Dr. Juying Wang presenting the effects of marine litter to different species worldwide.

Parallel Event 3

Addressing the Challenges of Marine Litter and Microplastics in the YSLME

The parallel event on marine litter and microplastics was held in Qingdao City of PR China on 18-19 July of 2019, co-organized by YSLME PMO in collaboration with NMEMC of PR China and KIOST of RO Korea.

The objectives of the session are to:

- Appreciate the methodologies in monitoring and analyzing marine litter (including micro-plastics) in the marine environment of the Yellow Sea;
- Understand the sources and distribution;
- Identify solutions and good management practices to management challenges; and
- Engage local governments and the public to take actions and remediation measures.

Mr. Zhengguang ZHU, Environment Officer from YSLME PMO gave the congratulatory speech. He warmly welcomed all the participants and briefly introduced the schedule of the meeting. Dr. Juying WANG from NMEMC of Ministry of Ecology and Environment, PR China, as the moderator, shared a brief story about YSLME and expressed her enthusiasm and expectations for the organization.

DAY 1

Under **Session 1**, speakers mainly talked about monitoring and analyzing methodology of marine litter in the marine environment of Yellow Sea.

The session was opened by a keynote address by Mr. Won Joon Shim from Korea Institute of Ocean Science and Technology (KIOST). Mr. Shim introduced the weathering and fragmentation process of plastics from macro to micro-plastics. Citing various environmental samples, microplastics have been found from river,

Dr. Juying Wang of NMEMC/MEE, PR China.

Mr. Won Joon Shim of KIOST, RO Korea.

Mr. Juyong Park of KOEM, RO Korea.

water, air, seawater, STP effluent and biota. He explained how macro-plastics convert into micro-plastics, a process which goes through diverse routes and cannot be seen by naked eyes. In a study conducted by his team, it was found that a month's sunlight exposure is enough to produce nano- and micro-sized particles. Rapid fragmentation occurs on surface of plastics exposed to sunlight and from which large amounts of nano-sized particles are produced but mass contribution was considered negligible compared to micro-sized particles. Their team will be conducting further studies to test the weathering of other common polymers, rate of fragmentation on water surface, etc.

The second keynote speaker, Dr. Juying WANG, cited several literatures or study which indicated the increasing proportion of solid waste in coasts and oceans ever since the large-scale production of plastics began in 1950s. Based on UNEP (2016), solid wastes both from land-based and sea-based sources represent up to 80 percent of marine litter found in surveys. She mentioned the impacts of macro-plastics and micro-plastics in three aspects: economical, physical and chemical. However, Dr. Wang emphasized that lack of standardized protocols greatly hampers data comparison across studies from specific regions, risk assessment of ecological and human health impacts, and the development of appropriate management and mitigation policies. Current governance strategies and approaches are still fragmented in approach and do not adequately address marine litter and microplastics. She believes that holistic approaches are needed to address the multifaceted, widespread and complex nature of this issue.

Session 2

Mr. Jong-Joo YOON, RO Korea, moderated Session 2 focusing on The Source and Distribution of Marine litter in Yellow Sea.

Mr. Juyong PARK, KOEM, RO Korea, introduced the status of marine litter in Korea and initiatives being undertaken to address the issue. 176,000 tons of marine litter is generated every year in RO Korea, 67 percent of this comes from land-based sources, while 33 percent is sea-based. In the YS area, the National Marine Litter Monitoring in RO Korea found that 77 percent of marine litter came from plastics and styrofoam. From 2012-2018, total of about USD 46 million has been expended on removal of marine litter by RO Korea. From 2009-2013, the 1st National Marine Litter Management Plan was implemented followed by the 2nd Plan covering 2014-2018. Building on this the 3rd Plan 2019-2023 is now in place, which aims to strengthen marine debris management at each stage and switch to a scientific and prevention-oriented management plan. As part of future actions, new laws are being developed in RO Korea: Marine Waste Management Act, and Fishing Gear Management Act.

