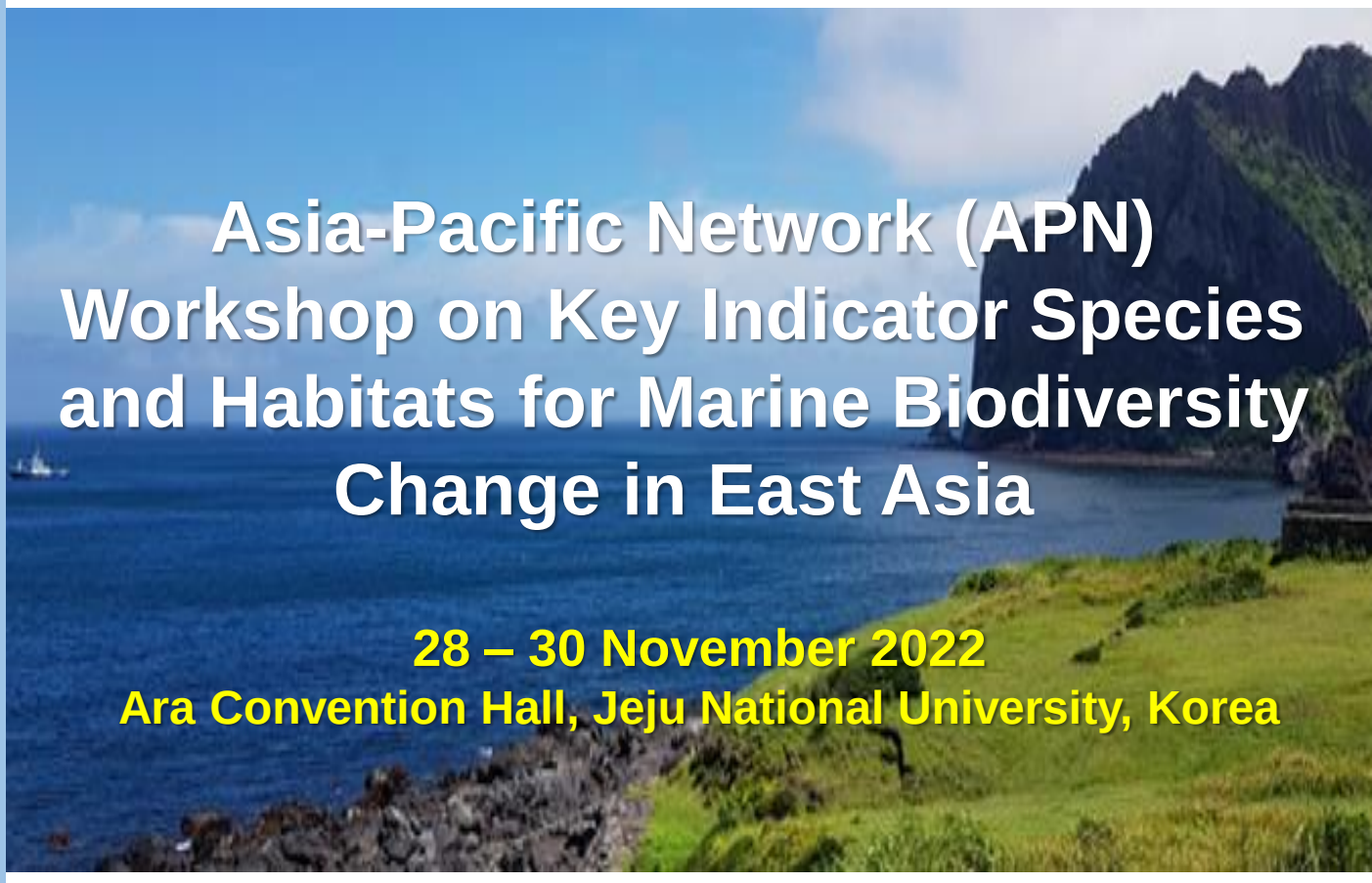

Asia-Pacific Network (APN) Workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia

28 – 30 November 2022
Ara Convention Hall, Jeju National University, Korea

Technical Summary

Organized by

Asia-Pacific Network for Global Change Research
Northwest Pacific Action Plan (NOWPAP)
Jeju National University, Korea

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1.0. Summary

The Asia-Pacific Network (APN) Workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia was held at Jeju National University, Jeju Island, Korea, from November 28 to November 30, 2022. The primary purpose of the workshop was to enhance capabilities for research on global change and sustainability in the region, as well as to support science-based decision-making both locally and globally. By focusing on key indicator species, ecosystem types, and major pathways affecting marine biodiversity changes in the Northwest Pacific, the workshop aimed to provide valuable insights into marine ecosystems' dynamics and conservation strategies.

The workshop featured a diverse program, including inspiring keynote addresses and invited talks delivered by eminent scientists and scholars in the field of marine biodiversity. These presentations enriched participants' understanding of the key indicator species, habitats, and pathways influencing marine biodiversity in the region. The event provided a conducive platform for researchers to share their findings, experiences, and expertise, fostering collaborative efforts to address marine biodiversity loss and change.

Led by prominent marine biodiversity institutions in East Asia, and supported by Jeju National University and the Northwest Pacific Action Plan (NOWPAP) of UNEP, the workshop successfully brought together stakeholders from academia, government, and non-governmental organizations. This collaborative effort aimed to enhance regional research capabilities and promote evidence-based science-policy decision-making processes.

The workshop results hold substantial value for the development of the NOWPAP Regional Action Plan on Marine and Coastal Biodiversity. By providing valuable insights into key indicator species and habitats, the workshop outcomes will contribute significantly to the conservation and sustainable use of marine resources in the Northwest Pacific. Additionally, aligning with the objectives of Sustainable Development Goal 14 (SDG 14) - Life Below Water, the workshop's findings and recommendations will help achieve targets related to marine biodiversity conservation.

2.0. Background

2.1. Introduction

The marine ecosystems of East Asia are facing significant anthropogenic pressures due to intensive urbanization and the escalating impacts of climate change. These pressures have led to substantial changes in the structure and functioning of marine biological communities in the region. Assessing the status of ongoing changes in marine and coastal biodiversity and habitats has emerged as a crucial research question with far-reaching implications for developing national and regional policies and coordinated monitoring strategies. In response to these challenges, the Workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia was organized. This workshop served as a platform for researchers to come together and share their findings, experiences, and expertise, fostering collaborative efforts to address the alarming trends of marine biodiversity loss and change.

The core focus of the workshop was the intersection of science, policy, and management for marine biodiversity conservation. Bringing together experts and stakeholders from four countries in the region, as well as invited partners from developing countries in Southeast Asia, the workshop aimed to advance scientific understanding of the concept of Key Indicator Species in the unique marine environment of the Northwest Pacific. The identification of critical research and monitoring gaps was another key objective to facilitate effective conservation measures. One crucial element of the workshop was its commitment to capacity building. It encouraged the participation and active involvement of young and mid-career scientists from the Asia-Pacific Network (APN). By facilitating networking opportunities between emerging and senior scientists, the workshop aimed to promote the exchange of knowledge and ideas, ultimately nurturing the next generation of experts in the field of marine biodiversity in East Asia.

The Workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia addressed the pressing need for collaborative, science-based approaches to tackle the challenges posed by human activities and climate change on marine ecosystems. Through interdisciplinary engagement and international cooperation, the workshop strived to lay the foundation for effective conservation strategies and policies that safeguard the marine biodiversity of East Asia for future generations.

2.2. Objectives of the workshop

Goal 1: Discuss the approach and methodology for identifying major key indicator species and the associated habitats and ecosystems characteristic for ongoing marine and coastal biodiversity changes, including standardization and new approaches to the study and conservation of marine biodiversity changes.

Goal 2: Discuss specific biogeographic regional units and identify key indicator species and ecosystems that are characteristic for ongoing marine and coastal biodiversity changes. Among candidate groups of species are the following: i) plankton organisms; ii) benthic organisms, and iii) free living animals (nekton and nektobenthos). In addition, specific ecotopes/ecosystems that have available longer-term measurements and ongoing monitoring data will be identified in East Asia region, specifically in coastal waters of Japan, China, R. Korea and Russia.

Goal 3: Review existing evidence on major threats, pressures, impacts and trends for key species groups and ecosystems.

