Guidelines and Recommendation on Vessel Innovation to Combat Marine Debris

APEC Ocean and Fisheries Working Group

April 2024

Asia-Pacific
Economic Cooperation

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APEC Project: OFWG 08 2021A

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APEC#224-OF-03.1

EXECUTIVE SUMMARY

Initial Guidelines and Recommendation Documents for the APEC OFWG 08 2021A Project is a guideline for implementing the concept of ship innovation, fleet management, and collaboration in international waters to tackle marine debris, which is planned to be held in a three-day symposium in Indonesia involving 21 APEC economies. The symposium will invite experts, contributors, and participants to discuss and develop an APEC Guidance document on handling marine debris using garbage collection vessels.

As we know the marine sector is very important for the APEC economy. Sustainable marine ecosystems provide food from fish, seaweed, and medicinal materials from coral reefs. Healthy marine ecosystems can also be used as marine tourism sites that encourage the creation of various jobs for many people in the APEC economy, such as boat operators, hotel operators, restaurants, dive guides, fishery services, etc.

This marine ecosystem is currently threatened by marine debris, such as floating plastic, nets, bottles, etc. Marine debris has been found washing up in coastal areas, contaminating surrounding areas, while others have drifted further into the Pacific Ocean. Many economies address this problem with their own strategies, with most initiatives focused more on terrestrial areas, particularly land, coast, or cities. Meanwhile, dealing with marine debris that leaks into the sea and washes up in remote areas requires special technology and collaboration between economies with the same paradigm to provide effective solutions.

The APEC OFWG 08 2021A Initial Guideline and Project Recommendation Document contains ship innovations that play an important role in combating marine debris because of their potential for effective and efficient waste collection, detection, and management. As we all know, traditional methods of manually removing and cleaning up debris have proven insufficient to tackle a large amount of marine debris in our oceans. Ship innovation gives rise to new technologies and engineering solutions that can enhance the ability to locate, track and remove debris from the marine environment. This has also enabled the development of specialized vessels designed for efficient management and disposal of debris. By using ship innovation, we can significantly increase our capacity to prevent, monitor and reduce marine debris.

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I. Introduction

A. Background of APEC OFWG 08 2021A Project.

The marine sector is exceptionally important for APEC economies. A sustainable marine ecosystem provides food from fish, seaweeds, and medical substances from coral reefs. A healthy marine ecosystem can also be utilized as a marine tourism site which promotes the creation of various jobs for many people in the APEC economies, such as vessel operators, hotel operators, restaurants, diving guides, fishing services, etc.

This marine ecosystem is currently under threat by marine debris, such as floating plastics, nets, bottles, etc. Marine debris is found stranded in coastal areas, polluting the surrounding area, while others drift further into the Pacific Ocean. Many economies addressed this issue with their own strategy, where most of the initiatives are focused more on terrestrial areas, particularly lands, coasts, or cities. Meanwhile, addressing marine debris that leaked into the sea and was stranded in remote area requires specific technology and collaborations among economies with a common paradigm to deliver an effective solution.

The APEC OFWG 08 2021A project aims to assist economies in addressing marine debris by using innovative vessel concepts and operational models. A three-day Symposium involving 21 APEC economies held in Indonesia, focusing on vessel innovation concepts, fleet management, and collaboration in international waters to tackle marine debris. The symposium invited experts, contributors, and participants to discuss and develop the APEC Guideline document on tackling marine debris by using waste collecting vessels.

B. Definition on Marine Debris

Marine debris refers to any human-made solid waste that ends up in marine and coastal environments [1], [2], [3]. It encompasses a wide range of materials, including plastics, glass, metal, rubber, and textiles, among others. Marine debris poses a significant threat to marine ecosystems, wildlife, and human health. It is a global problem that affects oceans, seas, and coastlines worldwide [4]. The accumulation of marine debris is primarily caused by inadequate waste management practices, improper disposal of waste, and insufficient infrastructure for waste collection and recycling.

In the world of maritime conservation, two key players have emerged: the International Maritime Organization (IMO) and the United Nations Environment Programme (UNEP). The IMO, through MARPOL Annex V, establishes strict regulations on waste disposal at sea, while the UNEP focuses on global collaboration and initiatives, such as the "UNEP Global Partnership on Marine Litter," to combat marine debris and plastic pollution. Together, they form a comprehensive strategy to protect the oceans. The IMO deals with the broader term "marine litter," which includes various discarded or abandoned solid materials in the marine environment, such as plastics, metals, glass, and rubber.

Marine debris refers to any solid, persistent human-made object that enters the marine and coastal environment. It encompasses a wide range of materials, including plastics, glass, metal, rubber, textiles, fishing gear, and abandoned vessels.

C. Importance of Vessel Innovation in Combating Marine Debris

Vessel innovation plays a crucial role in combating marine debris due to its potential for effective and efficient debris collection, detection, and management [5], [6], [7]. Traditional methods of manual debris removal and cleanup efforts have proven to be insufficient in tackling the vast quantities of marine debris present in our oceans. The Vessel innovation brings forth sustainable and appropriate technologies and engineering solutions that can enhance the ability to locate, track, and remove debris from marine environments. It also enables the development of specialized vessels designed for efficient debris management and disposal. By employing vessel innovation, we can significantly improve our capacity to prevent, monitor, and mitigate marine debris. Advanced sensor systems, data analytics, and remote sensing technologies allow for more accurate and timely detection of debris hotspots, helping target cleanup efforts in areas of high concentration. Moreover, innovative debris collection and containment systems integrated into vessels can facilitate efficient debris removal and reduce the risk of re-pollution.

Vessel innovation in combating marine debris aligns with SDG 14.1, which is one of the Sustainable Development Goals (SDGs) established by the United Nations to promote sustainable development and address global challenges. SDG 14.1

specifically focuses on preventing and significantly reducing marine pollution, including marine debris, that results from land-based activities.

The Sustainable Development Goals (SDGs) are a set of 17 global goals established by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. These goals are designed to address a range of global challenges and promote sustainable development in economic, social, and environmental dimensions. The SDGs cover a wide range of issues, including poverty, hunger, health, education, gender equality, clean water, sanitation, affordable and clean energy, decent work and economic growth, industry innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice, and strong institutions, and partnerships for the goals. The website : https://sdgs.un.org

D. Purpose of Capacity Building on Vessel Innovation

The purpose of capacity building on vessel innovation is to equip individuals, organizations, and communities with the knowledge, skills, and resources necessary to effectively utilize vessel innovation in combatting marine debris, especially in APEC economies. Capacity building initiatives aim to bridge the existing gaps in technological expertise, waste management practices, and policy frameworks related to vessel innovation [5], [6], [8]. Through capacity building, stakeholders can gain a comprehensive understanding of the latest advancements in vessel innovation, such as emerging technologies for debris detection and removal, vessel design and engineering, waste management techniques, and sustainable disposal methods. This knowledge empowers APEC member economies to make informed decisions and implement effective strategies for combating marine debris. Capacity building also focuses on training and education during symposium in identifying and collecting marine debris. By raising awareness about the impacts of marine debris and providing specialized training, capacity building initiatives promote a sense of responsibility and accountability among stakeholders.

Furthermore, capacity building (in terms of 3-days symposium) addresses the need for robust policies and regulations governing vessel innovation and marine debris management. It facilitates collaboration among APEC economies, and other stakeholders to develop and implement effective policies that support vessel innovation initiatives. After delivering 3-days symposium the outcome will foster partnerships between research institutions, government agencies, non-governmental organizations (NGOs), and industry players to pool resources, share best practices, and maximize the impact of vessel innovation projects.

Some of research tasks to be completed before undertake symposium are:

1. Surveying the quantity of plastic waste stranded on small islands and waste generation on small islands. The study location was in Karimun Jawa islands in Jawa Tengah Province, Indonesia.
2. Develop a basic design of vessel innovation from Indonesia's economic perspective. Including 2 (two) types of material for the vessel.
3. Develop initial Guidelines and Recommendations for vessel innovation to combat marine debris.

In conclusion, in the global fight against marine debris, a strategy emerges. It commences with capacity building, empowering communities and individuals through education and practical skills, equipping them to tackle this issue. Concurrently, the innovative vessel development takes the lead, merging advanced technology with consideration for the sustainability of the marine ecosystems. These vessels utilize eco-friendly technology and innovative methods to streamline cleanup efforts and enhance effectiveness. This harmonious approach ensures that marine life and ecosystems are safeguarded, marking substantial progress in the fight against marine debris. It's a tale of knowledge, technology, and environmental responsibility working together to protect our oceans for future generations.

II. Understanding Marine Debris

A. Category of Marine Debris

Marine debris can be further classified into two main types: macro-debris and micro-debris [9], [10], [11].