Mr. Maowei JU from NMEMC, PR China, presented the status of marine litter in YSLME including the consolidated baseline report supported by YSLME project. Based on global plastic production data, China is currently the largest producer of plastic followed by Europe. To address this concern, since 2007, the then State Oceanic Administration of China carried out the National Marine Litter Monitoring Programme, in 50 survey locations were along coastal areas, whereby 11 are located at Yellow Sea. In 2016, Marine Microplastic Monitoring Programme was launched and monitored in 17 stations in the YS the same year the Guidelines for Marine Microplastics was also released. Although China was considered a hotspot of plastic debris pollution, based on data collected and compared with other published reports, microplastic density in the Yellow Sea was found to be in the lower-middle level.


Mr. Maowei JU of NMEMC, PR China.


Ms. Liping You of Shandong Marine Resource and Environment Research Institute, PR China.

Ms. Liping YOU from Shandong Marine Resource and Environment Research Institute, PR China, introduced the status and current regulatory measures of Weihai Litter management. As part of its regulatory measures, Weihai established a coordinating body supported by technical working groups to address marine litter. Two key regulations are being implemented the Regulation on the Protection of Urban Features and Regulations on the Protection of Coastal Zones. Weihai is implementing a number of activities involving the public as part of its marine litter prevention and control initiative. Weihai became the first national demonstration area of marine ecological civilization, and even established a sister-city partnership with New York, USA. But addressing marine litter problem requires continuing efforts and as scuh Weihai intends to further strengthen the implementation of its marine litter prevention and control program, invest more on science and technology, established stronger collaboration, further improve marine litter monitoring and evaluation system, and further enhance publicity and educational campaigns on marine litter management.


Ms. Sang Hee Hong of KIOST, RO Korea.


Ms. Xiaoxia Sun of Chinese Academy of Science, PR China.

Session 3

Mr. Maowei JU from NMEMC of PR China, moderated session 3 of Special session on Microplastics in YS.

Ms. Sang Hee Hong, from KIOST, RO Korea presented on the historical and vertical distribution of micro-plastics in costal and shelf waters from YS of ROK. Their study showed the following: (a) relatively high microplastic contamination level was found in Korean coastal and shelf waters; (b) the positive correlation between microplastic abundance in coastal water and surrounding population indicates input of microplastics from the land-based sources; (c) Although the levels are lower than the surface water, sub-surface water contained considerable levels of microplastics including low-density polymer (e.g. PE and PP). Ms. Hong indicated that further study is required to evaluate relative contribution of various biological interactions for the downward movement of microplastics.

Ms. Xiaoxia SUN from the Institute of Oceanology of Chinese Academy of Science introduced micro-plastics in seawater and indicated the distribution of micro-plastic being discharged into seawater and ingested by zooplankton and fish. Studies have proven that ingestion of microplastics by zooplankton is the fundamental link for microplastics in entering the food web. As such studies on this is important so as to evaluate the potential risk of microplastics to humans. In the studies conducted, it was found that the risks of micro-plastics in the north and south part of the YS is higher than the middle part and


Mr. Jong-Joo Yoon of ChungNam Institute, RO Korea.


Mr. Feng Xiao of Rendu, PR China.

the concentration of the MPs is not high indicating that the ecologically relevant concentration and characteristics should be considered for further controlled experiments and risk assessment.

DAY 2

Session 4

The morning session was moderated by Dr. Ning LIU, NOWPAP of UNEP.

Mr. Jong-Joo YOON from ChungNam Institute, RO Korea presented on status and programs to mitigate marine litter in Chungnan Province in RO Korea. He first talked about the trends of marine litter issues and its accompanying damage. He introduced the marine litter monitoring system in ChungNam which is carried out bimonthly covering 60 survey points every 10 kilometers. In 2016, comprehensive management measures for marine litter were established in Chungnam with 60 detailed action policies. The province's integrated improvement measures also included four main plans divided into coastal litter, fishery litter, deposited litter, and island-left litter. Each year more and more projects are being introduced and in 2018 a total of KRW 18.8 billion was invested in 43 projects. To date, the amount of marine litter collection in Chungnam accounts for 17 percent of the nation's collection and has the third largest local government portion in RO Korea.