Goal 4: Identify monitoring gaps for indicators species in national biodiversity monitoring systems and other relevant monitoring methods (e.g., the use of environmental DNA).

Goal 5: Develop policy-relevant recommendations for NOWPAP member states (Japan, R. Korea, China and Russia), including marine biodiversity research gaps, needs for monitoring and integrated assessments, and the use of indicator species approach to develop further indicators for regional Ecological Quality Objectives.

2.3. Participants

The workshop brought together a distinguished group of participants, consisting of eminent scientists from Korea, Japan, China, and the Philippines, each possessing extensive background and expertise in various fields of marine biology (**See Annex I**). This diverse pool of experienced researchers contributed to the workshop's rich discussions and comprehensive insights into marine biodiversity change in East Asia.

In total, 45 participants actively participated in the workshop, encompassing young and mid-career scientists. Their active engagement and enthusiasm added a fresh perspective and energy to the proceedings, promoting knowledge exchange and collaboration among generations.

In addition, Dr. Ning Liu from NOWPAP/UNEP, attended the workshop, sharing his expertise and valuable thoughts on the policy matter. His contribution added a global perspective and enriched the workshop's discourse.

Furthermore, to ensure inclusivity and enable broader participation, the workshop was live-streamed, allowing attendees who couldn't be physically present to join virtually. This virtual aspect extended the workshop's reach beyond geographical boundaries, fostering a truly international and collaborative atmosphere.

2.4. Workshop Program

As in **Annex II**.

3. Opening Session

3.1. Opening Remarks

Professor Kwang-Sik Choi, Chair of the workshop, welcomed all participants attending the Asia-Pacific Network (APN) Workshop on behalf of the organizing committee. Acknowledging the challenges posed by the COVID-19 pandemic, the speaker expressed gratitude for the participants' commitment to adapting and responding to unprecedented times. Despite the limitations, the workshop was held through a combination of face-to-face interactions and digital platforms to disseminate knowledge from expert scientists in the region. He expressed deep appreciation to the collaborators and speakers from both the international and the Republic of Korea, who graciously shared their valuable findings and insights on marine biodiversity changes and innovative identification approaches. The presence of eminent scientists from China, Japan, the Philippines, the Russian Federation, and the Republic of Korea was recognized with gratitude, even as some joined the workshop through online platforms due to their busy schedules.

On behalf of the organizing committee, the chairperson sincerely thanked the Asia-Pacific Network for funding and supporting this much-needed workshop and Northwest Pacific Action Plan NOWPAP for the crucial role in co-leading the workshop and contributing to the development of the NOWPAP regional action plan. He further acknowledged the contribution of Jeju National University and the tireless support of the Shellfish Research and Aquaculture Laboratory staff were acknowledged and appreciated for making the workshop successful.

Finally, the chairperson declared the APN workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia officially open.

3.2. Welcome Messages

Welcome message from Prof. Eel-Hwan Kim, President of Jeju National University

The President of Jeju National University extended a warm welcome to all participants attending the Asia-Pacific Network (APN) workshop. He expressed appreciation to the project team for selecting a timely topic that addresses the current situation of marine biodiversity being impacted by intensive urbanization and climate change, resulting in substantial changes. Jeju Island, known for its rich marine biodiversity encompassing various marine creatures like finfish, shellfish, seagrass, and corals, is also experiencing the influence of recent climatic changes on its marine diversity.

President JNU further acknowledged that the APN workshop features inspiring keynote addresses and invited talks by eminent scientists and scholars. Finally he mentioned the workshop is considered a privilege and a pleasure for the university and extended his best wishes for the workshop's success and the participants' endeavors.

Welcome message from Dr. Do-Hyung Kang, Director of KIOST Jeju Center

On behalf of the KIOST, Jeju Center, Dr. Kang, Director of KIOST, Jeju Center, welcomed the distinguished keynote speakers and invited speakers, emphasizing their significant contributions to making the workshop fruitful and successful. Additionally, young scientists from the Republic of Korea and other international countries were welcomed, highlighting the importance of their participation in addressing the crucial issue of biodiversity changes in East Asia.

Dr. Kang expressed hope that the workshop would serve as a catalyst for action and outline essential steps to identify Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia. The participation of renowned experts from various sectors and backgrounds was recognized as crucial in addressing pressing issues and shaping future actions for global marine biodiversity conservation. Further, he stressed the urgency of the work ahead, acknowledging the threats posed by a changing climate and continued loss of biodiversity for water and oceans to planetary survival and human well-being. Immediate and coordinated global action was emphasized as necessary to address these challenges effectively.

Furthermore, the speaker congratulated the workshop collaborators, the organizing committee, the international scientific community, and young scientists for their support and contributions to the workshop's success. Special recognition was given to Professor Kwang-Sik Choi, the project leader, for his determination and leadership throughout the workshop.

Welcome message from Dr. Yegor Volovik, NOWPAP Coordinator

Dr. Volovik, NOWPAP Coordinator welcomed all participants attending the Asia-Pacific Network (APN) workshop and expressed his belief that the audience of the workshop plays a crucial role in shaping the present and future of environmental science and action. He highlighted the challenges faced in the densely populated Northwest Pacific region, where significant anthropogenic pressures and climate change impacts intensify the strain on marine ecosystems. Unsustainable aquaculture practices, over-fishing, and destructive harvesting habits further threaten coastal and marine ecosystems in the region.

Informing the audience about the adoption of five Ecological Quality Objectives (EcoQOs) in 2014 by NOWPAP Member States, Dr. Volovik emphasized the relevance of two objectives directly related to marine biodiversity. Additionally, he asserted that the workshop's outcomes would contribute essential information and inputs for the development of the NOWPAP Regional Action Plan on Marine and Coastal Biodiversity and align with the achievement of Sustainable Development Goal 14 – Life below Water.

4. Workshop Presentations

The workshop on "International Workshop on Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia" was a successful event that brought together experts and researchers from diverse fields to share their valuable insights and findings. The abstract of this comprehensive speech can be found in **Annex III**

To delve deeper into the wealth of knowledge shared during the event, readers can refer to the "**Programs & Extended Abstract Report**." This detailed document provides in-depth explanations of each talk, offering a comprehensive understanding of the research, methodologies, and conclusions presented by the esteemed speakers.

Session 1-1: Marine Biodiversity Indicators I

Session Overview:

The first session of the workshop, titled "Marine Biodiversity Indicators I," was chaired by Dr. Ning Liu. This session focused on exploring the biodiversity indicators and ecological aspects of high-latitude scleractinian corals and marine mollusks in Jeju Island, Republic of Korea, as well as the distribution and diversity of corals in Korea.

Session Details:

Title: Biodiversity and Ecology of High Latitude Scleractinian Corals in Jeju Island

Speaker: Dr. Kwang-Sik Choi, Jeju National University, Republic of Korea

In this presentation, Dr. Kwang-Sik Choi delved into the biodiversity and ecological characteristics of high-latitude scleractinian corals found on Jeju Island. His expertise shed light on the unique aspects of these corals and their significance in the context of marine biodiversity in the region.

Title: Biogeography of Marine Mollusks on Jeju Island

Speaker: Mr. Ronald G Noseworthy, Jeju National University, Republic of Korea

Mr. Ronald G Noseworthy presented on the biogeography of marine mollusks found on Jeju Island. His insights into the distribution and ecology of these mollusks provided valuable information on the diversity and habitat preferences of these important marine organisms.

Title: Distribution and Diversity of Corals in Korea

Speaker: Dr. Hye-Won Moon, National Marine Biodiversity Institute of Korea, Republic of Korea

Dr. Hye-Won Moon shared research on the distribution and diversity of corals in Korea. Her presentation highlighted the various coral species found in the region and their ecological importance, offering a comprehensive understanding of coral habitats in Korean waters.

Key Takeaways:

In the session on Marine Biodiversity Indicators I provided essential insights into the unique biodiversity and ecological aspects of high latitude scleractinian corals and marine mollusks in Jeju Island. The distribution and diversity of corals in Korea were also explored, enriching the participants' understanding of marine biodiversity in the East Asia region.

Discussion:

Following the presentations, the session was open to a vibrant Q&A discussion, allowing participants to engage with the speakers and further explore the research topics. The valuable information shared during this session will contribute to the broader dialogue on marine biodiversity conservation and the identification of key indicator species and habitats for the region.

