In accordance with Terms of Reference of IOC Sub-Commission for the Western Pacific, the report is provided to facilitate the consideration by the Sub-Commission on the progress made on the WESTPAC project – Ocean Forecasting System (OFS).

The report presents a summary of the activities and results of OFS over the last intersessional period. The Sub-Commission is invited to consider its workplan for the next intersessional period.
I. Project

The SEAGOOS Ocean Forecasting System program will provide an operational ocean forecasting system for Southeast Asia and its adjacent seas, and demonstrate the value in scientific research and ocean management, resources exploitation, reduction and prevention of the impacts of natural hazards, mitigation of the impact and adaptation to climate change and variability. The Ocean Forecasting System (OFS) includes ocean model, data assimilation, ocean monitoring and observation, products generation and visualization, products distribution and service.

II. Project objectives and expected outputs/outcomes

Objectives:
- Establishing a regional ocean forecasting system with higher resolution model for the geographic coverage;
- Establishing several pilot ocean-forecasting systems for selected subdomains;
- Improving the application of OFS to scientific research and ocean governance;
- Enhancing regional and national capacity for ocean modeling development, data assimilation, and model validation.

Expected outputs/outcomes:
- A regional ocean forecasting system with higher resolution model for the Southeast Asian seas
- Several pilot ocean forecasting systems for selected subdomains such as the Gulf of Thailand and the Malaysian East Peninsula Shelf.
- Enhanced understanding of key processes and scientific issues of regional seas in the region; and
- Enhanced regional capacity in numerical ocean modeling.

III. Principal Investigator (Chairperson) and Project Steering Group

Principal Investigator:
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Project Steering Group:
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Prof Dr Fredolin Tangang (tangang@ukm.edu.my)
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Phuket Marine Biological Center (PMBC), Thailand

Dr Budi Sulistiyo
Research and Development Agency for Marine and Fisheries
Ministry of Marine Affairs and Fisheries, Indonesia

IV. Terms of Reference of the Program Steering Group

- To discuss and determine the main research activities of OFS;
- To coordinate joint cruises;
- To organize and chair workshops;
To seek financial support for OFS; and
To guide the development of OFS.

V. Activities carried out during the last intersessional period (May 2017 – April 2019)

1. Remarkable progress has been made since May 2017. The Activities carried out can be divided into 4 stages: 1) Model development, 2) OFS launching and application, 3) Data collection and Joint Cruise and 4) workshop, training and outreach.

1. Model development

1.1. Breakthrough in the typhoon model considering the surface waves and rainfall

2. The OFS team explored the sensitivity of typhoon simulation to three physical processes using a fully coupled atmosphere-ocean-wave model. The effects of wave breaking-induced sea spray, ocean vertical mixing associated with nonbreaking surface waves, and sea surface cooling due to intense rainfall were assessed by means of a set of numerical experiments. They found that sea spray leads to an increase of typhoon intensity by enhancing the air-sea heat flux, while nonbreaking wave-induced vertical mixing and rainfall lead to a decrease. Each process can be relevant, depending on wind and wave conditions. These can vary dramatically when typhoons interact with not sufficiently well-defined coastal areas, typically an archipelago. The results were published in the *Journal of Geophysical Research: Oceans* in 2017 (Doi: 10.1002/2016JC012262).

1.2. Development and validation of FIOCOM

3. FIOCOM (surface wave-tide-circulation Coupled Ocean Model developed by the First Institute of Oceanography, Ministry of Natural Resources, is the state-of-the-art ocean model based on ocean circulation model of MOM5 (Modular Ocean Model, version 5) and the third-generation surface wave model of MASNUM. In FIOCOM, the non-breaking surface wave-induced mixing of Bv (Qiao et al, 2004, 2010, 2016) is incorporated into the K-profile parameterization (KPP) vertical mixing scheme.

4. The observations supported in this system have been divided into 3 kinds according to their location and time spreads, including the scatter points at sea surface, vertical profiles from Argo and in situ observing, and the field observation from satellites. In order to make this system more portable, more general application interface have been designed for different grid system commonly employed in those state-of-the-art ocean models including the Arakawa-C and Arakawa-B grid in horizontal, z-coordinate, sigma-coordinate and S-coordinate in vertical.

5. This ODA system has been applied into a global high resolution wave-tide-circulation coupled forecast system based on the FIOCOM (wave-tide-circulation coupled ocean model
developed by the First Institute of Oceanography, Ministry of Natural Resources of China) to setup an operational forecast system.

6. To validate the simulation and prediction ability of FIOCOM, the CORE2 climate atmospheric driving field is used to drive the model for 13 years. The reanalysis and hind cast ability of the forecasting system are tested.