The second speaker is Mr. Feng XIAO from Rendu, currently the only nonprofit organization in China focusing on marine debris issue. The Shanghai Rendu Ocean NPO Development Center is focusing on 4 key areas: coastal cleanup; environmental education, monitoring and research, and network building. In 2014, the Coastal Cleanup and Monitoring Project (CCMC) and network was launched. On the assessment of fishery-based marine litter in Yellow Sea, Mr. XIAO indicated that monitoring sites were established in 4 cities (Dalian, Yantai, Qingdao and Lianyuangang). Based on their experience the group further revised the data card used to collect fishing gear data in more detail. Monitoring method was also further modified to ensure better data quality. From May to late September 2019, the group will carry out 24 monitoring activities at 8 sites. Results of the monitoring reports will be reviewed by OSEAN and will be finalized by November 2019.

Ms. Zhenzhen LI from the BlueRibbon Conservation Association, shared the work of BROCA in establishing an ocean conservation network in China that is aimed at promoting ocean education, awareness, clean-up and coastal ecosystem conservation. Ms. Li cited the different


Ms. Zhenzhen Li of BlueRibbon Conservation Association.


Ms. Liwen Chen of Zero Waste Villages, PR China.

Dr. Ning Liu of NOWPAP, UNEP.

Mr. Maruf of Xiamen University, PR China.

the different accomplishments and outputs of the group under its 5 key program areas: (1) Blue Data; (2) Call for Blue Ocean; (3) Blue Forces; (4) Blue Volunteers; and (5) Blue Dialogue.

Ms. Liwen CHEN, from Zero Waste Villages, PR China started off with her personal story and realizations about waste in China. She highlighted the pollution caused by open-dump, landfill and incineration, the accompanying economic costs of burning wastes (i.e., over 1,000 RMB per ton), and environmental costs (i.e., mercury emission, dioxin, etc.). In 2015, the Waste Management Department issued a Guide to rural waste management, and a three-year planning for improving living environment in the countryside was issued in 2017. In Dongyang, Jiangxi province, for instance, over 90 percent of organic waste goes to composting, farmers get the organic fertilizer for farming, and over 90 percent of families have been observed to have undergone behavioral change. In promoting zero waste, the group promoted door-to-door communication changing behavior towards waste management one family at a time, while township and county government help with inspection. Results of waste separation were also published in the villages. The group believes that engaging stakeholders in the initiative is the key.

Session 5

The session 5 of Synergizing actions of responses to marine litter and micro-plastics through cooperation at regional level was moderated by Mr. Zhengguang ZHU, Environment Officer of YSLME.

Mr. Ning LIU from NOWPAP introduced the NOWPAP Regional Action Plan on Marine Litter and NOWPAP's mechanism. He highlighted the different outputs/ accomplishments made by the different NOWPAP regional activity centres under the three key elements of the Regional Action Plan: (a) prevention of marine litter input; (b) monitoring quantities and distribution of marine litter; and (c) removal of existing marine litter. In 2007 and 2011, NOWPAP published the 1st and 2nd Regional Overview on Marine Litter in the NOWPAP region. By end of 2019 the 3rd Regional Review on Marine Litter will be published. Apart from these reviews, NOWPAP also continues to organize International Coastal Clean-up campaigns in Korea, China, Japan and Russia. In September 2019, NOWPAP will undertake a Joint NOWPAP-Tripartite Environment Ministers Meeting Workshop on Marine Litter Management, and a Second Experts Group Meeting on NOWPAP's special project on "Monitoring and Assessment Methods for Microplastics Pollution".

Mr. Maruf from Xiamen University, PR China, discussed national policies and management of marine litter in Southeast Asian countries. While each of the countries in Southeast Asia have started to put in place policies to help manage marine plastic litter, existing regional cooperation still needs to be further strengthened. Mr. Maruf believes that the platform provided by China's 21st Century Maritime Silk Road (MSR) with a vision of strengthening maritime cooperation may be an option to address marine environmental problems in the region, particularly transboundary pollution.

The last speaker is Mr. Zhengguang ZHU, who introduced the ways of building a sustainable platform for innovation and learning across cities in YSLME through establishing a city alliance.

