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Microplastics in Coastal Aquaculture Systems: Development of Regulatory Frameworks, Practices and Mitigation Efforts in APEC Economies

APEC Ocean and Fisheries Working Group

June 2023

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APEC Project: OFWG 03 2021A

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APEC#223-OF-01.2

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EXECUTIVE SUMMARY

This White Paper aims to take stock of existing policy and regulatory frameworks regarding the prevention and mitigation of microplastic contamination and distribution in coastal aquaculture input chains in the APEC region. Of the invited 21 APEC economies to contribute to the study, 12 economies responded and provided varying degrees of data and information based on given standardized guidelines. In developing the White Paper, a desk study was carried out by contributors to collect the required data and information lasted from September to November 2022. Three separate virtual meetings were subsequently held on 2 November 2022 where the contributors from each economies presented the summary of their findings.

APEC and APEC economies have been working together to address marine debris and plastic pollution in the marine environment of the APEC region. Various policies, regulations, research and public discourses have been enacted to manage and reduce marine debris and plastic waste. As a result, most APEC economies have devised a national action plan supported by a primary policy/regulatory framework to ensure the road map can be implemented. However, each economy has developed and implemented its policies, regulations, and domestic road map related to waste management based on their current socio-economic conditions.

Several APEC economies (China; Indonesia and Viet Nam) are the major producers of seafood products from coastal aquaculture. Other APEC economies have also developed coastal aquaculture with different levels of farming systems, challenges and successes. It is predicted that the roles of coastal aquaculture will continue to increase due to the increased population and the relative stagnant production of capture fisheries. As an anthropogenic activity, coastal aquaculture will have significant effects on the marine environment, particularly its contribution to marine debris and plastic waste. APEC has acknowledged this issue by including the aquaculture sector as a contributor to marine debris and plastic waste. The commitment by APEC economies to combatting marine debris and plastic waste, including microplastics/micro debris, has been translated into more than 250 regulations by the 12 APEC economies participated in this study. Each APEC economy adopts or develops various methods and standard monitoring protocols for marine debris and microplastics, of which the UNEP and NOAA standard protocols are the most commonly used. However, the impacts of plastics, particularly microplastics, on coastal aquaculture input chains are currently not considered in APEC and APEC economies in regulatory frameworks and public discourses. Fortunately, microplastic contamination in fish, particularly from coastal aquaculture, is gaining momentum from the research point of view. One APEC report titled “Best Practices and Recommended Policies for Optimizing the Plastic Supply Chain in Southeast and East Asia” has highlighted that microplastic contamination in fish, including farmed fish, is no longer scientifically debatable.

The Republic of Korea; New Zealand and Chile are among the first economies within APEC that have invested interest in reducing microplastic in coastal aquaculture through policy development and public discourse. Other APEC economies, could have pursued a lesser extent compared to the three economies. But in any case, the policy development and public discourse still focus primarily on microplastics effects on farmed species and fish meals. A comprehensive policy or public discourse related to the whole input chains of coastal aquaculture has yet to be materialized, whether in APEC or APEC economies. In order to achieve this objective, building up scientific evidence of microplastic impacts on coastal

aquaculture input chains is one of the necessary ingredients to develop a good policy/regulatory framework within APEC and APEC economies.

This white paper concludes that the regulatory frameworks regarding the impacts, monitoring and prevention of microplastics in coastal aquaculture input chains in APEC are almost negligible. Public discourses and research related to the issues are also limited. It is then imperative that public discourse, as well as scientific activities, should be carried out continuously in order to develop a comprehensive policy within the APEC region. The comprehensive policy could allow faster adoption by APEC economies to improve the quality and safety of seafood products produced from coastal aquaculture in APEC economies. It is hoped that this White Paper and the overall project (APEC OFWG 03 2021A) will provide a strong baseline for APEC and APEC economies regarding the impacts of microplastics in coastal aquaculture input chains. A successful development of policy within APEC related to monitoring and preventing microplastics in coastal aquaculture input chains will improve seafood safety and increase global market share of coastal aquaculture products from APEC economies.

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ABREVIATION

AMS	Action Plans Member States
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
CEPA	Communication, Education & Public Awareness
CPR	Continuous Plankton Recorder
CSIRO	Commonwealth Scientific and Industrial Research Organization
FAO	Food and Agriculture Organization
IMO	International Maritime Organization
MP	Micro Plastic
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
OFWG	Oceans and Fisheries Working Group
PET	Polyethylene Terephthalate
PP	Polypropylene
RPOA	Regional Plan of Action
SDG	Sustainable Development Goal
UNEP	United Nations Environment Programme
USMDMP	United State Marine Debris Monitoring Program

1. INTRODUCTION

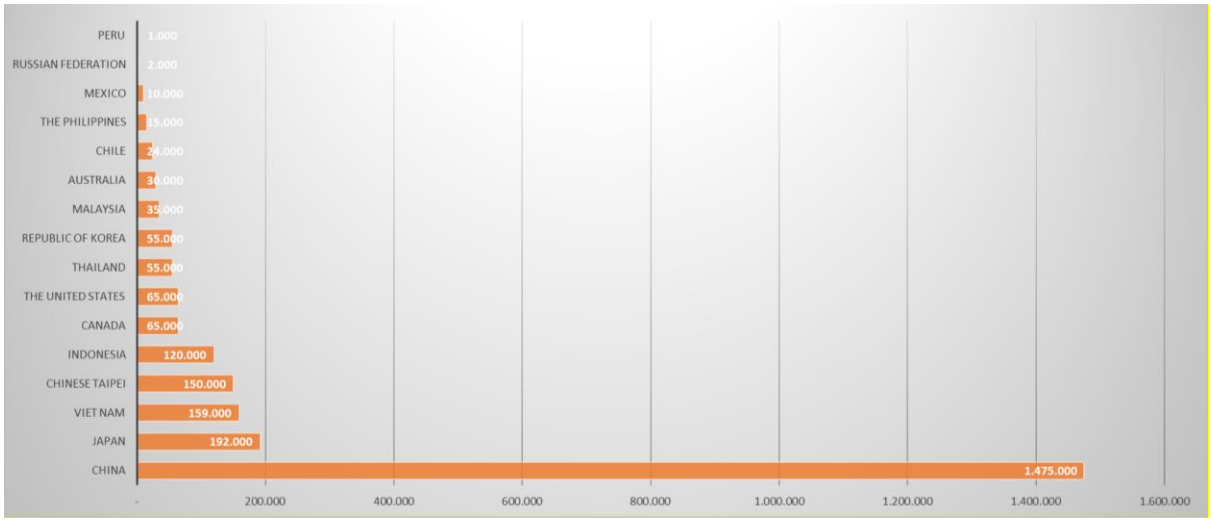
1.1. Background

Efforts to manage and reduce marine debris, including plastic litter, in the marine environment have been carried out throughout the globe. The efforts range from policy consensus and regulation intervention to research, education and community involvement. In APEC economies, concrete actions have been taken to address plastic litter, particularly microplastic pollution, based on the APEC principles of consensus, non-binding, voluntary participation, cooperation, and flexibility. However, information on sources, distributions, and mitigation plans for the APEC region's microplastic pollution within coastal aquaculture systems remains limited. The study of Van Cauwenberghe and Janssen (2014) estimated that an individual could ingest 11,000 particles of microplastics annually through seafood consumption. The estimation might be overly generalized to all regions and economies and has extrapolated microplastics contamination from shellfish to other marine species, including fish. However, this safety concern could discourage seafood consumption leading to a reduced market share of seafood products exported by most APEC economies.

Plastic litter contributes to most (around 80%) marine debris (United Nations Environment, 2016). Physical, chemical, and biological processes gradually break down these materials into smaller fractions/particles of 1 micrometer – 5 mm (microplastics) and inevitably to 1 – 1000 nm (nanoplastics). The sturdiness of these particles means that they remain in marine water columns and sediment over hundreds of years. As such, the probability of these non-degradable particles circulating through the marine food web and eventually ending up in humans is greater than most degradable/non-degradable particles.

Concerns over plastic waste from aquaculture operations are more frequently discussed than the exposure of aquaculture input chains and products to plastic waste (micro-nano plastics). Both the reports of FAO (2017) and APEC 2019 Senior Official's Meeting in Chile indicated such a tendency. The FAO (2017) report even reiterated insufficient information on the safety risk of plastic contamination in seafood processes and products, including aquaculture. Since aquaculture production will continue to be higher than capture fisheries (FAO, 2022), microplastics contamination could determine export acceptance of aquaculture products from APEC economies in international markets. APEC economies will likely face more significant challenges in the aquaculture subsector from microplastic pollution for the following reasons. Firstly, policy, research and public discourse regarding microplastics in coastal environments are heavily directed toward the impacts of microplastics on wild fish and the general marine environment. In contrast, microplastic distribution and its impacts on the coastal aquaculture input chains are relatively unknown.

Secondly, farmed fish are kept in a controlled environment for a certain period. Thus, the farmed organism can be exposed to microplastics during the farming cycle. Most of the mariculture centers in APEC economies are located within or near population or industrial centers from which plastic is released. Thirdly, coastal aquaculture input chains consisting of fishmeal, fish feed, and equipment are susceptible to microplastics contamination. For example, ten APEC economies imported at least 2.45 million metric tons of fishmeal used for various purposes, including fish feed (Figure 1). The number is almost the same as the total of fishmeal used in mariculture worldwide (2.5 million tons), which Thiele et al. (2021) estimated to contain up to 1.67 tons of microplastics.



Source: (USDA, 2021)

Figure 1. Import of fishmeal by APEC economies

Fourth, some APEC economies have their own regulations to avoid microplastics in seafood products. However, it is argued here that there is no existing regulatory framework within the APEC economies to address microplastics pollution and its mitigation in the coastal aquaculture input chains. For example, an absence of regulation and mitigation guidelines to limit microplastic contamination in seafood and other aquaculture products is evident in APEC member economies. Such missing regulatory components based on scientific evidence could put the APEC economies in a disadvantaged position if future Global Aquaculture Practice requires a minimum amount of microplastics in aquaculture products. Fifth, procedures for collecting and analyzing microplastic samples are varied among APEC economies. As a result, it is difficult to provide consistent and reliable information regarding the level and distribution of microplastics within the APEC region, particularly in coastal aquaculture input chains.

The 2019 APEC Roadmap on Marine Debris proposed that APEC will take action to address marine debris, including plastic litter, based on scientific evidence and lessons learned from regional efforts through the following strategies:

1. Encouraging an APEC consolidated approach by driving policy development and coordination at every level, from regional cooperation down to local governments, across all relevant fora and agencies;
2. Fostering research and innovation for the development and refinement of new methodologies and solutions for monitoring, preventing, and reducing marine debris;
3. Promoting sharing of best practices and lessons learned and enhancing cooperation; and
4. Increasing access to financing and facilitating private sector engagement to promote investment, trade and market creation in industries and activities that enable marine debris management and prevention.

Following up the APEC strategic approaches above to prevent and mitigate microplastic distribution in coastal aquaculture input chains, this APEC project was initiated to develop a White Paper with the following objective (Section 1.2).

1.2. Objective

This White Paper aims to take stock of existing policy and regulatory frameworks regarding the prevention and mitigation of microplastic contamination and distribution in coastal aquaculture input chains among APEC economies. In order to develop the white paper, the project invited contributors from all APEC economies to voluntarily identify regulatory frameworks and standard methods regarding microplastics in their own respective economies. The contributors performed a rigorous desk study to take stock of existing policy frameworks and identify gaps and needs across APEC economies regarding the prevention and mitigation of microplastics in the coastal and marine ecosystem, with a particular focus on the coastal aquaculture input chains. A formal guideline on data collection regarding the data and information needed was developed and distributed to all contributors to maintain the collected data and information consistency. The contributors collected the data and information from July to November 2022.

A one-day virtual meeting was held where the contributors presented the summary of the collected data and information and received inputs and comments from other contributors and invited participants. There were three consecutive virtual meetings held on 2 November 2022. Each meeting was attended by contributors from APEC economies grouped by their similar time zone. In total, 38 participants from 12 APEC member economies attended the virtual meetings.

The White Paper is expected to serve as a reference for the subsequent stages of this APEC OFWG 03 2021A project. This White Paper could also be used for APEC economies and non-APEC Economies member as a lesson-learned case study in

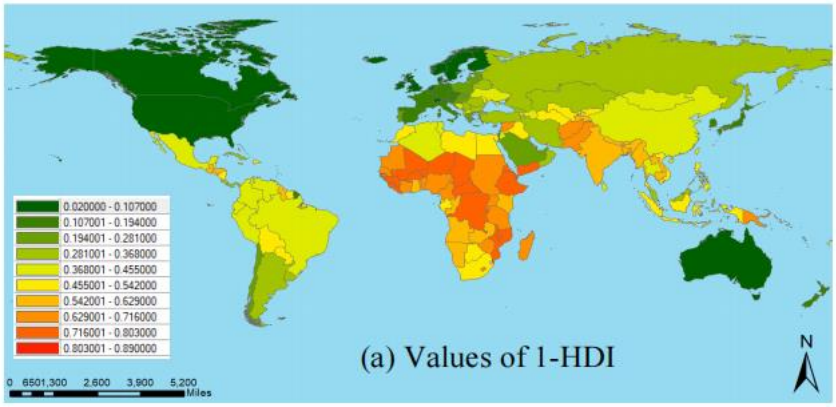
developing robust policy and regulatory framework to mitigate microplastic contamination in marine environments, particularly in coastal aquaculture input chains.