2. OFS launching and application

2.1 Official launch of the Ocean Forecasting System for the 21st Century Maritime Silk Road

7. Urged by increasing demand of accurate ocean forecasting results from member states, IOC/WESTPAC invited FIO to publish the OFS products on their official website. Ocean Forecasting Systems for the 21st Century Maritime Silk Road was officially launched on 10 December, 2018. The OFS provides 5-day forecast products and downloadable archived data of surface wave height, wave period, sea level, three-dimensional ocean current, sea temperature and salinity etc. The above forecasted crucial information could serve the needs of a variety of human activities related to the prevention and reduction of marine hazards, fishery management, protection of marine environment and conservation of marine ecosystems etc. All products are for non-commercial use with citation of “FIO-COM products”. The forecasting products can be easily accessed both through the website http://221.215.61.118:2018/#/ and the phone APP “Global Ocean on Desk” (GOOD).

8. China’s top ocean journal Acta Oceanologica Sinica reports this news in the form of cover story in its January 2019 volume.
2.2 Application in the Thailand ferry boat accident rescue in July 2018

At 17:45 July 5, 2018, two tourist boats sank due to heavy storm and strong surface wave near Phuket Thailand, and resulted in the missing of 47 Chinese citizens. To search and rescue the missing people, forecasting information from OFS was urgently needed. For the purpose of rescuing, hot discussion among Mr Wannakiat Thubthimsang, Prof Somkiat Khokiattiwong and Prof Qiao Fangli was effectively set up. An emergency technical support team with members from FIO, China and PMBC, Thailand was immediately established. Within 24h of the accident, the OFS team successfully provided the first forecasting report of surface currents and wave heights. Totally 7 forecast reports were provided by the OFS team and adopted by the Thailand rescue team. And OFS forecasting results were confirmed for the following rescue operations, which was a new success for practical applications.
Figure 7 Sank sites of the two ferry boats due to heavy storm near Phuket, Thailand on July 5, 2018

Figure 8 The forecast search area for missing people in action planning
2.3 Application in the prediction of oil spill

10. At 7:51 pm CST (China Standard Time or Beijing Time, GMT+8) on 6 January 2018, the Panamanian-flagged, Iranian-owned oil tanker *Sanchi*, which was carrying a full cargo of 136,000 metric tons of natural gas condensate, collided with the Hong Kong-flagged cargo ship *CF Crystal* in the East China Sea at (30°42ʹN, 124°56ʹE), 300 km off Shanghai, China. The OFS team established a comprehensive 3D oil spill model to simulate and estimate the pollution probability after the *Sanchi* sank. The wind, ocean current and surface wave data produced by the OFS was used to track oil particles for up to 180 days after the *Sanchi* collision event. The short-term simulations show consistent patterns with the synchronous satellite images and observations. The potential contaminated areas are dependent on the properties of the released oil.

![Figure 9 Comparison between simulated virtual oil particles (colored dots) and the reported oil pollution sites (colored circles,) up to April 1, 2018.](image)

11. The color indicates the days after the *Sanchi* sank. Dots and circles of different colors indicate days after the *Sanchi* sank. If the dates of observation (circles) are later than or consistent with the simulations (dots), it means the simulation results are consistent with the observations.

3. Data collecting and Joint Cruise

12. Joint survey cruises were carried out in the Gulf of Thailand, Malaysian Peninsula Eastern Continental Shelf and the Andaman Sea for providing data to OFS (Figure 10). Operational monitoring buoys have also been deployed in the region. The monitoring elements include temperature, salinity, current, meteorological parameters, etc. The observed data is used in data assimilation and validation of the OFS. Figure 11 shows the comparison between the observed (up) and forecast (down) temperature at mooring buoy station M5 in 2017. It can be seen that the forecasted temperature agree with the temperature chain observation. Figure 12 shows the comparison of the observed and forecasted currents at M5 in 2017. The forecasted northward velocity agrees with the ADCP observed velocity quite well. The forecasted eastward velocity generally agrees with the ADCP.
4. **Workshop, training and outreach**

4.1 **The 7th IOC/WESTPAC Technical Workshop on SEAGOOS Ocean Forecasting System (OFS) Strategy Development**

13. The 7th IOC/WESTPAC Technical Workshop on SEAGOOS Ocean Forecasting System (OFS) Strategy Development, co-hosted by UNESCO/IOC Sub-Commission for the Western Pacific and the First Institute of Oceanography of the Ministry of Natural Resources of China, was successfully held in Beihai, Guangxi, China on November 18, 2018. 32 experts and representatives from China, Thailand, Malaysia, Indonesia, Vietnam, Philippines, Myanmar, Bangladesh and WESTPAC attended the workshop.

14. The workshop included three sessions, the opening ceremony and invited talk, ocean model development and observation, and OFS action plan for the period 2019-2020.