Session 1-2: Marine Biodiversity Indicators II

Session Overview:

The second session of the workshop, titled "Marine Biodiversity Indicators II," was chaired by Dr. Tatsuya Kawakami. This session featured presentations that explored climate-change-driven range shifts of exploitable chub mackerel, potential host-associated evolution of monstrilloid copepods, and the role of seaweeds biodiversity in a globally changing environment.

Session Details:

Title: Climate-Change Driven Range Shifts of Exploitable Chub Mackerel (Scomber japonicus) Projected by Bio-physical Coupling Individual-based Model in the Western North Pacific

Speaker: Dr. Sukgeun Jung, Jeju National University, Republic of Korea

Dr. Sukgeun Jung presented his research on climate-change-driven range shifts of exploitable chub mackerel in the Western North Pacific. Utilizing a bio-physical coupling individual-based model, his findings provided projections of potential shifts in the distribution of this commercially important species, emphasizing the implications of climate change on marine ecosystems.

Title: An Integrated Phylogenomic Approach for Potential Host-Associated Evolution of Monstrilloid Copepods

Speaker: Dr. Donggu Jeon, Chung-Ang University, Republic of Korea

Dr. Donggu Jeon discussed an integrated phylogenomic approach to understand the potential host-associated evolution of monstrilloid copepods. His presentation shed light on the genetic and ecological interactions between these copepods and their hosts, contributing to a better understanding of marine symbiotic relationships.

Title: Seaweeds Biodiversity and Role in Globally Changing Environment

Speaker: Dr. Christophe Vieira, Jeju National University, Republic of Korea

Dr. Christophe Vieira's presentation centered on the biodiversity of seaweeds and their vital role in a globally changing environment. He highlighted seaweeds' ecological significance and potential contributions to addressing environmental challenges like climate change and habitat degradation.

Key Takeaways:

The Marine Biodiversity Indicators II session provided valuable insights into the potential impacts of climate change on the distribution of exploitable chub mackerel in the Western North Pacific. The research on monstrilloid copepods offered a deeper understanding of host-associated evolution and the ecological dynamics of marine symbiosis. Furthermore, the importance of seaweed biodiversity in mitigating the effects of a changing global environment was emphasized.

Discussion:

After the presentations, an interactive Q&A session allowed participants to engage with the speakers, promoting further discussions and exchanging ideas. The session's outcomes contribute to the collective knowledge of marine biodiversity indicators and offer valuable inputs for conservation and management strategies in the East Asia region.

Session 2 - Marine Biodiversity Changes

Session Overview:

The second session of the workshop, titled "Marine Biodiversity Changes," was chaired by Dr. Benjamin Jr. Vallejo. This session focused on research and insights related to changes in plankton functional groups in Jiaozhou Bay, marine environment and ecology monitoring and assessment in China, and the relationship between moonlight and coral reef organisms in Okinawa.

Session Details:

Title: Changes on the Plankton Functional Groups in Jiaozhou Bay, the Yellow Sea

Speaker: Dr. Xiaoxia Sun, Chinese Academy of Sciences, China

Dr. Xiaoxia Sun presented her research on the changes observed in plankton functional groups in Jiaozhou Bay, located in the Yellow Sea. Her presentation shed light on the shifts in plankton communities and their implications for marine biodiversity in the region.

Title: Overview of Marine Environment and Ecology Monitoring and Assessment in China

Speaker: Dr. Hongjun Li, National Marine Environmental Monitoring Center, China

Dr. Hongjun Li provided an overview of the comprehensive marine environment and ecology monitoring and assessment efforts in China. His presentation highlighted the systematic approaches used to monitor and assess marine biodiversity changes and their significance for informed decision-making.

Title: Relationship Between Moonlight and Coral Reef Organisms in Okinawa

Speaker: Dr. Shingo Udagawa, University of the Ryukyus, Japan

Dr. Shingo Udagawa's presentation explored the intriguing relationship between moonlight and coral reef organisms in Okinawa. His research shed light on how lunar cycles may influence the behaviors and ecology of coral reef inhabitants, providing valuable insights into the delicate balance of these ecosystems.

Key Takeaways:

The Marine Biodiversity Changes session offered valuable insights into the dynamic nature of marine ecosystems in East Asia. Researchers shared research on plankton functional groups in Jiaozhou Bay, providing a glimpse into the changing composition of marine communities. Additionally, the comprehensive marine monitoring and assessment efforts in China showcased the importance of data-driven approaches in marine conservation and management. Lastly, the unique relationship between moonlight and coral reef organisms in Okinawa highlighted the interconnectedness of natural factors shaping marine biodiversity.

Discussion:

Following the presentations, an engaging Q&A session provided participants with the opportunity to delve deeper into the research findings and fostered fruitful discussions. The knowledge shared during this session will contribute to the ongoing dialogue on marine biodiversity changes, informing future conservation strategies and management practices in the East Asia region.

Title: Overview of Marine Environment and Ecology Monitoring and Assessment in China

Speaker: Dr. Hongjun Li, National Marine Environmental Monitoring Center, China

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Discussion:

Following the presentations, an engaging Q&A session provided participants with the opportunity to delve deeper into the research findings and fostered fruitful discussions. The knowledge shared during this session will contribute to the ongoing dialogue on marine biodiversity changes, informing future conservation strategies and management practices in the East Asia region.

Session 3-1 - Marine Biodiversity Monitoring I

Session Overview:

The third session of the workshop, titled "Marine Biodiversity Monitoring I," was chaired by Dr. Kwang-Sik Choi. This session provided insights into innovative techniques and approaches for monitoring marine biodiversity, including the use of environmental DNA to detect fish biodiversity in the open ocean, monitoring changes in marine biodiversity in Jeju, Korea, and identifying patterns in the multitrophic community and food-web structure of a low-turbidity temperate estuarine bay.

Session Details:

Title: Environmental DNA as a Powerful Tool to Detect Fish Biodiversity in the Open Ocean

Speaker: Dr. Tatsuya Kawakami, Hokkaido University, Japan

Dr. Tatsuya Kawakami presented his research on the use of environmental DNA as a powerful tool for detecting fish biodiversity in the open ocean. His talk highlighted the potential of this cutting-edge technique to provide valuable insights into fish communities and distribution patterns, enhancing our understanding of marine biodiversity in vast oceanic ecosystems.

Title: How to Monitor Changes in the Marine Biodiversity in Jeju, Korea

Speaker: Dr. Hyun-Sung Yang, Korea Institute of Ocean Science and Technology (KIOST), Republic of Korea

Dr. Hyun-Sung Yang shared insights into monitoring changes in marine biodiversity in Jeju, Korea. His presentation outlined the methodologies and strategies employed by KIOST to effectively monitor and assess shifts in marine ecosystems, enabling evidence-based conservation and management efforts.

Title: Identifying Patterns in the Multitrophic Community and Food-Web Structure of a Low-Turbidity Temperate Estuarine Bay

Speaker: Dr. Hee Yoon Kang, Chonnam National University, Republic of Korea

Dr. Hee Yoon Kang's talk focused on identifying patterns in the multitrophic community and food-web structure of a low-turbidity temperate estuarine bay. Her research shed light on the complex interactions among different trophic levels, providing critical insights into the dynamics of estuarine ecosystems.

Key Takeaways:

The Marine Biodiversity Monitoring I session showcased innovative methodologies and tools utilized in monitoring marine biodiversity. Environmental DNA emerged as a promising approach for detecting fish biodiversity in the open ocean, while KIOST's monitoring efforts in Jeju demonstrated effective strategies for tracking changes in local marine ecosystems. Additionally, research on the multitrophic community and food-web structure of a temperate estuarine bay offered valuable insights into the intricate relationships within these habitats.

Discussion:

Following the presentations, an interactive Q&A session allowed participants to delve deeper into the research findings and fostered discussions on marine biodiversity monitoring practices. The knowledge shared during this session will contribute to the development of robust monitoring programs and facilitate informed decision-making for the conservation and sustainable management of marine ecosystems in the East Asia region.

Session 3-2 - Marine Biodiversity Monitoring II

Session Overview:

The third session of the workshop, titled "Marine Biodiversity Monitoring II," was chaired by Dr. Christophe Vieira. This session delved into the importance of monitoring marine biodiversity, particularly in detecting the presence of marine invasive species in ports and harbors using environmental DNA (eDNA) and understanding the artificial drivers of jellyfish blooms and the transport of non-native species.