Macro-debris refers to larger pieces of marine debris that are visible to the naked eye. It includes items such as plastic bottles, fishing nets, tires, and discarded furniture. These items can cause entanglement or ingestion hazards for marine organisms, leading to injury or death.

Micro-debris consists of small particles, typically less than 5 mm in size. It includes microplastics, microfibers, and other fragmented materials. Micro-debris poses significant challenges as it can be easily ingested by a wide range of marine organisms, entering the food chain and potentially accumulating in higher trophic levels.

B. Sources of Marine Debris

Marine debris originates from various sources, both on land and at sea, drifted through streams, and can travel long distances through ocean currents. The main sources of marine debris include:

1. Land-based sources.

The majority of marine debris originates from land-based activities. Improper waste disposal, inadequate waste management infrastructure, storm water runoff, and illegal dumping contribute to the entry of debris into rivers, estuaries, and coastal areas [2], [3], [12]. Urban centers, recreational areas, and industrial facilities are significant sources of land-based marine debris.

As a vast archipelagic economy with population of more than 279 million people, Indonesia is placed as the second highest contributor of global plastic litter into the ocean [3]. Most of these marine plastic litter originates from poor waste management system, mainly in major coastal cities in Indonesia.

The accumulation of these problems over the past decades has increased the dispersion of marine plastic litter, as showed by scientific studies in various locations in Indonesia, such as in Ambon Bay and Seribu Island of Jakarta [25], Kuta Beach of Bali [22], Spermonde Archipelago in Makassar Strait [31], northern coast of Surabaya city [23], and western and southern coast of Aceh city [26]. While around 20% of marine litter originates from activities at sea such as ghost nets, which pose a threat to marine life.

Addressing the issue of marine debris originating from land-based sources in Indonesia aligns with several Sustainable Development Goals (SDG), including SDG 14 (Life Below Water), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 15 (Life on Land), and SDG 6 (Clean Water and Sanitation). Improvements in waste management, pollution reduction, and conservation efforts can help mitigate the impact of marine debris on the marine environment and contribute to broader sustainable development objectives

2. Ocean-based sources.

Ocean-based activities such as shipping, fishing, aquaculture, and offshore oil and gas operations contribute to marine debris. Abandoned or lost fishing gear (known as ghost gear), shipping containers, cargo spills, and offshore platforms can all generate debris that pollutes marine environments [5], [6], [10], [11].

In response to this issue, MARPOL Annex V addresses the management of marine pollution from ships, particularly garbage. Relevant Sustainable Development Goals (SDGs) include SDG 14 (Life Below Water) and its targets on reducing marine pollution, SDG 12 (Responsible Consumption and Production) for responsible waste management, and SDG 15 (Life on Land) for land-based ecosystem protection to prevent contamination of oceans and marine environments. Addressing marine debris is vital for ocean sustainability and global conservation efforts

C. The Impact of Marine Debris

The impacts of marine debris are far-reaching and pose severe ecological, economic, and human health consequences. Some key impacts include:

1. Wildlife entanglement and ingestion.

Marine debris, particularly fishing nets, lines, and plastic items, can entangle marine animals, causing injuries, amputations, or suffocation. Marine organisms also mistake debris for prey and ingest it, leading to internal injuries, blockages, and reduced feeding efficiency.

Recent studies indicate that around 66% of marine mammals have been affected by microplastics, as well as 50 % of seabirds [32]. The urgent need for further research cannot be overstated, as it is crucial to fully comprehend the global ramifications of microplastics on various marine organisms. Additionally, mitigation measures should be implemented to curb the negative effects on environmental and water quality, with a particular focus on preserving the delicate balance of life associated with coral reef ecosystems.

There have been many reports from government agencies and NGOs regarding turtles or other marine mammals' entanglement cases caused by plastic litters in the form of fine mesh fishing nets which cause difficulty in movement and limit their foraging activities [27]. While a notable case of plastic litter ingestion case in Indonesia is occurred at the end of 2018, where a sperm whale (*Physeter macrocephalus*) stranded on the Kapota island of Wakatobi and 5.9 kg of plastics litter was found in its stomach.

2. Habitat degradation.

Marine litter, particularly made from plastics material (polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), or polyethylene terephthalate (PET) requires a very long time to decompose. And before fully decomposed, plastic litter will float and carried away by ocean currents, and some of them will be stranded in coastal areas.

The increasing number and dispersion of marine plastic litter have threatened marine organisms and potentially damage fragile coastal ecosystems. Marine debris can damage and degrade critical habitats such as coral reefs, seagrass beds, and mangrove forests. Debris can smother these ecosystems, block sunlight penetration, and disrupt essential ecological processes.

3. Economic costs.

The decomposition of floating plastic waste in the ocean follows a gradual process, fragmenting into macro-sized particles (diameter > 5 mm) before further disintegration into micro-sized particles (diameter < 5 mm). These microplastics can trigger bacterial colonization that potentially cause disease in the oceans.

For example, coral reefs with complex structures are potentially impacted by microplastics eight times higher, hence associated micro-habitats and organisms will also be affected [28], [30]. Coral polyps face the risk of blockages due to microplastics, and in severe cases, respiratory failure and death can occur in affected organisms [24]. This condition will certainly affect the cycle of the coral fishes' food chain which makes coral reefs their feeding area. Eventually it will impact economic losses in local scale if coral reefs are damaged due to reef fishes moving to other suitable locations.

Therefore, the economic impacts of marine debris are substantial. Coastal tourism and recreation industries may suffer due to littered beaches and contaminated waters. Furthermore, entangled debris can damage fishing gear, resulting in lost catch and productivity.

4. Human health risks.

Marine debris can pose health risks to humans through contaminated seafood consumption or direct contact with hazardous materials present in debris, such as chemicals or sharp objects. Additionally, the presence of debris in coastal areas can negatively impact the aesthetics and overall well-being of local communities.

D. Current Challenges in Combating Marine Debris

Despite increasing awareness about the issue of marine debris, several challenges persist in effectively combating and mitigating its impacts. Some of the key challenges include:

1. Global scale and complexity.

Marine debris is a global problem that requires coordinated efforts at local, regional, and international levels. The vastness of the oceans and the interconnectedness of marine ecosystems make it challenging to address debris hotspots and track the movement of debris over long distances [2], [3], [10], [12], [13].

Communities near beaches (local level) have a critical role in reducing marine trash/debris. Local programs, like beach clean-ups and educational campaigns, promote responsible waste management methods and increase awareness of the effects of marine debris. Participation of the local community in these initiatives decreases coastal pollution, stops litter from entering the water, and safeguards regional marine ecosystems.

While communities in small islands bear a heavier burden. Besides generating domestic waste on daily basis, they also have received stranded marine debris in their island from elsewhere (seasonal-based).

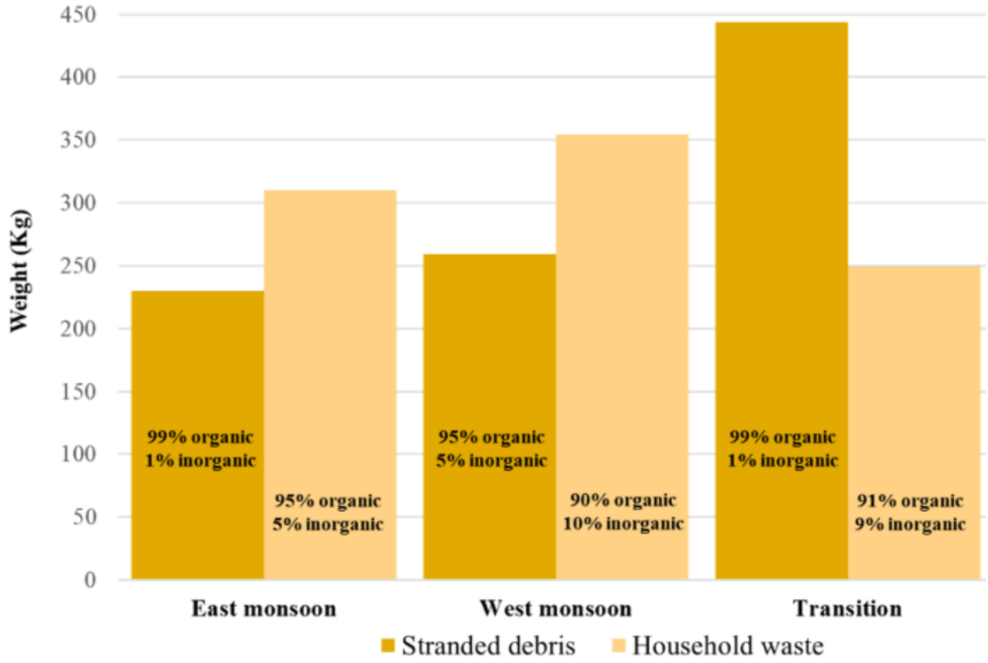

Figure 1. Comparison between total amount of seasonal stranded debris and household waste in Kulati Village, Wakatobi [12]. In total, stranded debris (51%) is slightly higher than household waste (49%).

