

Outline for the progress report on (Monitoring the Ecological Impact of Ocean Acidification on Coral Reefs)

1. Introduction and justification

A continuing increase in anthropogenic CO₂ emission reaches the maximum ever recorded in the earth's history in 2022, and one-third of the emission is absorbed by the ocean, resulting in increasing seawater acidity and carbonate system change which affects marine organisms and ecosystems. Under the UN Sustainable Development Goals (SDGs), the Intergovernmental Oceanographic Commission (IOC) is the custodian agency of SDG 14 Target 3 (Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels). It has taken responsibility for developing the SDG Indicator 14.3.1 Methodology, which calls for average marine acidity (pH) to be measured at the agreed to suit of representative sampling stations.

In supporting the achieving target of SDG-14.3, WESTPAC established the Monitoring the Ecological impacts of Ocean Acidification on Coral Reefs in 2015, under the framework of WESTPAC-Southeast Asian Ocean Observing System (SEAGOOS), which has a priority to the establishment of the regional network and develop the capacity building on monitoring seawater acidity and related parameters including impact on biodiversity in the coral reef, which is a crucial habitat contributing to coastal productivities and communities livelihood and economy.

Since 2015, WESTPAC has carried out a series of training workshops in the region, which cover the area of activities on the monitoring acidity (pH) of seawater, total alkalinity, and other ocean acidification-related parameters, including biodiversity of cryptobiotic organisms in the coral reef. The project has assisted member states in developing their capability to generate qualified data following SDG-14.3.1 (data portal) requirements and fulfilling their commitment to SDG-14.3. However, WESTPAC still needs to continue its efforts in the regional collaboration to sustain regional ocean acidification activities, particularly on existing and new OA monitoring sites, and research capacity in understanding better the impacts of OA on marine life and the ecosystem.

2. Timeframe and objectives

The proposed objectives for implementation of the project for the next four years (2023-2027):

Objective 1. To continue supporting capacity development on the transfer of marine technologies and knowledge to researchers, government agencies, and ocean-related stakeholders in generating qualified national/regional data and information relating to the OA and its impact, which extend study to marine organisms, fisheries, and ecosystem services, in supporting the formulation of national and regional ocean management and policy for adaptation and mitigation to the climate change;

Objective 2. To strengthen collaboration/network of research institutes and related government agencies to sustain the monitoring of ocean acidification in the region, particularly on acidity and related carbonate chemistry of seawater; and its impacts on the marine ecosystem in supporting the Member States to fulfill their commitment to the achievement of SDG-14.3 implementation and mitigation of OA impacts;

Objective 3. To collaborate with other OA-related activities under the WESTPAC framework and beyond in developing multidisciplinary ocean science knowledge, to better understand the complexity of coastal and ocean processes of OA impacts, in supporting the achievement of the UN Ocean Decade (2021-30) implementations at the national, regional, and global level.

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

3.1 WESTPAC Webinar Series on Ocean Acidification

A webinar series (4 webinars) was organized weekly on 5, 12, 19, and 26 May 2022 by the IOC Sub-Commission for the Western Pacific (WESTPAC) with 12 inviting selected speakers and an attendance of 150 participants. The objectives were to **1)** share the latest scientific advance on ocean acidification and its impacts on marine ecosystems and socio-economic development in the Western Pacific and beyond; **2)** exchange knowledge on the state-of-the-art ocean acidification-related research and monitoring methods, technologies, impact assessment, and initiatives in the Western Pacific and beyond; **3)** brainstorm an actionable plan for the WESTPAC Ocean Acidification Network for the next five to ten years, as a potential contribution to the UN Decade of Ocean Science for Sustainable Development (2021-2030) and the Global Ocean Acidification Observing Network (GOA-ON).

Webinar speaker presented their ongoing or planned study(ies)/assessments related to ocean acidification and its impacts on the marine ecosystem; how the study(ies) could contribute to addressing environmental and socio-economic challenges, such as climate knowledge, ecological services, seafood safety and security, and ecosystem health, etc.; and their concrete ideas/plans for conducting ocean acidification and its related studies jointly with others in the region, including any potential proposals for the UN Decade of Ocean Science.