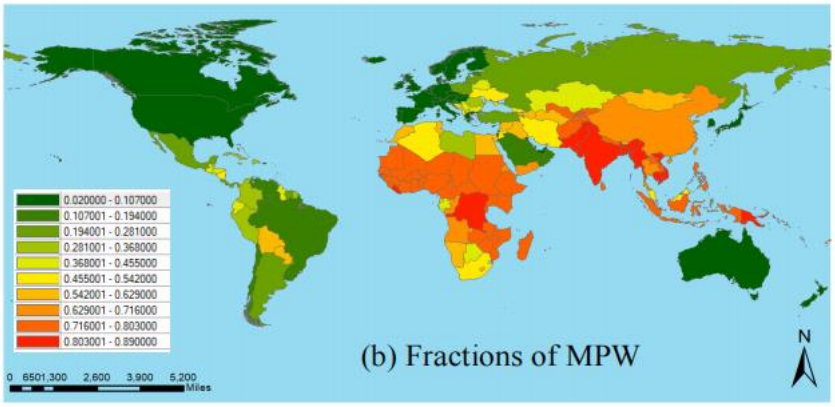
2. OVERVIEW

2.1. Marine Debris and Plastic Pollution in the APEC region

Marine debris and plastic waste is a global issue, including in the APEC region. These wastes enter the ocean via rivers, streams and areas adjacent to coastlines in various forms of metal, plastic, and other hard-to-degrade materials. Since plastic waste contributes to at least 80% of the total marine debris, some view that marine debris challenges can be resolved by managing the plastic supply chain and its final waste (APEC, 2022). Even before becoming waste, plastic manufacturing significantly releases greenhouse gases, a primary driver of climate change. For instance, PasticsEurope (2020) reported that the production of plastic materials in Europe accounts for between four and six percent of total gas and oil consumption. When plastic enters the environment as waste, it is partitioned into various matrices such as air, soil, water, bottom sediments, and organism tissues.

Moreover, the amount of plastic waste released from land to ocean has attracted increasing concern. A previous model has estimated plastic waste discharged from APEC economies based on the concept of mismanaged plastic waste (MPW), which has caused considerable controversy because the values obtained by this model were substantially greater than reported field measurements (Jambeck et al., 2015; Mai et al., 2019; Mai et al., 2020). This model defined the percent of MPW simply based on income, coastal population and plastic waste management practices without considering more complex and comprehensive social factors (Mai et al., 2020). Conversely, a robust model took the human development index (HDI) as the main predictor may fill this gap, which indicated that the amount of available plastic waste (APW) in APEC economies was dramatically lower than the range of MPW estimated by the previous model (Figure 2) (Mai et al., 2020). It is therefore of great importance to design more accurate model to further reduce the uncertainty of our estimate and make the objective conclusion (Zhang et al., 2023).





Source: Mai et al., (2020) Mai, L., Sun, X.F., Xia, L.L., Bao, L.J., Liu, L.Y., Zeng, E.Y., 2020. Global Riverine Plastic Outflows. Environ Sci Technol 54, 10049-10056.

Figure 2. Comparison results between available plastic waste (APW) and mismanaged plastic waste (MPW), which is displayed as the (a) values of 1-HDI and (b) fractions of MPW.

Marine debris and plastic waste management are handled differently among APEC economies. Developing economies rely heavily on landfill (Agamuthu, 2013), while developed economies have moved to prioritize recycling and energy recovery (in the form of heat, steam and electricity) (Ritchie and Roser, 2018). However, incorporating sophisticated and separation infrastructures for marine debris and plastic waste is capital expensive, which developing economies cannot afford. Waste management in the APEC region, particularly the developing economies, also faces several complex issues. The complexity relates to the typically unprotected landfills, waste dumps near the coast or riverine systems, uncontrolled littering along shorelines, unmanaged harbor activities, overflow from sewage systems, and extreme occurrences (i.e., storms). Although there are still various difficulties, concerted efforts have been undertaken to improve plastic waste management and treatment in developing APEC economies (an example of China can be found in Figure 3). It is firmly believed that effective control and proper disposal of plastic waste can be achieved in developing APEC economies with the socio-economic development (Mai et al., 2020).

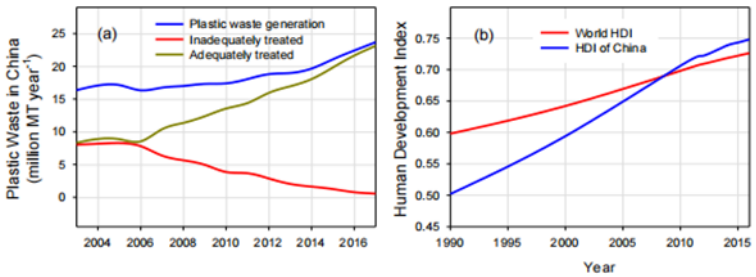


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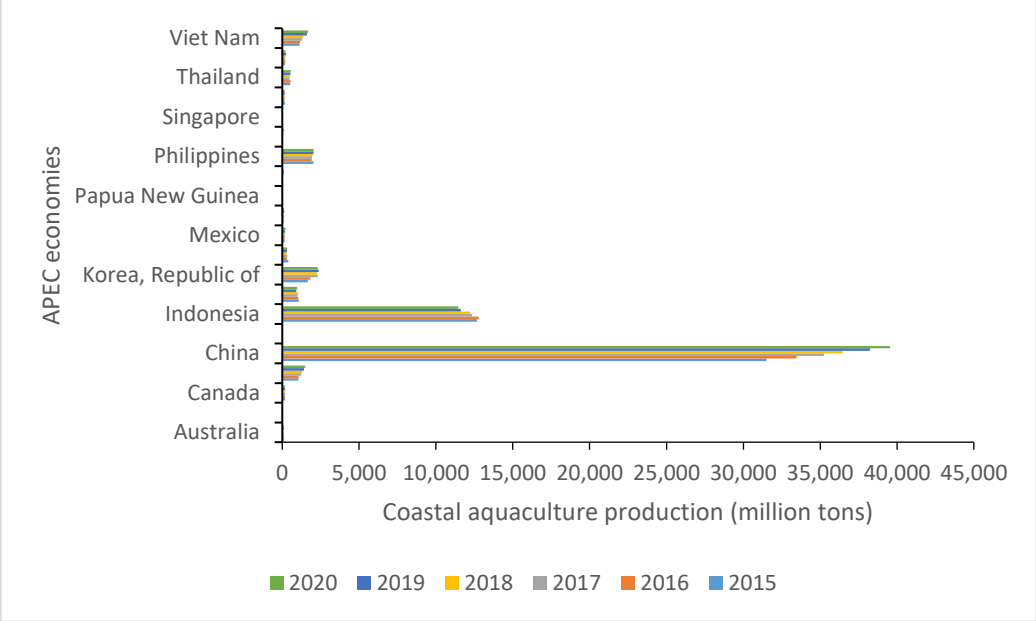
Figure 3. Temporal trends of plastic waste management and human development index (HDI) in China. (a) Plastic waste generation (blue line), adequately treated waste (brown line), and inadequately treated waste (red line). (b) World HDI (red line) and HDI for China (blue line).

2.2. Coastal Aquaculture Challenges and Opportunities in APEC Economies

In 2014, the top 25 producers of aquaculture accounted for 96% of the world's total production. Several APEC economies continue to dominate aquaculture production, indicated by an increase of up to 49.09% within the past five years (2015-2020). China; Indonesia; Thailand and Viet Nam, and other non-APEC economies (India and Bangladesh) contributed almost 81% of global aquaculture production (FAO, 2018). China; Indonesia and Viet Nam are the top three world producers of coastal aquaculture products (Figure 4).



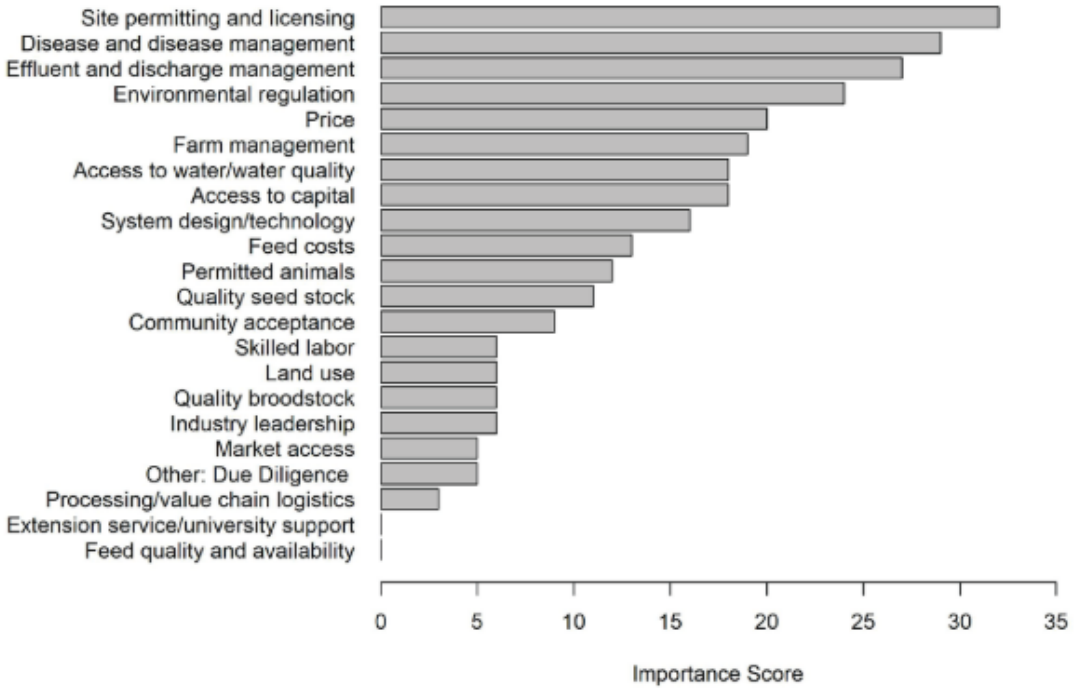
Source: FAO, (2022)

Figure 4. Aquaculture production in several APEC economies during 2015 - 2020

The recent statistical data published by FAO (2022) showed that the production from the APEC region's coastal aquaculture systems, including marine and brackish water aquaculture, accounted for 70.28% (61.5 million tons) of the total output of global aquaculture of 87.50 million tons in 2020. However, it is important to note that several economies have faced some drawbacks in maintaining consistent production. For example, the Philippines and Japan experienced a negative trend in coastal aquaculture production in 2021 which were -3.3% and -1.4%, respectively, compared to the previous years. Similarly, Viet Nam, despite being consistent in the top three major aquaculture producers, had only a slight increase of 1.8% in 2021 compared to the previous years.

The COVID-19 outbreak in early 2020 has been one of the major challenges faced by APEC economies in sustainable aquaculture production. Access to farming sites, limited and inconsistent input supplies such as feed, fries, fish health products and equipment, additional red tape for food safety certificates, cargo limitations, and

securing market access are among the new aquaculture challenges related to COVID-19. Seafood products produced from coastal aquaculture (frozen and fresh) face more demanding challenges since most highly valued products are transported between economies. Prior to the COVID-19 pandemic, business-as-usual challenges have been well studied, and strategies, as well as mitigation plans and implementation activities, partially solve most of them. Fish disease outbreaks, including emergent diseases, degradation of the farming environment, low quality of broodstock and seeds, and low quality of feed (Figure 5) have been well defined, including their solutions and mitigations through research, policy and practical applications.



Source: Camp et al. (2020)

Figure 5. The relative importance of challenges in aquaculture development

Coastal aquaculture depends on the availability of farmed fish species which is strongly influenced by geographic characteristics. APEC economies are distributed from the northern latitude down to equatorial and southern latitudes, where each economy has unique regional features. Such wide geographical distribution has resulted in different farmed fish species being developed in APEC economies. For example, based on APEC regional boundary, only 31 different fish species are farmed in APEC economies in the American region. In contrast, economies within the Asian region have commercially farmed more than 144 species of fish for aquaculture. Most marine and brackish water aquaculture species are used mainly for human consumption, while a small number of fish species are used for conservation purposes.

Table 1.Farmed species and available farming areas for aquaculture in the APEC region

No.	Economy	Coastal Species	Freshwater Species	Total Area (Ha)	Sources
1.	Australia	12	8	n/a	(FAO, 2022)
2.	Brunei Darussalam	9	3	18,946	(FAO, 2022); ASEAN Japan center, 2021
3.	Canada	14	3	n/a	(FAO, 2022)
4.	Chile	15	5	31,946	(FAO, 2022)
5.	People's Republic of China	51	50	7,450,000	(FAO, 2022)
6.	Indonesia	27	20	1,069,223	(FAO, 2022)
7.	Japan	20	7	n/a	(FAO, 2022)
8.	Republic of Korea	11	4	121,853	(Lu, 2021)
9.	Malaysia	32	27	329,847	(FAO, 2022)
10.	Mexico	13	8	16,200,000	Contributor
11.	New Zealand	4	1	8,000	(FAO, 2022); Contributor
12.	Papua New Guinea	1	3	5,418*	(FAO, 2022);
13.	Peru	3	8	17,404	(FAO, 2022)
14.	The Philippines	20	7	646,366	(FAO, 2022)
15.	Russia	9	16	180,460	(FAO, 2022, Kalinina and Zelenskaya, 2018)
16.	Singapore	28	8	n/a	(FAO, 2022)
17.	Chinese Taipei	32	26	74,000	(FAO, 2022);
18.	Thailand	18	21	78,688	Contributor
19.	The United States	20	11	353,400	(FAO, 2022);
20.	Viet Nam	13	13	1,135,000	(FAO, 2022)

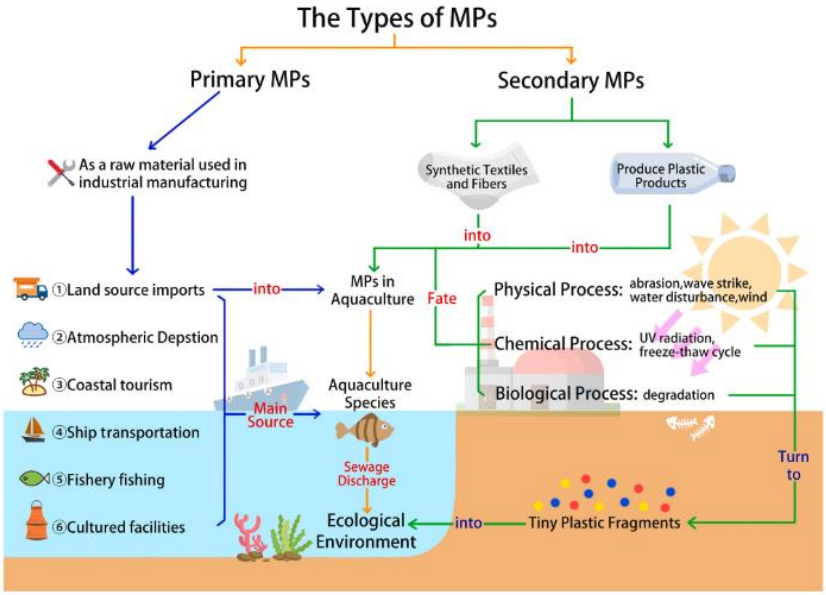
*Total Potential Area

2.3. Coastal Aquaculture and Marine Debris/Plastic Pollutions: The Relationship

Coastal aquaculture platforms installed on or near the marine environment simultaneously serve as contributors and receivers of marine debris/plastic waste. Types of marine debris/plastic waste from coastal aquaculture depend on the farming system used. In general, the most common marine debris/plastics waste from aquaculture systems are poles, frames, ropes, cages, feed bags, discarded nets, floats, ties, baskets, sorting equipment and even food utensils used by technicians/workers working on the farming platform. Some of these materials have a long usage time, but others have to be replaced after once or several farming cycles. For example, nets, ropes, poles, and float could be used for over 3 to 5 years. Once reaching their lifetime usage, they are relatively difficult to remove on-site due to their size or volume. It is a common practice that these materials are left on or released into the marine environment until they disintegrate into marine debris or plastic waste. Shorter lifetime materials such as baskets, equipment and ties are usually small in

size/volume. Burning on the platform, collecting for transferring to local land dumps or releasing to the sea are the typical fate of these materials.

