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Capacity Building on Global Marine Debris Monitoring and Modeling: Supports Protection of the Marine Environment

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ABBREVIATIONS AND ACRONYMS

ALDG	Abandoned, Lost or Otherwise Discarded Fishing Gear
AFD	*Agence Française de Développement*
AOFIC	APEC Ocean Fisheries Information Center
APEC	Asia-Pacific Economic Cooperation
APEC OFWG	APEC Ocean and Fisheries Working Group
BMKG	Meteorology, Climatology, and Geophysical Agency
BPPT	Agency for the Assessment and Application of Technology
CLS	*Collecte Localisation Satelite*
CNES	The National Centre for Space Studies
CSRIO	Commonwealth Scientific and Industrial Research Organisation
Dishidros AL	Naval Oceanographic Service of the Navy
DJPRL	Directorate General of Marine Spatial Management
EU	European Union
FEB RAS	Far East Branch of the Russian Academy of Sciences
FORKOMAPIN	Coastal and Fishermen Community Communication Forum
FVCOM	Finite Volume Coastal Ocean Model
GDP	Gross Domestic Product
HPC	High Performance Computing
HYCOM	Hybrid Coordinate Ocean Model
IFREMER	*Institut Français de Recherche pour l'Exploitation de la Mer*
IGM	Intergovernmental Meeting
ILC	Interlaboratory Comparison
IRD	*Institut de Recherche pour le Développement*
KM	Kilometers
LAPAN	National Institute of Aeronautics and Space
LIPI	Indonesian Institute of Sciences
MEMR	Ministry of Energy and Mineral Resources
MMAF	Ministry of Marine Affairs and Fisheries
MMT	Million Metric Tons
MOBIDRIFT	an Operational Drift Tool
MOEF	Ministry of Environmental and Forestry
MOHA	Ministry of Home Affairs
MPs	Microplasctics
MPWH	Ministry of Public Works and Public Housing
NASA	The National Aeronautics and Space Administration
NOAA	The National Oceanic and Atmospheric Administration
NOWPAP	Northwest Pacific Action Plan
NSCMB	National Scientific Center of Marine Biology
ODE	Ordinary Differential Equations
OMIS	Ocean Monitoring Information System
PAYT	Pay-as-you-throw
PET	Polyethylene terephthalate
PGI	Pacific Geographical Institute
PMUs	Project Management Units
POMRAC	Pollution Monitoring Regional Activity Centre
RFID	Radio Frequency Identification
SIDIK	Marine Prediction System
TPS	Temporary Landfill

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1. INTRODUCTION OF THE PROJECT

In 2016 APEC news release, Lead Shepherd of the APEC Oceans and Fisheries Working Group stated that “APEC economies are mobilizing to reduce the losses that they suffer due to marine debris which total an estimated USD 1.26 billion annually. Moreover, the presence of marine litters in marine species for human consumption and the high intake of seafood in some economies cause concern about the potential effects on human health and food security. To be able to participate in monitoring the marine debris and its impact, implementing some coordinative actions and a series of actual and updated data are needed”.

This project will cover topic on marine debris monitoring through ocean modeling, integrated with marine debris tagging and also will focus on marine debris sources, trajectory simulation and impact to coastal area and marine ecosystem. At the end of capacity building, participants will have ability to use this tools (monitoring and ocean modeling) to identify marine debris distribution and seasonal pattern. The project will also try to promote one regional monitoring program and share a virtual collective awareness in order to align the movement in the same directions and promotes better action plans in term to ocean sustainability through existing AOFIC (APEC Ocean Fisheries Information Center) web portal, which will lead to sustainability of the program.

The program is designed to encourage all APEC economies in term of prevention, preparedness and awareness by implementing and continuing the action plan of marine debris based on previous APEC capacity building experiences. Moreover, the workshop also wants to strengthen the connectivity between APEC economies’ institution that related to marine debris, so together will promote APEC to combat marine debris problems. This program is significantly useful for APEC economies by specifically targeting developing economy APEC members, especially merging the data with other agencies within APEC.

