudden decrease in sea water temperature among other impacts. In January 2016 Fiji experienced a short term increase in sea surface temperature and the following month, in February 2016, a category 5 cyclone. As a consequence, extensive coral bleaching was recorded in the fringing reefs. This study aimed to investigate *Pocillopora damicornis* recovery, mortality and changes in the dominant *Symbiodinium* clades after these two consecutive events. Two fringing reefs in Viti Levu, Fiji were monitored monthly for six months after the two events.

The results from this study suggested that more than 70% of the *P. damicornis* monitored reached full recovery within 6 months. This was due to *P. damicornis* harbouring the more thermo-resistant clades. At the beginning of the study clade D1 was found to be most abundant (40%) and after 6 months, it was found that clade D1a was the most dominant (82%) We also confirmed that the more thermally tolerant *Symbiodinium* clade D1 (*Symbiodinium glynni*) and D1a (*Symbiodinium trenchii*) were found to become dominant in the corals after the bleaching event.

This study is a first for the Fiji islands, therefore it is important to know the more thermos-resistant clades present in the commonly occurring genus present on the reefs and how coral bleaching and cyclones affect the dominant clade composition.

SC-598

Impact of 2016 bleaching on coral recruitment in the lagoon of the Dongsha Atoll (Pratas), South China Sea

Yen-Ling Peng, Nai-Syuan Yang, Ming-Jay Ho, Yie-Jia Chen, Sung-Yin Yang, Ya-Yi Huang, Shashank Keshavmurthy, Allen Chaolun Chen

Rising sea surface temperature (SST) caused by climate change has been suggested as a major global stressor to induce mass coral bleaching, a breakdown of symbiotic relationship between coral hosts and their associated dinoflagellates (jointly known as coral holobionts). Prolonged coral bleaching could eventually induce high mortality of coral holobionts, but also affect recovery of those survived coral holobionts after thermal stress is removed. In this study, we examined the recruitment pattern of scleractinian corals in the lagoon of the Dongsha Atoll (Pratas), South China Sea in 2016 and 2017 whereas in the former year a summer coral bleaching (August-October) was observed but not in the later year. By deploying and retrieving ceramic plates in April and in July for both 2016 and 2017, and examining living coral spats using fluorescent microscopy and DNA barcoding, we found that there is over a hundredfold difference in the recruitment rate between 2016 (156 recruits m^{-2} ± 51.32 SE) and 2017 (1.1 recruits m^{-2} ± 0.99 SE) in the lagoon of Dongsha Atoll. Our results highlighted that coral bleaching has a significant impact on coral recruitment of the consecutive year and, as a consequence, reduce the resilience of coral reefs in the Dongshal Atoll.

SC-646

Competition between macro algae and the coral reefs of the Thousand Islands, Indonesia

Kyra Bestari Wicaksono, Atika Rahmah

Competitive interactions between corals and macro algae has been recorded in several waters, and it affects the community structure of coral reefs. Human activities that lead to nutrient enrichment and overfishing of algae grazers contributes to this shifting community. To determine the competitive interaction between macro algae and corals, and if the coral reef community was shifting into a macro algae state in the waters of the Thousand Islands, we recorded the occurrence and effects of the macro algae and coral interactions on different coral lifeforms. The data was collected from the southeast and northwest of Pramuka Island, and northwest of Air Island. Methods used in this research are the line intercept transect and belt transect. The northwest of Pramuka Island has the most abundant macro algae on the coral reef among all sites. The first transect is dominated by branching corals, a fast growing lifeform, whereas the second transect is dominated by algae assemblage, and gradually changing into mostly slow growing lifeforms, such as encrusting on the third transect. The lifeform that has the most interaction with macro algae is the submassive. However, the interaction is most likely that macro algae outcompeted submassive corals. We also found that the encrusting corals have more resistance and 'wins' against algae while the submassive is the opposite. Moreover, the condition of the corals at the northwest of Pramuka Island is more severe than the other two sites, which indicates the impact of sedimentation to the health of the coral reefs.