Economies with stricter environmental regulations regarding waste might require these materials to be appropriately collected, stored, and transferred to local dumps for further process. However, coastal aquaculture in most economies, such as shrimp and finfish farming, operate in remote areas, far from the nearest local dumps or landfill. Unsurprisingly, the APEC Roadmap on Marine Debris launched at the Third Senior Officials' Meeting in Chile in 2019 considered aquaculture a significant contributor to marine debris/plastic pollution. It is important to note that this critical milestone did not address the opposite effects of marine debris on aquaculture, particularly plastic waste, despite more than half of the protein from fisheries having been supplied from aquaculture.



Source: Dong et al. (2021)

Figure 6. Sources, distributions, and behavior characteristics of microplastics in aquaculture environment

Coastal aquaculture receives plastic waste from micro-nano plastics distributed in the marine environment. Microplastics have been found in aquaculture ponds, estuaries, coastal biomes, the open ocean, and polar waters (Lusher et al., 2017). Recent findings have shown that microplastics have infiltrated aquatic animals through several infiltration points, i.e., trophic transfer, direct ingestion, suspension feeding, and filter feeding of microplastic-exposed animals (Figure 6).

Food chains in aquatic environments can bridge microplastic transfer where aquaculture species feed on microplastic-exposed organisms in the food chains. Zooplankton, phytoplankton, crustaceans, algae, aquatic plants, and small fish feed and absorb MP at the lowest trophic level (Botterell et al., 2019, Parker et al., 2020). Microplastic could also enter the aquaculture system via fishmeal used as the main

ingredient in fish feed. A case study in Malaysia found that three main commercial fishmeal contain a high level of microplastics, 78.2% of which were fragments of plastic polymers, followed by filaments and films (Karbalaei et al., 2020). This study indicates that cultured fish could be exposed to high levels of microplastics through the ingestion of microplastics-contaminated fishmeal. The third microplastic pathway to the coastal aquaculture system is through the direct contamination of farming environments such as farming media, equipment, and post-processing. These pathways have been frequently discussed in the literature, yet quantifying how much each contributes to the coastal aquaculture system remains unclear (Zhou et al., 2021).

The APEC economies have yet to investigate marine plastics' impacts on coastal aquaculture systems. The APEC economies' primary research currently focuses on studying the spreading of plastic pollution in the marine environment. This study has reviewed various reports from contributors of 12 APEC economies. All the reports from the contributors indicate that specialized microplastic research into the effects of MPs on aquaculture activities are almost negligible (see Annex 4). Such discrepancy compared to the research efforts on the effect or contamination of microplastics in other parts of marine ecosystems is profoundly disturbing. Aquaculture's role as the primary source of protein for the most significant part of the world population could face an unnecessary challenge from microplastic if this issue is not addressed via policy intervention and research as early as possible.

3. GENERAL POLICIES AND REGULATIONS IN MARINE DEBRIS AND PLASTIC/MICROPLASTIC POLLUTION IN COASTAL ENVIRONMENT

3.1. General Policies and Regulations on Marine Plastic Waste and Debris.

The Southeast Asian region has drafted several non-legally binding policy frameworks combating marine pollution related to the 2030 Agenda for Sustainable Development Goal (SDG) 14 on life below water (UNEP, 2019). According to the recently published ASEAN Regional Action Plan to Combat Marine Litter 2021-2025, further political efforts are needed to investigate all aspects of single-use plastic, including the root causes of creating a culture and habit of using disposable items (ASEAN, 2021). This Regional Plan of Action (RPOA) requests for Action with Ocean pollution by plastic, which individual ASEAN will tackle through domestic Action Plans Member States (AMS).

Within the APEC region, the 3rd APEC Senior Officials Meeting held in Puerto Varas, Chile, on 29-30 August 2019, proposes a roadmap for marine litter to encourage member economies to take specific steps by taking into account their respective internal circumstances. Table 2 lists the primary regulations enacted by 15 APEC economies before or after the event concerning combating marine debris and plastic pollution. These regulations are the regulatory products of APEC economies to deal with marine debris issues. The Philippines; Chile; Indonesia; the United States of America and Viet Nam are among the APEC economies with strong policy direction toward reducing marine debris and plastic pollution, indicated by the enactment of more than ten regulations to deal with the issues. For example, several city councils in the Philippines have started publishing local/regional regulations to ban plastic bags, polystyrene, and polystyrene (expanded) since 2008. The municipal level regulation was started for the first time in the City of Los Banos, followed by as many as 18 cities in the Philippines to ban the use of single-use plastic, including plastic packaging.

On the economies level, Malaysia; Singapore; Mexico and Chile joined the zero-waste nation movement in 2019 – 2020 (G20, 2021, MSE, 2022, MEW, 2021, MMA, 2021, Valencia, 2022). They commit to implementing the Zero Waste Act and developing a comprehensive action plan to achieve the goal. For example, Malaysia's National Marine Litter Policy and Action Plan 2021 – 2030 adopted five integrated policy measures to combat marine debris and plastic pollution consisting of Policy Adoption and Implementation; Deployment of Technologies, Innovation, and Capacity Building; Improve Monitoring and Data Collection on Marine Litter; Communication, Education & Public Awareness (CEPA) and Outreach; and Whole-Of-Nation and Multi-Stakeholders Approach. This Policy is substantiated by 17 action plans and 103 activities to be implemented in tandem with the Plastic Sustainability Roadmap 2021-2030 and the Roadmap Towards Zero Single-Use

Plastic 2018-2030, which focuses on the implementation of circular economy as a catalyst for resource sustainability.

The overall regulatory target published by each APEC economy is primarily focused on reducing marine debris pollution, increasing recycling, and banning the use of plastic with a similar target time frame of 2029–2050. It is important to note that the awareness of APEC economies on the detrimental effects of marine and plastic pollution is evident from the fact that all the economies that contributed to this study have sets of regulations and comprehensive road maps in combating marine litter and plastic pollution. Only Peru and Mexico are not yet identified to have a published marine debris and plastic pollution road map. An interesting finding was that of 15 APEC economies, less than 50% (6 economies) have specific regulations concerning microplastics or micro-debris. Compared with the more mature marine debris and plastic pollution, the awareness of microplastic impacts has yet to be translated into the regulatory framework of APEC economies. This is because the number of regulations is minimal, ranging from 1 – 3. Viet Nam is the only economy with three identified specific regulations concerning microplastics or micro debris.

This study has also found clear evidence regarding increased awareness on the level of policy making to the risks of contamination of marine plastic particles on seafood commodities and the contribution of the mariculture sub-sector to marine debris and plastic waste. Table 22 shows that APEC economies have started exploring appropriate legal and policy responses to the issue at the regional and international levels. However, most APEC economies' regulatory frameworks aim to limit marine plastic inputs from mariculture through tighter controls on accidental loss or disposal, circular economy approaches, and monitoring the presence and impact of plastic waste from mariculture to the surrounding marine environment. For example, Korea has banned the use of Styrofoam buoys for oyster mariculture to reduce plastic waste through the enforcement rule of the Fishing Ground Management Act. The New Zealand government has also published a specific report discussing handling plastic pollution from aquaculture activities and enacted the domestic Environmental Standard for Marine Aquaculture. The latter provides guidelines to manage the use of plastics in marine aquaculture. Both economies could be considered prime examples of efforts to prevent plastic waste from mariculture to the surrounding environment. Yet, APEC economies generally have no specific scientific-based regulatory frameworks to protect mariculture from microplastic contamination.

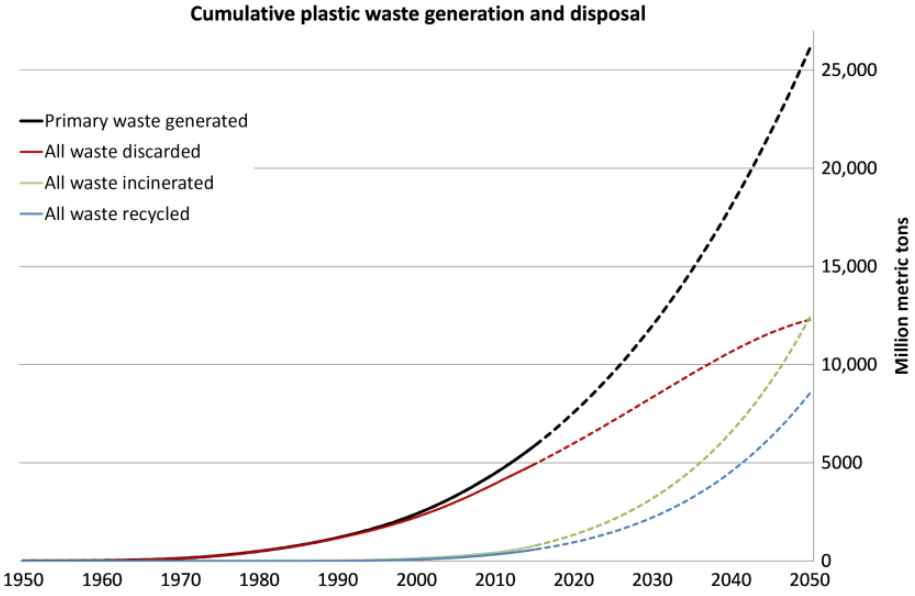
Table 2. APEC economies regulation on addressing marine debris and plastic pollution

Economy	Marine debris-related regulation	Zero waste act	Plastic waste regulation	Comply with MARPOL 73/78	Roadmap or action plan to reduce marine debris	Number of regulations on microplastic or microdebris	Regulation of plastic in fisheries or maricultu re	Goals on combating plastic waste and marine debris
Chile	15	Yes	13	Yes	Yes	NA	Yes	Using 70% of collected and recycled plastic to produce disposable plastic bottles by 2060 (Luhrman, 2021)
Indonesia	13	NA	10	Yes	Yes	2	NA	Reducing 30% of plastic waste from producers by 2029 and 70% of marine debris by 2025 (MOEF, 2019; Indonesia's Presidential decree, 2018)
Japan	7	NA	7	Yes	Yes	1	Yes	Achieving a rate of recycling/reusing containers and packaging of 60% by 2030, and realizing 100% effective utilization of used plastics by 2035 (Yu et al., 2022)
Republic of Korea	5	NA	5	NA	Yes	2	Yes	Reducing 60% of the total marine plastics debris inflow by 2030 and achieving zero plastic debris inflow by 2050 (MOF, 2021)
Malaysia	5	Yes	5	NA	Yes	NA	Yes	Increasing recycling rate on plastic packaging: 25% in 2025, 100% in 2030 (MEW, 2021b)
Mexico	4	Yes	4	NA	NA	NA	Yes	Targeting all plastic products to contain 20% recycled material by 2025 and reaching 30 % in 2030, recycling rate of 55% in 2030. In 2025, 70% of all PET should be recovered and 80% in 2030 (Michail, 2020)
New Zealand	7	NA	7	NA	Yes	0	Yes	Banning single-use plastic in 2025; hard-to-recycle plastics are proposed for phase-outs by January 2025 (ME, 2021)
Peru	1	NA	1	NA	NA	1	NA	Recycling 100 % of municipal reusable solid waste (those from homes and commerce) by 2024 (Verna et al., 2021)
The Philippines	26	NA	26	NA	Yes	NA	NA	Achieving zero waste in the Philippines waters by 2040 (G20,2021)
Russia	6	NA	5	Yes	Yes	NA	NA	Introducing a complete ban on the use of plastic bags from 2025 (G20,2021)
Singapore	6	Yes	5	Yes	Yes	NA	Yes	Increasing waste recycling rate to 70% and reducing waste-to-landfill per capita per day by 30% by 2030 (MSE, 2021)
Chinese Taipei	4	NA	4	NA	Yes	NA	Yes	NA
Thailand	3	NA	3	Yes	Yes	NA	Yes	Banning totally selected types of plastic by 2022 and replace with eco-friendly materials, 50% of target plastic-type will be recycled by 2022 (G20,2021)
The United States	10	NA	10	Yes	Yes	2	NA	Announcing, via the US Environmental Protection Agency, a Domestic Recycling Goal to increase the recycling rate in the US to 50% by 2030 (EPA, 2020)

Viet Nam	10	NA	10	NA	Yes	3	Yes	Reducing marine plastic debris by 50 % by 2025 and by 75% in 2030 (WorldBank, 2022)

3.2. Microplastic Handling Discourse in Public Domain

The production and consumption of plastic materials continue to increase globally. As a result, it is predicted that the total generated waste will follow an exponential rate by 2050 (Figure 7). In order to slow the rapid acceleration of plastic waste production, APEC economies have enacted and enforced science-based policies and regulations (see Appendix 5) to limit the consumption of plastic material (particularly single-use plastic), including handlings of plastic waste. As previously discussed, research carried out in APEC economies has shown disturbing evidence that microplastic has contaminated commercial fish and other marine biotas. However, regulations and research results must be disseminated to larger audiences, i.e., the public, through effective channels and means. Such engagement is vital to successfully increase public awareness and participation in reducing marine debris/plastic pollution.