The project is in line with APEC OFWG Working Plan 2016-2018, where it can help APEC economies especially developing economy to support APEC priorities, including: (a) Support the sustainable development and protection of the marine environment by providing appropriate tools to measure the marine debris movement, distribution and recommending the action plans in more effectively and efficiently which is in line with the OFWG commitment; (b) To ensure food security by knowing marine debris dispersions and taking appropriate countermeasure; (c) Strengthening the connectivity and role of APEC member states by encouraging APEC member participants on the disaster risk reduction against marine debris issues; (d) Understanding the role of ocean circulation related to marine debris impacts and

promoting mutual practice accordance to Blue Economy in term of sustainability and conservation.

2. SUMMARY PRESENTATION

2.1. Session 1

Indonesian representatives from the Ministry of Maritime Affairs and Investment and the Ministry of Marine Affairs and Fisheries, provide several regulations regarding waste management in Indonesia. Indonesia's Ocean Policy aims to "providing guidance for planning of development in various marine sectors in Indonesia". Strengthened by Presidential Decree 83/2018 on Management of Marine Litter, Indonesia will reduce waste by 3R (reduce-reuse-recycle) to 30% in 2025, while target a reduction of plastic waste as much as 70% in 2025. There are 5 National Action Plan which focusing on behavioral change, reduction of land-base leakage, reduction of sea bed leakage, enhancement of law enforcement, finance, as well as research and development. Indonesia has been implementing the 5 R concept as a foundation in combating plastic waste which are rethink, refuse, reduce, reuse, recycle.

Australia, represented by CSRIO, emphasize the importance of engagement between government and industry to support on effective and affordable solutions. Marine debris becoming a transboundary problem which required integrated responses. Integrated responses in 5 entities such as governance, research, producer, consumers, and waste management.

2.2. Session 2

IRD as The French National Research Institute for Development, presents an application for modeling the real marine debris problem. The presenter explains a method to evaluate the « realistic » input scenarios (van Sebille et al. 2015 vs. Lebreton et al. 2017) of marine litter (microplastics or whatever small floating material or debris), then followed by a simple approach which considering 1 million particles along the coasts (first ocean point in the model adjacent to land mask).

In Japan, field surveys of meso- and microplastics around East Asian Seas have been done since 2014. Sampling of small plastic fragments trapped using neuston net 0.75 x 0.75 m^2, net size of 350 µm) equipped with a flow meter. Microplastic surveys & monitoring are conducted as an "interlaboratory comparison (ILC) experiment" for measuring the abundance of microplastics in standard seawater samples. Three types of man-made MPs which prepared for ILC experiment have an irregular-shaped with MPs size >1.0 mm, 0.3 mm < rhombic MPs

<1.0 mm, and Fibers. Microplastic monitoring that conducted by the Ministry of Environment in Japan have been from 2014 to the present. These surveys indicate that the eastern part of Indian Ocean may be more contaminated by plastics compared to the East Asian Sea (Yona et al., in preparation). In particular, the highest concentration is appeared in the East Asian Sea, making this region as a hotspot for marine plastic pollution, with assumption that the past releases are proportional to the Gross Domestic Product (GDP) time series in each region.

Plastic waste are mostly produced from land and entering the ocean with total production of 0.46-1.29 Mil./year. It is estimated around 0.27-0.59 Mil/year according to LIPI in 2019. The national target is to reduce 70% by 2025. In Bali, marine litter are transported and distributed from Bali strait for about 15 days directed by dominant wind direction, then will reach and stranded on Kuta beach. Inorganic litter composition was higher than the organic one. A simple technology has been used to reduce the volume of marine litter which managed in land area, such as 3R, litter entrapment on river, and solid waste management.

2.3. Session 3

Marine debris in Indonesia had been spotted in many beaches. It is reported from sampling activities on 18 stations in 2017 that can represent a nation-wide status. Composition of these debris were varied, which then classified into 9 categories such as wood, plastic, metal, plastic foam, glass and ceramics, fiber, paper/cardboard, cloth, and others. Marine debris can impact biodiversity in a number of ways, namely through entanglement in, or ingestion of, debris items by individuals. Marine debris should be acknowledged as a major additional driver that contribute to the degradation of marine environments.