Nevertheless, there are various small-scale waste management practices in observed small islands (e.g.: Pulo Aceh, Seribu, Karimunjawa, Wakatobi), adjusted with their specific condition (e.g.: total population, daily waste generation, and availability of waste processing technology), including volume of seasonal stranded marine debris in their island (Table 1). Yet, the capacity of these initiatives remains inadequate.

Cooperation between nearby economies and organizations is essential in the regional fight against marine trash. Regional initiatives can concentrate on common issues and create coordinated plans to deal with the buildup of waste in certain places. Regional partnerships might, for instance, establish monitoring programs, standardize data collection techniques, and put into practice shared policies to control trash disposal and lessen plastic pollution.

At the international level, collaboration through platforms like the United Nations, Ocean and Fishery Working Group (OFWG) of Asia-Pacific Economic Cooperation (APEC), UNEP and international conventions (MARPOL 73/78 from the International Maritime Organization, IMO) is essential to tackle the global issue of marine debris.

Table 1. Waste management practices in four small islands in Indonesia resulted from field observation, deep interview and focus group discussion with relevant stakeholder on-site [12].

No	Existing Practices	Study sites			
		Pulo Aceh Island	Seribu Islands	Karimun-jawa Islands	Wakatobi Islands
Existing waste management practices (regular basis):					
1.	Eliminating organic waste using L-Box incinerator		✓		
2.	Compost heap and urban farming	✓	✓		✓
3.	Eco brick		✓		✓
4.	Hazardous and toxic substances (B3), as well as e-waste		✓		
5.	Transport waste residues to the terminal landfill (TPA) on the nearest mainland		✓		✓
6.	Waste bank	✓	✓	✓	✓
7.	Waste bioconversion using maggot		✓		
8.	Backfilling for land reclamation		✓		
9.	Recycled for handicraft or pots	✓	✓		✓
10.	Sorted inorganic wastes are shredded using waste shredder machine	✓			
11.	Develop waste dumpsite/landfill in the area			✓	✓
12.	Directly burned			✓	✓
13.	Waste to energy using pyrolysis machine				✓
Other initiatives for mitigating/reducing marine debris (occasional):					
14.	Beach clean-up action			✓	✓
15.	Educating local inhabitants on the importance of a good waste management			✓	✓
16.	Local government's regulation on banning the single use of mineral water cup/bottle			✓	✓
17.	Provisioning equipment for plastic and organic waste processing			✓	✓
18.	Develop building and equipment for waste processing machine			✓	
19.	Provisioning waste transporter equipment			✓	✓

Several current challenges associated with addressing this issue

1. **Data Collection and Monitoring.**

   Comprehensive and real-time data on the sources, types, and distribution of marine debris are essential for informed decision-making. Data collection and monitoring efforts need to be improved and standardized.

2. **Lack of proper waste management infrastructure.**

   Inadequate waste management infrastructure, particularly in developing economies and coastal areas, leads to the improper disposal of waste, increasing the likelihood of marine debris entering the oceans. Limited access to recycling facilities and the absence of comprehensive waste collection systems contribute to the persistence of marine debris [6], [9], [12].

The absence of thorough garbage collecting systems is one of the main causes of poor waste management infrastructure. Lack of structured waste collection services in many coastal and developing areas leads to careless dumping practices. Without authorized garbage collection locations and regular waste pickup dates, people may resort to burning or dumping rubbish in open spaces or bodies of water, which can ultimately eventually end up in the ocean. The issue is made worse by the lack of a coordinated garbage collection strategy since it becomes difficult to manage and dispose of waste in an environmentally friendly way.

3. Behavior and cultural attitudes.

Changing human behavior and attitudes towards waste generation and disposal is a significant challenge. Effective waste management practices, litter prevention, and responsible consumption habits are necessary to reduce the generation of marine debris at its source [11], [12], [14].

The most important thing is to raise awareness and educate people about how marine garbage affects ecosystems and public health. People will be better able to grasp the need for responsible waste management methods as their knowledge of the effects of improper garbage disposal grows. A sense of environmental responsibility and the promotion of sustainable consumption practices can be fostered through education campaigns, community outreach initiatives, and school curriculum.

Another crucial component of minimizing marine litter is adopting responsible consumption practices. People may help by being aware of their own consumption habits and adopting decisions that reduce trash production. This involves actions like choosing reusable products, staying away from single-use things, and supporting projects for sustainable packaging.

Indonesia already has 2 provinces that banning single-use plastic bags (Bali and Jakarta) in traditional markets and modern markets. Some coffee-shops already ban plastic straw in their products.

4. Difficulties in debris detection and removal.

Locating and removing marine debris can be challenging due to the vastness of marine environments, diverse types of debris, and the presence of debris in remote or inaccessible areas [5], [10], [13].

Identifying micro-debris and tracking its movement is particularly complex due to its small size and widespread distribution.

The large debris such as abandoned fishing nets or derelict vessels may be visible and easier to locate, but they often require specialized equipment and expertise for safe and efficient removal.

5. **Funding and resource constraints.**

Implementing comprehensive strategies to combat marine debris requires significant financial and technological resources. Many initiatives, such as vessel innovation projects, face challenges in securing sustainable funding and resources to scale up their efforts [4]–[6].

6. **Policy and governance gaps.**

Inconsistencies and gaps in domestic and international policies and regulations related to marine debris hinder effective management. Strengthening governance frameworks and implementing robust policies are crucial for addressing marine debris comprehensively [15], [16].

To overcome these challenges in APEC economies, concerted efforts are needed from governments, international organizations, NGOs, industry stakeholders, and local communities. Integrated approaches that combine vessel innovation, improved waste management practices, education and awareness campaigns, and strong policy frameworks are necessary to combat marine debris effectively.

IMO and UNEP is international level organizations that have same paradigm in protecting marine environments. The International Maritime Organization has MARPOL 73/78 Convention that address marine pollution from shipping and offshore activities. The United Nation Environment Program (UNEP) has seventeen (17) of the SDGs (Sustainable Development Goals) and the goal number fourteen (14) in for the marine protection, named “Life below water”. Collaboration of APEC member economies with them will boost effectiveness in combatting marine debris.

III. Overview of Vessel Innovation

A. Lesson Learned from Previous Vessel Innovation to combat Marine Debris in Indonesia.

The utilization of vessel to combat marine debris is not a new thing. Most of the vessels is used to collect floating debris and carrying waste from one point to another [5], [6]. Indonesia has been implementing this type of vessel in many small islands. Figure 1 shows one of the existing waste carrying vessel in Seribu Island. This ship was built in 2014 and began operation in 2015. The principal particulars are: LOA (Length Overall) = 28 m; B (Beam) = 6 m; forward draft [TF] = 1.2 m; aft draft [TA] = 1.6 m.

The local government of Seribu Island is operating 28 waste carrier vessels, with a capacity of 125 tons and 8 tons The 125-ton vessel only has a maximum speed of 4 knots, due to poor initial design and poor fabrication process. The Director for Environmental Service of Seribu Island Regency informed that the fuel cost for operating these vessels is around IDR4 billion (about USD260,000) per year, excluding maintenance costs and crew salaries.

The waste/debris that has been collected in Seribu islands is then transported to mainland Java and transferred to Muara Angke port in Jakarta, where this transfer process has a high possibility of leaking waste into the sea. Figure 1 (b) shows the garbage transferring method.

The government operates 1 to 2 vessels to transport the waste from Seribu Island per week, depending on the holiday season. Sometimes, between December and February (during the rainy season), all vessels cannot sail due to high waves and strong winds. Totally there are 8 ships that serve transportation from the Kepulauan Seribu regency to Jakarta round trip, and there are 7 ships for collecting garbage on the coast of Jakarta Bay. The rest collect garbage on the coast of the Thousand Islands. The average weight of garbage on the coast of Jakarta Bay is 9.4 tons per day.

Referring to those problems and requirements in managing land-based debris, especially operational cost, a new innovative vessel design was made in 2021 to solve the requirements. Figure 2 shows the debris incinerator vessel (DIV) as the innovative design to minimize transportation cost and social problem in the island.