Parallel Event 4

Nutrient Management in YSLME

The Parallel Event 4 on Nutrient Management in YSLME was conducted from July 18-19, 2019. The event looked into several studies conducted in PR China and RO Korea regarding the status of nutrient inputs from selected river basins, atmosphere-based and sea-based sources, as well as progress made in nutrient reduction in the Yellow Sea. Based on the information and data available, the session also discussed possible opportunities to further strengthen policy developments and regional cooperation in improving nutrient reduction.

On behalf of PR China, the session was opened by Mr. Ziwei Yao, NMEMC, PR China, who shared a short background about NMEMC, particularly its roles in monitoring the Bohai Sea, developing technical standards for marine environment and publication of annual reports on marine environmental quality. NMEMC has been supportive of the YSLME initiative related to nutrient reduction since its first phase. Mr. Yao hoped that this event would contribute to better understanding root causes and distribution of nutrients, as well as find ways to better manage reduction of nutrient load in the Yellow Sea region.

On behalf of RO Korea, Mr. Chang Hee Lee from Myongji University, RO Korea, delivered the opening address. Mr. Lee indicated that Yellow Sea is one of the most exploited seas in the world, and has often experienced harmful algal blooms: red tide, green tide and golden tide. Furthermore, increasing population also contributed significantly to increase nutrient enrichment in coastal areas. As such, nutrient control practices need to be put in place. Under the YSLME project and with the YSLME Strategic Action Program's (SAP) target to reduce nutrient loading from land-, ocean-, and atmosphere-based sources, there are good opportunities for regional cooperation in this aspect.

Keynote Address

Setting the tone of discussions were two keynote presentations, with Mr. Joong Ki Choi moderating the session.

Mr. Ziwei Yao of NMEMC, PR China.

Ms. Milcah Ndegwa, Associate Programme Management Officer, UNEP, Nairobi, Kenya, delivered the first keynote on GPA/Global Partnership on Nutrient Management (GPNM), progress and prospects. According to Ms. Ndegwa, the accelerated use of nitrogen and phosphorus is becoming one of the key issue areas that provide both development benefits and environmental problems. There are two major projects on nutrients management: (1) the Global foundations for reducing nutrient enrichment and oxygen depletion from land-based pollution in support of Global Nutrient Cycle (GNC) which was implemented from 2012 to 2019; and (2) the ongoing International Nitrogen Management (INMS) project. Under the GNC project, a GPNM policy toolbox was developed and related trainings were conducted. Ecosystem health development report cards were also published (i.e., Chilika Lake; Laguna de Bay). These initiatives are contributing to achieving UN SDG 14.1 which aims to significantly reduce marine

Ms. Milcah Ndegwa of UNEP, Kenya.

Dr. Ning Liu of NOWPAP.

Dr. Chang Hee Lee of Myong-Ji University, RO Korea.

pollution of all kinds, in particular from land-based activities by 2025. In March 2019, the United Nations 4th Assembly (UNEA4) adopted the *Sustainable Nitrogen Management Resolution* which called for improved coordination of policies across the global nitrogen cycle at the national, regional and global levels; improved management of the global nitrogen cycle, through the sharing of assessment methodologies, best practices and emerging technologies for recovery and recycling of nitrogen; coordinated management of information to facilitate decision-making particularly around the quantification of health; and economic benefits and contributing to capacity building. The INMS Project will implement a substantial part of this resolution by developing evidence based effective practices for global nitrogen management.

In line with Ms. Ndegwa's keynote, Dr. Ning Liu of NOWPAP shared a brief information on the NOWPAP Eutrophication Assessment Tool (NEAT) which uses a satellite imagery technique for timely detection of potential dead zones in the sea.