Strategies for prevention at source, need to be identified as key factor to minimize the surge of marine debris and its associated impacts. Controlling marine debris is something that can be done in a framework approach that focuses on prevention. There are numerous policies, programs and instruments which have been successfully used to Address the Challenge of Marine Debris. These measures can be effectively used in reducing debris at points of origin and in improved life cycle management.

IRD mentioned that around 60 to 90% of marine debris composition is plastic which found in various form, such as cigarettes butts, fishing gears, food containers, plastic bags, etc. Many sectors have been impacted, including shipping, fishing, aquaculture, and tourism. Total loss due to marine debris is estimated up to $ 8 billion/year (fisheries, aquaculture, marine tourism, cleanups). It is reported that marine ecosystem (reef) is experiencing a mechanic destruction, where 11.1 billion plastic items entangled the coral reefs across Asia-Pacific. Reef-building

corals with plastic debris have different disease assemblages than corals without plastic debris. Plastic waste influences disease susceptibility of reef-building corals. Marine debris also become a polluted sediment in deep seafloor. Filter feeder larvaceans introduce the particles into food webs from near-surface waters to the deep seafloor. As deep-sea ecosystems are poorly known, precise impact remains inestimable. In addition, marine debris also killing marine life through entanglement, suffocation, congestion, false satiety, and lethal ingestion of macro and microplastics by megafauna.

In 2015, Dr Jenna R. Jambeck et. al. published the study on plastic debris in the ocean worldwide, where put Indonesia as the 2nd largest contributor of marine plastic litter in the world (+1.29 MMT annually). Marine debris impacting Indonesia's marine ecosystem. Marine debris is a complex problem and transboundary in nature. Considering the geographical factor and the scale of Marine Debris impact on our marine ecosystem that also affecting biodiversity as well as human being, we need to have a collaboration/joint research on marine debris to study the impact of Marine Debris to our marine ecosystem in an efficient and effective manner; and the more important thing is to find applicable solutions/prevention. Impact of Marine Debris on the species from the base of food chain up to the human health.

2.4. Session 4

In accordance with the mandate of Presidential Decree No. 83/2018 regarding Indonesian Action Plan to Combat Marine Debris, A government agency under MMAF/KKP (namely DJPRL) conducts several activities as part of Marine Debris Management in Coastal Area (Strategy 3) such as: Beach and Underwater Clean Up (*Gerakan Bersih Pantai dan Laut/GITA LAUT*) and 5R campaign. Recycling activity was done by provisioning the press equipment, training on the collection and sorting of waste that facilitated by Forkomapin Garbage Bank, where the output from waste management activities can increase by about 4 times than before. This achievement is indicated by significant increase of revenue by the end of December 2019, where it almost reaching Rp 10,000,000. DJPRL also trained community groups that doing handicraft activities, where they have been able to convert plastic sachet waste into wallets, tissue containers, and bags. Other housewives' group are now able to create various products from used paper, such as spoon, candy container, flowerpot and calligraphy. Recycling activity captures value from used materials, increasing producers' efficiency, create jobs and direct investments in small/localized waste collection infrastructure, which will reducing litter in upland and eventually reduce the litter that entering ocean.

Ocean Conservancy is working to protect the ocean from today's greatest global challenges. Together with their partners, they create science-based solutions for a healthy ocean, and the

wildlife and communities that depend on it. Waste pickers are less likely to collect low-value, high-bulk plastic waste. They delivered a multi-stakeholder project that engaged experts from across the public and private sectors, at a global scale. There are 4 major themes of measurements which are: finance the collection, reducing problematic and unnecessary single use plastics, design for circularity, develop recycling and treatment markets for public sector and private sector. Thus, development on the recycling industry, with major investment in sorting, logistics, and recycling infrastructure, besides mechanical recycling, scale-up other suitable treatment technologies or options.