The webinar contributed to maintaining momentum and strengthening the collaboration of the OA network in the region and seeking the future development of OA activities in serving the need of the member states in mitigation of the impact of climate change, supporting ocean-related policies development and fulfilling their commitment to the UN Sustainable Development Goals (SDGs) including UN Ocean Decade (2021-30)

3.2 Decade Action Incubator on “Ocean Solution”

The WESTPAC-OA project was a partner in organizing the decade incubator on ocean solutions, as a part of the First Kick-off of the UN Ocean Decade in the WESTPAC and its adjacent area, during 25-26 November 2022, Virtual, Bangkok, Thailand.

The incubator convenor was Dr. Aileen Tan Shau Hwai (Centre for Marine & Coastal Studies, Universiti Sains Malaysia). The session moderator was Dr. Maria Lourdes San Diego-McGlone (Marine Science Institute, University of the Philippines).

The aims of the incubator were (1) to Understand the impacts of multiple stressors and their impacts on natural ecosystems and coastal communities, (2) to explore and share the multidisciplinary finding approaches and practices on the research and monitoring of multiple stressors and their impacts, (3) Develop a regional network to advance multidisciplinary research and engagement with coastal communities and provide workable science-based solutions to benefit people, nature, and livelihoods.

3.3 Intercalibration Exercise on pH and Total Alkalinity Measurement.

In early 2022, WESTPAC had close communication and consultation with OA partners in member states in planning the OA activities to support capacity and the SDG-14.3

implementation.

The intercalibration of pH and TA measurement was planned for 2020. However, it could not implement due to the unprecedented pandemic, as the Andrew Dickson Laboratory, Scripps Institute of Oceanography, USA, which is only a producer of the Certified Reference Materials for pH and TA, closed the production line of CRM of pH and TA. With the strong support of Andrew Dickson Laboratories, we could order enough CRMs of pH (TRIS) and TA for the exercise in late 2021 and be able to ship to WESTPAC in early 2022.

A call for expression of interest in joining the WESTPAC Intercalibration Exercise on pH and Total Alkalinity Measurement was made to IOC National Focal Points for WESTPAC in September 2021. We received an expression of interest in participating in the Intercalibration Exercise from 19 research institutes in 9 countries.

The CRMs of pH and TA were shipped to most of participating institutes in March 2022, exception of one participating lab in Russia that could not receive the CRMS due to no operating shipping companies at the time being, and the results of the intercalibration exercise were submitted entirely to the WESTPAC in late 2022. Eighteen participating labs presented pH measurement results, and only 16 submitted acceptable results following the technical guidelines for the intercalibration exercise, while seventeen participating labs submitted Total Alkalinity (TA) measurement results.

The pH and TA measurement results of a majority of the participating labs could reach the data quality requirement of SDGs-14.3.1.

3.4 Training material (video) for the operation of the Autonomous Reef Monitoring Structure (ARMS) and calcification accretion Unit (CAU) in monitoring biodiversity in the coral reef area.

As part of the efforts to monitor the ecological impacts of ocean acidification on coral reef ecosystems, the IOC Sub-Commission for the Western Pacific (WESTPAC) promotes the use of Autonomous Reef Monitoring Structures (ARMS) as a standard method to examine and monitor the most diverse community of organisms on coral reef, the cryptobiotic. The ARMS design aims to simulate a reef's structural complexity to attract colonizing marine invertebrates. The Standard Operating Procedures for ARMS can be found here (<http://file.iocwestpac.org/OA/SOP/Chapter%203/Chapter%203-draft%20ARMS%20SOP-01%20Nov%202018.pdf>)

To meet the demands and develop the capacity of Member States and their research institutions for monitoring the environmental impact of ocean acidification on coral reefs, WESTPAC produced an audio-video material introducing the use and processing of ARMS and CAUs. The product will be shared widely with interested institutions in the region and ensure the data that could be collected and comparable over the long years.

WESTPAC and regional experts worked very closely with the professional consultant in producing the audio video introducing the use and processing of ARMS and CAUs.

3.5 National Training Workshop on Ocean acidification and its impacts on marine ecosystems in Malaysia, Thailand, and Vietnam.

The IOC Sub-Commission for the Western Pacific (WESTPAC) seeks to support our Member States in the region in preparing for and responding to ocean acidification by improving research capacity, transferring marine technology, and advancing our understanding of ocean acidification and its impacts on ocean ecosystems.