Session Details:

Title: Using eDNA to Detect the Presence of Marine Invasive Species in Ports and Harbors

Speaker: Dr. Benjamin Jr. Vallejo, University of the Philippines, Philippines

Dr. Benjamin Jr. Vallejo presented his research on the utilization of environmental DNA (eDNA) to detect the presence of marine invasive species in ports and harbors. His talk highlighted the potential of eDNA as a powerful tool for early detection and monitoring of invasive species, enabling effective management and prevention measures.

Title: Artificial Drivers of Jellyfish Blooms and Transport of Non-Native Species

Speaker: Dr. Jinho Chae, Marine Environmental Research and Information Laboratory, Republic of Korea

Dr. Jinho Chae's presentation focused on exploring the artificial drivers behind jellyfish blooms and the transport of non-native species. His research provided insights into the anthropogenic factors contributing to jellyfish proliferation and the implications for marine biodiversity and ecosystem dynamics.

Key Takeaways:

The Marine Biodiversity Monitoring II session emphasized the significance of monitoring marine ecosystems to address critical challenges posed by invasive species and jellyfish blooms. Dr. Benjamin Jr. Vallejo's research showcased the potential of eDNA technology in early detection and management of invasive species in ports and harbors. On the other hand, Dr. Jinho Chae's study shed light on the role of human activities as artificial drivers impacting jellyfish blooms and non-native species dispersal.

Discussion:

Following the presentations, an interactive Q&A session allowed participants to engage with the speakers, facilitating a deeper understanding of the research findings and fostering discussions on marine biodiversity monitoring strategies. The knowledge shared during this session will contribute to the development of effective measures for mitigating the impact of invasive species and understanding the ecological dynamics of jellyfish blooms in the East Asia region.

***For visual representations and images related to the workshop, please refer to **Annex IV**

5. Conclusions and Acknowledgements

The successful execution of the workshop on "Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia" was achieved with adherence to the planned program, fulfilling our overall objectives. The participants actively engaged in the workshop, and it is evident that they greatly benefited from the knowledge exchange and insightful presentations.

Throughout the workshop, the speakers highlighted the strengths, weaknesses, and recommendations pertaining to marine biodiversity change, allowing for a comprehensive understanding of the challenges and opportunities in the field. Their expertise and research contributions have undoubtedly enriched the workshop discussions.

As we conclude this workshop, we encourage participants and stakeholders to refer to the **summary of policymakers** to access key findings and policy recommendations. The insights gathered from this summary are invaluable in informing science-based decision-making processes and advancing regional marine biodiversity conservation and management policies.

The workshop's success is attributed to the collaborative efforts of the Asia-Pacific Network (APN), the Northwest Pacific Action Plan (NOWPAP), Jeju National University, and all the esteemed collaborators, speakers, and attendees. Together, we have taken significant strides in enhancing our knowledge of marine biodiversity changes and identifying key indicator species and habitats.

Annex I

Keynote Speakers

Name	Organization
Dr. Kwang-Sik Choi	Jeju National University, Republic of Korea *skchoi@jejunu.ac.kr*
Dr. Sukgeun Jung	Jeju National University, Republic of Korea *sukgeun@jejunu.ac.kr*
Dr. Xiaoxia Sun	Institute of Oceanology, Chinese Academy of Science, China *xsun@qdio.ac.cn*
Dr. Tatsuya Kawakami	Hokkaido University, Japan *kawakami@fish.hokudai.ac.jp*
Dr. Benjamin Jr. Vallejo	University of the Philippines, Philippines *bmvallejo1@up.edu.ph*
Dr. Tatyana Orlova	National Scientific Center of Marine Biology, Russia *torlova06@mail.ru*
Dr. Ning Liu	NOWPAP/UNEP *ning.liu@un.org*

Invited Speakers

Name	Organization
Dr. Jinho Chae	Marine Environmental Research and Information Laboratory, Republic of Korea *jinhochae@gmail.com*
Dr. Hye-Won Moon	National Marine Biodiversity Institute of Korea, Republic of Korea *hwmoon@mabik.re.kr*
Dr. Donggu Jeon	Chung-Ang University, Republic of Korea *donggu84@gmail.com*
Dr. Christophe Vieira	Jeju National University, Republic of Korea *cvcarp@gmail.com*
Dr. Hongjun Li	National Marine Environmental Monitoring Center, China *hjli@nmemc.org.cn*
Dr. Shingo Udagawa	University of the Ryukyus, Japan *shingouda0117@gmail.com*
Dr. Hyun-Sung Yang	Jeju Research Institute, Korea Institute of Ocean Science and Technology, Republic of Korea *hsyang@kiost.ac.kr*
Dr. Hee Yoon Kang	Chonnam National University, Korea *heeyoun0809@naver.com*
Mr. Ronald G Noseworthy	Jeju National University, Republic of Korea *rgnshells@yahoo.ca*

Annex II

Workshop Schedule

28 November 2022 (Monday)

09:00 – 09:30 **Workshop Registration**

09:30 – 10:00 **Opening Address**
Prof. Kwang-Sik Choi (Chair of the Organizing Committee)

Welcome Address
Prof. Eel-Hwan Kim, President of Jeju National University
Dr. Do-Hyung Kang, Director of KIOST Jeju Center
Dr. Yegor Volovik, NOWPAP Coordinator

Group Photo

10:00 – 10:30 **Conserve Marine Biodiversity in the Northwest Pacific Region**
Dr. Ning Liu
NOWPAP/UNEP

Session 1-1 : Marine Biodiversity Indicators I

Chair : Dr. Ning Liu

10:30 – 11:00 **[Keynote Speaker]**
Biodiversity and Ecology of High Latitude Scleractinian Corals in Jeju Island
Dr. Kwang-Sik Choi
Jeju National University, Republic of Korea

11:00 – 11:30 **[Invited Speaker]**
Biogeography of Marine Mollusks on Jeju Island
Mr. Ronald G Noseworthy
Jeju National University, Republic of Korea

11:30 – 12:00 **[Invited Speaker]**
Distribution and Diversity of Corals in Korea
Dr. Hye-Won Moon
National Marine Biodiversity Institute of Korea, Republic of Korea

12:00 – 13:30 **Lunch & Break**

Session 1-2 : Marine Biodiversity Indicators II

Chair : Dr. Tatsuya Kawakami

13:30 – 14:00 **[Keynote Speaker]**
Climate-Change Driven Range Shifts of Exploitable Chub Mackerel (*Scomber japonicus*) Projected by Bio-physical Coupling Individual-based Model in the Western North Pacific
Dr. Sukgeun Jung
Jeju National University, Republic of Korea

14:00 – 14:30 **[Invited Speaker]**
An Integrated Phylogenomic Approach for Potential Host-Associated Evolution of Monstrilloid Copepods
Dr. Donggu Jeon
Chung-Ang University, Republic of Korea

14:30 – 15:00 **[Invited Speaker]**
Seaweeds Biodiversity and Role in Globally Changing Environment
Dr. Christophe Vieira
Jeju National University, Republic of Korea

15:00 – 15:10 **Coffee Break**

Session 2 : Marine Biodiversity Changes

Chair : Dr. Benjamin Jr. Vallejo

15:10 – 15:40 **[Keynote Speaker]**
Changes on the Plankton Functional Groups in Jiaozhou Bay, the Yellow Sea
Dr. Xiaoxia Sun
Chinese Academy of Sciences, China

15:40 – 16:10 **[Invited Speaker]**
Overview of Marine Environment and Ecology Monitoring and Assessment in China
Dr. Hongjun Li
National Marine Environmental Monitoring Center, China

16:10 – 16:40 **[Invited Speaker]**
Relationship Between Moonlight and Coral Reef Organisms in Okinawa
Dr. Shingo Udagawa
University of the Ryukyus, Japan

16:40 – 16:50 **Coffee Break**

16:50 – 17:30 **Discussion**

17:30 **Session Closing**

18:00 **Networking Dinner**

29 November 2022 (Tuesday)

Session 3-1 : Marine Biodiversity Monitoring I

Chair : Dr. Kwang-Sik Choi

10:00 – 10:30 **[Keynote Speaker]**
Environmental DNA as a Powerful Tool to Detect Fish Biodiversity in the Open Ocean
Dr. Tatsuya Kawakami
Hokkaido University, Japan