The second innovation, which is the use of an electric power system with net zero emissions for the marine debris collecting vessel, aligns with several Sustainable

Development Goals (SDGs), primarily those related to sustainable energy, climate action, and environmental conservation:

1. SDG 7 - Affordable and Clean Energy: This innovation promotes the use of clean and renewable energy sources, as evidenced by the inclusion of a solar panel system. It supports SDG 7's target to ensure access to affordable, reliable, sustainable, and modern energy for all.

2. SDG 13 - Climate Action: By utilizing an electric power system with net zero emissions, the vessel contributes to mitigating greenhouse gas emissions. It aligns with SDG 13's objective to take urgent action to combat climate change and its impacts.

3. SDG 14 - Life Below Water: The innovation in this marine debris collecting vessel directly supports SDG 14 by working to prevent and reduce marine pollution, including marine debris. The electric power system and cleaner energy sources contribute to the goal's aspiration to conserve and sustainably use oceans, seas, and marine resources.

Figure 2. The island-based waste carrier vessel in Indonesia economy, with 120-ton waste capacity. Operation route from Seribu islands to Muara Angke port in Jakarta, Indonesia [6], [12].

Figure 3. The Transfering of garbage from Seribu Island to dump trucks in Muara Angke port, Jakarta.

Figure 4. Vessel Innovation to combat marine debris, by using local parameters in Seribu islands [6]. The Industrial Design Patent granted in Indonesia in year 2023.

On the other small islands, the Karimun Jawa Islands, the local government has applied a similar land-based debris management approach to the Seribu Islands but without waste carrier vessels. Karimun Jawa islands sub district has 3 km-square mangrove forest, 27 islands, 13 km-square tropical lowland forest, and 1,101 km-square seawater territory. Based on an unofficial source, the local official plans to use vessels to transport the waste to mainland Java.

The recent survey also showing that every day there are 2 tons per day waste generated in 27 islands in Karimun Jawa, Jepara regency, Jawa Tengah province, Indonesia.

B. Basic Design of Vessel Innovation to Combat Marine Debris in Karimun Jawa Islands.

Karimun Jawa islands located in Jawa Tengah province, in Indonesia. Figure 3 shows the location, marine debris stranded in a gulf and landfill facility with plastic waste shredder workshop. The reality of land-based debris and ocean-based debris is ubiquitous. Based on data collected, there are two tons households waste produced per day. It is not including stranded marine debris. Collecting and managing marine debris is urgent to do, with help of the debris collecting vessel.

Figure 5. Location of Karimun Jawa Islands (red colored marker).

Figure 6. Stranded marine debris in remote area of Karimun Jawa (left), and Landfill facility with plastic waste shredder workshop (right).

The ship design and engineering has a long and fascinating history. There have been many key milestones in ship design, and experts are always researching and developing new trends to design future-proofed ships. One of the key milestones in ship design was the introduction of the “design spiral” in 1959. This quickly became the cornerstone of ship design and engineering, and is still widely used today, more than 60 years later [17].

Another key milestone was the move away from “single point designs” to “multi-point optimization”. Until the early 2000s, around 95% of vessels were built to a single point design. This meant that the vessel’s hull shape, bow, and engine capacity would perform excellently at one specific speed and draft. However, designers realized that with relatively small changes, they could boost ship efficiency by 5 to 10%, sometimes even 20%, which for large deep-sea vessels equaled up to USD1 million in savings per year [18].

The design for marine debris collecting vessel will optimize it’s operational speed, waste bin capacity and stability.

The First innovation (Aluminum Hull Material)

The process in developing an innovation of the waste collecting vessel following the spiral design steps procedures [17], [6], [19]. Figure 4 explain the steps to be achieved in each cycle before getting approved (final) vessel design. The cycle can take into many times depending complexity of design. The initial capacity of waste bin onboard was decided 5 tons.

After running about three (3) cycle in designing the best marine debris collecting vessel, we have the final design as shown in Figure 5. The first innovation is the bow (front) wheel position. This innovation was derived from discussions with a boat operator who uses a rear wheel position type and inhales waste gases during travel time.

General Specification & Dimensions:

Material	: Aluminum Construction
Total Capacity	: 5 Ton
Length O. A.	: 9.8 m
Depth	: 1.1 m
Beam	: 4.3 m
Draught	: 0.38 m

Solar Panel : 2840 Watt Peak

Generator : 8.5 Kva

Battery : Lithium iron phosphate 48V 100 ah x 12 Unit

Service speed : 8 knot

Max speed : 10 knot

Engine power : 2 x 14 hp

Type : Outboard engine

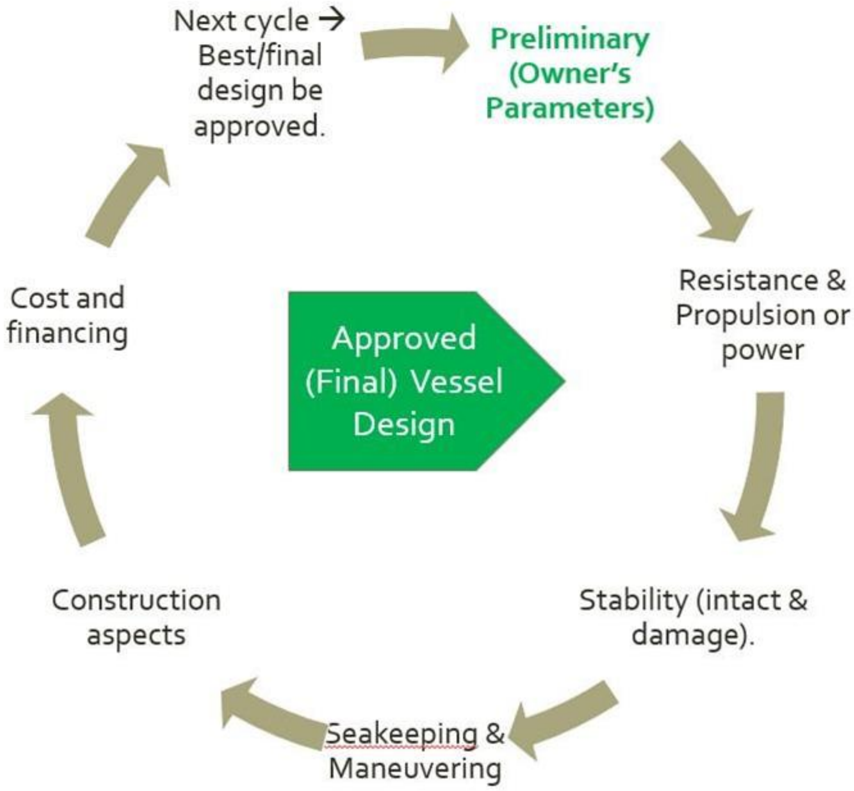

Figure 7. The cycle of vessel design process. Many vessel designers call it "spiral design process" [19], [6].

Endurance Calculation

Battery Capacities : 12 x 48V 100Ah = 57.6 kWh

Capacity after DOD (deep of discharge) : 50% x 57.6 kWh = 28.8 kWh

Power input at 14 knot : 12.4 kW

Power input at 10 knot : 4.43 kW

Endurance for 14 knot speed :

Capacity after DOD / Power input at 14 kn

28.8 kWh / 12.40 kW = 2.32 hours

Endurance for 10 knot speed :

Capacity after DOD / Power input at 10 kn

28.8 kWh / 8.86 kW   = 3.25 hours

This vessel design will be able to sail up to sea state 5 parameter (Beaufort scale number 5). See Table 1 (The parameters of sea state). This conclusion is based on stability calculation, which shows the vessel will be able to return to normal position under 6-8 feet wave height and 17-21 knots wind speed (Beaufort 5).