SC-709

Influences of seasonality on coral diseases in Thailand

Heru Kusdianto, Matthika Deangyeam, Dewi Embong Bulan, Nilnaj Chaitanawisuti, Naraporn Somboonna, Suchana Chavanich, Voranop Viyakarn

Incidences of diseases in corals have been linked to numerous biotic and abiotic stressors throughout global reefs. Among these are the wide-ranging impacts caused by changing global climate such as elevated sea surface temperatures (SSTs) and increased frequency of extreme weather phenomena, such as storms. The influence of rainfall and nutrient loading on coral diseases has been documented from numerous locations around the globe but such links have not been made in Thailand. Transect surveys along coral reefs at Trang (Andaman Sea) and Chonburi (Gulf of Thailand) were carried out in 2016 and 2017 during both South-West (June to September) and North-East (October to February) monsoon seasons. Both sites see increased rainfall during South-West monsoons when compared to the North-East monsoon which undergoes less precipitation. Coral diseases were documented at 5.9% (+/-1.1) and 10.1% (+/-3.5) at Chonburi and Trang respectively during the North-East monsoon, with both sites showing increased prevalence during South-West monsoon at 14.8% (+/-1.2) and 12.5% (+/-0.9) at Chonburi and Trang respectively. The most common disease observed was White Syndrome. Microbial analyses were carried out on healthy and recently diseased colonies of *Platygyra* corals in ex-situ hatchery conditions at Chonburi, immediately after the South-West monsoon period of 2015, prior to which these diseases were absent at the hatchery. Results showed a sharp increase in *Vibrio* spp. bacteria in diseased corals at 42%, making it the dominant group in the corals. Healthy corals observed dramatically reduced abundances of *Vibrio* spp. making up only 7% of bacterial density. These findings support numerous studies implicating elevated abundances of *Vibrio* spp. bacteria in coral disease incidences, and additionally suggest that *Vibrio* densities in the upper Gulf of Thailand may be influenced by post-monsoon, cooler waters where nutrient densities are also higher.

SC-712

Microplastics in corals in the upper gulf of Thailand

Niranjan Divakaran, Suchana Chavanich, Voranop Viyakarn

Microplastics account for more than 45% of all marine debris along the coast of Thailand. In this study, samples of *Symphillia spp.* were collected from Samae San island of Chonburi Province to investigate for microplastic ingestion. Samae San is in the Royal Thai Naval base but the area is heavily influenced by nearby fishing and tourism activities. Results showed a high concentration of microplastics in a single colony indicating high amounts of microplastics in the water. Results were also showed that the size of microplastics ingested ranged from 0.1mm to 1.5mm with an average of around 0.6mm. Approximately 30% of all polyps analysed had atleast one microplastic particle. These particles are embedded deep in the polyps showing possibilities that it could affect normal functioning.

SC-734

Spatial and diel variation of tintinnid ciliates in Masinloc-Oyon Bay Marine Reserve

Jane Abigail Santiago, Ma. Carmen Lagman

The present study is the first bay wide assessment of Masinloc-Oyon Bay Marine Reserve using biological and environmental parameters. Tintinnids were collected through vertical and horizontal tow during July 2017. Night- and day-time collection was conducted to verify the diel characteristic of tintinnid species. Environmental parameters (temperature, salinity, pH, DO, TDS) were measured using YSI 6600 multiparameter. The nine identified tintinnid species in this study are first records in Masinloc-Oyon Bay (MOB). The warm water species *Helicostomella longa* (Brandt, 1906) dominated the tintinnid assemblage during wet season of July (29-33°C). Tri—plots from multivariate analysis showed that stations (1, 6-7) far from Marine Protected Areas (MPAs) create a different cluster compared with the stations (2-5) within MPAs. Station 1 is inside the power plant's outfall and consistently had the lowest abundance and diversity. The power plant thermal discharge has a negative effect on abundance and diversity of tintinnids assemblage. No significant difference was observed between night and day-time abundances using horizontal tow. A significant P-value (.000, P>.05) was recorded between night and day-time abundances using vertical tow. The said initial result suggest that tintinnids deviate from the generalized diel characteristic of zooplankton community. The diel and spatial tintinnid variation in this study presented the uniqueness and diversity of MOB's marine environment. Ecological tools such a tintinnids can be used as a bio-indicator to assess the water masses and water quality of such complex site.