Source: (Geyer et al., 2017)

Figure 7. Trends of cumulative plastic waste generation and disposal (in a million metric tons). Solid lines indicate historical data from 1950 to 2015; dashed lines are projected trends by 2050 generated from historical data

Based on the information provided by the contributors of 12 APEC economies, the most researched topic is microplastic contamination in fisheries and aquaculture products, followed by plastic litter distribution and its abundance status in coastal and marine environments (Figure 8). The high percentage of studies related to contamination of microplastic contamination in fisheries and aquaculture products could be misleading due to the focus of this study on collecting stock of the related research activities. However, there is unambiguous scientific evidence of increased microplastic contamination in marine organisms posing potential risks to human health, food security and safety (Barboza et al., 2018).

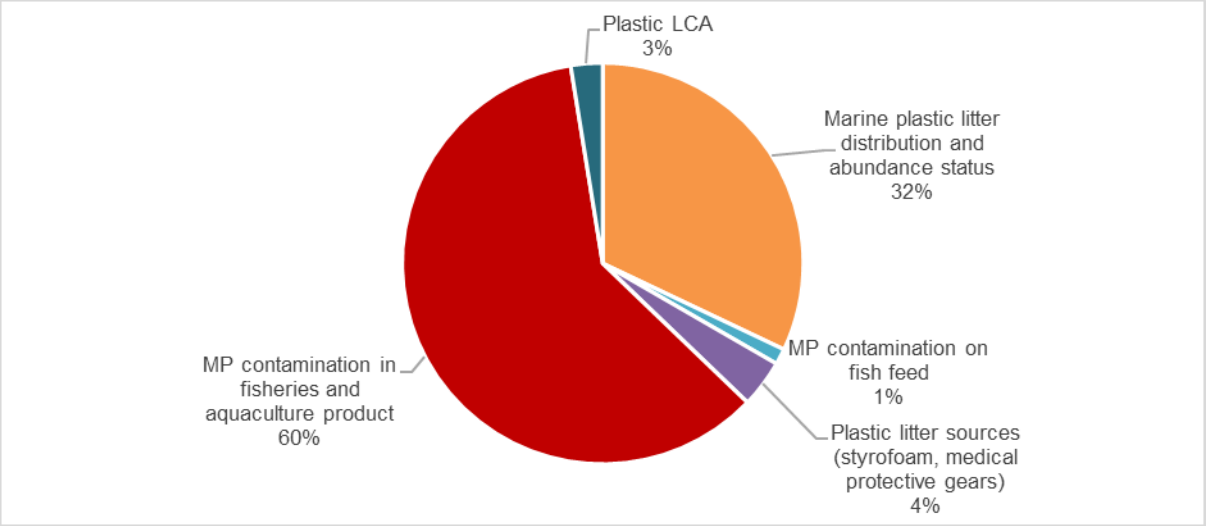


Figure 8. Thematic research on plastic/microplastic pollution in APEC economies

Numerous campaigns, dissemination of research, community outreach, and public discourse concerning marine debris/plastic waste have been carried out in APEC economies. Various dissemination channels were used, such as talk shows, website media releases, symposiums, and seminars. The participants of these events ranged from government agencies, NGOs, and local communities (see Appendix 5). Interestingly, from all the public discourse identified by the contributors, plastic waste/microplastic contamination dominate the discussion compared to marine debris. This shift in public discourse hints that plastic waste issues in marine environments have gained greater public attention than marine debris issues. This could be related to the fact that plastic waste dominates the proportion of the total marine debris entering our oceans and has potential health risks to marine organisms and humans (United Nations Environment, 2016).

3.3. Sampling Techniques and Analysis of Microplastic in Aquatic Environment

Various methods are employed by APEC economies to assess marine debris and microplastic accumulation. They include protocols provided by global institutions such as the United Nations Environment Programme (UNEP), the Intergovernmental Oceanographic Commission (IOC), The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), the *International Maritime Organization* (IMO), and the Beach Litter Monitoring Programme, OSPAR Commission of the EU. GESAMP (2019) has established the Guidelines for the monitoring and assessment of plastic litter and microplastics in the ocean, while the Global Manual on Ocean Statistics (UNEP, 2019)

Additionally, several economies have also developed their domestic protocol, including the USA (National Oceanic and Atmospheric Administration/NOAA, US

Marine Debris Monitoring Program/USMDMP); Australia (The *Commonwealth Scientific and Industrial Research Organization/*CSIRO); Japan (Guidelines for Mexico Harmonizing Ocean Surface Microplastic Monitoring Methods); Korea (Monitoring and Analytical Methods for Floating and Beach Microplastics) and Indonesia (Guidelines for Monitoring Marine Debris: Beach Debris, Floating Debris and Seabed Debris). NOAA method is the most widely adopted in APEC economies such as Mexico; Peru; Viet Nam; Malaysia; Indonesia; Chinese Taipei; Singapore and Thailand (Table 33). Russia has developed its own method of water sampling using the filter instrument of HydroPuMP, a special sampler with replaceable filters with various mesh sizes (50-100 microns). A vessel flow-through system sampler has also been used in Russia as an alternative survey method for microplastic sampling at sea (Ershova et al., 2021).

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There are three common approaches to marine litter monitoring globally and adopted in APEC economies, i.e., beach surveys/shorelines, at-sea surveys (ocean surface, seafloor), and estimation of the amounts entering the sea. The first two methods are commonly used in APEC economies. The beach survey is preferable due to its simplicity and relatively cheaper than the survey at sea, in which the floating litter is estimated on the surface, and water samples are taken to assess the microplastic abundance in the water column. The litter monitoring approaches using UNEP (2019), NOAA (2012), GESAMP (2019) and OSPAR protocol collect and measure all litter between the waterline and the highest strandline on the upper shore. The remaining other methods measure litter within fixed areas or collect and measure samples of buried litter. In the Arctic region, the AMAP recommendations have been developed recently (Ershova et al., 2021) for litter monitoring in the Arctic environment based on all previous experiences of the listed recommendations.

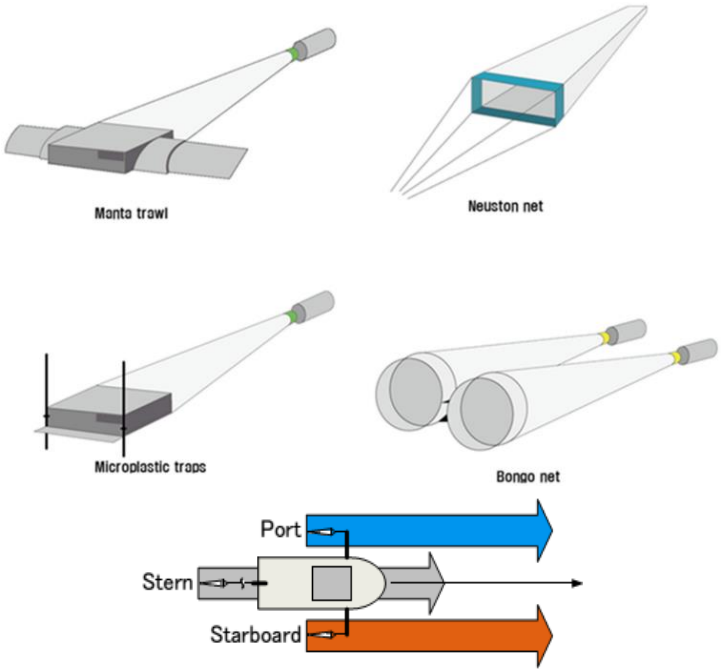
Table 3. List of guidelines and standard methods for marine debris and microplastic monitoring in aquatic ecosystems of APEC economies

No	Economy	Methods	Reference
1.	**Australia**	CSIRO (The Commonwealth Scientific and Industrial Research Organization)	CSIRO (2020)
2.	**Chile**	UNEP (United Nations Environment Programme) CSIRO (The Commonwealth Scientific and Industrial Research Organization)	UNEP (2016) CSIRO (2020) Hinojosa et al. (2011)
3.	**Indonesia**	GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) NOAA (National Oceanic and Atmospheric Administration) Guidelines for Monitoring Marine Debris: Beach Debris, Floating Debris and Seabed Debris	GESAMP (2019) Masura et al. (2015) Prajanti et al. (2019)
4.	**Japan**	Guidelines for Harmonizing Ocean Surface Microplastic Monitoring Methods, Ministry of the Environment Japan	Michida et al. (2019)

No	Economy	Methods	Reference
5.	**Republic of Korea**	A Guideline for Sampling and Analysis of Floating Microplastics- KIOST A Guideline for Sampling and Analysis of Microplastics on Sand Beach- KIOST	Lee et al. (2015) Lee et al. (2017)
6.	**Malaysia**	NOAA (National Oceanic and Atmospheric Administration) UNEP (United Nations Environment Programme)	Masura et al. (2015) Opfer et al. (2012)
7.	**Mexico**	NOAA (with modification of 10 segments in 100 m)	Kavya et al. (2020) Alvarez-Zeferino, et al. (2020)
8.	**Peru**	NOAA (with modification of 12 segments in 100 m)	Mc Dermid et al. (2004) De-la-Torre, et al. (2020)
9.	**The Philippines**	UNEP/IOC guidelines on survey and monitoring of marine litter	Cheshire et al. (2009)
10.	**Russia**	NOAA, OSPAR and AMAP recommendations are adapted and used for Monitoring in Russia (PlasticLab laboratory (RSHU) and Laboratory for marine physics (IO RAS))	Ershova et al., 2021, Ershova et al., 2022, Chubarenko et al., 2021
11.	**Singapore**	NOAA (National Oceanic and Atmospheric Administration) UNEP (United Nations Environment Programme) GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection	Ministry of Sustainability and the Environment-Singapore (2021) Curren et al. (2020) Nor & Obbard (2014) Ng & Obbard (2006)
12.	**Chinese Taipei**	NOAA (National Oceanic and Atmospheric Administration) EU-JRC (European Commission-Joint Research Centre) Environmental Analysis Laboratory of Environmental Protection Administration (2018)	Masura et al. (2015) Vighi, M., et al. (2022) EC-JRC (2013) Belz et al. (2021) Chen et al. (2020)
13.	**Thailand**	NOAA (National Oceanic and Atmospheric Administration) UNEP (United Nations Environment Programme)	Masura et al. (2015) Cole et al. (2014) Jabeen et al. (2017) Avio et al. (2015) Leslie et al. (2017) Jin-Feng et al. (2018) Abreo, et al. (2018).
14.	**The United States**	UNEP (United Nations Environment Programme) USMDMP (US Marine Debris Monitoring Program)	Masura et al. (2015) Sheavly (2007)
15.	**Viet Nam**	NOAA (National Oceanic and Atmospheric Administration) UNEP (United Nations Environment Programme)	Masura et al. (2015) Razeghi et al. (2021)

The United Nations Environment Programme (UNEP) has developed a set of guidelines to standardize beach survey methods. For standing-stock and accumulation studies, the best approach is to record all litter from the sea edge to the highest strandline (in most cases, the edge of terrestrial vegetation). Both the numbers and mass of plastic items are recorded, but counts may be sufficient for specific types of litter. Sample width is commonly at least 50 m for standing stocks and 500 m for accumulation studies. The approaches of the at-sea survey employ as sampling area of approx. 1 km x 1km square of guideline introduced by UNEP-IMO (2007).

Marine debris surveys at sea can be performed on surface water, water columns, and seafloor. Surface net sampling is preferable due to easier deployment and able to filter larger volumes of water. Floating litter can be collected using manta, neuston, bonggo or plankton nets with mesh sizes between 100-350μm (Park & Park, 2020). Each sampling net type has features, such as neuston nets, that can capture the sea surface layer in wavy conditions. Additionally, manta nets can maintain a constant immersion depth at sea. Filtered water volume can be estimated accurately using a flow meter attached to the net, providing no waves on the sea surface and the net maintains its position. Plankton and bongo nets are the other options for collecting plastic debris, especially from the water column.



a. Neuston net b. Manta net c. Net position

Source: Michida et al. (2019); Park & Park (2021)

Figure 9. Sampling techniques of at-sea survey

Sampling nets are generally positioned on either side of the vessel (port/starboard) or at the stern (Figure 9). Net immersion depths have been reported between 10 cm and 100 cm. Manta net immersion depth is measured as the height of the net's mouth, whereas a neuston net is often set at about 1/2 to 3/4 of the height of the net's mouth. Neuston nets with a side length of about 45 to 100 cm or manta nets with a width of 60 to 100 cm and a height of about 15 to 40 cm are the most commonly used to collect plastics from the ocean surface. The neuston net used in Japan had a square net mouth width and height of 75 cm each and a net with a 0.35 mm mesh opening. When towing the neuston net, immersion depth is set at approximately 1/2 of the height.