WESTPAC has succeeded in implementing the ocean acidification project in the region, the member states enable to monitor ocean acidification and generate qualified data in contributing to the SDG-14.3.1 data portal. However, implementation of OA activities at the national level is still limited to a few research institutes, such as those collaborating closely with the WESTPAC OA project. Therefore, capacity building at the national level needs to be expanded to accelerate OA research and monitoring in the country to understand better the impacts of OA on marine organisms, livelihood, and the economy. Three national training were conducted by the leading research institutes of WESTPAC OA in Malaysia, Thailand, and Vietnam in late 2022. The training subjects were technical chemical analysis of pH and Total Alkalinity, application of ARMS and CAU, data and information requirements for SDG-14.3.1, and impacts of OA on marine organisms and habitats that are required by the countries. The highlighted topics were adjusted to each country's background and needs. The participants came from diverse stakeholders, such as researchers, academics, policymakers, and government agencies. The training aimed to understand the status of OA, increase awareness of OA impacts, and sustain OA-related activities through close collaboration among research institutes, universities, and government agencies in the countries and regions

The host of the training in each country is listed below;

1. Malaysia: Centre for Marine and Coastal Studies (CEMACS), Universiti Sains Malaysia (USM), Penang;
2. Thailand: Prince of Songkhla University, Phuket Campus, and Phuket Marine Biological Center, Phuket, Thailand
3. Vietnam, Institute of Oceanography, Nha Trang.

4 A summary of key achievements since its establishment

- Established the WESTPAC ocean acidification network and 21 pilot OA monitoring sites in 2015, and later expanded to about 90 sites in the region for monitoring of pH, total alkalinity (TA), and other related carbonate parameters, including cryptobiotic biodiversity change overtime in correlating to the OA in the coral reef sites.
- Developed Standard Operating Procedures (SOPs) for pH and Total Alkalinity (TA) analysis, including seawater sampling and preservation methods, and the Autonomous Reef Monitoring Structure (ARMS) and Carbonate Creation Unit for monitoring of cryptobiotic biodiversity in the coral reef.
- Capacity development for monitoring pH, TA, and other related parameters, and impacts of OA on coral reefs, particularly on effects of OA on cryptobiotic biodiversity using ARMS and CAU, as well as improved capability of laboratories on analysis of pH and TA through training workshop and exchange visiting researchers among the Member States in improving their data quality of pH and TA measurement to meet the requirement of SDG-14.3.1 (data portal).
- Organize intercalibration exercise on pH and TA measurement, which aimed to understand better the analytical capability status of the laboratories in the region and further improve their capability, if required.
- Many WESTPAC Member States have started submitting OA-related data from joining efforts with the WESTPAC-OA activities to the SDG-14.3.1 (data portal).

Self-assessment on implementation against objectives

The implementation of the OA project has received strong support and active participation from the partners, such as research institutes, universities, and government agencies, in developing the OA activities and establishing OA monitoring sites in their countries.

The project has successfully coordinated and established the OA network in the region, with WESTPAC providing technical support. A training workshop series has provided an opportunity for the member states to escalate their capability to the monitoring of OA and its impacts on the coral reef and could contribute the data and information to achieve their commitment to the target of the SG-14.3.1 and contribute to the development of national policy on adaptation and mitigation to the climate change.

However, capacity building is still required in the region, particularly at the national level, which needs to be strengthened their collaboration on research, monitoring, and building awareness of OA impacts, which needs much effort to carry out by using the standard method to ensure that the generated data can be compared to better understand the OA situation and predicting its impact in the future at the national regional, and global level. The national training in Malaysia, Thailand, and Vietnam in late 2022 has shown that participants have committed to strengthening their collaboration within the country to implement OA activities together.

There were outputs which producing from the implementation of OA activities in the countries, such as the publication of a manual/guideline/guidebook for implementation of OA monitoring in local languages, including the national report on the status of OA and research publication on OA impact of coral and marine environments.

Problems encountered and recommended actions

- 4.1 The project implementation encountered difficulty implementation of project activities following the work plan due to the ongoing pandemic in the region, most regional activities were conducted through virtual and correspondence. However, with close communication and collaboration between WESTPAC and partners in the member states, the national training on ocean acidification and its impacts on the coral reef was initiated when the situation in some member countries allowed conducting in-person activities, Three countries, Malaysia, Thailand, and Vietnam, enable to run national training in late of 2022.
- 4.2 Some countries need long-term financial support to implement the OA monitoring, so it may need to be reflexed in the Intergovernmental Session of WESTPAC (2023) to make the countries in the region aware of the need for support.