The second keynote was delivered by Dr. Chang Hee Lee, President of the Korean Society of Water Environment and Head of the Department of Environmental Engineering and Energy, Myongji University, RO Korea. His presentation focused on mitigation of chemical oxygen demand (COD) and total phosphorus (TP) by implementing Total Pollutant Load Management System (TPLMS) in the Shiwa coastal reservoir (SCR). The first-phase TPLMS action plan was implemented in 2013 to accomplish the interim water quality targets by 2018. Maximum daily loads were allocated to four municipalities within the SCR watershed. The load reduction measures included traditional point source measures as well as diverse nonpoint source control measures (i.e., construction of nonpoint source (NPS) treatment facilities, road sweeping, wetland improvement, and dredging contaminated sediments). While these measures were implemented timely and considered successful, the scheduled development projects experienced some delays because of recent economic setback. The 2nd phase of TPLMS is seen to be more challenging due to additional water quality targets that were set in the inner area where tidal mixing is limited, and load reduction measures for NPS are also seen as inefficient due to high cost and low reduction amount.

During the discussion, Mr. Lee further underscored the need to establish a national coordination mechanism which will involve coordination with relevant ministries on nutrient management, to effectively implement the plan that was developed by the Ministry of Oceans and Fisheries (MOF) of RO Korea. He further emphasized that putting up treatment facilities require tremendous investment, currently two facilities have been established, but none yet for NPS.

As for NOWPAP, Dr. Liu indicated that most of their efforts are focusing on scientific research and through the help of partner governments, they hope to bridge the gap between science and policies.

Ms. Ndegwa further clarified that UNEP was given the mandate to implement the UNEA4 resolution, and as such linkages will be made in the GNC and INMS projects, but INMS project will be on a larger scale.

Session 1

The first session focused on status of nutrients inputs from land-, atmosphere- and sea-based sources. The session was moderated by Mr. Ziwei Yao.

Mr. Lijun Wang of NMEMC, PR China.

Mr. Hong Lae Cho of HydroCore Ltd., RO Korea

Mr. Lijun Wang, from the National Marine Environmental Monitoring Center (NMEMC), Ministry of Ecology and Environment, PR China, shared the study on land-based nutrient loadings in Haizhou Bay, Jiangsu Province. For the nutrient production and discharge estimation, a series of data was collected, including the information of the river network, the data of DEM, land use, river water flow, amount and type of livestock farming, urban and rural population, industry wastewater discharge, fertilizer use, etc. ArcGIS software was employed for export coefficient model building. The result showed that Linhong River is the major nutrient pollutant source to Haizhou Bay. Mr. Wang underscored that while the contribution of pollution sources showed an almost equal/ identical TN and TP loading, the potential loading from fertilizer use should not be ignored, especially in the wet year or flood season, when nutrient loading may dramatically increase.

Mr. Hong Lae Cho, CEO of HydroCore Ltd, RO Korea, shared their study on watershed modeling and nutrient loadings in Han River, RO Korea. Mr. Cho emphasized the importance of understanding the spatio-temporal distributions of pollution loads in order to effectively reduce pollution loads in the Yellow Sea. Focusing on Han River watershed which accounts for 34.3 percent of total area of RO Korea.

To effectively decrease the pollution loads to the YS, it is critical to understand the spatio-temporal distributions of pollution loads. In RO Korea, there are four major river systems that flow to the YS: the Han, Geum, Mankyoung-Dongjin, and Youngsan rivers. The pollution loads from each of these river systems need to be evaluated using the best available science-based methodology. Using REDPOLL as watershed model in Han River, flows and pollution loads to the YS were evaluated for the year 2016 based on simulation results. River flows and pollution loads have a very wide range of daily and monthly variation. As affected by the monsoon weather system, the monthly volume of river flows in July reaches 7,484 x 106 m^3/ month accounting for 35.2% of the annual discharge. Likewise, the monthly pollution loads in July comprise more than a quarter of the annual loads: SS 49.4%, BOD 40.0%, TN 30.9% and TP 41.6%. In the Han River Watershed, the majority of pollution loads come from the diffuse sources: SS 99.8%, BOD 86.8%, TN 75.2%, and TP 92.7%.