15. Professor Somkiat Khokiattiwong, co-PI of the OFS program, summarized the learned course of OFS and its recent progresses and spoke highly of the progresses made recently, especially China’s main contribution. Professor Somkiat pointed out that in Thailand the forecast products of OFS have been directly applied in such fields as marine disaster mitigation and prevention, maritime search and rescue, prediction of oil spill drift, pollution diffusion and management of marine resources, from which Thailand has benefited a lot. In particular, the OFS system played a critical role in the shipwreck accident in Thailand on 5 July, 2018. It was actually applied in Thailand rescue, and the accuracy of its prediction results was verified by the follow-up
search and rescue. The ongoing work includes organizing joint cruises to obtain observation data to verify the OFS system. He mentioned that the program team is expected to release the OFS forecast results of a larger region as soon as possible to benefit more countries, and it is also hoped to cooperate with China to develop high-resolution subdomain models.

16. Professor Qiao Fangli, PI of the OFS program, summarized the progress and achievements made by OFS over the past two years. According to Professor Qiao, the typhoon models have made a breakthrough with the wave-induced mixing and the spray processes. The OFS, whose forecast products were published on the official website of Malaysian Meteorological Department, has become the national marine forecasting system of Thailand. Using the OFS forecast products, a highly accurate oil-spilling and search and rescue model has been developed, which forecasted ocean surface currents, surface waves and the scope of search and rescue in the search and rescue operation after the shipwreck incident happened in Phuket in 2018 and whose forecast products were confirmed by the follow-up rescue operations, creating a new and successful paradigm for application. A visualization system of the new forecast products and a phone APP have also been developed.

17. Attendees spoke highly of OFS and were especially interested in its applications in the search and rescue in Thailand shipwreck. OFS was expected to be used in the Maritime Silk Road waters and provide forecast products on marine environments. Attendees said that they were going to actively participate in the cooperation on OFS and popularize OFS in their own countries, hoping the whole region’s capacity in marine ecosystem protection and disaster prevention and mitigation could be improved by means of the high-level practical forecast on marine environment.

![Image](image_url)

Figure 11 Group photo of the 7th IOC/WESTPAC Technical Workshop on SEAGOOS Ocean Forecasting System

**4.2 The 2018 WESTPAC ODC Training Course on Ocean Forecast System was successfully accomplished in Qingdao**

18. On 7 July 2018, the eighth ODC training course on Ocean Forecast System was accomplished in Qingdao. The course covered all the components of the ocean forecast system, including circulation, tide, wave models and their coupling in coastal regions, data assimilation and the interpretation of the forecasted results. This training course was organized in the First Institute of Oceanography (FIO) of the Ministry of Natural Resources, China, together with the first CLIVAR-
FIO summer school from 25 June to 7 July 2018. There were 14 world famous experts from Australia, France, Germany, Italy, UK and China to participate in lectures and related practices. There were 47 trainees from 28 countries (Argentina, Bangladesh, Brazil, Cameroon, Cuba, Ecuador, Egypt, Ethiopia, Germany, Guatemala, India, Indonesia, Iran, Kenya, ROK, Malaysia, Mexico, the Netherlands, Nigeria, Pakistan, the Philippines, Poland, Russia, Sri Lanka, Thailand, USA, Vietnam and China).

19. Beside the training courses, the trainee reports, group discussions and group reports have also been carried out in order to enrich the activities and help them to initiate some primitive cooperation during these two weeks. At last, certifications have been issued to those trainees who have completed all the courses and 4 trainees (Mr Tim Hermans from NIOZ, the Royal Netherlands Institute of Sea Research; Dr Long Xiaoyu from the University of Hawaii Sea Level Center, USA; Mr K M Azam Chowdhury from the University of Dhaka, Bangladesh and Mr Amr Salama from the Alexandria University of Egypt) were honored as the best trainees based on their performance during these 2 weeks. The practices and activities carried out in this training course created a pleasant learning environment with more opportunity for trainees and experts to discuss. Through these 2 weeks, all trainees have grasped new knowledge and skills, and the friendship among them had been established. Different from previous training courses, the trainees for this year were not mainly from the WESTPAC region, and future cooperation on modeling the ocean will be promoted worldwide.
VI. Outputs generated during the intersessional period (May 2017 – April 2019)

- Breakthrough in the typhoon model considering the surface waves and rainfall
- Official launch of the Ocean Forecasting System for the 21st Century Maritime Silk Road

VII. Problems encountered and actions to be considered by the 12th Intergovernmental Session, scheduled for 2-5 April 2019, Manila, the Philippines
## VIII. Workplan and Budget for May 2019 – April 2021

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<td>To develop subdomain high-resolution models such as the Thailand waters in the Anderman Sea with scientists Thailand</td>
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