Report of the Study Group on *Impacts of Mariculture on Coastal Ecosystems*

In order to share the progress of the Study Group on *Impacts of Mariculture on Coastal Ecosystems* (SG-IMCE) among PICES member countries, an MEQ Workshop (W19) on "*The impacts of mariculture to coastal ecosystems*" was held on October 19, 2019 in Victoria, BC, Canada, with the following main objectives: a. To review recent research, activities and priorities related to the effects of pathogenic and harmful organisms derived from mariculture on coastal marine ecosystems in PICES nations (*SG-IMCE Endnote 1*) and b. To discuss the new Terms of Reference (ToRs) for a proposed Working Group (*SG-IMCE Endnote 2*). The meeting was attended by 15 participants from China, Korea, Japan and two members from the United States and Canada via video link.

Workshop participants at PICES-2019. Back row, from left: Shufang Liu, Qiufen Li, Yumi Okochi, Qingli Zhang, Zhuojun Ma, Toyomitsu Horii; front row, from left: Tetsuo Fujii, Zengjie Jiang, In-Kwon Jang, Miyoung Cho. Attended virtually: Michael B. Rust, Mark Polinski, Linda Rhodes, Kristi Miller, Xianshi Jin.

1. Brief summary of the meeting

The invited speaker, Dr. Qingli Zhang, Professor of Yellow Sea Fisheries Research Institute, China Academy of Fishery Sciences, gave a presentation titled "Ecological risk of covert mortality nodavirus: from ponds to wild sea". The presentation focused on covert mortality nodavirus (CMNV), an emerging *Alphanodavirus* responsible for viral covert mortality disease (VCMD) which has caused widespread economic losses of shrimp aquaculture in Asia. The high prevalence of covert mortality nodavirus (CMNV) in coastal ponds is causing increasing concerns of CMNV becoming widespread in the marine environment. In the presentation, Dr. Zhang detailed comprehensive surveys of CMNV infection in organisms in farming ponds, drainage canals and wild marine waters were conducted to assess the virus' ecological risk. First, CMNV was revealed to be prevalent in crustaceans farmed in the coastal provinces of North China. Further analysis demonstrated that invertebrates inhabiting crustacean farming ponds constituted new biological risk factors for CMNV. A high percentage of CMNV infection in mollusks, crustaceans, polychaetes and teleosteans in the outfalls of ponds were uncovered by more extensive

investigation. Moreover, serious CMNV infections were also identified from most wild offshore invertebrates, and the major decline of traditional dominant crustaceans of the investigated seas was speculated to relate with large-scale epidemic of CMNV. These findings revealed the ecological hazard of CMNV spread from farming ponds to the wild marine ecosystems.

The other invited speaker, Dr. Michael B. Rust, Chair of the Aquaculture Steering Group of ICES, and *ex officio*, representing ICES, contributed to the workshop by sharing a valuable video presentation titled "Working towards an ecosystem approach to North Atlantic marine aquaculture". The presentation gave an overview of the ICES Aquaculture Steering Group and recent progress of 7 working groups in aquaculture. It provided a very useful reference for SG-IMCE.

Dr. In-Kwon Jang (Korea) presented a review of biofloc technology in shrimp farming. He summarized the development status, existing problems, and challenges of shrimp culture in Korea, and focused on the characteristics of biofloc technology and its application and industrialization in high-density intensive shrimp culture.

Dr. Zhuojun Ma (Chinese Academy of Fishery Sciences) made a report entitled "Overview of fish meal and fish oil utilization in China", introduced the current situation of fish meal and fish oil production in China and its application in aquaculture. He pointed out that aquaculture in China is characterized by low trophic level species and high non-feeding rates, with high ecological transformation efficiency and input-output ratio compared with the high trophic species.

2. Comments from participants

In terms of the new ToR upgrading from a Study Group to a Working Group, the participants expressed different opinions. Some suggested that the ToRs were too narrow in only focusing on the pathogen and disease aspect. Mariculture, in particular bivalves and seaweed mariculture, is a "green" industry and provides a positive ecological service function (such as food provision, climate regulation, *etc*.) if practiced in a scientific way. The disease argument is only part of the issue together with the rapid (although potentially not sustainable) development of the mariculture industry. Concern was voiced that too much attention to disease impacts on the surrounding ecosystem will lead to inadvertent enhancement of other potential negative (or positive) impacts of mariculture to marine ecosystems. It was proposed that the Working Group's ToRs should be more comprehensive to enhance collaboration opportunities with other organizations and attract more participants.

Other participants suggested that the current ToRs' narrow focus for the Working Group is in line with the working group structure of PICES and was specifically tasked by the previous PICES Working Group –Working Group (WG 24) on *Environmental Interactions of Marine Aquaculture*. Indeed, in PICES Scientific Report No. 44, the WG 24 members recommended that "any future marine aquaculture-related PICES expert group should be more narrowly focused to not only allow for more direct work, but also to increase the likelihood of experts from all PICES member countries being able to participate and contribute." This sentiment was communicated in the narrow and specific ToRs provided to SG-IMCE, namely, to specifically address the impacts of mariculture pathogens on coastal ecosystems and the need to address preparedness for emerging and re-emerging diseases/pathogens in PICES member countries.

3. Recommendation

Considering that some SG-IMCE members considered the Study Group title "Impacts of Mariculture on Coastal Ecosystems" in its broadest sense, while other members believed it necessary to focus a future Working Group and ToRs in line with previous WG 24 recommendations, the members suggested the establishment of two independent but linked working groups: one focused on ecological issues and ecosystem-based management, the other focused on the pathogenic disease issues of mariculture and their impacts on ecosystems (*SG-IMCE Endnote 2a and b*).

