

Outline for the progress report on
Healthy, Productive and Sustainable Asian Marginal Seas: Understanding changes in the marine environment in response to global climate change
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1. Introduction and justification

Marginal seas in the Western Pacific Ocean are located within the boundaries between the continents or islands and the open ocean. Given the advances of climate change, it is essential to understand what happens in the Asian Marginal Seas (AMS), which is a very important region for human society due to its productivity, fishery resources, and human population on adjacent land. Significant changes in the hydrological and biogeochemical cycles due to the changing climate, together with increasing human economic activities, will affect the ocean structure and ecosystem in the AMS. These environmental changes in the marginal seas, including coastal and shelf regions, strongly influence the area's biological structure, fisheries, and marine ecosystems. To maintain healthy and productive marginal seas, international cooperative studies by countries around the marginal seas are essential.

There are various scientific questions that need to be addressed by cooperative studies, such as quantitative evaluation of water mass mixing, nutrient transport, and biological response, which are often controlled by a complex combination of physical and biogeochemical processes. Since the marginal seas are close to areas of human habitation, they can be expected to interact both positively and negatively with human life. It is an urgent issue to evaluate environmental risk since the marginal seas are strongly linked to human society. In particular, the AMS are located from tropical to subpolar regions along the Asian continent. The AMS connect each region like a chain, and it is necessary to consider the interaction between the seas, instead of just a single marginal sea. These marginal seas play a decisive role in the sustainable development and environmental adaptation/protection in confronting global climate change. Therefore, it is an urgent matter to advance cooperative studies to improve our common understanding of the changes in heat and nutrient circulation in marginal seas, which would affect the primary production, marine ecosystems, fisheries, and society.

The program consists of two projects and several tools that allow the projects to be efficiently operated. The projects are oriented to form a common understanding on two scientific issues: 1) quantitative evaluation of mixing processes by physical and geochemical methods to understand the regional circulation and nutrient cycles, which will support a productive and healthy AMS, and 2) better forecasts of long-term variations of processes underlying hydrological and biogeochemical cycles in the marginal seas responding to global warming, which would contribute to a safe, predicted, and accessible AMS.

2. Timeframe and objectives

The program should be operated continuously for 10 years since it focuses on contributions to the Ocean Decade. It consists of three stages. In the first stage (2021–2024), we will focus on cooperative interdisciplinary studies to understand the relevant phenomena and their changes in response to advancing global climate change and human activities in the AMS. In the second stage (2025–2027), associated with the scientific findings, we will start communication with fisheries scientists, meteorologists, and economists and other social scientists. Then in the **final stage (2028–2030)**, the results of communication will be delivered to make recommendations concerning policy and society. During the duration of activities, committee members will be added and replaced according to the progress of the program.

The objective of this program is to advance our understanding of the marine environment and biological productivity responding to increased global warming and human activities in the AMS while contributing to the Ocean Decade through the exchange of information and knowledge on the key phenomena and processes in the individual marginal seas and their interactions. Common understanding in these marginal seas can be achieved via a broad interdisciplinary cooperative study and enhanced communication among oceanographers, fisheries scientists, meteorologists, and economists and other social scientists. The scientific findings will be delivered to make recommendations for the public and society

3. Major activities, outputs and outcomes over the last intersessional period (May 2021-April 2023)

The **first activity** was having a session as Incubator-5 in the UN Ocean Decade Kickoff Conference, where several presentations on the nutrient footprints and long-term variation in the Asian marginal seas were scheduled, as well as guest presentations of social and fisheries scientists to expand the communication with fishery, climate and social sciences. A session, Incubator-5, was organized in the “Decade Action Incubator Series-UN Ocean Decade Kickoff Conference for the Western Pacific and its Adjacent Areas” held on 25 Nov. 2021 online.

Contents of the session are mainly organized with the topics of the AMS program, namely from three talks concerning Project I: nutrient footprint, two concerning Project II: the long-term variations, and two related to tools, remote sensing and numerical modeling. Keeping in mind the direction of the program, topics from fisheries and social sciences were associated.