TBE-5

Restructuring the traditional suborders in the Order Scleractinia based on embryogenetic morphological characteristics

Nami Okubo

The order Scleractinia includes two distinct groups, which are termed 'complex' and 'robust' as indicated by the molecular phylogeny of mitochondrial 16S ribosomal gene sequences. Since this discovery, coral taxonomists have been seeking morphological characters for grouping this deep division in the order Scleractinia. Recently, morphological characteristics during embryogenesis that facilitate grouping the two clades as 'complex' and 'robust' were reported, thus clarifying a deep division in the Scleractinia. In the recent paper, I established two new suborders, Refertina and Vacatina, on the basis of the embryogenetic morphological characteristics, molecular data, and new observations of Tubastraea coccinea and Cyphastrea serailia embryogenesis. The new suborder Refertina consists of the families that belong to the 'complex' clade and have no or little blastocoel. The new suborder Vacatina is composed of the families that fall into the 'robust' clade and have an apparent blastocoel.

TBE-91

Identification of *Sarcophyton* sp. in the coastal waters of Hainan Island

Weidong Li, Peizheng Wang, Yang Zhou

According to 26 *Sarcophyton* sp. collected in the coastal waters of Hainan Island, Based on the morphological identification and molecular phylogenetic analysis, For the first time,species identification of *Sarcophyton* sp. in China from two sides of sclerites and msh1 gene. The results showed that the collected samples of 26 Sarcophyton.sp were initially identified as 5 species, Respectively: *Sarcophyton cherbonnieri* Tixier_Durivault 1958, *Sarcophyton crissum* Tixier_Durivault 1946, *Sarcophyton trocheliophorum* von Marenzeller 1886, *Sarcophyton glaucum* Quoy & Gaimard 1833 and *Sarcophyton ehrenbergi* v. Marenzeller 1886. This study provides a reference for the identification of *Sarcophyton* sp. in the coastal waters of Hainan Island, and provide data support for the research on the identification of soft corals in China

TBE-121

An assessment of net primary production and respiration in corals from Phuket, Thailand

Pathompong Pramneechote, Sutinee Sinutok, Koraon Wongkamhaeng, Ponlachart Chotikarn

Photosynthesis and metabolism of Scleractinian corals can be measured *in situ* by several types of benthic flux chamber. This study aims to investigate the net and gross primary production (NPP and GPP) of corals using budget benthic flux chamber. Respiration and oxygen-production (net primary production) of corals in reef flat and reef slope at the southeast fringing reef of Phuket Island were measured using 12x20 inch dark and light chambers, respectively. Dissolved oxygen concentration in chambers were estimated during *in situ*incubations hourly from 11.00 a.m. to 14.00 p.m. Average gross primary production (GPP) in reef slope was 18.26 (±3.06), 17.19 (±2.89) and 21.91 (±3.00) μmol O_2/l/h in June, July and August, respectively. GPP in reef flat was 25.17 (±6.35), 19.39 (±2.23) and 32.90 (±10.22) μmol O_2/l/h in June, July and August respectively. Average GPP of reef flat was higher than average GPP of reef slope at all months. The highest GPP was in August both reef flat and reef slope due to different physical characteristics such as depth, light intensity, weather and different biological characteristics such as percent of live coral cover, number of microalgae and symbiont density. This study suggested that primary production was mainly driven by number of organisms, light availability and depth