10:30 – 11:00 **[Invited Speaker]**
How to Monitor Changes in the Marine Biodiversity in Jeju, Korea
Dr. Hyun-Sung Yang
Korea Institute of Ocean Science and Technology (KIOST), Republic of Korea

11:00 – 11:30 **[Invited Speaker]**
Identifying Patterns in the Multitrophic Community and Food-Web Structure of a Low-Turbidity Temperate Estuarine Bay
Dr. Hee Yoon Kang
Chonnam National University, Republic of Korea

11:30 – 13:30 **Lunch & Break**

Session 3-2 : Marine Biodiversity Monitoring II

Chair : Dr. Christophe Vieira

13:30 – 14:00 **[Keynote Speaker]**
Using eDNA to Detect the Presence of Marine Invasive Species in Ports and Harbors
Dr. Benjamin Jr. Vallejo
University of the Philippines, Philippines

14:00 – 14:30 **[Invited Speaker]**
Artificial Drivers of Jellyfish Blooms and Transport of Non-Native Species
Dr. Jinho Chae
Marine Environmental Research and Information Laboratory, Republic of Korea

14:30 – 15:00 **[Keynote Speaker]**
TBD
Dr. Tatyana Orlova
National Scientific Center of Marine Biology, Russia

15:00 – 15:10 **Coffee Break**

15:10 – 16:00 **Discussion**

16:00 **Session Closing**

18:00 **Networking Dinner**

30 November 2022 (Wednesday)

10:00 – 12:00 **Field Trip**
Sungsan Fork Village
Intertidal Area

Conserve Marine Biodiversity in the Northwest Pacific Region

Ning Liu

NOWPAP/UNEP

The Northwest Pacific is home to tens of thousands of marine life species and, at the global scale, is one of the most biologically diverse regions. Yet, habitat destruction, pollution, non-indigenous invasive species, over-fishing, and climate change have been threatening the wealth of fauna and flora inhabiting Northwest Pacific seas and coasts.

The Northwest Pacific Action Plan (NOWPAP) was adopted by China, Japan, the Republic of Korea, and Russia in 1994 as part of the United Nations Environment Programme's Regional Seas Programme. The overall goal of NOWPAP is "the wise use, development and management of the coastal and marine environment so as to obtain the utmost long-term benefits for the human populations of the region, while protecting human health, ecological integrity and the region's sustainability for future generations".

For nearly three decades, the NOWPAP Member States have invested resources in biodiversity conservation, including assessing major pressures on marine biodiversity in the region, maintaining a database on IUCN red list species in the region, assessing the state of marine protected areas, setting Ecological Quality Objectives, assessing the regional distribution of 'blue carbon' sinks – seagrass beds, developing "State of the Marine Environment Report for the NOWPAP region" reports, assessing marine invasive species, as well as a series of other efforts.

The assessments and tools developed have supported the national governments' response to environmental threats from eutrophication and hypoxia, harmful algal blooms (HABs), marine litter, and intensified pressures on seagrass habitats. A Regional Action Plan on Marine and Coastal Biodiversity Conservation (RAP BIO) was prepared in 2022 to facilitate regional cooperation in biodiversity conservation.

Currently, NOWPAP continues assessing pressures caused by harmful algal blooms, invasive species, eutrophication, habitat modifications, and other adverse factors impacting the Northwest Pacific's marine and coastal biodiversity. The major projects on biodiversity conservation implemented by NOWPAP include an assessment of tidal flats and salt marshes distribution, several case studies on estimating seagrass blue carbon, advancing the development of the NOWPAP Eutrophication Assessment Tool (NEAT) for the assessment and monitoring of eutrophication using satellite chlorophyll-a, and, finally, the compilation of species of the IUCN Red List.

Furthermore, NOWPAP strengthens the collaboration with the North Pacific Marine Science Organization (PICES) in developing and applying effective area-based conservation measures and identifying non-ingenious species, penetrating the region with the use of the modern Environmental-DNA method. NOWPAP will also continue cooperating with the Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) in Integrated Coastal and River Basin Management and other fields to enhance regional ocean governance.

Biodiversity and Ecology of High Latitude Scleractinian Corals in Jeju Island

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Coastal benthic communities in temperate regions have been influenced by climate change, including increasing sea-surface temperature. Nevertheless, scleractinian coral *Alveopora japonica* Eguchi, 1968, is thriving in shallow subtidal hard bottoms around Jeju Island, off the southern coast of Korea. The presence of this corals has negatively impacted subtidal kelp populations in Jeju Island. However, there is no study to document how the presence or absence of this coral relates to other benthic communities. This study investigated the benthos in three shallow subtidal sites (Shinheung (SH), Bukchon (BC), and Seongsan (SS)) in northern Jeju using underwater photography. Macro-benthic organisms appearing on a 1 × 20 m line transect installed at depths of 5, 10, and 15 m at each site were analyzed. Results showed that of the three sites investigated, *A*. *japonica* colonies were most abundant at BC, accounting for 45.9% and 72.8% of the total transect area at 10 m and 15 m, respectively. At SS, *A*. *japonica* occupied 15.3% of the total area at 15 m and less than 1% at 5 m and 10 m. The same at SH accounted for 10% of the total area at 5 m, and less than 1% at 10 m and 15 m. Dead and bleached colonies accounted for 1.2–11.5% and 1.8–5.7%, respectively, at 5, 10, and 15 m at three sites. At SS, canopy-forming brown algae *Ecklonia cava* and *Sargassum* spp. accounted for 20.2 and 24.3% of the total transect area, respectively, at 5 m depth. In contrast, the percent cover of *E*. *cava* and *Sargassum* spp. at SH and BC ranged from 0.1 to 1.8%, respectively. Moreover, non-geniculate coralline algae dominated the subtidal substrate at SH, ranging between 60.2 and 69% at 15 and 10 m. The low cover of *A*. *japonica* in SS (at 5 m) coincided with a high percent cover of canopy-forming brown algae. However, canopy-forming brown algae were rare at all depths at SH and BC and were dominated instead by coralline algae and the scleractinian corals. This study, by utilizing a non-destructive method, provides a baseline qualitative and quantitative information for understanding the site and depth-dependent distribution of *A*. *japonica* and algal populations, which is important to understand climate change related changes in benthic communities in Jeju and elsewhere

Biogeography of Marine Mollusks on Jeju Island

Ronald G. Noseworthy and Kwang-Sik Choi

Jeju National University, Republic of Korea

Jeju Island is Korea's largest island with an area of about 1800 km². It is located about 80 km south of the Korean Peninsula. The island has a subtropical climate with mild winters and hot, humid summers, and an average yearly temperature of 16°C. The warm Tsushima Current branches from the northeastward flowing Kuroshio Current and flows past Jeju Island through the Korea Strait. Although cooler water currents exert some influence, particularly to the north of Jeju Island, the warm Tsushima Current predominates; the southern coastal area of the island having somewhat warmer sea temperatures The blending of warm and cool currents has given Jeju Island a rich mollusk fauna, with over 1000 species presently recorded.

A survey of mollusk distribution along the Jeju coastline reveals that most species occur on the south and east coasts, where the Tsushima Current exercises a stronger influence as it flows northeastward into the East Sea, and this influences the coastal distribution of mollusks. Gastropods, such as Cypraeidae, Conidae, and Ovulidae, which are mostly tropical in distribution occur mainly on the south coast, and most others are also found along the south and east coasts. Although many common bivalves are found on all coasts of the island, the largest number of species, including those with tropical distribution such as the Pteriidae, occurs on the south coast only, with a slightly smaller number found on both south and east coasts. The Polyplacophora and Cephalopoda (mainly cuttlefish and argonautids), also have a mostly southerly island distribution. The Scaphopoda are divided evenly between the south and east coasts.

Zonal-geographical groupings more clearly show the biogeographical affinities of mollusk species. The Jeju fauna is mainly a combination of subtropical (Korea and Japan to Taiwan) and tropical/subtropical species (southward to southeast Asia). There has been a large number of new species reported for the Jeju fauna. Since the first catalogue of Jeju Island mollusks was published in 2007, which indicated that a subtropical influence predominated, almost three dozen new species have been added, almost all with a tropical/subtropical affinity, giving the island a fauna which is increasingly influenced by the warming ocean currents. The exception is the Polyplacophora, which is subtropical/low boreal in distribution, preferring cooler water.