The session consisted of two parts, the first was based on the contents of the program, two from Project 1, two from Project 2, and two from Tools, the second was from the outside of the Program, social and fisheries sciences.

1. Issues concerning the Program

1-1. Project I: the nutrient footprints

1) Sources, transport, and long-term variations of nutrients in the AMS were presented, and the necessity of long-term observation programs was suggested, because changes caused by global warming appear more clearly and earlier in the AMS than in the open ocean.

2) Nutrient loads from rivers in the upper Gulf of Thailand were reported, which influences formation of hypoxic water. Global warming would enhance the influence of the loads to coastal environments through higher temperature, stronger stratification, and larger river discharge.

3) An example of eutrophication in the coastal region of the Sea of Okhotsk was introduced and the nutrient sources were discussed. Transport of nutrients was also argued considering the highest levels of the food chain.

1-2. Project II: the long-term variations

1) Historical activities of international cooperative studies and current activities for long term observations in the East China Sea and the MSJKR were introduced. Future plans related to the AMS-program were also explained, showing the roadmap.

2) Long-term variations of the MSJKR were presented and clearly increasing sea water temperature and decreasing dissolved oxygen were shown, suggesting possible processes.

Then contributions to the UN Ocean Decade through the long-term variations of the MSJKR was suggested.

1-3. Tools

1) Satellite remote sensing for coastal water monitoring was introduced. Satellite remote sensing is a very useful and powerful tool to catch the situations in coastal areas. Even for biological factors remote sensing would provide useful information. On the other hand, it was also suggested that accurate models and algorithms were required for more effective utilization of remote sensing observations.

2) Hydrodynamic numerical models used in the marginal seas were introduced and their application to ecosystem in the coastal region was shown. For example, the environmental issues in the Gulf of Thailand may be properly explained with numerical models.

2. Communication with fishery, climate, and social sciences

In order to explore the possible outputs of this program, we have considered the issues that need to be addressed with input from communities outside of the marine science community.

1) The life history of fishes obtained from long-term field studies in the coastal region was introduced. It was shown that the life history is strongly related to the marine environment particularly during the period from spawning to juvenile.

It is usually mentioned that the fields of marine environment would be related to fishery resources. However, there is a big gap between the two fields, and the various processes between them are treated as a black box. If we can collaborate with scientists who study life history of fishes, quantitative evaluation for the relationship of the marine environment to fishery resources could be achieved.

2) International law related to UN Ocean Decade was introduced. Activities of international organization, international legal regime, and international law's response to Ocean Decade were also explained.

As the second activity, we started two specific core-projects in the Project 1. We firstly start a core project concerning influences of riverine and groundwater to coastal and shelf waters with mainly biogeochemical approaches.

Starting the core project, "International Brainstorming Workshop on Healthy & Sustainable Terrestrial and Coastal Waters" was held on Nov. 30, 2022 at the University of Toyama, Japan, with concurrent zoom meeting. The objective of the workshop was to gather up-to-date information on existing knowledge, research gaps and challenges related to the fluxes of nutrients and heavy metals in WESTPAC countries (Thailand, Indonesia, Bangladesh, China, Korea and Japan) with inviting participants from Cameroon in West Africa. In the workshop, where various topics concerning characteristics of terrestrial and coastal water system, coastal research methods (fieldwork and laboratory analyses), existing coastal research seeds (data, problems, gaps and challenges), experiences in holistic coastal water management, climate change and anthropogenic signatures on coastal water resources are presented as case studies in Japan, Indonesia, Cameroon, Thailand, China, Korea and Bangladesh. Brief contents of each case are as follows.