Having launched in 2018, McKinsey.org's first initiative aims to empower every community to build green, inclusive and economic recycling systems. They emphasized the fact that 8 Metric tons plastic are entering the ocean every year and 3.5 Metric tons of solid waste are produced every day. Around 2 billion people are live in communities that have no waste collection and 40% of waste are subject to open burning. Current recycling practice is trapped in a vicious cycle of volatile demand and poor supply, resulting under-investment in infrastructure. McKinsey work to break this cycle by developing collaborative solutions for both supply-and demand-side challenges. On the supply side, community encouraged to develop self-sustaining recycling systems that maximize quality and quantity of recyclable waste supply. On the other hand, industry plays on the demand side are expected to stabilize and improve regional markets to reliably absorb all recyclable material at a fair price.

2.5. Session 5

The Indonesian archipelago requires continuous monitoring, analysis and forecast of sea conditions to respond to regional and global scale phenomena which until now have not been fully understood. The Ocean Research and Observation Center has participated in Indonesian sea observation activities through a joint and independent program. OMIS (Ocean Monitoring Information System) is an observation and modeling prototype. The long-term marine observation program is important to provide data and information source for assessing the state of the marine and fisheries environment, monitoring and assessment of integrated water cycles, management of marine resources, enhancing the safety and efficiency of sea transportation, anticipating and mitigating the effects of environmental disasters, the study of marine climate variability, also for coastal management and planning. This system is supported by HPC (High Performance Computing), where HPC can perform an Ocean Remote Sensing, Ocean Modelling and Coastal Dynamics computation. Development of SIDIK (*Sistem Prediksi Kelautan*) is expected to provide ocean observation data for several institutions such as LAPAN. BMKG, Dishidros, MoEF, Academics, BPPT, LIPI etc. This

agency also involved in collaboration with other institutions in Indonesia to implement the Operational Oceanography through data and information sharing and capacity building.

CLS was established in 1986 by CNES, the French Space Agency, and IFREMER, the French Oceanography Research Institute, to operate the NASA – NOAA - CNES Argos program. Currently, they run a 2-years program (2020-2021), which is the combination of: oceanography simulation, tests and studies using existing model in-situ marine debris-like drifters tracking system. By comparing the model and actual drift data, the model can be improved and can help to identify statistically presence of debris hotspots at sea. All results will be displayed and useable by trained KKP personnel via a web portal. They will be able to run drift simulation themselves. Once some statistical hotspots have been identified, verification & survey at sea or on shore will be performed to validate/optimize the system further. In this program, 70 marine debris-like drifters will be released and the data will be compared with the drift simulation model.

2.6. Session 6

The modeling based study that conducted by Marine Research Center, MMAF, indicated that the majority of the plastic marine debris was floating on the surface (2-3 m depth) and only 20-30% that sink until 7-8 m depth. With discontinuous source, the remain of the plastic marine debris was distributed until 900 m from the beach on the west monsoon (after 40 days) and 300-400 m from the beach on east monsoon (after 46 days). Result from Banten Bay Model are (i) Wind direction is a dominant factor for the trajectory and distribution of plastic marine debris; (ii) On the east monsoon, the wind direction dominant to the west so the plastic marine debris from Banten river was moved along the shore to the west meanwhile on the west monsoon, it will moved to the east; (iii) Plastic marine debris that coming from the Banten river is potentially washed away to the Sunda strait during east monsoon and to the Jakarta bay during west monsoon. The trajectory model showed the distribution of marine debris on Banten bay and Jakarta bay and their potential impact vice versa. The model should be improved with better data input and need validation of marine debris trajectory.

Marine debris trajectory simulation that has been applied by CLS named MOBIDRIFT. MOBIDRIFT is a tool for operational drift simulations at sea level. This tool has global sea coverage, which can hold data for 6 months also has real time and forecast data. This tool can detect multiple objects. MOBIDRIFT is placed in the area to be examined as an object, then it will process existing data. The displayed results will be observed using float/radar/in situ. The parameters used in MOBIDRIFT include temperature, wind field, surface currents, tidal current, and bathymetry. It can be applied to view oil spills in an area, the distribution of

Sargassum Algae and Marine Debris drift. The selection of rivers as a source of study establishes 5-6 rivers for the first time to be studied to determine their impact on the Indonesian sea. There are 25 starting points in each river. Data recorded on the drifter will be combined with current and tidal data (100% from HYCOM) and wind data (30% from NCEP).