Table 2. Sea State Condition According Beaufort Scale
(link: https://en.wikipedia.org/wiki/Beaufort_scale)

Beaufort number	**Wind Description**	**Wind Speed**	**Wave Height**	**Visual Clues**
0	Calm	0 knots	0 feet	Sea is like a mirror. Smoke rises vertically.
1	Light Air	1-3 kts	< 1/2	Ripples with the appearance of scales are formed, but without foam crests. Smoke drifts from tunnel.
2	Light Breeze	4-6 kts	1/2 ft (max 1)	Small wavelets, still short but more pronounced, crests have glassy appearance and do not break, wind felt on face. Smoke rises at about 80 deg.
3	Gentle Breeze	7-10 kts	2 ft (max 3)	Large wavelets, crests begin to break, foam of glassy appearance.
4	Moderate Breeze	11-16 kts	3 ft (max 5)	Small waves, becoming longer. Wind raises dust. Smoke rises at about 50 deg.
5	Fresh Breeze	17-21 kts	6 ft (max 8)	Moderate waves, taking more pronounced long form. Wind felt strongly on face. Smoke rises at about 30 deg.
6	Strong Breeze	22-27 kts	9 ft (max 12)	Large waves begin to form. White foam crests are more extensive everywhere (probably some spray). Wind stings face in temperatures below 35 deg F

Beaufort number	**Wind Description**	**Wind Speed**	**Wave Height**	**Visual Clues**
				(2C). Slight effort in maintaining balance against wind. Smoke rises at about 15 deg.
7	Near Gale	28-33 kts	13 ft (max 19)	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of wind. Necessary to lean slightly into the wind to maintain balance. Smoke rises at about 5 to 10 deg.
8	Gale	34-40 kts	18 ft (max 25)	Moderately high waves of greater length. Edges of crests begin to break into the spin drift.
9	Strong Gale	41-47 kts	23 ft (max 32)	High waves. Dense streaks of foam along direction of wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	Storm	48-55 kts	29 ft (max 41)	Very high waves with long overchanging crests. The resulting foam, in great patches is blown in dense streaks along the direction of the wind. On the whole, the sea takes on a whitish appearance. Visibility affected.
11	Violent Storm	56-63 kts	37 ft (max 52)	Exceptionally high waves (small and medium sized ships might be for time lost to view behind waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere, the edges of the wave crests are blown into froth. Visibility is seriously affected.
12	Hurricane	64+ kts	45+ ft	The air is filled with foam and spray. The sea is completely white with driving spray. Visibility is seriously affected.

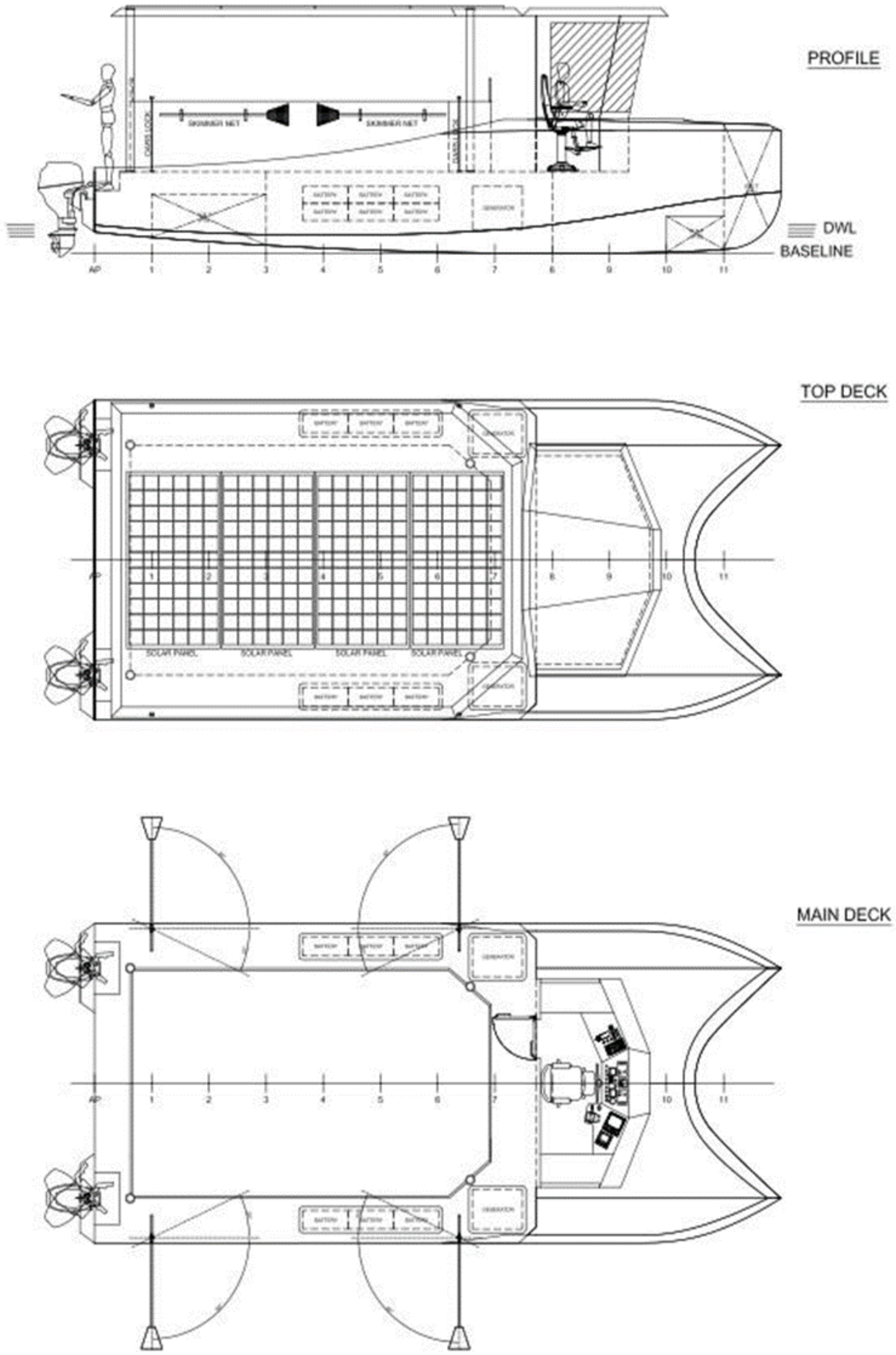

Figure 8. The basic design of Vessel innovation for collecting marine debris, by using electrical power (net zero emission). Hull material using aluminum.

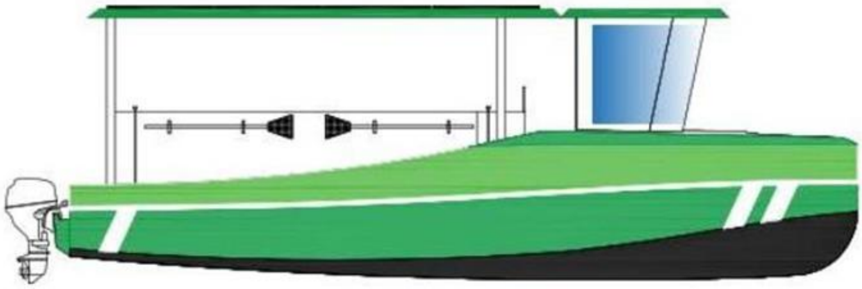

Figure 9. The boat/vessel illustration side view.

The maneuverability of this design is for sea-state 5, with wind speed at maximum 21 knots, wave height 6 ft. and moderate waves.

The fiber-glass hull material.

This analysis requires for 4th and 5th cycle of vessel design process. Due to material density of aluminum is higher than fiber-glass, the width and the waste bin capacity being lock (make permanent) for 4.3 meters and 5 ton. As consequences, another dimension will be changed according material density of fiber-glass. Of course, the stability parameters, powering parameters and other dimension will also change. Figure 6 is the basic design concept for fiber-glass hull material.

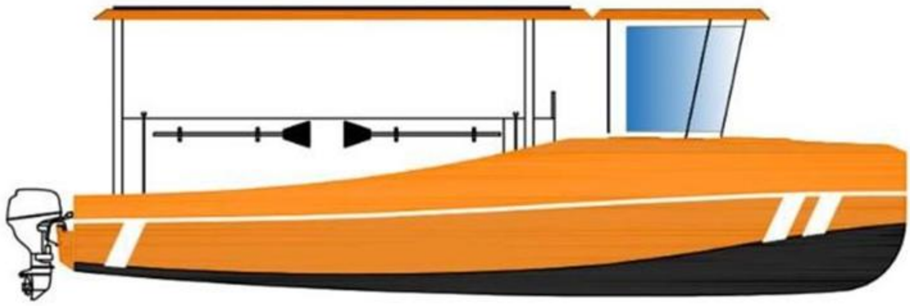

Figure 10. The fiber-glass hull of marine debris colleting vessel illustration (side view).

General Specification & Dimensions:

Material	: Fiber-glass hull construction
Total Capacity	: 5 Ton (waste bin capacity)
Length O. A.	: 10.5 m
Depth	: 1.1 m
Beam	: 4.3 m

Draught : 0.35 m

The preference for using catamaran type hull boat than monohull type boat is stability against wave load [17]. Where in marine coastal area, the wave period is shorter than in open ocean.

A catamaran is a type of boat that has two hulls, while a monohull boat has only one hull. The hull is the bottom part of the boat that floats on the water. Stability is how well a boat stays balanced and doesn't tip over in the water. Just like when you're riding a bicycle, you want to stay balanced and not fall over. Boats also need to be balanced to stay safe and not tip over.

When we compare a catamaran and a monohull boat, we can see some differences in their stability. Catamarans have two hulls that are placed parallel to each other. This design makes them wider than monohull boats. Imagine if you were riding a bike with two wheels side by side instead of one wheel in front of the other. The wider base of the catamaran helps it to be more stable.