Case in Japan: It was presented that nutrient regulations do not necessarily lead to the restoration of rich and healthy oceans. It is necessary to reproduce water and nutrient cycles and predict the impact on the ecosystem. Case in Indonesia: Natural resources and the environment are becoming scarce due to over exploitation and lack of attention to sustainability. There are various problems, such as pollution, physical degradation of the habitat, over exploitation of natural resources, beach abrasion, conservation of protected areas into buildings, and natural disasters. Case in Thailand: water pollution and eutrophication, high loads of organic and inorganic substances in the Upper Gulf of Thailand (UGoT). Issues on red tide and hypoxia in UGoT as well as climate change were presented. Case in Cameroon: No comprehensive data on terrestrial and coastal water nexus. Urbanization is deteriorating the coastal environment and altering the ecosystem. There are problems related to industrial effluents and other anthropic activities, which would influence the flux of nutrients, water pollutants and hydrogeochemical dynamics. Presentation from China mentioned global coastal water problems such as eutrophication, deoxygenation, coastal acidification. Submarine groundwater discharge (SGD) is also important as a link between terrestrial systems and coastal water ecosystems. Examples are what the SGD-derived nutrients and carbon fluxes and their seasonal variations are in the Bohai Sea, or what the controlling mechanism and contribution of SGD on coastal acidification is? Participant from Korea concerned long term changes and current budgets

of nutrients in the AMS. In Bangladesh, it is interested in coastal and marine pollution such as, pollutants in coastal and marine water, determining the level of pollution, assessment of the ecological and health risks of consuming the main foods.

It was also presented where and when the field studies could be operated and who could be in charge of the studies. Possible sources of financial support were also suggested.

Another core project, on the mixing processes for understanding the nutrient footprint, has been planned and the first negotiation on the core project meeting was carried out.

The third activity is capacity building conducted in Indonesia. Two experts from Japan visited Indonesia in December 2022, to give lectures and hands on training in the laboratory and field for students and young researchers. Details are as below.

People from University of Toyama, Japan, and Jenderal Soedirman University, Indonesia, had a meeting to explore the potential for collaboration at Jenderal Soedirman University, in December, partly supported by WESTPAC resources.

During the workshop, a lecture was given by J. Zhang from University of Toyama to increase students' knowledge and insights in the field of environment, especially regarding groundwater, water circulation, research in the environmental field and research in the marine/coastal field. Then, potential collaboration between both universities in various research fields was discussed. A field trip to a lagoon was also carried out in order to conduct hands on training for coastal field survey, which provided increased knowledge capacity for students and young researchers regarding what research can be carried out in that area, and also provided capacity building for the young researchers regarding sampling techniques that could be carried out in marine sciences in the coastal waters, as well as providing knowledge about what steps could be taken to protect and preserve the surrounding environment so that it is not damaged

Through the workshop between the two universities, processes for capacity building and research collaboration in the coastal marine science fields between Japan and Indonesia have been set up. This is a pilot program for international collaboration in various research fields and could be set up between other countries.

4.A summary of key achievements since its establishment

A session as Incubator-5 in the UN Ocean Decade Kickoff Conference, where several presentations on the nutrient footprints and long-term variation in the Asian marginal seas were held, where guest presentations of social and fisheries scientists were invited to expand the communication with fishery, climate and social sciences. Through the session, we confirmed our common interests and possible cooperation in the following decade.

We set up specified two core projects in **the Project 1. Brainstorm workshop on one of the core projects was held, and scientists from seven countries shared the present situations on the nutrient footprint in the coastal and shelf waters in AMS.** We realized that there were various environmental stages depending on countries and recognized the importance of sharing advanced knowledge and skills, which resulted in planning of pilot programs.

A pilot program started for the capacity building, where an expert gave a lecture and hands on training of sampling and analysis in a coastal area. Similar programs can be implemented in other regions and various developments can be expected in the future.

5. Self-assessment on implementation against objectives

Invitation of fisheries and social scientists were involved in the session. It would be helpful to progress our activities aimed at interaction with the fisheries and social science communities.

Two core-projects were launched targeting the specific needs, with good understanding of the differences and the state existing between the emerging and developed countries.