Another common but important technique is water sampling to determine the content of microplastic particles using the flow-through vessel systems, with the sampler at the end, like the one developed by PlasticLab laboratory in Russia. The HydroPuMP sampler is built into the vessel's flow-through system, and the sea water is filtered through a metal filter sized 50-100 μm. The average volume of filtered seawater is 1500 liters per sample. This method has shown to be very robust and cost-effective for catching particles lower than 330 microns using the manta- and neuston nets. Collecting microplastics below 300 microns are extremely important to assess the contamination of these particles in the food chain. Only microparticles below this size range are considered a threat to biological organisms. For example, microparticles sized 5 -150 could be absorbed in an organism's intestine through the paracellular route (Wright and Kelly, 2017). Another advantage of the method is the high accuracy of measurement of sampled water since the system always has a flow meter.

Since some plastics are denser than seawater, it is important to sample mid-water and bottom loads of plastic debris. Suspended debris can be sampled with bongo nets with a 0.33 mm mesh or measuring the abundance of suspended plastic within 10 – 30 m of the sea surface. The Continuous Plankton Recorder (CPR) offers a valuable subsurface tool to track changes in the distribution and composition of plastic particles at sea. Sediments are sampled with different types of bottom grabs (Van Veen, box-corers, etc.) in order to analyze the sample for microplastics, and additionally, surveys of macro-debris load on the seabed can be conducted with divers and trawl surveys.

3.4. Analysis of Microplastics

Microplastic analysis generally includes two laboratory steps, i.e., sample preparation (thermochemical processing, separation, filtration, flotation, drying) and MP identification and quantification (Stereomicroscope, IR spectrometry, Raman spectroscopy, and Pyrolysis-Gas Chromatography/ Mass Spectrometry (Py-GC/MS) as presented in Figure 10. Laboratories perform sample digestion using hydrogen peroxide and divalent iron solvent (H_20_2, Fe^{2+}), potassium hydroxide (KOH), or biochemical digestion using a digestion enzyme.

Microplastic measurement using photos of plastic particles and image processing software with two common methods for counting the number of particles by size, counting the number of particles remaining in the sample after fractionating by size using various sizes of sieves. Based on this study's findings and recent literature by researchers in the APEC region (e.g., Van Ryan Kristopher et al. (2021), De-la-Torre et al. (2020), Kozak et al. (2021), Alvarez-Zeferino et al. (2020), Eo et al. (2018), Paredes-Osses et al. (2021), most economies recommend the classification of plastic particles by morphological traits such as beads, fragments, foams, pellets, and fibers.

The most frequent methods/laboratory instruments for plastic polymer characterization in APEC economies are mainly Fourier Transform Infra-Red (FTIR), including micro-FTIR, and only recently micro-Raman spectrometer. Each instrument has different sensitivity and is chosen mainly related to the cost of the instrument. In general, FTIR can measure microplastic objects up to approx. 100 µm, while micro-FTIR is more sensitive at up to 10 µm. Additionally, a micro-Raman spectrometer can measure objects up to 1 µm, while Py-GC/MS is often used to identify smaller microplastic particles not identified by the former instruments.

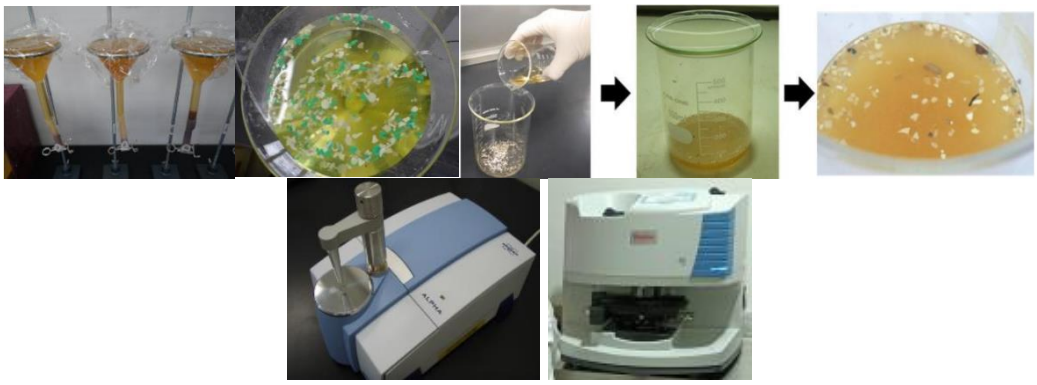


Figure 10. Sample preparation (top pictures) and spectrometric analysis of microplastics (bottom pictures)

There are various techniques of sample collection and analyses of macro debris and microplastic in the aquatic environment. Each approach has its advantages and disadvantages. A beach survey of marine debris is preferred due to its simplicity and relatively less costly than a survey at sea. Additionally, surface nets, such as manta and neuston nets, are preferred for microplastic sampling from surface water due to easier deployment and able to filter larger volumes of water. Albeit the differences, FTIR and Raman Spectrophotometer are the most commonly used instrument in microplastic identifications.

3.5. Mitigation Strategies to Reduce Marine Debris and Plastic Pollution

Marine debris and plastic pollution issues must be addressed to prevent long-term and mitigate possible harmful effects on the marine ecosystems in the APEC region. Tackling issues related to marine debris and plastic pollution is even more critical, particularly for the aquaculture system, considering the increased role of the aquaculture subsector in the world's food security. As a result of more than two decades of effort in increasing awareness regarding the risks of marine debris and plastic pollution, most APEC economies have incorporated marine debris and plastic pollution into working policies and regulations such as laws, decrees and domestic plans (road map or plan of actions).

Most APEC economies have already developed action plans or roadmaps as a mitigation effort to control plastic pollution in the environment, particularly in marine ecosystems. For example, Viet Nam; Malaysia; Thailand and Chinese Taipei have addressed the issue in their domestic action plans. Based on the information collected in this study and the literature, only Mexico and Peru have not yet published a domestic action plan or roadmap to mitigate plastic pollution in the environment. The list of action plans or road maps from several economies is provided in Table 4.

Table 4. List of mitigation actions undertaken by APEC economies

Economy	Implemented action
Chile	Prohibition on litter, throwing or abandoning garbage on beaches, rivers, lakes
	Limit the single-use plastic and plastic bottles
	Establish the conditions for treatment and final disposal of wastes from aquaculture activities
Indonesia	Limit plastic used in inland activities
	Support usage of biodegradable product
	Develop Procedures for Rehabilitation of the Aquaculture Environment, including microplastic
Japan	Dissemination of Marine pollution, Maritime disaster and Waste Management and Public Cleansing Act policies
	Develop a guideline on microplastic monitoring for sea surface water
	Treatment of general waste and the disposal of industrial waste,
	Forming a 'recycling-oriented society.'
	Promote 3R+Renewable
Malaysia	Control the disposal of fishing gear and tackle
New Zealand	Control the discharge from dumping, vessel discharge and waste water discharge
	Develop Domestic Environmental Standards for Marine Aquaculture
Peru	Limit single-use plastic
The Philippines	Prohibits the use of plastic bags for the packaging of dry goods and non-biodegradable plastic and Styrofoam.
	Charge plastic bags for use in commercial purposes for 2 pesos
	Adopt biodegradable alternatives to packaging materials,
Russia	Develop guidelines for macro-, meso- and microplastic monitoring in water and on the beaches (by 2025)

Economy	Implemented action
	Limit the single-use plastic at public events
	Selective waste disposal in many regions of Russia
	Raising awareness and NGO work with the public (public campaigns like beach clean-ups in different coastal regions of Russia, campaigns like Clean Cost, Clean Arctic, etc.)
Singapore	Enforce permits for the disposal of materials to water bodies
	Enforce circular economy (3R) for any kind of packaging
	Impose fines for any person or industry that dumps plastic waste into Singapore waters
	Sanctions for anyone who throws garbage carelessly
	License the use of fishing gear and fish farms and those activities must implement any relevant practical measures that will minimize the impact on the surrounding environment and water condition
Chinese Taipei	Bann plastic trays and packages boxes
	Ban microbeads in personal cleaning products
	Limit of plastic bags, straws, single-use utensils and beverage cups
	Develop a packaging reduction guideline for e-commerce
	Develop a rental services guideline for reusable cups
	Remove floating litter, remove marine debris and ghost net and gear marking
	Cage limitation, floating / buoy material management, limit the use of Styrofoam as buoys
Thailand	Ban single-use plastic, find alternative materials, Improvement of the recycling system, Management of after-used plastics
	Coastal and island-based management
	Fishing gears management system
Viet Nam	Reuse, recycling and treatment of plastic waste
	Limit single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics
	Raise awareness and social responsibility of farming communities, fishermen, and plastic waste businesses,
	Carrying out scientific research, application, development, and transfer of technologies related to marine plastic waste management in the fisheries sector.
	Developed database on marine plastic waste in fishery

In a broad sense, the roadmap and action plans serve as guidelines for policy implementation to mitigate the impacts of marine debris and plastic waste. As discussed previously, most APEC economies have already developed an action plan or roadmap as a mitigation effort to control plastic pollution in the environment, particularly in the marine ecosystem. Specific legal measures to reduce and/or manage plastic pollution are developed by Indonesia; Korea; Viet Nam; the Philippines; Thailand; Japan; Peru; Chile; Chinese Taipei and Russia. However, each economy relies on different mechanisms to implement legal measures due to differences in domestic priorities and existing conditions. Some regulations control plastic use in daily activities because most of the waste originates from or is produced by land-based activities.

The data from contributors of this study showed that there are four approaches to mitigation actions employed by APEC economies:

1. Policy approaches to prohibit and limit the use of plastic
2. Social approaches to disseminate the regulation and increase community awareness
3. Technical approaches and guidelines development to accumulate data and information on plastic pollution through research
4. Technology development to find feasible and practical solutions

More specific and detail actions to mitigate the plastic pollution impacts by APEC economies are implemented as follows:

a. Prohibition of dumping waste into aquatic ecosystems.
   Regulations to prohibit dumping waste into aquatic ecosystems such as rivers, coastal ecosystems and lakes have been implemented in some economies.
b. Limiting the use of plastic.
   Regulating plastic use in daily activities effectively reduces and mitigates plastic waste from land-based activities to the marine environment. Some economies, namely Viet Nam; Indonesia; the Philippines; Thailand; Chile and Peru, have prohibited the use of single-use plastic products and plastic bottles and limited the goods that contain microplastics. Chinese Taipei has banned the use of plastic trays and packing boxes and limited the use of plastic bags, straws, single-use utensils and beverage cups. In the Philippines and Indonesia, a popular and successful method to limit single-use plastic is to charge the consumers directly for every plastic bag used in commercial activities. In some cities in the Philippines, a single-use plastic bag is charged 2 pesos. In Indonesia, a similar policy of charging consumers for every single-use plastic bag for 200 rupiahs has been implemented successfully for at least three years without any significant challenges from the community. However, this regulation only works primarily in big cities' business premises that have an agreement with the government to implement the measures. In a rather different approach and field, Malaysia has implemented a specific regulation to control plastic inputs from marine activities such as fishing gear and tackle disposal.
c. Circular economy for plastic products.
   Encouraging the re-utilization of plastic products or materials can significantly minimize the amount of plastic waste. The programs on reuse, recycling and treatment of plastic waste also contribute positive economic impacts in the communities where the circular economy programs were applied.
d. Promote the use of biodegradable plastic.
   Innovative products based on biodegradable plastic have been developed and entered the market, such as packaging, utensils and binding materials based on seaweed, cassava starch, corn starch, sugar cane and wheat. Due to relatively expensive and limited supply, products made of biodegradable plastic are currently

used by certain restaurants and other business premises with strong concerns about plastic pollution issues.

e. Raise awareness and social responsibility on plastic pollution issues.
   To promote daily plastic use reduction, Viet Nam has a program to increase awareness and social responsibility on plastic pollution issues to fish farming communities, fishermen and plastic waste businesses.
f. Dissemination and campaign.
   APEC economies have carried out campaigns to limit the use of single-use plastic and promote biodegradable plastic. Japan's government has a dissemination program of Marine pollution, Maritime disaster and Waste Management and Public Cleansing Act policies.
g. Establish treatment units and final waste disposals.
   Actions to mitigate plastic pollution from industrial sector are evident, at least in some of the developed economies in the APEC region. For example, Japan has implemented a regulation on treating general waste and disposing of industrial waste. The regulation has contributed to reducing the concentration of plastic or microplastic in wastewater. The government of Chile has specifically established the conditions for the treatment and final disposal of wastes from aquaculture activities.
h. Develop guidelines, procedures and standards for monitoring and analyzing plastic pollution in aquatic ecosystems and aquaculture.
   The government of Japan has implemented a mitigation action by developing guidelines for monitoring and analysis plastic pollution in the aquatic ecosystem (Michida et al., 2019). The Indonesian government is currently prioritizing the development of aquaculture industries. In anticipating the development, specific procedures are established to improve the environmental condition of aquaculture zones. The procedures have not yet included the prevention or reduction approaches of microplastic contamination in aquaculture areas.
i. Develop databases on marine plastic pollution.
   Databases on microplastic issues in the marine environment are being developed and collated through scientific research, citizen science efforts, and government program. An innovative project to build the database is currently being carried out by Singapore, involving cataloging existing policies, regulations, research, and community participation worldwide on plastic pollution in the marine environment.
   In Russia, a web portal has been developed to accumulate results of scientific research devoted to marine litter and microplastics. The web portal is Microplastics Consortium which can be accessed at http://microplasticsiberia.com. It is governed by the Tomsk State University and combines the efforts of many institutions to share the available information on microplastics research in Russia. The web-portal provides an interactive database for users.

In some economies, the regulations and policies on plastic pollution are not specifically available or mentioned in the regulations. The economies established the regulations as general rules to protect the environment from waste pollution in inland areas, rivers

and marine ecosystems. For example, Russia and New Zealand have issued general environmental protection and waste management regulations, including marine debris, particularly from inland activities. Russia has no special legal arrangement to control microplastic in the environment. New Zealand has established specific waste management regarding dumping and vessel activities. However, the term microplastic is not explicitly mentioned.