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

- 5.1 To achieve objectives 1 and 2, the project will organize the technical consultative workshop and follow-up training workshop of the OA expert and lead implementing institutes of WESTPAC-OA to seek agreement in developing study/research of ocean acidification impacts on marine organisms, ecosystem, and fisheries, which build on previous capacity building and activities, including selected study sites in different countries, agree of selected organisms/habitat/activities to be carried out in the region, which are common concerns and require of the Member.
- 5.2 To achieve objective 3, the project will collaborate and be active in participating or partnering with other OA-related activities under the WESTPAC framework and seeking the possibility of integrating knowledge or activities to synergic effort in developing new activities that could

generate the multidisciplinary scientific knowledge to help understand the synergetic impacts of OA with other occurring stressors and oceanographic processes in the coastal area, which is vital to fisheries, livelihood, and economy of the countries. One possible participating event is the organizing incubator of WESTPAC, particularly on the development of the “Ocean Solution” project to support the UN Ocean Decade challenges, which drafty planned for early 2024.

5.3 The project will keep close communication with the Member States and WESTPAC-OA network in supporting capacity development through encouraging and supporting capacity building, particularly in countries that may have different requirements from country to country. The project will also take the opportunity to organize the OA’s session at the WESTPAC International Marine Science Conference and workshop to exchange knowledge and lesson and learn of OA research, application in transferring research results to support policy development on mitigate and adapt and management of the coast and ocean.

6 Planned activities for May 2023- April 2025

[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)	
Monitoring the Ecological Impact of Ocean Acidification on Coral Reefs	1. Workshop on strengthening the regional development of OA monitor and research on OA affecting the coastal ecosystem.	<ol style="list-style-type: none"> 1. Review the progress of the regional OA project and national activities of OA -related 2. Develop the collaboration on studying the OA impacts on marine ecosystem functions and services, including identifying potential study sites in the region and strengthening capacity development 	<ol style="list-style-type: none"> 1. The actionable regional research and monitoring of the OA impacts. 2. Establish the pilot's study sites/selected organisms/ecosystem-related function in participating member states. 3. Identified good practices to be used for project implementation 	Late 2023	18,000 US\$		

Program					Funding Required		Remark
	Activities	Objectives	Expected outputs/outcomes	Date and place	IOC	Other sources (i.e., from national or international)	
	2. Training workshop on the regional development of OA monitor and research on OA affecting the coastal ecosystem.	1. Follow up the progresses OA activities in Member States, based on agreement at the first workshop including reviewed progresses of OA monitoring sites. 2. Identify the good practices for OA impacts study and build up the capacity for monitoring and research	1. The participating research institutes, university, and government agencies formulated the OA impacts study/research and keep maintain the monitoring sites of OA in supporting the SDG-14.3. 2. The ecological function/service impacts of OA study/research have established in the Member States and started implements.	Mid or late 2024	18,000		

Program					Funding Required		Remark
	Activities	Objectives	Expected outputs/outcomes	Date and place	IOC	Other sources (i.e., from national or international)	
	3 Organize OA Session and workshop at the WESTPAC International Marine Science Conference, Thailand (2024)	<ol style="list-style-type: none"> 1. Knowledges and up-to-date technologies exchange based on research results to bring up the concerning OA impacts and discussion on the development future action. 2. Follow up the progresses of OA project activities. 3. To strengthen collaboration of OA research and related concerning actions 	<ol style="list-style-type: none"> 1. Strengthening regional OA network and update information and knowledge of the region and glob. 2. Getting more partners and idea to develop the direction of OA activities to fulfil requirement of the Member States in contributing to their commitment to the UN SDG-14.3. 	April 2024	3,000 US\$		

Program					Funding Required		Remark
	Activities	Objectives	Expected outputs/outcomes	Date and place	IOC	Other sources (i.e., from national or international)	
	4 Partner with other WESTPAC projects in Develop Session of WESTPAC Incubator	1. To take opportunity, in joining effort with other WESTPAC projects, to develop the UN Ocean Decade project in supporting the implementation of UN Ocean Decade (2021-30)	2. To join an effort with other partners to establish the UN Ocean Decade project under the WESTPAC framework, particular on the Ocean Solution Incubator which was first organized at the Incubators session of the First Regional Ocean Decade Conference in November 2021	April 2024	3,000 US\$		