TBE-128

Preliminary identification of *Aldersladum* sp. in the South China Sea

Peizheng Wang

Most of the soft corals belong to the soft coral family. The description of their morphological with subtle differences is still difficult and the classification and identification of most soft corals is identified by the feature of the bone slices. In this study, a soft coral collected from the South China Sea was identified basing on Msh1 sequence which will provide references for studying the soft coral in South China Sea. The soft coral has 8 long tentacles like open umbrella of which color are brown. The body of this soft coral has a distinct column base with height up to 10 cm. According to sequencing data of the soft coral MSH1, this soft coral is the most similar to the species of *Aldersladum jengi voucher* which belong to Alcyonidae. The result of the phylogenetic tree shown that soft coral with evolution distance from the near to the distant with this soft coral were alcyonium, Xenia, pieterfaurea, dendronephthya and Sinularia, elbeenus, Paralemnalia, saroophyton. Clavularia is more far related from the other soft corals. Eleutherobia, plumigorgia, gyrophyllum and sclerobelemnon and distichoptilum were grouped into one group, which had the most distant relationship with other soft corals in this study. These results indicated that the msh1 gene can be used as a taxonomic marker for studying the evolutionary relationships of soft coral.

TBE-321

The Coral Book Project: a user-friendly guide to coral taxonomic in Southeast Asia

Chialing Fong, Jia-Ho Shiu, Yoko Nozawa, Takuma Mezaki, Hironobu Fukami

Both 'Staghorn Corals of the World" (Wallace, 1999) and 'Corals of the World' (Veron, 2000) are two global references of coral taxonomy. Virtually all coral researchers have been relying on these books, in particular, for coral species identification. However, these taxonomic books have some inherent difficulties to use as field guides. Firstly, Veron (2000) includes too many species to select for identification and information for similar species is often ambiguous. Wallace (1999) limits the amount of live images and the descriptions are too scientific and detailed. Secondly, these books are nearing two-decades old and cannot cope with recent and drastic changes in coral systematics, applied at family and genus levels. Thirdly, a localized taxonomic guide is more useful than a global taxonomic book that includes many species, some of which do not exist in Southeast Asia. These problems in taxonomic books have been creating problems in coral species identification, and have created certain barriers to study coral taxonomy. Here, we attempt to create a user-friendly guide to coral taxonomy in Southeast Asia. As a first step, we will create a field guide for Taiwan based on a list of > 200 dominant species, obtained from surveys in Lyudao from 2013 to 2017. The field guide has the following features: (1) the most update and minimal of descriptions, (2) simple English, (3) an abundance of live coral images taken locally, (4) clear identification and information for similar species, and (5) PDF format available and free to download on the internet. The Taiwanese version could be used as a basis for various locations by adding or subtracting species. We are looking forward to collaborating with other groups to create other local versions across Southeast Asia. Download here: http://www.biodiv.tw/index.php/en/research/publish-books/the-field-guide-to-common-stony-corals-of-lyudao-taiwan

TBE-688

Factors affecting the cover of soft corals in Bolinao, Pangasinan, Philippines

Jue Alef Avanzado Lalas, Ma. Czarmayne Victoria Jude Tejada Escoro, Janine Bobadilla, Melchor R Jacinto, Maria Vanessa Baria-Rodriguez

Soft corals are known to be significant components of coral reef communities. They are well- known for natural products and are increasingly being considered as a major source of new therapeutics. Most of the studies on its distribution were done some parts of Asia Pacific. While the Philippines is known as the center of marine biodiversity, information on soft coral distribution, biology and ecology is largely unknown. Knowledge on their distribution is important since some soft coral species are known to be competitors of other benthic organisms such as hard corals and macroalgae. Soft corals might also have the potential to be indicators of environmental changes. This study was conducted to determine soft coral distribution in selected reef sites in Bolinao, Pangasinan, northwestern Philippines. Three sites were selected based on its proximity to a mariculture area; Trenchera (nearest), Lucero and Malilnep (farthest). Covers of soft corals were assessed using the photo-quadrat method. Water samples were collected and measured for physico-chemical properties such as nutrient levels (NH_4, NO_2, PO_4, and SiO_4), carbonate chemistry (temperature, salinity, pH, pCO_2, total alkalinity, dissolved inorganic carbon and aragonite saturation state), and total suspended solids. Results show that Malilnep had the highest soft coral cover among the sites (One-way ANOVA, $p<0.05$). Among the parameters measured, nitrite levels were significantly different among sites, Trenchera having the highest (One-way ANOVA, $p<0.05$). Preliminary results suggest that soft coral cover decreases from high to low nutrient reefs. Further analysis on species distribution at the genus level will be done. In addition, wave exposure of the study sites will be measured.