4. COASTAL AQUACULTURE AND MICROPLASTICS

4.1. Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics Pollution

Within the last ten years, research activities focusing on marine plastic waste and its impacts on marine organisms and the environment have been frequent. Yet, very few reported results related to aquaculture, especially in Southeast Asia. Similarly, on the policy level, the 2019 ASEAN Framework of Action on Marine Debris only accounts for contributions of coastal aquaculture activities to sea-based debris and plastic pollution. In the same fashion, most economies-level regulations governing marine debris and plastic pollution do not touch on microplastic pollution from coastal aquaculture, let alone the impact of microplastics on coastal aquaculture. These regulations primarily regulate waste dumping and discharge from vessels and wastewater, including potential contaminants (plastics) to natural waterways (freshwater, estuarine or coastal waters).

Research on microplastic pollution in coastal aquaculture is relatively recent, with limited reported results on certain farmed species, such as bivalves. Such limited information and interest have led APEC economies not to follow up or be informed of the research results related to microplastic pollution in coastal aquaculture. On the contrary, the rapid development of coastal aquaculture has triggered concerns that coastal aquaculture could potentially be a significant contributor to plastic/microplastic pollution. Unsurprisingly, several APEC economies have adopted special regulations to mitigate plastic waste originating from coastal aquaculture activities.

Based on multiple marine debris/plastic pollution regulations enacted by APEC economies, the most closely related regulations to coastal aquaculture are:

1. New Zealand's Resource Management Act 1991. The act provides a framework to implement domestic Environmental Standards for Marine Aquaculture. It also has the potential to include further control of the use of plastics in aquaculture operations. This means that subsequent measures will have to be introduced by local government agencies. For example, reducing the use of plastic material on coastal aquaculture platforms or banning the disposal of plastic nets and buoys could be set as standards of compliance in coastal aquaculture practices
2. Chile's Decree 64 of 2021 set a clear-cut and more advanced regulation regarding managing plastic waste from different stages of aquaculture activities. The decree has identified various inorganic non-hazardous waste from coastal aquaculture, 14 of them are plastic materials such as ropes, nets, expanded polystyrene, brushes, food bags, flashlight, and strainers which are prohibited from being discarded into the surrounding waters. The decree also set a high standard of sludge treatment from aquaculture to prevent solid retention from the waste entering the marine environment.

3. Chinese Taipei's Shallow Sea Oyster Aquaculture Management Autonomous Regulations was published to manage the development of oyster aquaculture. Although it is intended to regulate the oyster aquaculture zoning system, the regulation contains specific articles where oyster farmers are encouraged to use non-Styrofoam buoys via subsidy. The government carries out this effort to prevent microplastic shedding from Styrofoam buoys.

Unfortunately, other APEC economies arguably have not shared similar interests regarding the possible plastic waste contribution from coastal aquaculture. Viet Nam could have been another APEC economy that integrated plastic wastes with coastal aquaculture via its regulation titled Decision No. 911/QD-TTG on approving scheme for environmental protection in the fishery sector in the 2021 – 2030 period. The regulation stipulates that the percentages of collection, classification, reuse, and processing of plastic waste from fishery activities must be increased. However, this regulation does not explicitly mention aquaculture, indicating that the referred plastics waste in fisheries activities here are meant for discarded or lost fishing nets. None of the regulatory products of other APEC economies contain specific articles connecting coastal aquaculture with plastic pollution.

It is then difficult to imagine if there are policy interests or regulatory measures from any APEC economies concerning the contamination of microplastic in coastal aquaculture input chains and products. A thorough document analysis from the 15 APEC economies contributed to this study revealed that no policy or regulatory document discusses microplastic contamination in coastal input chains and products. This contradicts the current research findings that microplastics have entered coastal aquaculture supply chains and products. For example, a recent study found that 99% of coastal farming zones have high amounts of microplastic (Lin et al., 2022, Zhou et al., 2021). This study also determines that microplastic can enter coastal aquaculture input chains and products through plastic materials used in farming activities.

4.2. Potential Sources and Contaminations of Plastics/Microplastics in Coastal Aquaculture Input Chains

Various materials, equipment, tools and others used in aquaculture systems are suspected to be a source of plastic/microplastic contaminants, including plastic bags, large woven polypropylene heavy-loading bags, single-use utensils, plastic trays, packing boxes, microbeads in personal cleaners, and plastic bags (Table 55).

Table 5. Common plastic material/equipment used in aquaculture operation

No.	Equipment/tools (hatchery and nursery)	Type of plastic used
1.	Holding tanks	PP (polypropylene) fiberglass
2.	Raceways	PE (polyethylene)
3.	Pond liner/geo-membrane	HDPE
4.	Size grader	Acrylic/Plexiglas
5.	Transport/packaging	Polystyrene (Styrofoam)
No	**Equipment/tools (grow-out)**	**Type of plastic used**
1.	Pond liner/geo-membrane	HDPE
2.	Floating cage	PE (polyethylene)
3.	Transport/packaging	Polystyrene (Styrofoam)
4	Feed packaging	Polypropylene, HDPE PP and BOPP, PP Woven

These materials are used in harvesting, transporting and packaging aquaculture products. Plastic-lined bags and woven polypropylene heavy-loading bags are used to transport fish feed. Heavy-load bags are often reused, while plastic-lined bags are thrown in landfills. Polystyrene (expanded) buoys are still widely used in aquaculture despite being considered a primary source of marine debris and microplastics. Accidental loss during use, intentional disposal after use, and difficulties in collecting and recycling of plastic buoys contribute to marine debris and microplastics in the marine environment.

Table 6. Identified potential sources of plastics/microplastics in coastal aquaculture in some APEC economies

No	Economy	Potential sources and contaminations of plastics/microplastics in coastal aquaculture input chains
1.	**Japan**	Accidental loss or discharge of fishing gears and aquaculture equipment in fishing and aquaculture industries.
2.	**Republic of Korea**	Polystyrene (expanded) buoys used in the aquaculture industry are the most important source of marine debris and microplastics in Korea. Unintended loss of Buoys in use, Intended discard of buoys After use, Difficulties in collection and recycling.
3.	**New Zealand**	Plastic in the harvesting, transport and packaging of aquaculture product • Plastic is used extensively in the harvesting, transporting and packaging of New Zealand aquaculture products. • Plastic-lined bags and large woven polypropylene heavy-loading bags are used for transporting fish feed. The heavy-loading bags are reused, and the plastic-lined bags are dumped into landfill.

No	Economy	Potential sources and contaminations of plastics/microplastics in coastal aquaculture input chains
4.	**Peru**	Potential sources of microplastic contamination in aquaculture in Peru: 1. Contamination in fishmeal (https://www.sciencedirect.com/science/article/pii/S0048969721061271). Microplastic contamination found in aquaculture product in Peru: 2. Microplastic Presence in the Mangrove Crab Ucides occidentalis (Brachyura: Ocypodidae) (Ortmann, 1897) Derived From Local Markets in Tumbes, Peru: (https://journals.sagepub.com/doi/full/10.1177/11786221221124549). 3. Plastic debris and natural food in two commercially important fish species from the coast of Peru: (https://www.sciencedirect.com/science/article/pii/S0025326X21010730). 4. Abundance and Characteristics of Microplastics in Market Bivalve Aulacomya Atra (Mytilidae: Bivalvia) (https://revistas.unal.edu.co/index.php/actabiol/article/view/88832) 5. *Primer registro de ingestión de microplásticospor un pez de importancia comercial en la* Ciudadde Iquitos, Amazonía Peruana: (https://revistas.iiap.gob.pe/index.php/foliaamazonica/article/view/521/563)
5.	**Chinese Taipei**	Oyster cords and Polystyrene (expanded) buoys used in oyster aquaculture, unintended loss of cages and buoys, plastic-lined bags for fish feed, floating litter and litter on board, and underwater debris.

4.3. Existing Management Strategies in Preventing/Reducing Microplastic Pollution in Coastal Aquaculture Input Chains

This study has determined that the 12 participating APEC economies have yet to develop management strategies to prevent or reduce microplastic pollution in coastal aquaculture input chains. Fishmeal imports from areas or regions allegedly that have high microplastic contamination continue to increase despite the results of several studies, such as the recent publication by (Wang et al., 2022). Input chains of coastal aquaculture post-feed processing are largely unmonitored from contamination of microplastics. The most concerning issue is that there are no regulatory measures or standards to ensure that the final products of coastal aquaculture contain minimal or no microplastics. Such measures are of the utmost importance considering the majority of research have shown that exposure to microplastics could cause health issues in human. Very few studies in human clinical trials have shown the negative effects of microplastics on humans. However, various studies such as Li et al. (2020), Lu et al. (2018), Luo et al. (2019), Jin et al. Jin et al. (2019), and Stock et al. (2019) have found inflammation, reduced mucus secretion, metabolic disorder and neurobehaviour effects in organism exposed to microplastics, respectively.

Several APEC economies have started devising management strategies to reduce microplastics from coastal aquaculture (Table 77). However, these efforts mainly focus on reducing plastic/microplastic litter from aquaculture. For example, New Zealand

has developed a management strategy to provide guidelines and requirements for processing and final disposal of waste from aquaculture activities and managing the recycling of oyster rafts and culture buoys. Chinese Taipei and Chile have also issued similar management strategies for oysters (Chinese Taipei) and general waste management strategies, including plastic waste from coastal aquaculture platforms (Chile).

Table 7. Existing management strategies to prevent or reduce microplastics in coastal aquaculture in APEC economies

No.	Economy	Existing Management Strategies in Preventing/Reducing Plastic/Microplastic Pollution In Coastal Aquaculture Input Chains
1.	**Chile**	There is one decree (Decree 64/2021) that explicitly regulates the conditions for the treatment and final disposal of wastes from aquaculture activities and one domestic strategy, in general, to reduce plastics in the environment.
2.	**New Zealand**	The domestic environmental standards for marine aquaculture. voluntary initiatives from industry, supported by the government, are a central part of the current approach to providing for better management of plastic release into the aquatic environment from aquaculture activities.
3.	**Chinese Taipei**	The Tribute to the Ocean – Plan of Coastal Clean-up and Management (2020) has strategies related explicitly to coastal aquaculture (manage the recycling of oyster rafts and aquaculture buoys)

4.4. Plastic/Microplastic Public Discourses and Research Activities Related to Coastal Aquaculture Input Chain

Unlike marine debris and plastic waste, the public discourses and research activities in APEC economies related to microplastic pollution in coastal aquaculture input chains are few and far between. This indicates that the issues have not yet received sufficient attention from related institutions, particularly the government.

Regarding research activities, multiple studies within APEC economies have reported that plastics/microplastics have been found in wild marine species such as mangrove crab (*Ucides occidentalis*), bivalve (*Aulacomya Atra*), *Ethmidium maculatum*, *Mugil cephalus*, *Trachurus declivis,* and other species. Aguirre-Sanchez et al. (2022) found for the first time the presence of microplastics in the gills and digestive tract of the mangrove crab *Ucides occidentalis* derived from local markets in Tumbes, Peru. Microplastics were identified in 100% of the crab samples. The total number of microplastic particles was 921 items consisting of 475 items (52.57%) found in the gills and 446 (48.43%) found in the digestive tract. The size of microplastics ranged from

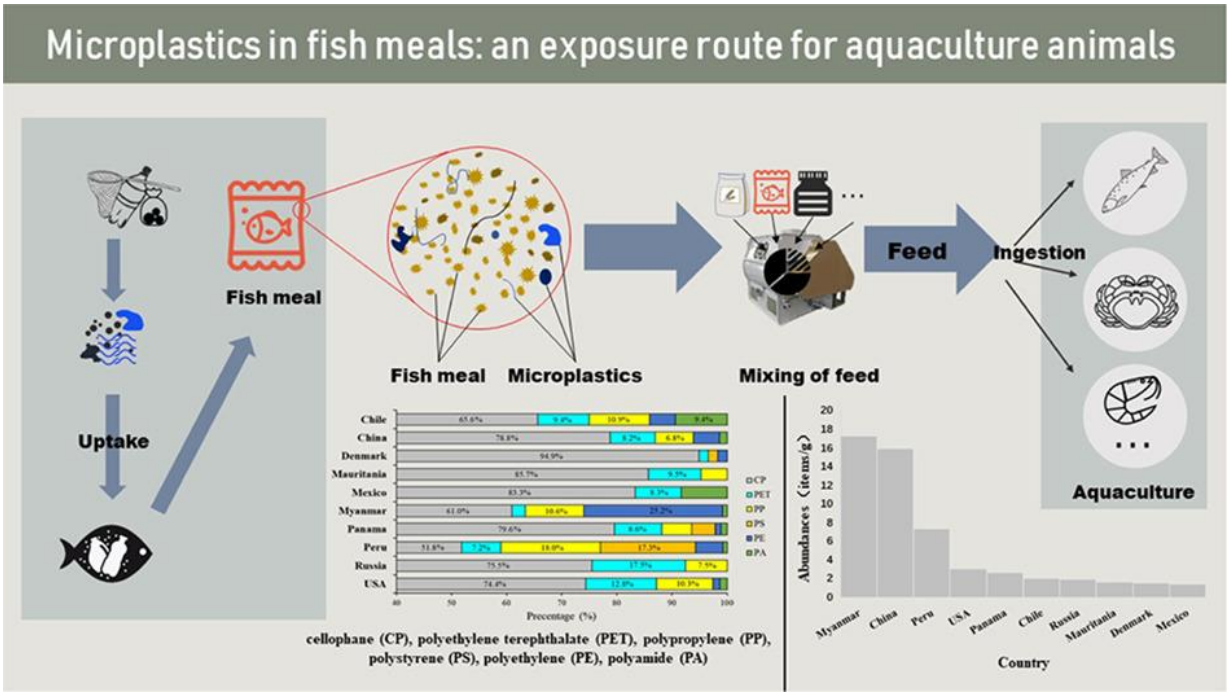
2 to 250 µm, 250 to 500 µm, 500 to 1 mm, and 1 to 5 mm. The microplastics sized 2-250 µm were the most commonly identified (53.79%) in the digestive tracts and 90% in the gills. Six different types of microplastics were recorded, with the highest percentage being fibers (59.64%–61.05%), followed by films (19.28%−36.63%). Clear fibers were the most prevalent microplastic type found in both gills and digestive tracts. Fernández-Ojeda et al. (2021) also found high plastic contamination in the diatoms and farmed fish. The authors reported that *Mugil cephalus* consume diatoms, copepods, and dinoflagellates containing microplastics. From the analyzed plankton samples, 0.3% contained nine microplastic fragments (0.72–4.54 mm) and one mesoplastic fragment (6.65 mm), of which green and blue polyethylene and polypropylene are the most commonly found plastic types.