Dr. Yoonseok Choi, Korea Laboratory Accreditation Scheme Assessor, National Institute of Fisheries Science in West Sea Fisheries Research Institute (WSFRI), RO Korea, introduced the results of investigations on temporal and spatial variations conducted in the west coastal areas of Yellow Sea covering years 1974 to 2014. Water samples were collected at 60 stations and physicochemical parameters were analyzed including water temperature, salinity, SS, DO, Chlorophyll a and nutrients. Medium-term trends and distribution patterns of water quality were investigated. Spatial distribution patterns of temperature, pH and DO were not clear among stations but the seasonal variations were distinct except ammonium. The results of water quality evaluation index (WQI) values is 25, and ecology-based seawater water quality criteria were grade II (Good).

Dr. Tae Wook Kim, Assistant Professor, Korea University, RO Korea, presented on atmospheric deposition of inorganic nitrogen to East Asian marginal seas. Dr. Kim emphasized that the atmospheric deposition of anthropogenic nitrogen is an increasingly important new source of nitrogen to the ocean. His presentation showed the concentrations and depositional fluxes of nitrate and

Dr. Yoonseok Choi of WSFRI, RO Korea.

Ms. Limin Yu of NMEMC, PR China.

ammonium in airborne total suspended particles and precipitation, and factors affecting them based on three-year observation data collected in Uljin, eastern coastal site of RO Korea, which is adjacent to the East Sea. Their study found that atmospheric nitrogen deposition could contribute to approximately two percent of phytoplankton production in the southwestern East Sea. Furthermore, nitrogen and oxygen isotopic ratios in atmospheric and seawater samples also have significant contribution of atmospheric nitrogen deposition to the nitrogen pool in the East Sea. This atmospheric deposition also directly reduces ocean alkalinity. Similar investigations are also being conducted in Songdo, western coastal site of RO Korea and to an ocean site in Yellow Sea.

Ms. Limin Yu, Senior Engineer, NMEMC, Ministry of Ecology and Environment, PR China, shared the results of their monitoring of the dry and wet atmospheric deposition of nitrogen and phosphorus over the west coast of Yellow Sea. Their study showed that the size distribution of ammonium exhibited bi-modal in the dust season and uni-modal in the other seasons, while the remaining nitrogen components exhibited bimodal/multimodal size distribution, and multimodal distribution for phosphorus in atmospheric aerosols. The deposition velocities of the particulate nitrogen were calculated with the improved Willimas model. It was showed that the proportion of aerosol pollutants in fine particles has little effect on the overall dry deposition velocities, while the proportion of coarse particles may be the most important factor. The atmospheric deposition of nitrogen and phosphorus in the Yellow Sea was estimated. The atmospheric wet deposition of nitrogen and phosphorus in the Yellow Sea was higher than that of dry deposition. And the scouring effect of rainwater on ammonium salt was higher than that of nitrate.

In the session discussion, Ms. Yu further clarified that their monitoring already considered the different sizes of particles in order to assess different behaviors.

Session 2 discussed the impacts of excessive nutrients loadings in the Yellow Sea, and was moderated by Ms. Milcah Ndegwa.

Dr. Baodong Wang, from the First Institute of Oceanography, Ministry of Natural Resources, PR China, presented the historical evolution and ecological effects of nutrient status in Jiaozhou Bay in the past 40 years. The results showed that the DIN concentration increased continually in Jiaozhou Bay before the late 2000s, while the DIP and DSi concentrations decreased slightly and then increased rapidly in the same period. Since the late 2000s, the concentrations of nutrients decreased rapidly in Jiaozhou Bay. The nutrient limitation shifted from nitrogen limitation in the early 1980s to silicon limitation in the 1990s, and finally to phosphorus limitation in recent years. The annual average concentration of chlorophyll a has been fluctuating before 2015 but it has decreased in recent years. The zooplankton biomass increased significantly in the last two decades compared with the previous two decades. Analysis found that the increase in nutrient fluxes and reduction of sea area of the bay were the main reasons for the increase of nutrient concentrations before the late 2000s; whereas in recent years, the implementation of comprehensive environmental remediation measures was the main reason for the reduction of N and P fluxes to Jiaozhou Bay. Before 2010, shellfish culture was the main factor controlling the phytoplankton biomass in Jiaozhou Bay. However, the decrease of dissolved inorganic phosphorus concentration and the increase of zooplankton biomass were the main reasons for the decline of chlorophyll concentration in recent years.