Most Jeju mollusk species are associated with rocky and sandy coastlines; mudflats are virtually nonexistent, and mudflat-associated mollusks, such as Rapana venosa and Meretrix spp. do not occur on Jeju Island. Most of its 92 species of hard and soft corals are found mainly on the south coast, and many species of nudibranchs, cypraeids, ovulids, and chamids inhabit the corals.

Climate change caused by global warming has caused many marine organisms to expand the geographical range of their habitats and is a strong possibility for the addition of new mollusk species to Jeju Island's fauna. The region around Jeju Island has been reported as one of the fastest warming regions in the world, and the sea surface temperature has risen significantly over the last century.

Coastal development, especially port development, has caused a loss of habitat along some parts of Jeju Island's coastline. Overcollecting of edible species is becoming a problem in certain areas; intensive collecting also disturbs the habitats of other species, resulting in a loss of biodiversity. Tourist pressure has also had a detrimental effect, which can be seen in the "hotspots" of mollusk diversity where, a decade ago, large numbers of species could be obtained, but now yield far fewer.

Distribution and Diversity of Corals in Korea

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The class Anthozoa comprises approximately 7,500 species in the world. Among them 170 species, including soft corals (80 species of the order Alcyonacea), hard corals (35 species of the order Scleractinia), sea anemones (30 species of the order Actiniaria), and black corals (12 species of the order Antipatharia) have been reported from Korean waters by examining the specimens collected in the coastal areas of Korea from 1965 to 2021. This study aims to clarify the distribution of coral species along the coastal waters of Korea and to identify indicator species for the long-term monitoring of the changes in the distribution of coral species in response to climate change. Geographical analyses were performed to determine the distribution of coral species and to compare the species composition between regions in Korean waters. The 170 recorded coral species have been distributed in the following four regions, Korea: East Sea (28 species), Yellow Sea (21 species), South Sea (68 species), and Jejudo Island (124 species). As a results, it is shown that Jejudo Island has the highest diversity of coral species (73%) while the Yellow Sea has the lowest diversity of coral species (12%). The results reflect that most coral species in Korea are limitedly distributed along the Kuroshio warm Current.

In particular, given that scleractinian corals are significantly influenced by climate change in various ways, including because of their symbiotic relationship with zooxanthellae, the species composition and distribution of scleractinian corals as a key species provide critical baseline information to predict future environmental change in Korean waters. Most scleractinian corals in the tropical oceans are zooxanthellate. Six species of 35 scleractinian corals recorded in temperate Korean waters are zooxanthellate. As sea temperatures increase, the distribution of tropical zooxanthellate scleractinians expands northward. For example, we have found that one of the zooxanthellate scleractinian *Montipora efflorescens* Bernard, 1897 (빛단풍돌산호) is dominantly expanding from the southern part to the northern part in Jejudo Island. In this respect, it is considered that this species would be important as an indicator species for monitoring environmental consequences induced by climate change.

Climate-Change Driven Range Shifts of Exploitable Chub Mackerel (*Scomber japonicus*) Projected by Bio-Physical Coupling Individual-Based Model in the Western North Pacific

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We projected the effects of warming ocean on the range shift of biomass of chub mackerel (*Scomber japonicas*) covering from the larval to the adult stages up to age 3 yr by developing and applying individual-based models (IBM) based on a regional ocean circulation model for the western North Pacific and two climate change scenarios. From laboratory experiments, we observed a diurnal cycle in the buoyancy of larval mackerel. Our IBMs tentatively suggested that the larval and juvenile mackerel in the Korea Strait, the Japanese coastal areas and the Kuroshio extension areas are mostly transported from the East China Sea where they were hatched. Despite the greater uncertainty, the preliminary results of our IBMs projected that, by the 2050s, the strengthened Tsushima warm current in the Korea Strait and the East Sea, driven by global warming, will shift the young-of-the-year mackerel biomass distribution north to the East Sea, and adult mackerel biomass north, especially in the Yellow Sea. To improve the model performance, international cooperative research among the regional countries is required, especially for extensive ichthyoplankton surveys in the East China Sea.

An Integrated Phylogenomic Approach for Potential Host-Associated Evolution of Monstrilloid Copepods

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The order Monstrilloida Sars, 1901 is one of the most mysterious groups of Copepods with an unusually atrophied morphology and a complex semi-parasitic lifestyle. The lack of common diagnostic features from their morphological peculiarity and little information about the endoparasitic juveniles have caused many uncertainties and ambiguities in their taxonomy and phylogeny. To elucidate phylogenetic relationships and evolutionary significance of these organisms, we first generated two genomes and three transcriptomes from four monstrilloid species and analyzed the 25 nuclear protein-coding genes from 40 arthropod species. The molecular phylogenomic results supported the monophyly of Monstrilloida within Podoplea. Our analysis revealed that Monstrilloida was more closely related to Harpacticoida (Oligoarthra) than Siphonostomatoida which has been regarded as a sister group of Monstrilloida. These phylogenomic relationships for Copepoda were confirmed by statistical tree topology tests and the previously known phylogenies were rejected. Our arthropod phylogeny identified a long branch leading to Monstrilloida. Given the new phylogeny, we investigated hypotheses about monstrilloid evolution by integrating the known morphological and ecological traits of four monstrilloid genera.

Seaweeds Biodiversity and Role in Globally Changing Environment

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The world is confronted with major environmental challenges, in a large part due to anthropogenic stressors, which are critically affecting natural ecosystems. Among others, the impact that pollution and climate change pose on terrestrial and marine ecosystems is particularly alarming. In order to detect the effects of human activities on the quality of the environment and natural ecosystems, humans have used biological systems, species, and communities – i.e., biological indicators or bioindicators. Because of their moderate tolerance to environmental variability, bioindicators can effectively indicate the condition of their environment and ecosystem and therefore be used to obtain integrated qualitative data, which cannot necessarily be derived from technical measurement alone. Specific bioindicators need to be identified for particular ecosystems and should be easy to measure and allow to detect environmental and ecosystem changes. Seaweeds or macroalgae have emerged as valuable indicators in marine environments. While seaweeds contain a considerably much lower species diversity than their terrestrial counterparts, their ecological importance in global oceans' rocky coastal systems remains no less fundamental as primary producers and ecological engineers. Environmental changes have already considerably affected seaweeds globally, leading in worst cases to ecosystem phase shifts. Seaweed species are responding differently to environmental changes, thus leading to algal species composition shifts with some seaweeds becoming rare or disappearing, and others to bloom. Their critical ecological roles in combination with their sensitivity to environmental changes make some seaweed species potentially valuable bioindicators. Past efforts have mainly been oriented toward evaluating seaweed value as biological indicators of trace elements and contaminants presence in waters. Nevertheless, seaweeds function as bioindicators need to extend beyond mere measures of water quality; seaweeds may detect impacts from other anthropogenic stressors including climate change (e.g., changes in temperature and pH), habitat destruction, exploitation, and invasive species. Future research efforts on seaweed potential functions as bioindicators need to be directed in those directions.

Changes on the Plankton Functional Groups in Jiaozhou Bay, the Yellow Sea

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Understanding the long-term change of marine ecosystem is one of the most important issues for the health and sustainable development of marine ecosystems. Here, we takes Jiaozhou Bay, the Yellow Sea as an example to study the variation trends of plankton functional groups in temperate coastal seas in the past 10 years, and the combined effects of climate change, human activities, and environmental protection on plankton was analyzed and discussed.

Chlorophyll *a* (Chl *a*) concentration showed a decreasing trend after 2006 in Jiaozhou Bay, which was quite different from that before 2006. The abundance of diatoms has declined, leading to the increased dominance of dinoflagellates. In all four seasons of the year, the proportion of dinoflagellate in total phytoplankton community has increased significantly since 2006. Therefore, the phytoplankton community has shifted from a diatom-dominated community to diatom and dinoflagellate co-dominated community in Jiaozhou Bay in recent decades.

The abundance of copepods has decreased gradually in the Jiaozhou Bay, especially in May, August and November when compared with the same period in early years. At the same time, the proportion of large-sized copepods has decreased, and the proportion of small-sized copepods has increased. The abundance of a microzooplankton species *Noctiluca* also increased significantly. Therefore, there is a decreasing trend for copepods abundance and a miniaturization trend of the zooplankton community in Jiaozhou Bay in recent years, which is most probably caused by seawater temperature rising.