When the waves in the water try to push the boat from one side, the two hulls of the catamaran work together to keep the boat steady. It's like having two legs on each side of your body when you're standing. This extra support helps the catamaran to stay balanced and not tip over easily.

On the other hand, monohull boats have only one hull, which is more like a traditional boat shape. They are narrower compared to catamarans. This narrow shape can make them less stable in rough water or strong winds.

When the waves hit the side of a monohull boat, it can cause the boat to tilt or lean to one side. This can make it feel a bit wobbly, just like when you're standing on one leg. The boat needs to use its weight and a keel (a fin-like structure under the boat) to help it stay balanced. The keel acts like a counterweight and helps the boat to resist tipping over.

Both catamarans and monohull boats can be safe and enjoyable to ride, but catamarans are generally known for their better stability in rough water. They can handle waves and wind more easily because of their wider base and two hulls.

It's important to remember that even though catamarans are more stable, it's always essential to wear life jackets and follow safety rules when you're on any type of boat.

So, in simple terms, a catamaran is like a boat with two legs that help it stay balanced, while a monohull boat is like a boat with one leg. The two legs of the catamaran make it more stable and less likely to tip over.

In the technical terms, it is required to calculate the Righting Moment and the Metacentric Height for calculation its stability [6], [17]. The calculation can be manually checked (using excel software) or using various software such as Maxsurf, AutoShip, or others. Assistance from academia and professionals will be required to help non-technical peoples.

The second innovation

The next innovation is electric power system, or many called it net zero emission vehicle. Figure 7 shows the mechanism of electrical power system of this marine debris collecting vessel.

The endurance design of this system is 8 hours operating in 10 knot vessel speed. The solar panel capacity is 2,840 Watt Peak (which means during maximum sunlight intensity, it can deliver 2,840 watt in to battery). Meanwhile, the purpose of generator is as backup for rainy-day or cloudy day for supplying battery capacity.

For construction aspects, this vessel do not require sophisticated crane and launching track. The cost and financial aspects varies depend on each of APEC members.

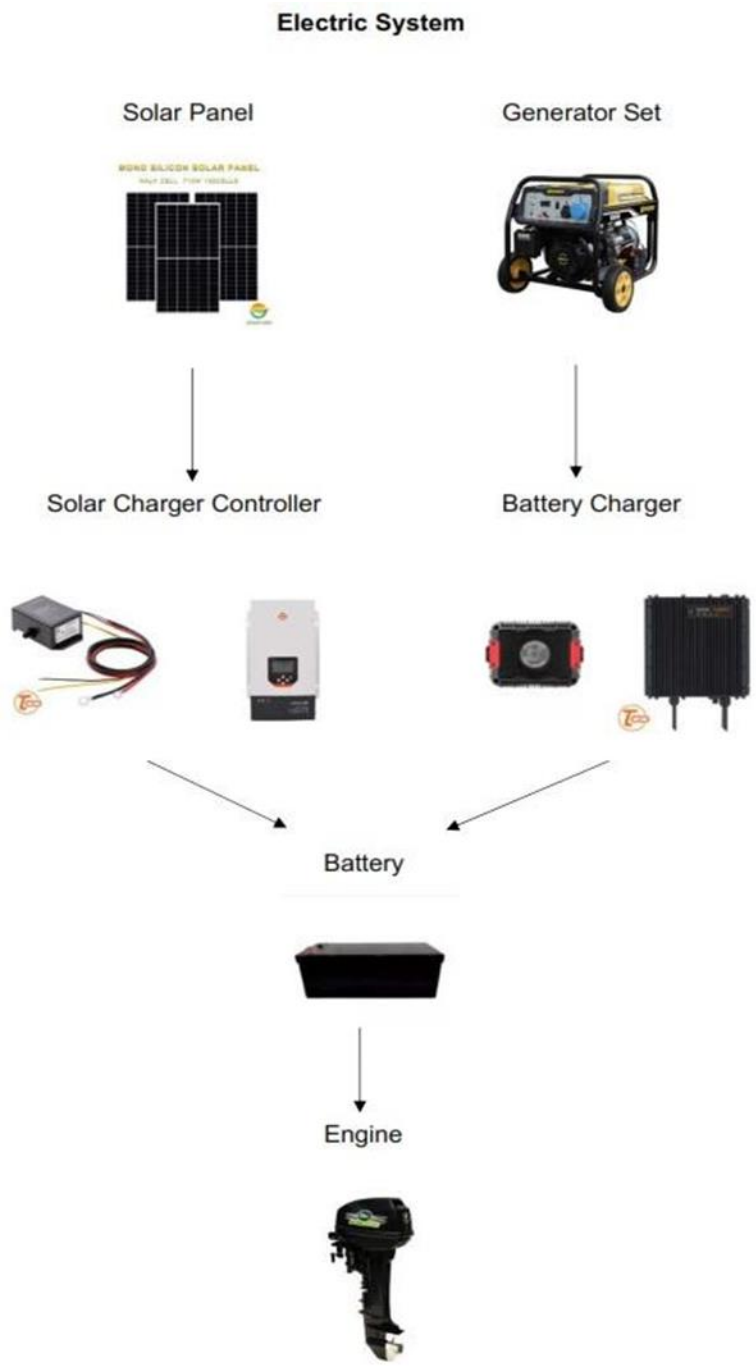

Figure 11. The electrical power system (net zero emission vehicle) of marine debris collecting vessel.

C. The International Examples of Vessel Innovation

There are two (2) most famous successful vessel innovation projects that have made a significant impact in combating marine debris worldwide.

1. The Ocean Cleanup.

The Ocean Cleanup is a prominent example of a vessel innovation project dedicated to removing plastic debris from the oceans. Their system consists of a passive drifting network of booms and screens that capture and concentrate debris, which is then collected by vessels. This project has successfully deployed its technology in pilot projects, demonstrating its effectiveness in large-scale debris removal. Visit the link: (https://theoceancleanup.com/).

2. WasteShark

The WasteShark is an autonomous surface vessel designed to collect floating debris, including plastics and other waste, from water bodies. Equipped with sensors and cameras, it can navigate waterways and actively remove debris. This project has been successful in areas such as harbors, canals, and rivers, where traditional cleanup methods are challenging. Visit the link: (WasteShark - Projects: Robotics Innovation Center - DFKI GmbH (dfki-bremen.de))

The primary aspect for those 2 start-up innovative company is great financing and cost disbursement. For APEC economies, this model of innovation is heavy to carry up, except for developed economies.

D. Benefits and Potential Impact of Vessel Innovation

Vessel innovation offers numerous benefits and has the potential to make a significant impact in the fight against marine debris. Some of the key benefits and potential impacts include:

1. Enhanced Debris Removal Efficiency:

Vessel innovation can significantly improve the efficiency and effectiveness of debris removal operations. Advanced collection systems, remote sensing technologies, and autonomous or remotely operated vessels can cover larger areas, increase debris removal rates, and reduce the time required for cleanup activities.

2. Reduction of Environmental Impact:

By integrating environmentally friendly technologies and design concepts, vessel innovation promotes sustainability and reduces the environmental impact of debris removal operations. This includes the use of clean energy sources, optimized fuel consumption, and the implementation of waste management systems onboard vessels to minimize pollution.

3. Prevention of Secondary Pollution:

Vessel innovation helps prevent secondary pollution that can occur during debris removal operations. Advanced debris containment systems and improved handling techniques reduce the risk of debris escaping back into the environment, ensuring that removed debris is properly managed and disposed of.

4. Advancements in Debris Detection and Monitoring:

Vessel innovation contributes to advancements in debris detection and monitoring capabilities. Through the integration of advanced sensor systems and data analytic, vessel-based technologies can provide accurate and up-to-date information on debris distribution, facilitating targeted cleanup efforts and improved understanding of marine debris dynamics.

5. Collaboration and Knowledge Sharing:

Vessel innovation initiatives foster collaboration among stakeholders, including vessel operators, researchers, government agencies, and NGOs. This collaboration promotes knowledge sharing, exchange of best practices, and the development of standardized approaches to tackle marine debris, ultimately leading to more efficient and coordinated efforts.

6. Inspiration for Sustainable Practices:

Vessel innovation projects serve as inspiration and catalysts for sustainable practices in the maritime industry and beyond. They demonstrate the feasibility and benefits of incorporating advanced technologies and innovative design concepts, encouraging stakeholders to adopt more environmentally friendly approaches to vessel operations and waste management.