TBE-711

Cryopreservation of sperm from the coral *Acropora humilis*

Voranop Viyakarn, Suchana Chavanich, Gabriella Chong, Sujune Tsai, Chiahsin Lin

Corals are sensitive to minute changes in their environments, and their continued existence is substantially threatened by the increasing number of destructive anthropogenic activities and unprecedented rates of climate change. Although cryopreservation has been successfully to preserve mammalian gametes for decades, coral cryopreservation was attempted for the first time less than 15 years ago, and freezing protocols exist for only a handful of coral species. The present study developed a cryopreservation protocol for the sperm of the common Indo-Pacific reef-builder *Acropora humilis*. Colonies of reefs of Sattahip Bay, Chonburi Province, Thailand were collected from 3 m depth with a mesh net during a spawning event. Immediately after collection, the sperm were isolated and subjected to a two-step freezing method featuring DMSO, polyethylene glycol, or methanol as the cryoprotectant. Viability and motility were assessed via a bioluminescence technique and a "computer-assisted semen analysis, and it was found that a 15-min equilibration with 2 M DMSO followed by cooling at 41.7°C was the optimum cryopreservation protocol for *A. humilis* sperm. The post-thaw sperm achieved 45% fertilization success, and 35% of the fertilized eggs developed into blastopore larvae. The present optimized protocol can therefore facilitate the preservation of sperm for future propagation efforts of this species and provide an experimental platform for optimizing cryopreservation protocols for gametes of other scleractinian coral species.

TBE-756

Species identification, distribution and ecological role of black corals (Antipatharia: Anthozoa: Cnidaria) from the selected sites of Bohol and Cebu, Central Philippines

Hyacinth N. Suarez, Jeremy Horowitz, Renante Violanda, Danilo T. Dy

Antipatharians are colonial anthozoans characterized by small polyps with six tentacles. They have a spiny and organic skeleton that is brown or black in color, hence, black corals. Ecologically, they can host associated fauna, contributing to the three-dimensionality of the coral reefs. This study identified the species of black corals found in Jagna and Anda, Bohol and Moalboal, Cebu using morphological techniques. Furthermore, it described the distribution pattern, occurrence and ecological role of black corals in terms of their capacity to host associated macrofauna.

There were 13 species of black corals identified belonging to three (3) families and five (5) genera. However, one (1) whip black coral cannot be identified even at the genus level. Seven (7) of these species were described for the first time in the Philippines. Anda and Jagna, Bohol have the most number of species common to both places and shares the least with Moalboal. Also, depth regardless of site is an important parameter that could explain the spatial distribution of these black corals. The bathymetric distribution in this study demonstrated a highest occurrence and number of species at depth between 20-30 m, extending towards the deeper portion, dominated mostly by *Antipathes spp.*

In Jagna, Bohol, the black coral assemblage support biodiversity at depths between 20-40m. We found that among the surveyed black coral species, 68% hosted associated macrofauna. All the branching types tend to be a favorable habitat for this macrofauna. While 100% of the branching types have associated macrofauna, the whip type may support a higher macrofauna density per unit area. The increase in species richness of black corals with depth implies that these corals are an important functional group in areas no longer inhabited by scleractinian corals. Our results contribute an important consideration in coastal management planning as most marine protected areas are mostly concentrated in shallow depths inhabited only by stony corals.