SG-IMCE Endnote 1

SG-IMCE Terms of Reference

1. Review recent research, activities and priorities related to the effects of pathogenic and harmful organisms derived from mariculture on coastal marine ecosystems in PICES nations;
2. Assess the opportunities to partner with other organizations to address the issues identified above;
3. Prepare Terms of Reference for a Working Group to address the issues identified;
4. Where appropriate, identify opportunities for future PICES expert groups to address issues related to the impacts of aquaculture that were not addressed in the Terms of Reference of the proposed Working Group. This is added in anticipation that the range of issues identified may exceed the capacity for a single PICES working group, in keeping with the recommendation from Working Group 24 to keep subsequent Working Groups focused on specific and tractable objectives;
5. Review capacity for forecast/projects on the impacts of mariculture on coastal ecosystems to support mariculture management.

SG-IMCE Endnote 2

(a) Draft proposal for an "IMCE" Working Group

Suggested title: Working Group on *Ecosystem-based Mariculture Management*

Background

With global food security becoming an increasing concern, mariculture is becoming recognized as the possible solution to meet the growing seafood demand worldwide. In this context, maricultural production has grown rapidly in recent decades and then the interactions between rapid development of mariculture and ecosystem are paid more and more attention. From a philosophical point of view, the impact of mariculture activities on surrounding ecosystem is bi-directional and species-dependent. The working group aims to improve the understanding of interactions between mariculture activities and coastal ecosystems and review the latest several Ecosystem-Based Aquaculture Approaches developed in PICES member countries. Furthermore, the new PICES working group will try to seek the opportunity to build the bridge with other international organizations.

Suggested Terms of Reference

1. Identify the major ecological issues in Mariculture and update PICES Report 44 on the interaction between mariculture and environment (reference for Previous Report of Working Group 24 on Environmental Interactions of Marine Aquaculture. PICES Sci. Rep. No. 44);
2. Review legislative and regulatory framework relating to mariculture activities management in PICES member countries;
3. Review the practiced sustainable mariculture approach and implementation effect in PICES member countries, particular attention should be given to Integrated Multi-Trophic Aquaculture, Land-based operations and offshore aquaculture;
4. Review of the ecosystem services provided by mariculture;
5. Identify key knowledge gaps and propose future research direction critical to establishing sustainable mariculture practices;
6. Seek collaboration with other organizations: ICES, IMBeR, *etc*.

Proposed membership

1. JIANG Zengjie, China, jiangzj@ysfri.ac.cn
2. CHANG Zhiqiang, China, changzq@ysfri.ac.cn
3. Beth Sanderson, NOAA, USA, beth.sanderson@noaa.gov
4. Bogdan Vornicu, MOWI, Canada
5. In-Kwon Jang, Korea, jangik2001@gmail.com
6. Jang K. Kim, Korea, jang.kim@inu.ac.kr
7. Michael B. Rust, NOAA, USA (*ex-officio*, representing ICES), Mike.Rust@noaa.gov
8. Japan, to be decided
9. Russia, to be decided

Proposed leadership

Chair: JIANG Zengjie
Co-Chair: Beth Sanderson or Bogdan Vornicu

(b) Draft proposal for "IMCE" Working Group

Suggested title: Working Group on *Impacts of Mariculture Pathogens on Coastal Ecosystems*

Background

Mariculture, especially large-scale mariculture, is an important factor affecting coastal ecosystems yet remains a necessary enterprise in meeting sustainable food production needs of human society. In PICES Scientific Report No. 44 published in 2013, a PICES expert group (Working Group 24) provided (a) analyses of environmental interactions of marine aquaculture, (b) discussion of marine aquaculture legislative frameworks regarding environmental interactions, and (c) an overview of our current methods for understanding putative pathogen transfer between wild and farmed aquatic animals. To expand and further these investigations with specific regard to aquatic pathogens, the SG-IMCE was tasked with preparing ToRs for a subsequent working group to address activities and priorities in PICES member countries related to the effects of pathogenic and harmful organisms derived from mariculture on coastal marine ecosystems. Following discussion among SG-IMCE and other PICES members, a working group has been proposed to fulfil the following objectives relating to describing the current knowledge, gaps in knowledge, and potential further direction of PICES nations in mitigating harmful impacts of mariculture pathogens on coastal ecosystems.

Suggested Terms of Reference

1. Update PICES Report 44, Section 3 (Pathogens of Aquatic Animals: Detection, Diagnosis and Risks of Interactions between Wild and Farmed Populations in PICES Member Countries) with current knowledge and practices;
2. Review the legislative framework for regulating transfer and undertaking ecological risk assessments of mariculture pathogens in PICES member countries;
3. Review current options and propose best practices relating to biosecurity and pathogen surveillance of mariculture pathogens in PICES member countries. Particular attention should be given to assessing the feasibility of establishing an internationally unified/coordinated biosecurity approach and surveillance database;
4. Identify key elements needed to allow and/or improve upon the implementation of predictive modelling to inform mariculture management and undertaking ecological risk assessments with regard to mariculture pathogens;
5. Identify key knowledge gaps and propose future research direction critical to establishing sustainable mariculture practices.

Proposed membership

1. Linda Rhodes, NOAA, USA, linda.rhodes@noaa.gov
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3. Toyomitsu Horii, FRA, Japan, thorii@affrc.go.jp
4. Miyoung Cho, NIFS, Republic of Korea, mycho69@korea.kr
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6. ZHANG Qingli. China, zhangql@ysfri.ac.cn
7. Russia, to be decided

Proposed leadership

To be decided