Numerical model can simulate flows in realistic ocean basins with a realistic sea floor. The numerical model is influenced by viscosity and non-linear dynamics. The numerical model can also calculate the likelihood of future flows. The numerical model can interpolate data of rare observations of the sea produced by ships, drifters, and satellites. Stages in making a simulation, namely (i) Defining the problem, (ii) Reviewing the theoretical background, (iii) Formulating the equation, (iv) Making the structure of the model, (v) Determining the formulation of methods for solving Equations, (vi) Determining the formulation of methods computing, (vii) Validation of models, (viii) Conducting sensitivity analysis. Preliminary Study on Plastic Transportation indicates that waste in Bali is dominated by organic waste and the rest is plastic, paper, metal, glass and others.

2.7. Session 7

The Ministry of Marine Affairs and Fisheries conducted a Preliminary Research on marine litters. For example, marine litters in Bali was calculated using modeling, and this study indicates that the amount of marine litter in February 2016 (during the west monsoon) is 4 times higher than the amount in April 2015 (transition season). Actions is needed in managing marine debris include regulation, monitoring and control. In minimizing waste, technology is needed to apply 5R (Rethink, Reduction, Reuse, Recycle, Recovery). Research and development must be continued to determine the effectiveness of a regulation.

The programming structure that needed for Solid Waste Management consists of 4 components. Component 1: Institutional Development and Policy Development, National Government (e.g. MoEF, MPWH, MEMR, MOHA) institutional analysis and strategic studies to support policy reform, planning, and capacity building to support solid waste sector. Component 2: Planning Support and Capacity Building for Local Government and Communities, Direct technical assistance to cities/districts across Indonesia to improve their planning and management of solid waste management services (approximately 50 cities). Component 3: Solid Waste Infrastructure and Services in Selected Cities, Support for the construction of large complex infrastructure including advanced treatment technologies (approx. 10 cities) and smaller incremental investments (20-30 cities)–tailored to city capacity. Component 4: Implementation Support and Technical Assistance, Provide technical support,

advisory services and training of Program Management Units (PMUs) at national level, provincial, and district levels as necessary.

AFD provides a large range of financial tools for development. Methods and policy for marine debris monitoring and distribution means scientific knowledge, standards but also tools to implement the methods (Methods), regulatory framework, stakeholders, implementation, adequate budget and responsibilities (Policy), if mismanaged any kind of waste is likely to become a marine debris within a more or less long time period (Marine debris); follow-up of project regularly, quality assessment (Monitoring), and geographic, seasonal, community related and also policy related (especially when it is local policies).

In 2015, PGI and FEB RAS carried out a preliminary work on microplastic distribution and concentration assessment in the coastal water of the Amur Bay. In the end, long term monitoring is important because it would show positive or negative effects of policies implemented in the area of plastic waste management, how it changes over time. For example, tracing the effects of restriction of single use plastic production policy, plastic import bans, etc. Pacific Geographical Institute in cooperation with NSCMB currently carries out assessment of microplastic contamination in the Amur River (under research grant from National Geographic Society) and Lake Khanka (which feeds one if its tributaries via Ussuri River).

3. CASE STUDIES DURING THE WORKSHOP

Global Plastic Leakage Project aims to estimate loads on land, drivers of leakage, and plume from unmanaged (plastic) waste involving economy partners from economy partners from Bangladesh, China, Korea, Peru, Philippines, South Africa, Sri Lanka, Thailand, United States, Chile, Ghana, Kenya, Seychelles, Mauritius, Nigeria, Australia, Chinese Taipei, Viet Nam, Brazil, India, Indonesia, Malaysia, Pakistan. The objectives are to validate and estimates the pollution, identify hotspots for loss, investigate drivers, global baseline (+national/regional), measure successes/change.