Besides that, Pinho et al. (2022) reported the presence of microplastics in the digestive tract of batoids in the Gulf of California for the first time. The FTIR-ATR analysis revealed that polyamide or nylon polyethylene, polypropylene, and polyacrylic were found in sediments and gastrointestinal tracts of round rays. Polyethylene terephthalate and polyacrylamide were only found in the gastrointestinal tracts of the rays. These polymers are consistent with the human activities undertaken in this area, specifically intensive small-scale and industrial fisheries which use fishing nets, plastic bags, storage containers, clothing, and fishing boat maintenance.

Despite the growing number of microplastic research in wild marine species, very few studies on the related subject are available on aquaculture input chains. Among the few published research related to the issues that the contributors in this study have identified are:

1. Fish feed (Microplastics in fishmeal: An exposure route for aquaculture animals. Wang et al., 2022. Science of the Total Environment. Volume 807, Part 3, 10 February 2022, 151049).
2. Styrofoam debris as a source of hazardous additives for marine organisms. M Jang, WJ Shim, GM Han, M Rani, YK Song, SH Hong Environmental Science and Technology (50, 4951-4960) 2016).

The research conducted by Wang et al. (2022) has found that microplastic pollution was detected in fishmeal from ten producing economies (Figure 11). The average microplastic abundance in fishmeal was 5.5 ± 1.6 items/g. Fibers were the primary shape type; the most common size was 500–1000 µm (25.1%). Cellophane, PP and PET are the most common polymers among the six identified types. The MP ingestion number by cultured animals from fishmeal ranged from 55 to 82,500.



Source: Wang et al. (2022)

Figure 11. Microplastics distribution pathways in fishmeal

Despite limited coverage, a few examples of governmental efforts in APEC economies also have touched on the aquaculture input chain. For instance, the government of Korea, through the Ministry of Food and Drug Safety, published a report in 2017 discussing plastic/microplastic contamination status in food products as part of food safety management. A subsequent report published by the Ministry of Oceans and Fisheries of Korea also reported the result of an internal survey on marine microplastic distribution status in Korea. Both reports have indicated that microplastics have contaminated farming areas and farmed species despite their focus being on the farmed coastal species and not on the other input chains of coastal aquaculture.

All contributors from 12 APEC economies have unanimously implied that specific public discourses on microplastic contamination in coastal aquaculture input chains are almost non-existent. This study can only identify two specific public discourses related to the issues. The first one was the effort by Our Sea of East Asia Network (OSEAN), which organized a series of workshops to develop policy measures for reducing Polystyrene (expanded) buoys from aquaculture. This non-profit, civic group and research institution promoted the replacement of high-density Polystyrene (expanded) buoys used in Korea for oyster aquaculture with environmentally friendly buoys. In combination with implementing the Fishery Regulation Act, Republic of Korea successfully increased the use of environmentally friendly buoys by up to 34.4% in 2021. The combined efforts have also resulted in the ban of Polystyrene (expanded) buoys by 2023.

The other one is a symposium on “Plastics and microplastics in the marine environment and their impacts on aquaculture activities,” held in Chile in 2018. These

public discourses are the rare efforts within APEC economies to raise awareness of microplastic contamination in aquaculture products.

However, there has been hitherto no comprehensive public discourses in APEC economies or APEC region to discuss:

1. Contamination of microplastics s in aquaculture input chains
2. The development of a regulatory framework within APEC economies and non-binding or regional-wide policy measures within APEC region to reduce or prevent the distribution of microplastics within coastal aquaculture input chains
3. A breakthrough standard/mitigation plan/road map to ensure that aquaculture products contain no or safe amount of microplastics deemed to pose health risks to humans based on the available scientific information.

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

This study has collected existing policy and regulatory frameworks in 12 contributing APEC economies coupled with the recent available literature related to marine debris and plastic pollution with a specific focus on microplastics in coastal aquaculture input chains in the APEC region. This recent report also provides a general synthesis to describe the relative development of policy and regulations in these economies.

As hypothesized prior to commencing the study, marine debris and plastic pollution in the marine environment have been one of the major domestic issues within APEC economies. The development of policy, regulation, research and public discourse is directed toward better managing and reducing marine debris and plastic waste, supported by APEC and other regional and international organizations. It is not surprising that almost all APEC economies have devised a domestic action plan. The domestic is, at least, backed up by a primary policy/regulatory framework to ensure that the road map can be carried out. However, each economy has designed its policy, regulations, and domestic road map as well as the implementation of waste management based on their current socio-economic conditions.

One of the interesting findings of this study is that several developing economies have enacted more regulatory frameworks related to marine debris and waste management compared to most developed economies. This finding could raise two interesting interpretations: the management of marine debris/plastic waste in APEC developing economies is lagged behind and more complex compared to developed economies. Therefore, multiple regulations with different objectives and targets had to be established to catch up with the achievement of the developed economies, or the regulatory frameworks for marine debris and plastic waste in the developed economies have matured enough. This has led to the simplification of the regulatory frameworks with efficient measures and effective implementation. Future studies could provide some insights into whether one of these is the case or whether other underlying reasons play greater roles.

Similar to other reports and research findings, APEC economies have used or adopted various guidelines and standard methods to monitor marine debris, including plastic/microplastics in aquatic environments. UNEP and NOAA standard protocols are the most commonly used in APEC economies. Some economies have developed specific protocols for specific purposes, such as Chinese Taipei; Russia; Japan and Korea. The APEC economies also use the same method of quantifying or characterization of microplastics, Fourier Transform Infra-Red (FTIR), including micro-FTIR due to its combined sensitivity and associated cost. However, the availability of and access to this equipment are limited, and it is relatively expensive, especially in developing economies. Increasing the number of and easier access to such essential

equipment is very important to ensure that policy and regulatory framework are supported by sound and consistent analysis results.

Aquaculture is projected to replace capture fisheries as the main supply of protein for human consumption. China; Indonesia and Viet Nam currently sit within the top five global aquaculture producers, while the other APEC economies also contribute significantly to global production. Therefore, the issues of microplastic contamination in fish, particularly from coastal aquaculture, are gaining momentum, at least from the research point of view. One APEC report titled “Best Practices and Recommended Policies for Optimizing the Plastic Supply Chain in Southeast and East Asia” has highlighted that microplastic contamination in fish, including farmed fish, is no longer scientifically debatable. This study also concurs with the report’s conclusion.

Nevertheless, this study’s findings reveal that the mainstream policies, regulations, research and public discourses are directed toward preventing or reducing plastic waste from aquaculture to the marine environment. Very few of these regulatory frameworks are focused on the fact that coastal aquaculture and its supply chains have been contaminated with microplastics. This study has determined that Korea; New Zealand and Chile are some of the pioneers in bringing up this issue within their domestic interest. However, it is important to note that the other APEC economies not covered in this study could have established these aspects in their economies. Therefore, collaboration with these economies is crucial to get the whole picture of regulatory frameworks in APEC regions regarding the prevention and reduction of microplastics in coastal aquaculture.

In conclusion, the policy, regulatory measures, research and public discourse related to coastal aquaculture input chains and microplastics require further intervention to increase public awareness and responsibility for the issues. A final thought from this conclusion would be instigating a mitigation plan within the APEC region to prevent or reduce microplastic contamination in coastal aquaculture input chains based on scientific evidence. The mitigation plan could include a proposed standard of food safety where microplastics are included as one of the standard safety parameters for coastal aquaculture products. Adopting this potential measure will improve the quality and market access of aquaculture products from APEC economies in the global aquaculture trade.

5.2. Recommendations

1. Supporting more research and public discourses to allow the development of scientific-based policy and regulatory frameworks with high public acceptance in APEC economies regarding microplastic contamination in coastal aquaculture input chains.
2. Developing and/or adopting standardized protocols and analysis of microplastic contamination in the aquatic environment within APEC regions.
3. Establishing a standard protocol, mitigation plan and standard seafood safety in the APEC region to continuously monitor and prevent microplastic contamination in coastal aquaculture input chains and products.

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Appendices

Appendix 1. List of regulation based on area management in APEC economies

No	Economies	Land	Coastal &Ocean/Marine	Environment Both Land and Ocean	Seaport & Shipping Activities
1.	**Indonesia**	1) UU No 18 / 2008 (Waste Management Law) enacted by People's Representative Council and Indonesia government to regulate waste management in Indonesia. This act has some derived laws to regulate household waste and household-like waste such as PP No 81 / 2012 (Government regulation), Perpres No 97 /2017 (presidential regulation), Permen LHK No 13 / 2012 (Ministerial government), Permen LHK No P.10 / 2018 (Ministerial government), Permen LHK No P.75 / 2019 (Ministerial government), Permen LHK No 6 / 2022 (Ministerial government), Permen LHK No 14 / 2021: The management of waste bank (Ministerial government), Permen PU No 3 /2013 (Ministerial government).	2) UU No 18 / 2008 (Waste Management Law) also has some derived laws to regulate category of specific waste including marine debris. PP No 27 / 2020 (Government regulation), Perpres No 83 .2018 (Presidential regulation), Government Regulation No. 22 of 2021 on environmental protection and management.		3) UU RI No 17 / 2008 (Shipping) enacted by People's Representative Council and Indonesia government to regulate shipping activities including pollution and waste from aboard. This act has some derived laws such as PP No 21 / 2010 (Government regulation) and Perpres No 29 / 2012 (presidential regulation).
2.	**Japan**	Article 3, Act No. 137 of 1970 11/18/2022: Waste Management and Public Cleansing Act	Article 11, Act. No. 136 of 1970 : Act on Prevention of Marine Pollution and Maritime Disaster, MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto), Act on Promoting the Treatment of Marine Debris Affecting the Conservation of Good Coastal Landscapes and		

No	Economies	Land	Coastal &Ocean/Marine	Environment Both Land and Ocean	Seaport & Shipping Activities
			Environments to Protect Natural Beauty and Variety,		
3.	**Republic of Korea**	Measures against plastic waste from household	Management Of Marine Debris and Contaminated Sediment Act, The First Framework on Marine Debris Management (2021~2030)		
4.	**Malaysia**	Solid Waste Management and Public Cleansing Corporation Act 2007 (Act 673)	Fisheries Act 1985, Section 61, National Marine Litter Policy and Action Plan 2021 - 2030	Environmental Quality Act (EQA), 1974. Act 127, Local Government Act 1976	
5.	**Mexico**	Domestic vision towards a Sustainable Management: Zero Waste (2019-now), An initiative to amend the General Law for the Prevention and Integral Management of Waste (LGPGIR) 2019-now		General Law on Ecological Equilibrium and Environmental Protection 1988 (LGEEPA) 1988-Now, The Law Of Dumping in Mexican Marine Areas (Ley De Vertimientos En Las Zonas Marinas Mexicanas) (LVZMM)	
6.	**New Zealand**	Waste Minimization (Microbeads) Regulations 2017, Waste Minimization (Plastic Shopping Bags) Regulations 2021, Waste Minimization (Plastic and Related Products) Regulations 2022	Resource Management Act 1991, Resource Management Act 1991 (working with plastic), Fisheries Act 1996	Litter Act 1979	Resource Management (Marine Pollution) Regulations (1998-now)
7.	**Peru**			Law #30884 on Single Use Plastic (2018-Now)	
8.	**The Philippines**	Republic Act No. 9003 - Ecological Solid Waste Management Act of 2000, DILG	Republic Act No. 9275 – the Philippines Clean Water Act	Presidential Decree 1152 – the	

No	Economies	Land	Coastal &Ocean/Marine	Environment Both Land and Ocean	Seaport & Shipping Activities
		Memorandum Circular 2020-147, 11 City ordinance and municipal ordinance	of 2004, Presidential Decree No. 979 - Marine Pollution Decree of 1976,	Philippines Environment Code, 1972	
9.	**Russia**	The regulatory and legal framework for waste management in Russia is very complex and includes federal laws, decrees of the Russian Government, sanitary norms and rules, building codes, state standards, as well as norms and rules for handling hazardous waste. Of these, the most important is the Federal Law of June 24, 1998 No. 89-FZ «On industrial and consumer waste», which defines the goals and principles of waste management.	Federal Law No. 167-FZ Water Code (does not separate marine environment), law on territorial sea and law on continental shelf,	Law on Environmental Protection (2002)	Order No. 87 of the Ministry of Natural Resources and Ecology validating the Regulation on calculation of damages caused to water bodies by the infringement of water legislation 2009
10	**Singapore**	Resource Sustainability Act (RSA) in 2019,	Fisheries Act, Marine litter policy landscape(2020),	Zero Waste Nation Act (2019-2030)	Maritime and Port Authority of Singapore Act 1996 https://sso.agc.gov.sg/Act/MPASA1996>
11	**Chinese Taipei**		Action Plan of Marine Debris Governance (2018-2022), Tribute to the Ocean – Plan of Coastal Cleanup and Management, Eco-flotilla, Eco-Diver		
12	**Thailand**	Roadmap on Plastic waste management (2018-2030) and Phase I of the Action Plan on Plastic Waste Management (2020 until 2022)	Thailand's Draft Action Plan on Marine Plastic Debris (2023-2027)		
13	**Viet Nam**	Directive No. 33/CT-TTg dated August 20th, 2020,	Decision No. 1746-QD-TTg on introducing domestic action plan for management of marine plastics litter by 2030, Decision on No. 687/QD-BNN-TCTS on Approval of the action plan on marine plastic waste	Law on Environmental Protection No.72-2020-QH14 (2020), Decree No. 08/2022/ND-CP, Directive No. 33/CT-Ttg on Regarding	