In conclusion, vessel innovation plays a crucial role in addressing marine debris by enhancing debris detection, collection, and management capabilities. Through advanced technologies, specialized vessel designs, and data-driven decision making, vessel innovation has the potential to significantly improve the efficiency, effectiveness, and sustainability of debris removal operations. The benefits and potential impacts of vessel innovation extend beyond debris cleanup, inspiring sustainable practices and promoting collaboration among stakeholders to combat marine debris comprehensively.

IV. Guidelines for Designing Innovative Vessel to Tackle Marine Debris.

A. Technology and Engineering

1. Design and development of specialized vessels for debris management

Capacity building in vessel design and development focuses on equipping participants with the general of basic knowledge and skills necessary to create specialized vessels tailored for efficient debris management. This includes understanding the key design considerations, engineering principles, and operational requirements. Topics to cover in this area include:

a. Vessel Design Principles (for general or non-technical people)

Participants should learn about the fundamental principles of vessel design, including vessel's purpose, basic hydrodynamics, basic stability, and structural integrity. They should understand how these principles apply to vessels designed specifically for debris collection, removal, and containment.

b. Innovative Vessel Features.

Capacity building programs should highlight innovative features that can be incorporated into vessel design to enhance debris management capabilities. This includes advanced debris collection systems, storage and containment solutions, and onboard waste management facilities. Participants should learn about the design considerations for these features, their integration into vessel systems, and their impact on operational efficiency.

2. Introduction to innovative technologies for debris collection and detection

Capacity building in the area of technology and engineering focuses on providing knowledge and skills related to innovative technologies for debris collection and detection. This includes introducing participants to cutting-edge tools, systems, and methodologies that enhance the effectiveness of debris management efforts. Key topics to cover in this area include:

a. Remote Sensing Technologies for detecting marine debris.

Remote sensing plays a crucial role in detecting and monitoring marine debris. Capacity building programs should provide an overview of remote sensing technologies such as sonar, lidar, and optical sensors. Participants should learn how these technologies work, their applications in debris detection, and how to interpret and analyze the data obtained from remote sensing systems.

b. Robotics and Autonomous Systems.

Robotics and autonomous systems have the potential to revolutionize debris collection and removal operations. Capacity building initiatives should introduce participants to the principles and applications of remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and unmanned aerial vehicles (UAVs). Participants should learn about the capabilities of these systems, their deployment, operation, and maintenance, as well as the integration of sensors for debris detection. The international project from WasteShark (link: WasteShark - Projects: Robotics Innovation Center - DFKI GmbH (dfki-bremen.de)) is a good example of utilization of robotics systems.

c. Environmental Sustainability.

Capacity building initiatives should emphasize the importance of environmental sustainability in vessel design and operation. Participants should learn about the use of clean energy sources, emission reduction technologies, and eco-friendly materials in vessel construction. They should also understand the significance of waste management systems onboard vessels to minimize pollution and promote sustainable practices.

B. Waste Management and Disposal

1. Treatment and disposal methods for collected marine debris

Most marine litter/debris has a very low decomposition rate (as plastics, which are the most abundant type of marine debris), leading to a gradual but significant accumulation in the coastal and marine environment [10], [9], [3].

Once extracted from the water, incineration is the method most widely used to treat marine debris. Other treatment methods have been tested, but they still need some improvement and so far have only been used in some economies.

Marine debris is collected mostly by boats. Usually, each port has a waste manager which is responsible for collecting the waste generated by both port facilities and boats.

The best marine debris disposal method will vary and depend on the location, availability, and resources of the specific removal effort. In some cases, the most environmentally friendly option for disposing of marine debris and natural debris encountered during removal efforts may include recycling, reuse, waste-to-energy, landfill or other innovative disposal methods [6], [12].

2. Recycling and re-purposing initiatives for recovered debris

Efficiently recycling plastic by conventional means is notoriously difficult, and only 9% of all plastic ever made has been recycled into new plastics. But what if there was a way to turn plastic back into the stuff it was made from? The "next grand challenge" for polymer chemistry – the field responsible for the creation of plastics – is learning to undo the process by turning plastics back into oil. This process – known as chemical recycling – has been explored as a viable alternative to conventional recycling for decades. So far, the stumbling block has been the large amount of energy it requires [15], [20]. This, combined with the volatile price of crude oil sometimes makes it cheaper to produce new plastic products than to recycle existing plastic.

Changing the way we consume is at the heart of the solution. A circular vision for the e-waste sector will promote the elimination of waste and could yield up to USD4.5 trillion in economic benefits by 2030 [21].

C. Policy and Regulation According IMO’s MARPOL 73/78 Convention

The International Maritime Organization (IMO) is regulatory body for shipping industry. IMO already implementing waste management onboard for commercial ship since 1983, called MARPOL 73/78, specifically for Annex I and II.

MARPOL (short for “marine pollution”) 73/78 is one of the most important international marine environmental conventions. It was developed by the International Maritime Organization with an objective to minimize pollution of the oceans and seas, including dumping, oil and air pollution. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983 [18], [17].

Currently, 153 member economies are a party to the Convention, representing 98.52% of the world shipping tonnage, which means that it has worldwide application [22].

The MARPOL Convention consists of several annexes, each addressing different types of marine pollution. Annex I focuses on oil pollution prevention, Annex II covers noxious liquid substances carried in bulk, Annex III deals with harmful substances packaged in a specific form, Annex IV pertains to sewage pollution, and Annex V addresses the disposal of garbage, and Annex VI, Air Pollution.

By implementing these annexes, the IMO has set strict requirements for the handling, storage, and disposal of waste materials generated by ships. This includes regulations on oil tanker construction, the use of pollution prevention equipment, the treatment of sewage, and the proper management of garbage. These measures aim to minimize the potential for waste spills and reduce the amount of marine debris generated by shipping activities.

MARPOL 73/78 addresses ship waste dumping facilities in ports through various provisions and requirements. The convention emphasizes the importance of providing adequate reception facilities for the proper disposal of ship-generated waste. Here's how MARPOL regulates ship waste dumping facilities in ports (MARPOL 73/78 Annex I until V):

1. **Port Reception Facilities (PRFs):** MARPOL requires local port to establish and maintain PRFs to receive ship waste. These facilities are responsible for safely receiving, processing, and disposing of various types of waste generated by ships, including oily residues, sewage, and garbage.

   For garbage management from ships (Annex V), the regulation take into global implementation (entry) as 1 January 2013 [23], [22], [24]. There are 147 Contracting Parties (Ports and Authorities). The capacity of vessel impacted is 98.03% of world tonnage. It prohibits the discharge into the sea all of plastics, and set rules for discharge of different type of garbage depending on whether the ship is within or outside a special area.

2. **Adequate Facilities:** Domestic port are obligated to ensure that PRFs are sufficient in number, size, and capacity to handle the waste generated by ships calling at their ports. This includes having appropriate reception facilities for oily wastes, such as oil residues, bilge water, and sludge (Annex I & II).

Reception facilities regarding garbage from ships, must also be addressed for international ports. This is according to Annex V of MARPOL 73/78.

3. **Advance Notification:** The convention requires ships to provide advance notification to the relevant port authorities regarding their waste quantities and types. This allows the local port to prepare the necessary reception facilities and resources to handle the waste effectively.
4. **No Discharge without Adequate Reception Facilities:** MARPOL prohibits ships from discharging their waste, such as oily water, sewage, or garbage, into the sea unless they are using adequate reception facilities. This provision aims to prevent improper waste disposal at sea and encourages ships to use PRFs for waste management.
5. **Reporting and Documentation:** Ships are required to maintain accurate records and document their waste management activities, including the disposal of waste at PRFs. This documentation serves as evidence of compliance and can be inspected by port control authorities during inspections.
6. **Port Economy Control Inspections:** Port state control (PSC) authorities conduct regular inspections of ships to verify compliance with MARPOL waste disposal requirements. These inspections assess whether ships have utilized the available PRFs and followed proper waste management procedures. Non-compliant vessels may face penalties or be detained by port authorities.

   PSC is the inspection of foreign ships in domestic ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these instruments and ensure maritime safety and security and prevent pollution [22].
7. **International Cooperation:** MARPOL 73/78 encourages international cooperation among port authorities to facilitate the provision of adequate reception facilities. Economies are encouraged to establish agreements or arrangements with neighboring or nearby economies to ensure seamless waste reception services across different jurisdictions.

   It is clear that IMO manage the waste spill from shipping activities well and already implemented since 1983 (Annex I until V). Therefore, it is a systematic and global approach to minimize leakage of marine debris from activities on the ocean (sea-based marine debris leakage).

Through the enforcement of MARPOL regulations, including PSC inspections and penalties for non-compliance, the IMO has effectively managed waste spills from shipping activities. This has led to increased awareness and responsible waste management practices within the maritime industry. Ship operators are now more conscious of the potential environmental impact of their operations and take proactive measures to prevent waste spills and minimize the leakage of marine debris into the ocean.