From the perspective of ecosystem health, good water exchange and the existence of sufficient filter-feeding shellfish are important and beneficial for maintaining the health condition of the Jiaozhou Bay ecosystem. Although water quality has improved due to the decrease in nutrient concentrations in recent decades, it is still necessary to keep an eye on the effects of climate change and human activities. Under the background of global change, the health assessment, scenario prediction and ecosystem-based management of the marine ecosystem are important measures to maintain the sustainable development of the ocean.

Overview of Marine Environment and Ecology Monitoring and Assessment in China

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The coastal zone of China comprises an area of more than three million square kilometers, and possesses an 18000 km coastline stretching across tropical, subtropical and temperate zones. The Ministry of Ecology and Environment is responsible for supervising human activities in marine environment, and organizing the investigation, monitoring, surveillance and evaluation of the coastal environment. The Bulletin of Marine Ecology and Environment Status of China has been published annually for more than twenty years, and is responsible for directing, coordinating and supervising marine environmental protection work throughout the nation. In 2021, we monitored seawater quality in 1,350 national monitoring sites, 193 riverine sections flowing into the sea, 442 sewage outlets with daily discharge volume exceeding 100 tons, and 31 bathing beaches. We also monitored the marine sediment quality of 540 national monitoring sites and the ecological status of 24 typical marine ecosystems. The monitoring results showed that China's marine ecology and environment status remained stable in 2020. The overall quality of marine water was getting better, with 96.8% of the marine water under jurisdiction of China according with the Seawater Quality Standard Grade Ⅰ. In the coastal area, 77.4% of these areas had Excellent or Good water quality, up by 0.8% compared with the previous year. The polluted areas were mainly located at Liaodong Bay, Yellow River Estuary, Jiangsu Coast, Yangtze River Estuary, Hangzhou Bay, Zhejiang Coast, and Pearl River Estuary. The dominant indicators failing the Seawater Quality Standard were inorganic nitrogen and active phosphate. The health status of typical marine ecosystems remained stable overall. The water quality of all the monitored sea-entering rivers is Slightly Polluted on the whole, with no significant change compared with the previous year. The marine environment quality in the ocean dumping zones and oil/gas exploration zones basically met the environmental protection requirements for marine functional zones. The environmental quality of marine fishery areas was generally in good status. Both the frequency and the cumulative area of recorded red tides have slightly decreased from the previous year.

Relationship Between Moonlight and Coral Reef Organisms in Okinawa

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Most of the organisms inhabiting a variety of environments on Earth synchronize their own ecological and physiological activities to their habitats. Periodic changes in the environment (e.g., circadian, circatidal, circalunar, and circannual) have a variety of effects on marine organisms. These are caused by the environment with cyclic changes in light and darkness (approximately 24 hours), tidal change (approximately 12.4 hours), moon phase (approximately one month), seasonal change (approximately one year), and so on. Most organisms have developed an endogenous clock that allows them to anticipate daily and seasonal changes and adapt their physiological, behavioral, and biochemical activity accordingly. Endogenous clocks are entrained to their local conditions by environmental cycles through input cues such as light or nutrition. In fish, entrainment of biological activity to habitat environmental factors is an important adaptive strategy and is essential for improving reproductive success and reducing predation risk. It is generally accepted that cyclic changes in the photoperiod and water temperature are potent environmental factors, and that daily and yearly periodicity in these factors is closely related to the initiation or termination and acceleration or deceleration of synchronous reproductive activity in fishes that inhabit temperate and higher latitudes. In the fishes inhibiting coral reefs, various reproductive events are known to be often synchronized with periodic changes associated with the Moon. This presentation will be introduced their moon-synchronized reproductive events, physiological changes, and the effects of moonlight on them, with a focus on the groupers (*Epinephelus*) and *Siganus,* which have been studied in my laboratory. Additionally, the impact of artificial light from our living environment (ELP: ecological light pollution) on marine organisms, for which light is an important factor in their ecological and physiological activities will also be introduced.

Environmental DNA as a Powerful Tool to Detect Fish Biodiversity in the Open Ocean

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Monitoring marine biodiversity on a global scale, particularly the distribution of indicator species, will provide essential baseline data for uncovering changes in marine ecosystems. Recent advancements in the analysis of environmental DNA (eDNA), which is extra-organism DNA extracted from various environmental samples, have made it possible to obtain information about fish diversity in aquatic ecosystems in a less laborious, non-invasive, and cost-effective way. However, the majority of eDNA research has been conducted in freshwater or coastal environments, and applications in the open ocean are still uncommon. For the successful use of the eDNA survey to improve our understanding of marine ecosystems, it is recommended to conduct a pilot study.

This study aimed to evaluate the ability of eDNA to characterize the distribution of pelagic fish and detect a transition in fish species composition in the open ocean, covering multiple biogeographic zones. First, the fish community structure in pelagic water was analyzed using eDNA metabarcoding, which can comprehensively identify eDNA in a sample. During the Arctic cruise of the R/V Mirai (JAMSTEC) held in 2020, eDNA samples were collected latitudinally from the coast of Japan to the Arctic Chukchi Sea (45 sites in total). The result indicated a clear latitudinal cline in taxonomic richness (2–48 taxa per site), with a notable boundary in the Kuroshio-Oyashio transition zone. Successive clustering and ordination analysis revealed that the fish community composition derived from eDNA metabarcoding closely matched the conventional biogeographic classification of pelagic waters. Second, species-specific eDNA detection was performed on these samples to provide an overview of the distribution of polar cod, *Boreogadus saida*, throughout the Pacific Arctic region. The polar cod is closely associated with sea ice and is considered a key species in the Arctic ecosystem. Polar cod eDNA was detected primarily in the central part of the Chukchi Sea shelf and the vicinity of the sea-ice-covered region, indicating that polar fish prefer cold and low-salinity water.

These findings indicated that eDNA is a powerful tool for detecting fish biodiversity in the open ocean and describing the geographical distribution of target species across a wide range of oceans. Although several technical difficulties (such as reducing contamination risk, preventing false negatives, and ensuring the accuracy of taxonomic assignment) need to be overcome, eDNA can be a reliable tool for replacing or supplementing conventional approaches. In conjunction with oceanographic research, continuous eDNA surveys will enhance our understanding of the marine ecosystem.

How to Monitor Changes in the Marine Biodiversity in Jeju, Korea

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Increasing seawater temperatures driven by climate change have negative impacts on marine biodiversity. Jeju Island has been suggested as an area capable of supporting high biodiversity, due to its geographical position and the different water masses influencing the marine environment around the island. Jeju is located within temperate latitudes, but borders to environmental changes, providing an ideal testbed for assessments on life under rapid climate change. However, a major limitation of monitoring programs is the difficulty to compare and quantify results generated by different methods. The MarineGEO program from the Smithsonian Institution's Tennenbaum Marine Observatories Network (TMON) developed a quantitative, standardized method of sampling monitoring data, called Autonomous Reef Monitoring Structures (ARMS) to overcome these problems. This is the first report to provide an inventory of marine biodiversity from Jeju waters in Korea using ARMS. We deployed ARMS units in Jeju (Kangjung, Bomok, and Seongsan) in 2018. After 12 months, the ARMS units were retrieved and a taxonomic analysis determining the marine biodiversity conducted. A total of 191 marine species were identified from ARMS; 109 species from Gangjung, 106 species from Bomok, and 91 species from Seongsan. The most abundant phylum was arthropods, followed by mollusks, annelids, and echinoderms. So far, we found two new species of Osctracoda and one unrecorded species of gastropod from the ARMS units. We expect this baseline data will provide further information to detect “climate refugees”, i.e. newly extended species due to climate change, as well as species new to science of understudied taxa. These “climate refugees“ would disturb marine ecosystems as they compete with indigenous marine organisms. Besides investigating changes in marine ecosystems caused by climate change, and detecting invasive marine species, this standardized monitoring method (ARMS) is applied to understand the role of biodiversity in sustaining resilient coastal marine ecosystems under climate threat.