Many rivers in Indonesia such as Cipinang river in Jakarta, Kali Bahagia in Bekasi, Cikapundung river Bandung, Kali Brantas in East Java Province, Winogo river in Yogyakarta, Deli River in Medan, Takala river in Manado are full of plastic garbage that washed away into the ocean. Besides, Scientific Reports Anthropogenic Debris in Fish and Marine Biodiversity showed the Living fossil "Coelacanth": captured by fishermen, found concuming marine plastics debris in Manado, 2012. Plastic size 0.2 mm found in IkanTeri/Anchovy fish (LIPI, 2017). There are 76 fish of 11 species in Paotere Fish Market, Makassar, amount 28% of fish eat plastic with debris size 0.1 –1.6 mm.

Marine science program form Padjadjaran University conducted research on Microplasctic Tracking from Pacific Garbage to Northen Indonesia Sea. Simulation of the trajectory of microplastic particles for 1 year showed that the microplastic waste sourced from Great Pacific Garbage Patch did not reach the northern waters of Indonesia. With the widespread of research in marine debris, the impact of marine debris would be impacted into tourism, fisherman activities, local income especially in east Indonesia with the high diversity of fish and ecosystem.

Program Desa Kedas is a program to accelerate the transition towards circular economy through community-based recycling. Trainings on waste separation were given for households and businesses at the source of domestic waste. Capacity building also provided for workers in Bali on how to operate efficiently. Methodology on inclusive and collaborative approach is showing result and impact in first 10 months. Participating households gain 5 times of increasing revenue and Operation reached its profit since April. Therefore, all workers can be paid above minimum wage. Another successful indicator by percentage of waste which diverted from landfill. Composting throughput increased 4 times.

Two (2) Marge-T drifters have been released as a trial on Friday 7 March 2020 by MMAF, MoEF, Coordinating Ministry for Maritime Affairs and Investments, and CLS at the Cisadane river mouth. The first Marge-T beached on shore and was collected by a fisherman and the second Marge-T is still drifted in the Java sea. All results will be compared with the model, and published in Marine litter web portal. Marine litter web portal has been developed by World Bank and Ministry of Marine Affairs and Fisheries. It can display drifter tracking, drift simulation run, drift simulation dataset and hotspots probabilistic identification.

The distribution of marine debris in Bali was calculated using the CSIRO Method. Food wrappers (PF.6) are the most common item, followed by plastic sheeting and carry bags. Hard plastic items are less common than elsewhere, e.g. H10 –hard unknown fragments are usually very common. Fishing items do not appear in top 10 of most common fragments. Some items are very common. Food related items are common, like bottle tops, straws, foam food container, and thin film carry bag. Glass is relatively rare. One of the numerical models that used in this study is the Finite Volume Coastal Ocean Model (FVCOM). FVCOM is a hydrodynamic model. FVCOM uses the equations of momentum, continuity, temperature, salinity, density and tidal elevation. Derived from all these equations will produce Ordinary Differential Equations (ODE). Where x is the position of the particle at time $tt.\ vv$ (xx (tt), tt) velocity at 3-D (xx, yy, zz) of the hydrodynamic model.

POMRAC activity ‘Micro plastics abundance in river run off and coastal waters of the NOWPAP region’ was approved by the 21 NOWPAP IGM in 2017 as part of the activities on WG River and Direct inputs of contaminants into the marine environment of the NOWPAP region. The goal of this activity is to obtain background information on the distribution of different kinds of micro plastics in the some major rivers within Russian part of the NOWPAP region, and to trace possible impact of river run off on micro plastics quantity and composition in the coastal waters within the Russian part of the NOWPAP region. According to the current survey results, transboundary transport is an important factor in the distribution of plastic particles in the coastal marine water area of the Russian Far East. Besides, its impact is reflected in the river discharge, by the example of such rivers as Tumen and Razdolnaya/Suifendue to the economic importance and high concentration of population of their basins.

4. RECOMMENDATION OF GUIDELINES ON MARINE DEBRIS AND USING MARINE DEBRIS PORTAL

Recommendations that can be generated are related to the guidelines on marine debris and using the marine debris portal are:

1. Building commitment among ministerial/local governments/organization to reduce and eliminate marine debris.
2. Building community awareness-socialization/community involvement through communication, information and education.
3. Integrated research and development.
4. Cooperation, collaboration, and coordinative action plan on :
    a) Combating Marine Debris,
    b) Capacity Building,
    c) Law enforcement,
    d) Financing.