TBE-769

Revealing coral symbiont productivity and nutrient translocation by δ13C and δ15N tracer labelling experiment

Arthur Ching, Inga Conti-Jerpe, Taihun Kim, David M Baker

By hosting *Symbiodinium* dinoflagellates, the mutualistic association provides scleractinian corals with photosynthetically derived nutrients, allowing the coral host to survive in oligotrophic environments. Such autotrophic nutritional pathways have been studied within certain coral species, yet relatively less researches has compared the extent of autotrophy in different species. Here, a 13C and 15N inorganic tracer labelling experiment with 6 different coral species (*Acropora digitifera, Goniopora columna, Pavona decussata, Porites lobata, Platygyra sinensis, and Oulastrea crispata*) incubated in light and dark bottles of enriched seawater was carried out to compare their relative enrichment. Generally, δ15N in both host and symbiont fractions showed higher dissimilarity than δ13C among different species. Nitrate assimilation in the dark treatment was also observed, showing there was a light-independent mechanism for nitrate uptake. The results suggested that nitrogen dynamics between coral host and symbiont varies in different coral species. To further investigate the host-symbiont nutritional partitioning relationship among coral species, a follow up one week 13C and 15N inorganic pulse-chase tracer labelling experiment that recorded 13C and 15N fluctuation was also conducted to reveal the nutritional interaction dynamic overtime in several coral species.

TBO-78

Caught in action: The rabbitfish *Siganus guttatus* (Bloch, 1787) feeding selectively on seagrass in a tropical seagrass meadow

Nina Ann Jin Ho, Yang Amri Affendi, Jillian Lean-Sim Ooi, Ving Ching Chong

Coral reef fishes are known to utilise adjacent seagrass meadow for food. This study documented the herbivorous behaviour of Rabbitfish (f: Siganidae) on seagrass adjacent to coral reefs at Pulau Babi Besar, Johor, Malaysia. Exclusion cages ($1m^3$ with 15mm mesh size) were deployed in the seagrass meadow for three months (April to June 2014). This allowed the seagrass to grow in the absence of grazing. Underwater video cameras were set up to document grazer behaviour immediately after the exclusion cages were removed. Within 12 minutes after cage removal, a school of five adult *Siganus guttatus* from the adjacent coral reefs arrived and started to graze on the seagrass actively. In the end, grazing had removed 80% *H. ovalis*, 60% *H. uninervis* and 10% *C. serrulata* from their initial abundance. Furthermore, the school appeared to target *H. ovalis* first before moving on to the other species. This finding is interesting as it appears that rabbitfish prefer certain seagrass species, with *H. ovalis* being the favourite. This is perhaps the first in-situ video evidence of rabbitfish selectively feeding on seagrass species.

TBO-290

Sea urchins (*Diadema* spp.) facilitate coral recovery in Taiwan

Yoko Nozawa, Che-Hung Lin, Pei-Jie Meng

The long-term trend of coral decline has become a global problem. Theories indicate that two anthropogenic disturbances, overfishing and eutrophication in coastal waters created algal dominated environment hindering coral recovery via recruitment after repeated mortality events (e.g. coral bleaching). In order to understand the situation in Taiwan, we examined the quantitative relationship of three key functional groups (herbivores, algae, corals) at three coral reefs (Kenting, Lanyu, Lyuado) in 2012–2015. Results highlighted strikingly low densities of both herbivorous fishes and gastropods at the coral reefs, suggesting their loss of function as herbivores in Taiwan. Instead, remnant sea urchins, *Diadema* spp. now became the dominant herbivore in the coral reefs, enhancing coral juvenile density and hence coral resilience. Indeed, higher coral recovery was observed at study sites with higher *Diadema* densities. No correlation was seen between macro-algae and coral juvenile density, suggesting that it would be not macro-algae but small algae (turf algae) that negatively affect coral resilience in the Taiwanese coral reefs. Because overfishing and eutrophication are common problems, the situation would be similar in many coral reefs in Southeast Asia. Given the dominancy and impact of *Diadema* spp., the *Diadema* herbivory should be proactively incorporated into management planning of coral reefs in our region.