Dr. Baodong Wang of FIO/MNR, PR China.

Dr. Qinsheng Wei of FIO/MNR, PR China.

Dr. Qinsheng Wei from the First Institute of Oceanography, Ministry of Natural Resources, PR China, highlighted the scientific significance of acidification and deoxygenation in obtaining an in-depth understanding of the evolution and ecological responses of the marine environment. Using time series observations in the Yellow Sea, China, their study illustrated the seasonality of deoxygenation and associated mechanisms in this semi-enclosed shelf ecosystem, and explored the linkage of acidification with anthropogenic eutrophication. Results show that the DO content displayed a decreasing trend in the water column in vertical-mixed winter. The rapid decline in DO and pH was observed in the bottom water in a stratified summer. In winter, when the water column is vertically homogeneous, the seawater warming is the most plausible driver of deoxygenation. In the stratified summer, increased nutrient availability and consequently enhanced productivity are responsible for the drawdown of DO and pH in the bottom layer, and the stoichiometric pattern between DO depletion and nitrate also suggests a cascading linkage between the exacerbation of eutrophic conditions and bottom deoxygenation. Results provide strong evidence that a rapid shelf-scale decline in DO and pH is underway, which may lead to the hypoxic and acidified Yellow Sea, thereby highlighting the necessity of nutrient reduction strategies in the future.

During the session discussion, it was further indicated that in recent years nutrient input to Jiaozhou Bay has significantly declined with the construction of more sewage treatment plants around the Bay.

It was also emphasized that under China's ecological civilization initiative, the drive towards nutrient reduction is now very strong. Most of the water quality along the coasts are to be assessed and every year local governments will be assessed if they have achieved the set targets. Registration Guidelines related to nutrient reduction are also already in place in China.

Session 3, also moderated by Ms. Ndegwa, focused on nutrient reduction or remediation through nature-based solutions.

Mr. Guoxiang Liao, Deputy Director of Coastal Wetland and Marine Protected Area Research Center, NMEMC, China, introduced four case studies on restoring coastal wetlands as nutrient sinks. First, the case of Wuyuan Bay, Xiamen, Fujian Province, which highlighted the returning fish and salt ponds to bays and coastal marshes. The second case is Ningbo, Zhejiang Province, where wetland is used for tertiary treatment associated with sewage treatment plants. The third case is in Longhai, Fujian Province which demonstrates the use of species and aquaculture to achieve the co-benefits of sustainable harvest and environmental performance. Lastly is nutrient bio-extraction in coastal areas through restoration in Yellow River Delta, Shandong Province, PR China. Mr. Liao proposed several recommendations on strategies, approaches and methods to enhance investment, capacity, knowledge and awareness raising to mainstream use of wetland into urban planning, marine park development, coastal wetland restoration projects and other investment decisions to enlarge wetland sink areas.

Ms. JeongHee Shim, Researcher, East Sea Fisheries Research Institute of National Institute of Fisheries Science, RO Korea, presented the investigation conducted on contribution of microalgae to biogeochemical nutrient and carbon cycles. They measured the uptake rates of nutrients and CO_2 by *Undaria pinnatifida*, *Saccharina japonica* and *Porphyra yezoensis Ueda* using an incubation

Mr. Guoxiang Liao of NMEMC, PR China.

Ms. JeongHee Shim of ESFRI/NIFS, RO Korea.

method in an acrylic chamber. *U. pinnatifida* and *S. japonica* were sampled at Ilkwang, whereas *P. yezoensis* sampled at Nakdong-River Estuary, Busan, southeast coast of Korea. The initial and final concentrations of nutrients, DO, total alkalinity, and pH of the chamber water were measured, and production/uptake rates were calculated using concentration changes, chamber volume, and incubation time. DO and the consumption rates of nitrate, phosphate and DIC, respectively, suggesting that these factors may serve as good indicators of photosynthesis for the seaweeds. There was a negative logarithmic relationship between fresh weight or length of thallus and uptake rates of nutrients and CO_2, which suggested that younger specimens were much more efficient at nutrients and CO_2 uptake than old specimens for all the three species. However, inorganic nitrogen & carbon demands for mariculturing *P. yezoensis* in Busan and Jeollabuk-do provinces, calculated by monthly mass production and culturing area, were much higher than those of Jeollanam-do province, the highest harvesting area in Korea. Chlorosis events at Jeollabuk-do recently might have developed due to the heavy culture in narrow area and insufficient nutrients in maximum yield season (December–January) due mostly to shortage of land discharge and weak water circulation. Future research should be focused on evaluating the roles of seaweed aquaculture to the coastal nutrients cycles and global carbon cycle.