In conclusion, the IMO has successfully managed waste spills from shipping activities through the implementation of MARPOL since 1983. The comprehensive regulations and guidelines outlined in MARPOL's Annex I to V have significantly reduced the leakage of marine debris from sea-based activities. By setting standards for pollution prevention and waste management, the IMO has fostered a culture of responsible environmental stewardship within the shipping industry, leading to a cleaner and healthier marine environment.

V. Capacity Building Scenario During 3-days Symposium

A. Identification of current MD collecting/carrier vessel in each APEC economies

Example of Marine Debris collecting and Carrier Vessels presented during the symposium:

1. Indonesia
   a. Garbage Carrier Ship

      Type of vessel:

      a) Monohull

      b) Garbage Carrier Ship

      Year implemented: 2015

      Principal Particular:

      a) LOA : 28 m

      b) B : 6 m

      c) T : 1.5 m

      Garbage bin capacity : 120 ton

      Location : Seribu Islands Regency, Jakarta.

Figure 12. Monohull – Garbage Carrier Ship

   b. Garbage collector vessel.

      Type of vessel:

      a) Monohull

      b) Inter-island garbage carrier boat

      Year implemented: 2018

      Principal Particular:

      c) LOA : 7 m

      d) B : 2.5 m

e) T : 0.7 m

Garbage bin capacity : 3 ton

Location : Seribu Islands Regency, Jakarta

Figure 13. Monohull – Inter-island Garbage Carrier Boat

c. Catamaran

Type of vessel:

a) Catamaran

b) Marine Debris (MD) collecting boat

Year implemented: 2017

Principal Particular:

c) LOA : 6 m

d) B : 3 m

e) T : 0.5 m

Garbage bin capacity : 2 ton

Location : Menado, North Sulawesi.

Figure 14. Catamaran – MD Collecting Boat

2. Thailand

a. MD collectors of the DMRC, Thailand: DMRC01 to DMRC06.

Type of vessel: Monohull

Waste carrying capacity: 4 ton

Principal Particular:

a) Waste carrying capacity : 4 ton
b) LOA : 13 – 15 metres
c) Breath : 3 – 4 metres
d) Draft : 1.2 – 1.5 metres
e) Engine power: 180 – 550 Hp
f) Maximum speed: 6.6 – 12.0 knots

Other function: oil spill recovery system

Location: Rayong, Phuket, Songkhla, Samut Sakorn, Surat Thani, and Trang Provinces.

Figure 15. MD collectors of the DMRC – When collecting debris, bow-hull parts be opened to widen the intake area to conveyor

Figure 16. MD collectors of the DMRC – When Sailing, the bow hull closed to minimize drag force

b. Commercial fishing vessels in cooperating between DOF, Thailand and Private sector

Type: Monohull, mainly wooden fishing vessels

Waste carrying capacity: N.A.

Location: all 23 coastal provinces of Thailand along the Gulf of Thailand and Andaman Sea

Figure 17. Fishing vessel tha modified to collect marine debris

c. Waste/hyacinth collectors of the Department of Public Works and Town & Economy Plannings

Type of vessel: Monohull

Principal Particular:

a) Breath: 3.4 meters

b) Carrying capacity: 4 ton

Location: Rivers in Thailand

Year implemented: 2021

Source:

https://www.youtube.com/watch?v=qJaeJjulHhU

Figure 18. Waste/hyacinth collectors of the Department of Public Works and Town & Economy Planningas

d. Waste/hyacinth collectors of Bangkok Metropolitan Administration

Type of vessel: Monohull

Location: Chao Praya River, Bangkok

Figure 19. Waste hyacinth collectors of Bangkok Metropolitan Administration

e. Waste collecting activity by public and private sectors using kayaks

Type: Kayak

Location: 10 provinces along the Chao Praya River and its tributaries

Year implemented: 2018

Source: www.77kaoded.com/news/panor-chompusri/255849

Figure 20. Waste collecting activity by public and private sectors using kayaks

3. Malaysia

   Pictures and information will be sent after the symposium. Especially, for implementation in Port klang River Project.

   Unfortunately, up to the finalization of Document there are no more information sent.

4. People's Republic of China

   Pictures and information will be sent after the symposium. The documents require approval from other Departments.

   Unfortunately, up to the finalization of Document there are no more information sent.

B. Sharing best practices and lessons learned from vessel innovation projects.

Lesson learned from Indonesia are:

1) Government involvement in combating marine debris is important. This leadership action is required to initiate activities.

2) Following the first point, budgeting for building vessels, manpower mobilization and operational administration are the next step to combat marine debris.
3) Universities, consultants or experts can assist the technical design and vessel procurement matters.

Thailand gives some experiences in vessel innovations:

1) Small modifications can be applied to combat marine debris, by using fishing vessels.
2) Local people and government officials should collaborate in action to combat marine debris.
3) Catamaran type is preferred for vessel design to operate in coastal waters.
4) The trash-boom buoy is also effective in reducing leakage from rivers into the ocean.

Malaysia delegation give some experiences in combating marine debris:

1) Collaboration with the private sector can also be implemented to combat marine debris.
2) The non-governmental organization (NGO) such as Ocean Cleanup, helps local government with their vessel in the estuary of Port Klang River.

People's Republic of China (PRC) have another point of view:

1) Managing waste and litter started in terrestrial water is suitable for their geography.
2) The PRC also has the trash-boom buoys in the rivers and dams to collect litter and wastes.

C. Collaboration Model for Future Actions to maximize impact and efforts.

1. Developing APEC MD observing system projects

There are many opinions of presenters and participants for developing an observation system in combating marine debris.

The simplest method is to stay over the boat and collect as many as they can do. This method already be implemented in Indonesia coastal waters.

The other way is collecting information from fishermen that returning from fishing the location of marine debris hotspots.

The next level of marine debris observation is by using surface current modeling. This method can be used to spot the location of pooled marine debris. There are many software to model the surface current and also websites to see the surface current.

The highest level of marine debris observation is using satellite. This observation method requires special skills and collaboration among economies.

This marine debris observing system open the possibility for research and innovation to be developed among APEC economies.

2. Conceptualized online regular assessments and data collection on debris removal

During the symposium, this topic is difficult to be discussed due to the expertise of participants not in information technology.

For developing online data collection and assessment of collected MD, it is requiring a team do work on it. This requirement is difficult to be implemented during the symposium.

One important suggestion is to build a website that using GIS (geographical information system) to inform MD hotspots among APEC economies. The main problem is who will initiate it? During the symposium it is considered to be the next project after this one.

3. Analyzing the effectiveness of vessel innovation strategies.

The effective MD collecting boat first we must know what type of debris to be collected, the weight, and boat's operating range. The port near the hotspot is also important according to experience from The Seacleaner. Daily or monthly data of collected MD can be used for analyzing effectiveness of vessel design. Next design can be based on these data.

According to Mr. Nugroho (BRIN, Indonesia), each coastal region or sea area require special vessel due to different characteristic of MD. The vessel design should consider this difference to optimize operation process. All participants agree the operational cost is important for designing a MD vessel.

VI. Conclusion

A. Summary of The Importance of Capacity Building on Vessel Innovation for Combating Marine Debris

The importance of the symposium can be excepted by all participants. Almost all representatives from four economies show their concern regarding Marine debris by implementing many vessels innovation in the rivers and coastal areas.

Other than economic participation in cleaning marine debris there is participation from non-governmental organization in People's Republic of China; Indonesia; Malaysia; and Thailand. The collaboration among economics and non-governmental organization in the APEC communities can foster the effectiveness of cleaning marine debris.

The capacity building for managing marine debris from upstream to downstream is vital. The current symposium is only one part of the down stream's activities to handle marine debris. The comprehensive action is required to combat Marine debris issues.

The development of a website plays a prominent role in the APEC region, where the importance of addressing marine debris cannot be overstated. This website harnesses cutting-edge technology, utilizing satellite imagery, GIS, and various other tools to not only detect but also track marine debris in real-time. The real strength of this platform lies in its ability to be shared seamlessly among APEC member economies, fostering collaboration on an unprecedented scale. It stands as a centralized hub of comprehensive data on online marine debris, offering a treasure trove of information for all APEC economies. This idea should become the next project after this one.

B. Final thoughts on the future of vessel innovation in preserving marine ecosystems

The innovation in terms of combating marine debris by using vessels is not only creating new technologies. It is also using appropriate, existing and cheaper technologies.

Sharing the best practices among the APEC economies is vital to combat Marine debris regionally and globally. In the end, human welfare can be preserved by preserving good marine ecosystem from marine debris.

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