For capacity building, using WESTPAC resources and individual national funds, experts were sent to developing countries, where the experts established a pilot program for international collaboration in the various interdisciplinary fields, such as lecturing in laboratory, hands on training in the field, helping to raise further research funds in developing countries

6. Problems encountered and recommended actions

Various geopolitical and international economic issues induced various difficulties for international cooperation, particularly for the field sciences in the marginal seas. COVID-19 was also serious hindrance to collaborative research requiring close communication. On the other hand, importance of environment in the emerging countries are increase. Under such obstacles and requirements, we establish a few specific core groups to move the science and activity forward, promoting the entire program more effectively.

7. Objectives to be achieved, if applicable, over the next intersessional period (May 2023-April 2025)

Submit a proposal for the UN Decade Action based on the core project, biogeochemical approaches on the nutrient footprint.

8. Planned activities for May 2023- April 2025

We first started cooperative research activities related to the Project 1, as a core project, which is the first active project of this program. The project is concerning the nutrient footprint in the coastal and shelf regions, with mainly biogeochemical approaches, particularly focusing on the “healthy” ground water discharge, under the collaboration of the scientists in Thailand, Indonesia, China, Korea and Japan. Changing of the marine environment in the concerning areas, under the condition of global warming and economic development in the coastal countries which is still challenging and urgent issues particularly in the developing countries, will be examined. International and/or domestic research funds related to the core project have been partly approved. Based on this core project, scientific meeting will be held in the session of JpGU in May 2023. We are also preparing a proposal and registration of a UN-Decade Action based on the activities of this program.

- Following the first brainstorming workshop held in Nov. 2022, the second workshop on the core project will be held in the JpGU session, 2023.
- Experts on ground water discharge are planning to continuously visit Indonesia and Thailand etc. for capacity building.
- A scientific session of the program will be proposed for the 11th WESTPAC International Scientific Conference, if it is scheduled in 2024.
- We will pursue international joint research through 2023 to 2024 based on individual research funds, and the third workshop of the core project will be held in 2024 to exchange new information.

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Workshop on the second core project related to the Project 1 will be held in June, 2023. While the first core project is mainly related to biogeochemical processes, the second core project could be concerning physical one, namely mixing processes. The importance of the mixing processes was emphasized in the proposal of this AMS program.

Mixing processes are quite important to understand how materials such as nutrients could be transported in the coastal and shelf waters. Therefore, once a common understanding has been developed in each core group, the two can be discussed together to determine what can be done to understand the transport of materials in the marginal seas.

On the Project 2, similarly to Project 1, a specified core research group will be set up. Participants of the core group are currently under consideration.

[provide, in tabular form, the action items that should be included in the work plan and budget]

Program					Funding Required		Remark
	Activities	Objectives	Expected outputs/outcomes	Date and place	IOC	Other sources (i.e., from national or international)	
AMS (Healthy, Productive and Sustainable Asian Marginal Seas: Understanding changes in the marine environment in response to global climate change)	1. Scientific session in the JpGU	Open the activities of the program to the public along with role of Project meeting	Making the program known to the public, and getting various information from the public	21 May 2023 Japan		Japan	
	2. Capacity building in Thailand; part-I, for core project 1	Start the second case of the capacity building following the case of Indonesia and Japan	Establishing close relationship for capacity building and cooperative research	May, June 2023 Thailand	WESTPAC	Japan & Thailand	
	3. Workshop on the core project 2 concerning mixing processes	Exchange information on the mixing processes and	Making mutual understanding related to cooperative research	June 2023 Japan		Japan	
	4. Session in the scientific meeting of WESTPAC	Open the progress of the program to the WESTPAC community	Publicizing the activities of the program to wider community	2024 Thailand	WESTPAC	Japan & Thailand	
	5. Capacity building in Thailand; part-II, for core project 1	Second stage of the capacity building in Thailand	Establishing close relationship for capacity building and cooperative research	2024 Thailand		Japan & Thailand	
	6. Project 1; core1&core2 joint meeting, program meeting	Confirmation of the progress of Project 1, and AMS program	Mutual understanding how the nutrient footprint can be traced.	Jan 2025	WESTPAC		