Mr. Birun Lin shared the key results of a World Bank Project in Guangdong, China focusing on agricultural pollution control for prevention of water eutrophication. The project, launched in 2014 and is expected to be completed on 30 June 2021, is considered as the largest project in Asia using a World Bank loan. It is also the first pollution control project funded by the World Bank in China, with a total investment of USD 213 million (RMB 1.34 billion). Achievements include: (1) Establishment of compensation mechanism for agricultural pollution control based on informationization (information dissemination); (2) Establishment of incentive mechanism for promotion of agricultural pollution control technology focusing on villages and towns; (3) Establishment of goal-oriented monitoring and evaluation mechanism for agricultural pollution control; (4) Creating a new model of high-rise ecological breeding; (5) Creating a new model of conservation agriculture in the Southern area; and (6) Establishment of a new model for fund management of agricultural projects. By 2018, the cumulative reduction of pesticides (active ingredients) and chemical fertilizers (total amount) as well as reduction of COD, BOD, ammonia nitrogen and TP were significant. The project achievements have made significant contribution to the protection of water n in the national water quality standard all year round.

Mr. Mihai Constantinescu, Specialist for Agriculture and Afforestation, Coordinator of the Nitrates Directive Review and Revise Project in Romania, presented the implementation of EU Nitrates Directive in Romania. The EU Nitrates Directive was approved in 1991, which is aimed towards prevention and reduction of the nutrient pollution from agricultural sources, based on the experience of the old Member States. However, the EU expansion towards East-Europe implied also a full takeover of the EU legislation for the newcomers. As Romania has not only large intensive farms, but also still a consistent small-farming sector, this Directive brought certain challenges. In line with the nitrates policies/legislations, four interlinked intervention areas were put in place: research; policymaking; institutional implementation capacity; and knowledge transfer. The EU and national interventions include: provision of subsidies which is linked

Mr. Birun Lin of World Bank Guangdong Project, PR China.

Mr. Mihai Constantinescu of NDRRP, Romania.

to Nitrates Directive provisions under cross-compliance; agri-environment payments help promote sustainable management of grasslands; investments; and communal manure platforms. The interventions done were seen effective, but consolidation of the monitoring and control system still has to continue as part of the efforts for the consolidation of the institutional capacity.

During the discussion, it was clarified that while the problem posed by microalgae to farmers and tourism industry, some institutes are also developing plans on how to make full use of microalgae as biofuel.

In the case of spartina, it was recognized that while it can serve as carbon sinks, negative effects in other areas cannot be discounted. In Tianjin, China, for instance after removal of spartina and rehabilitation was undertaken significant increase in migratory birds have been observed. However, most local governments find it difficult to remove spartina as the cost can be very high and new techniques are needed to effectively remove spartina.

In the case of agriculture in Romania, the country was divided into two: modern agriculture and traditional agriculture. Romania continues to maintain this set up and provides incentives to farmers who continue to use the traditional method.

In closing, the session identified the following areas that need to be further strengthened or undertaken in support of nutrient management in the Yellow Sea:

- need to distinguish nutrient sources in open areas;
- manage nutrient control from the source;
- establishment of stronger waste treatment systems from land-based pollution;
- transfer good research developments, information and know-how on nutrient management to on-the-ground stakeholders (i.e., farmers) to
- the whole country to effectively implement nutrient management programs;
- strengthen implementation, build partnerships, and simplify knowledge on nutrient management; and
- develop a nutrient reduction strategy for the Yellow Sea.