Identifying Patterns in the Multitrophic Community and Food-Web Structure of a Low-Turbidity Temperate Estuarine Bay

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Food web dynamics outline the ecosystem processes that regulate community structure. Challenges in the approaches used to capture topological descriptions of food webs arise due to the difficulties in collecting extensive empirical data with temporal and spatial variations in community structure and predator-prey interactions. We use a Kohonen self-organizing map algorithm (as a measure of community pattern) and stable isotope-mixing models (as a measure of trophic interaction) to identify food web patterns across a low-turbidity water channel of a temperate estuarine-coastal continuum. We find a spatial difference in the patterns of community compositions between the estuarine and deep-bay channels and a seasonal difference in the plankton pattern but less in the macrobenthos and nekton communities. Dietary mixing models of co-occurring dominant taxa reveal site-specific but unchanging food web topologies and the prominent role of phytoplankton in the trophic base of pelagic and prevalent-detrital benthic pathways. Our approach provides realistic frameworks for linking key nodes from producers to predators in trophic networks.

Using eDNA to Detect the Presence of Marine Invasive Species in Ports and Harbors

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With the global extent of maritime trade, the risks for introducing marine invasive species in ports and harbors worldwide is great. A majority of member states of the International Maritime Organization (IMO) have acceded to the Ballast Water Management Convention of 2004 (BWMC) and the Antifouling Systems Convention of 2001 (AFS) which aim to reduce the risks of introducing non-indigenous and invasive species in ports. The IMO has set certain standards of ballast water release compliance, the D1 and D2 standards. The installation of ballast water treatment systems on ships have reduced the risk but not eliminated risks of marine invasive introductions. The current ecological count methods of assessing compliance are time consuming and tedious that only 1% of global shipping is regularly scientifically assessed. Environmental DNA (eDNA) metabarcoding presents a promising approach for rapid assessment of marine biological invasion risks in ports but presents certain methodological difficulties especially in the lack of environmental baseline and genomic databases. I present initial results of our research on tropical ports on eDNA and in ballast water that show the practicalities and promising directions of using eDNA in ballast water compliance assessment and in port ecological baselines.

Artificial Drivers of Jellyfish Blooms and Transport of Non-Native Species

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Recent studies have perceived that the jellyfish increase is a global trend, portrayed as a symptom of ocean degradation. Changes in marine environments due to human activities could enormously contribute to the jellyfish abundance; overfishing, marine construction, eutrophication, global warming, etc., may benefit jellyfish populations over fish. However, others suggested that this perception is based primarily on a few case studies and anecdotal evidence. Thus, the perception of a worldwide trend toward increased jellyfish abundance may still be unsupported because of many exaggerated and sometimes even distorted information by citation mistakes and lack of confidence in existing evidence. We have examined the causation of jellyfish blooms, the impacts of newly found non-indigenous species on the endemic communities, artificial effects on jellyfish feeding and distribution for *Aurelia coerulea*, *Blackfordia* spp., and *Carybdea brevipedalia*, the ecologically interesting but often problematic jellyfish species.

Because the population size of polyps may be a crucial factor in determining the intensity of medusa blooms in the next seasons, we have located polyp populations of *Aurelia coerulea* and determined their total amount around the Korean coast using underwater photographs collected by SCUBA diving. Diving observation has been made approximately in ca 2,600 sites, finding substantial (significantly large) polyp populations from more than 800 sites. Downward-facing surfaces of various underwater artificial structures were the most frequently observed habitats of the jellyfish polyps. We found polyp populations in only one natural habitat. These results provide compelling evidence that the increase in coastal development and construction is the primary cause of the rise of *Aurelia coerulea*, the most frequent and large-scale blooming species.

Medusa individuals of *Blackfordia virginica*, non-indigenous hydromedusae, were first found at Shihwa Lake in 2013, while the polyps were photographed formerly in 2004 which were identified recently. *Blackfordia virginica* and *B. polytentaculata* were simultaneously found for the first time at Seomjin estuary in 2021. We first recorded these two congeneric species in Korean waters and examined their distribution in various estuaries, long-term population dynamics, and trophic relationships. *Blackfordia virginica* blooms (the highest mean density of 679.3 ind m^{-3}) almost every years in 2013-2020 in Shihwa Lake. Copepods and barnacle larvae were the primary food sources of the jellyfish, according to a stable isotope-ratio analysis. Copepods, the dominant prey, were exhausted soon after the hydrozoan blooms, and then bell shrinkage of the jellyfish occurred consecutively. *Blackfordia polytentaculata* in the Seomjin estuary was recorded only from its type location, Jiulong River, Fujian province in China before this study.

A very venomous box jellyfishes, *Carybdea brevipedalia* is a small to medium sized cubozoan only distributed in Japan and southern coast of Korea. We examined swimming and feeding behavior to understand the mechanisms employed by this species to capture its prey. Larger zooplankters such as decapod and fish larvae, mysids, and swimming polychaetes (> 0.2 Cmg^{-1} ind^{-1}) were the major prey items, while copepods (< 0.05 Cmg^{-1} ind^{-1}), the most predominant in the study area were little found in the gut. Feeding was minimal during the day. More than 80 % of individuals observed at 20:30-03:00 involved 1–6 prey in their digestion pouch. It was a strong vertical migrator, conspicuously ascending right before sunset. They distinctly elongated their tentacles under dark conditions. PIV analysis shows that it swims a long distance at night, the feeding time. Even though the species is a fast swimmer and voracious predator, having a complex visual structure including lens eyes, it is a passive hunter, fishing rather than hunting. Tentacle elongation and agile swimming are the most important means to succeed in feeding on the faster swimming prey. Ascending to the surface water at sunset may lead its position to more frequently encounter nocturnal prey species. We assumed the impacts of artificial light on their feeding rate because of the solid positive phototaxis to the collimated light, both predators and prey; however, the light pollution affecting their productivity has not been elucidated. The possible northward shift onto the eastern coast of Korea was found recently.

ANNEX IV Some glimpse of the workshop Day 1

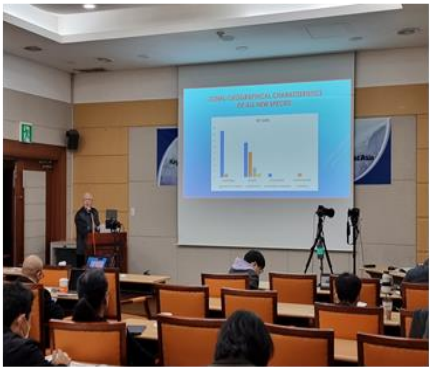
An Opening Address delivered by Prof. Kwang-Sik Choi, Chair of the Organizing Committee

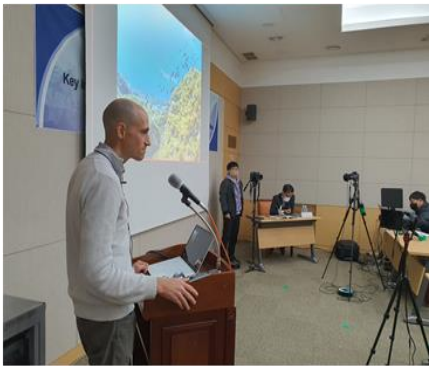
Welcome Address delivered by Prof. Eel-Hwan Kim, President of Jeju National University

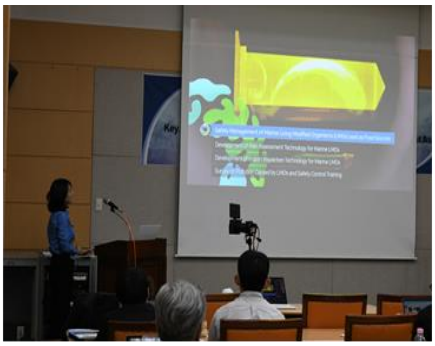
Welcome Address delivered by Dr. Yegor Volovik, NOWPAP Coordinator

All the resource persons of the workshop gathered with guests together, posing for a group photo.

A Moment of Collaboration and Knowledge Exchange workshop Day 1



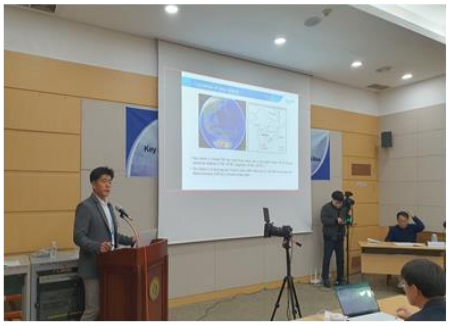





A Moment of Collaboration and Knowledge Exchange. Workshop Day 2








ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

Key Indicator Species and Habitats for Marine Biodiversity Change in East Asia

NOWPAP
Northwest Pacific Action Plan

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