TBO-297

Reproduction-temperature nexus influencing spawning of pectinids in tropical and temperate countries

Christian De Sagun Cabiles, Victor Salcedo Soliman

This paper aims to summarize the current state of knowledge on key environmental factors in the marine environment influencing reproduction in Pectinidae in marine waters. Sixteen relevant published studies were examined as the source of secondary information wherein 62% of which are in temperate waters and 38% are in tropical waters. Spawning of scallops from tropical and temperate environments were reportedly affected by and correlated to mostly variations in water temperature, the most influential factor identified to naturally activate spawning. In temperate waters, about 90% of the spawning of different species occurs during warm months or when highest temperature was recorded (summer), while only 10% of the temperate species reproduce during fall when water temperature was cold. Similarly in tropical waters, 67% of the spawning activities of scallops occur during warm months with few species spawning during cold months. The transition or shift from cold temperature to warm temperature seemingly served as "trigger" to spawning. A strategy to maximize collection of scallop spats for stock enhancement or growth-out mariculture should consider the warm months such as summer in the Philippines when economic activities during this period are afforded with many advantages.

TBO-466

A new genus and two new combination of sea cucumber from Australia (Holothuroidea: Stichopodidae)

Sau Pinn Woo

A new genus, Notostichopus, from Australia is described along with its phylogenetic relationship within the family Stichopodidae based on two species of sea cucumbers previously described under Stichopus. Notostichopus is characterized by the absence of rosette ossicle and table ossicles that have at most one crossbeam in the dorsal body. This genus is represented by two species revised here (*N. ludwigi* and *N. ellipes*), distributed in the shallow, subtropical and temperate waters of Australia. *Notostichopus ludwigi* is from southeast Australia and examination of material from near the type locality confirmed that it distinct from Stichopus. The type locality of *N. ellipes* is subtropical northwestern Australia. As material from the type locality of this species was not available, it remains possibility that the material examined here for this nominal taxon from temperate eastern Australia, are from an undescribed Notostichopus species. Phylogenetic and genetic distance analyses indicated that this genus is closely related to the genera Isostichopus and Stichopus but constitutes a separate genus based on ossicle morphology and phylogenetic analyses.

TBO-567

Colony decision making of three-stripe damselfish (*Dascyllus aruanus*) populations towards presence of intruders

Max Angelo Tubilan Echevarria, Cleto L Nanola Jr.

The presence of intruders disrupts an individual's activities, such as foraging and mating, to defend itself. Responding to intruders in a threat-sensitive manner allows an organism to limit the fitness trade-off that this event causes. The study aimed to identify avoidance behaviors of three-stripe damselfish (*Dascyllus aruanus*) against the presence of intruders and the factors that affect it. In situ, an underwater camera setup was used to capture and measure *D. aruanus* responses when exposed to several treatments in the form of a small and large individual from three different species, namely the Greenblotched Parrotfish (*Scarus quoyi*), Duskytail Grouper (*Epinephelus bleekeri*), and Longrakered Trevally (*Ulua mentalis*), categorized as a non-predator, ambush predator, and chasing predator, respectively. The *D. aruanus* colony responded consistently to the treatments at a distance of 0.5 to 1 meter from the refuge and all treatments were significantly different from the control. Stronger responses were elicited when presented with a predator than a non-predator species. The size of the predator in relation to its foraging tactics may also be discernible by *D. aruanus* as observed in its weaker response to a large grouper approaching the territory. The ability of *D. aruanus* to discern between intruder species was previously known but this adaptive flexibility of its responses to has not been observed. The size of *D. aruanus* did not play a significant role in an individual's response as quorum-like decision making was utilized by this social species. The ability of the species to ascertain intruder characteristics based on visual cues such as size and coloration coupled with the social decision making in species colonies has allowed *D. aruanus* to become threat-sensitive throughout its lifetime.

TBO-610

Influence of herbivore biomass and soaking period on the density of coral recruits between caged and uncaged tiles

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One of the most prominent indicators of a healthy coral reef is the relatively high number of coral recruits. This is influenced by the presence of grazing herbivores, which halt algal domination and consequently promote coral reef resiliency. In this study, the impact of herbivorous reef fishes to the density of coral recruitment was determined using caged and uncaged tile experiments set in shallow and deep waters of Tamisan MPA and Catmunan reef in Pujada Bay, Philippines. Results of the t-test had shown that the algal cover between the caged and uncaged tile experiments in the 4-month soaking period was statistically significant in two sites (Tamisan: $P<0.0001$; Catmunan: $P<0.0001$) but not during the 8-month soaking period (Tamisan: $P=0.1506$; Catmunan: $P=0.5555$). Furthermore, the relationship between algal cover and coral recruitment was statistically correlated in both sites only for the 4-month soaking period. This spatio-temporal variation indicates that algal type over 4-month soaking period is palatable to herbivores, which resulted to a high number of coral recruits represented by a total of 13 coral genera in both sites. Moreover, the genera having the highest density of coral recruits were *Acropora* and *Porites*. The average herbivore biomass over the entire duration of the experiment was 17.5 g/m^2 for Tamisan and only 3.23 g/m^2 for Catmunan. The latter value was too low to qualify for a reef to be resilient (>10 g/m^2). Our findings suggest that there are other types of herbivores that can significantly contribute to reef resiliency aside from reef fishes.

TBO-732

Assess the influence of a coral-killing sponge, *Terpios hoshinota*, on coral reef fish assemblages

Yu-De Pei, Colin KC Wen

Coral reef ecosystems are affected by wide-range of disturbances, leading to coral loss, habitat change and consequent alteration in coral reef fish assemblages, and decline in the abundance and diversity of some coral reef fishes could undermine the ecosystem function provided by them. A coral-killing sponge, *Terpios hoshinota*, has recently been recognized as a threat to coral reefs due to its abilities to demise corals through toxicity and rapid overgrowth, as well as occasionally massive outbreaks being reported across the Indo-Pacific Ocean that over eighty present of hard substrate has been infested in the extreme cases. So far, interactions between *T. hoshinota* and corals have been discussed in abundant literature; however, none of them have reached the scope of influences of the sponge on reef fishes, in which a massive outbreak of *T. hoshinota* could potentially change the assemblages of coral reef fish over time. To test our speculation, in this study, we compared fish assemblages associated with corals with different growth forms (i.e. submassive and encrusting) under four habitats (i.e. live, dead, and sponge-covered corals). Furthermore, we classified fishes into three functional groups (i.e. transient, residential and cryptic) according to the association of fishes with object corals. Currently, we mainly focus on small patches of sponge due to the less availability of large patches, and our preliminary results show that there are no significant differences in fish assemblages between two growth forms and among different habitats. Though there is a significant difference among functional groups, but the fish assemblages are statistically alike when tested with other factors. Based on our current results, we can yet draw any conclusions; further efforts will be focused on functional approaches to evaluate the influence of sponge on fish assemblages.

TBO-770

Temporal and spatial changes in species abundance and composition of corals and fishes in the Bunaken National Park, North Sulawesi

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Coral reefs represent a major hotspot of marine biodiversity. They are considered to be endangered due to complex factors on local as well as global scales. However, there is a paucity of empirical data for evaluating various kinds of impacts particularly in South-East Asian reef ecosystems. Here, we present a preliminary report of our surveys from the Bunaken National Park in North Sulawesi, the reefs of which have been exposed to serious damages and critically degraded over the recent decade despite its national park status. In general, species richness and abundance tended to decrease while species composition underwent changes. Patterns of change in abundance were variable depending on morphological types of corals and taxa of fish, and also among sites. Outbreaks of *Acanthaster planci* and physical damages due to increased tourism are major local perturbations in this area, which may mask the direct effect of global environmental changes. It is urgent that effective local policies be implemented for the protection and management of coral reef ecosystems in the region.

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