No	Economies	Land	Coastal &Ocean/Marine	Environment Both Land and Ocean	Seaport & Shipping Activities
			management for the fisheries sector, 2020-2030 period	Strengthening of Management, Reuse, Recycling, Disposal and Reduction of Plastic Waste, Decision No. 1316-QD-TTG on Approving - Proposal for Strengthened Management of Plastic Waste in Viet Nam	

Appendix 2. List of published government reports, journals, or other publications related to microplastics studies with a specific interest in coastal aquaculture input chain systems

No	Economies		Author	Summary Of The Research	Object	Tool
1	Indonesia	1	Purba et al, 2017	Using the global International Coastal Cleanup (ICC) Network to conduct a survey and identify different types of marine debris		
		2	Purba et al. 2018a	Savu Sea Marine National Park macro debris quantification and identification		
		3	Purba et al. 2018b	Investigating the abundance and composition of macroplastics on Pangandaran Beach in Indonesia		
		4	Rochman et al. 2015	The amount to which fish and shellfish in Makassar; Sulawesi; Indonesia; and Half Moon Bay, California, USA, contained microplastics was assessed.		
		5	Syakti et al. 2018	Quantifying marine debris and floating microplastics; detecting microplastics using FTIR spectroscopy.		
2	The Philippines	1	Janairo & Argamino, 2016	Microplastics from mussels in Bacoor Bay were found to harbour microplastics	*Perna viridis*	
		2	Lira et al., 2020	Fish pastes from Balayan, Batangas, which are derivative products of aquaculture, were found to contain microplastics	Fish paste	
		3	Obanan et al., 2020	Characterization and quantification of microplastics in slipper-cupped oyster *Crassostrea iredalei* (Faustino, 1932) from Cañacao Bay, Cavite City, Philippines	Oysters	
		4	Bilugan et al., 2021	Detection and quantification of microplastics from cultured green mussel Perna viridis in Bacoor Bay, Cavite, Philippines	*Perna viridis*	
		5	Braña et al., 2021	Microplastics in farmed oysters (Crassostrea iredalei) from Capiz, Philippines	Oysters	
		6	Osorio et al., 2021	Microplastics occurrence in surface waters and sediments in five river mouths of Manila bay	Surface waters and sediments	
3	Viet Nam	1		Abundance of microplastics in cultured oysters (*Crassostrea gigas*) from Danang Bay of Viet Nam	Cultured oysters *(Crassostrea gigas)*	µFT-IR

No	Economies		Author	Summary Of The Research	Object	Tool
		2		Anthropogenic fibres in white clams, *Meretrix lyrata*, cultivated downstream a developing megacity, Ho Chi Minh City, Viet Nam	*Meretrix lyrata,* cultivated	
		3		Efficiency assessment of microplastic extraction from green mussel P*erna viridis linnaeus*	Green mussel *Perna viridisl linnaeus*	
		4		Assessment of microplastics contamination in commercial clams in the coastal zone of Viet Nam	*Meretrix lyrata* and *Tapes dorsatus* in aquaculture farms	
		5		First observation of microplastics in surface sediment of some aquaculture ponds in Ha Noi city, Viet Nam	Sediment of Aquaculture ponds	
		6		Contamination of microplastics in bivalve: first evaluation in Viet Nam	*Perna viridis*	µFTIR
		7		Microplastics in the surface sediment of the main Red River Estuary	River sediment	
		8		Characteristics of microplastics in shoreline sediments from a tropical and urbanized beach (Da Nang, Viet Nam)	Sediment	
		9		Preliminary results on microplastics in surface water from the downstream of the Day River	Surface water	
		10		Microplastics accumulation in Pacific Oysters from Danang Bay, Viet Nam	Oysters	
		11		Investigation of microplastics existence in Mussel (Perna viridis) from Ha Long bay, Viet Nam	*Perna viridis*	µFT-IR

Appendix 3. Compilation and summary of regulations on marine debris and plastic waste from 15 APEC economies

A. Chile

No.	Regulation	Regulation Summary
1.	DFL 725 Sanitary Code (DFL: Decretos con fuerza de ley / Decrees with force of law) 1968	It establishes the obligation of the municipalities to collect, transport and eliminate by appropriate methods the garbage, residues and waste that are deposited or produced in the urban road (article 11 letter b). For its part, in paragraph III of Title II (articles 78 to 81) it refers to "**waste and garbage**"; it establishes the sanitary authorizations of different waste management facilities
2	DFL 1; Law 18.695. published in 2006	Law N° 18.695. Organic of Municipalities: establishes the cleaning and adornment of the commune as the exclusive function of the municipalities (article 3 letter f) and attributes the **garbage extraction service to the environment, cleanliness and adornment unit**
3	DECREE - DTO 258 of 2008 from the Ministry of Foreign Affairs, enacting Annex V of the **MARPOL 73/78** convention. Published in 2009	Establishes regulations for the prevention of pollution by **litter from ships**.
4	South Pacific Regional Fisheries Management Organization (SPRFMO). Published in 2012	Minimize pollution and waste originating from fishing vessels, **discards** or **abandoned gear**
5	Law 20.920 related to extended producer responsibility (Spanish significate and Acronym: REP). Published in 2016	This law establishes the regulation for six priority products (lubricants, electric and electronic devices, **containers and packaging**, tires, car batteries, and alkaline batteries).
6	Law 21.100 that prohibits the use of single-use plastic bags. Published in 2018	This law was enacted specifically to reduce the entry of **plastic** items into natural **environments**
7	Law 21.123 which it is not allowed to litter, throw, or abandon garbage on beaches, rivers, lakes, national parks, reserves, natural monuments or in other biodiversity conservation areas declared under official protection. Published in 2018	This law was enacted specifically to **reduce the entry of plastic items into natural environments**
8	Chilean National Waste Policy. 2018-2030	Achieve a sustainable management of natural resources, through the **circular economy** approach and the environmentally sound management of waste, hoping to increase the recovery rate of waste generated by economic activities and by those of household origin
9	DECREE 64, which regulate the waste from aquaculture activities. Published in 2021	This decree approves the regulation that establishes the conditions on treatment and final disposal of wastes from **Aquaculture activities**
10	Programa "Elijo Reciclar" ("I choose to recycle" Program).Published in 2020	Seeks to provide clear information to consumers and promote **recycling** and the **circular economy**
11	Law 21.368 which regulates the single use plastic and plastic bottles. Published in 2021	This law was created to regulate the use of **single use plastic** and **plastic bottles**
12	Acuerdo de producción limpia: "Eco-Etiquetado" (Clean production agreement: "Eco-Labelling"). Published in 2022	The labels, green seals or eco-labels, which give consumers information about the sustainability characteristics of products or services are being increasingly required
13	Law 21.413 prohibits smoking on sea, river or lake beaches, within a strip of 80 meters wide measured from the line	Its fundamental purpose is to avoid environmental **contamination** with **cigarette butts** in various public

No.	Regulation	Regulation Summary
	of highest tide of the coast of the coast and of the coastal fiscal lands up to a distance of 80 meters measured from where the riverbank begins. Published in 2022	spaces, specifically in **sea**, lake, **beaches** and to facilitating their recycling or reuse.
14	Hoja de Ruta de Economía Circular (Circular Economy Roadmap). 2020-2040	Domestic roadmap to the **circular economy** for a **Chile without garbage**

B. Indonesia

No	Regulation	Summary of the regulation
1	UU No 18 / 2008 : Waste Management Law	To organize integrated and comprehensive waste management, fulfilment of the rights and obligations of the community, as well as the duties and authorities of the Government and local governments to manage waste in an integrated and comprehensive manner including the duties and authorities of the Government and local governments to carry out public services.
2	Government Regulation Number 27 of 2020 on the Management of Specific Waste (derived from UU No 18 / 2008)	The handling of **specific waste**, whether due to its characteristics, volume, frequency of occurrence or other factors, requires handling methods that are not normatively sequential but require a methodology that is only suitable for specific situations and conditions.
3	President Regulation Number 83 of 2018 on Marine Waste Handling(derived from UU No 18 / 2008) and also derived law of national action plan for combating marine debris in Indonesia for 7 years (2018 - 2025).	To handle **plastic waste pollution in the ocean**, in particular micro and nano-sized plastic content in marine biota and resources in Indonesian waters that are harmful to aquatic ecosystems and human health and to fulfil the commitment of the Government of Indonesia to deal with marine plastic waste by 70% until 2025.
4	PP No 81 / 2012 (Government regulation)	House hold waste
5	Permen PU No 3 / 2013 derived from PP No 81 / 2012 government regulation on house hold waste (Ministerial regulation)	Building infrastructures and facilities to support household waste and household-like waste management in Indonesia such as build the final garbage dump in Indonesia
6	Perpres No 97 / 2017 (Presidential regulation)	Strategy to reduce household waste on land (2017-2025)
7	Permen LHK No 13 / 2012 (Ministerial regulation)	Waste Bank
8	Permen LHK No P.10 / 2018 (Ministerial regulation)	Regulating **waste management** in land or **coastal area** in **local government authority** including household waste and household-like waste type (organic and inorganic waste)
9	Permen LHK No P.75 / 2019 (Ministerial regulation)	The restriction target of **plastic food packaging** by 2030. This regulation specifically attempt to manage plastic waste which produce by producer. The waste reduction target by producers in 2029 is 30% of the total waste generation.
10	Permen LHK No 6 / 2022 (Ministerial regulation)	Building the domestic information system of waste management (SIPSN) on website
11	Permen LHK No 14 / 2021 (Ministerial regulation)	Waste bank
12	UU RI No 17 / 2008: Shipping	**Protection of the maritime environment** by waste and pollution come from shipping activities
13	PP No 21 / 2010 : The protection of maritime environment (derived from	**Protection of maritime environment from waste and pollution**. It includes law about prevention and control waste

No	Regulation	Summary of the regulation
	UU RI No 12 / 2008: Waste Management Law)	on the board, marine and seaport. This policy regulate waste and pollution (solid, liquid and gas type) in coastal (seaport) and ocean in general.
14	Perpres No 29 / 2012 (presidential regulation)	The international conventional for the prevention of pollution from ships 1973 as modified by the protocol of 1978 relating there to. The presidential regulations for ratification international law about the **prevention of pollution from ships**. This policy is about waste management (organic and inorganic waste type) and also pollution (solid, liquid, and gas type) in shipping activities.

C. Japan

No.	Regulation	Regulation Summary
1.	Article 11, Act. No. 136 of 1970 : Act on Prevention of Marine Pollution and Maritime Disaster	Prohibited waste dumping from vessel, prevent **marine pollution** and maritime disasters, ensure the proper implementation of international agreements on the prevention of marine pollution and maritime disasters, and contribute to the preservation of the marine environment and the protection of human life, limb and property
2	Article 3, Act No. 137 of 1970 11/18/2022 : Waste Management and Public Cleansing Act	1. Enterprises should properly dispose of waste generated during their business activities on their own responsibility. 2. The law defines the definition of waste, the responsibilities of citizens, businesses, the state and local authorities, the treatment of general waste and the disposal of industrial waste, in order to reduce waste emissions and to protect the living environment and improve public health through proper separation, storage, collection, transport, recycling and disposal.
3	MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978)	To eliminate intentional **marine environment pollution** through hydrocarbons and other toxic substances and to reduce the accidental discharge of such substances.
4	Act on Promoting the Treatment of Marine Debris Affecting the Conservation of Good Coastal Landscapes and Environments to Protect Natural Beauty and Variety	To provide basic principles for measures required for the smooth treatment of **marine debris** and control of its generation and to clarify the responsibilities of the domestic and local governments, business entities and the people of Japan, while setting out the basic policy established by the domestic government and other necessary matters for promoting measures against articles that drift ashore, thereby comprehensively and effectively promoting measures against articles that drift ashore to contribute to ensuring the lives of the people of Japan of both the present and future generations are healthy and cultured.

D. Republic of Korea

No.	Regulation	Regulation Summary
1.	Management Of Marine Debris and Contaminated Sediment Act	Contributing to the conservation of the marine environment and the improvement of citizens' quality of life by prescribing matters necessary for environmentally friendly and systematic management of **marine debris** and polluted marine sediments

2	The First Framework on Marine Debris Management (2021~2030)	Enhancing the life cycle of **marine debris** production, collection and disposal, along with the strengthened partnerships with relevant authorities
3	Measures against plastic waste from household	1)Reducing the production and consumption of plastics at the source, and 2) promoting **recycling** of **collected plastics**, and, 3) devising concrete measures to promote transition to Plastic Free Society

E. Malaysia

No.	Regulation	Regulation summary
1.	Environmental Quality Act (EQA), 1974. Act 127	Legislation for the control of industrial waste. This act aimed to prevent and control pollution and set up a system to punish those who recklessly harm the environment. This act is used to punish pollution of the land and **internal waters.**
2	Local government act 1976	To empower local government to address solid waste including **marine debris**
3	Fisheries Act 1985, Section 61	To make suitable provisions with regards to the disposal of **fishing gear and tackle**. Act relating to fisheries, including the conservation, management and development of maritime and estuarine fishing and fisheries, in Malaysian fisheries waters, to turtles and riverine fishing in Malaysia
4	Solid Waste Management and Public Cleansing Corporation Act 2007 (Act 673)	An Act to provide for the establishment of the Solid Waste and Public Cleansing Management Corporation with powers to administer and enforce the solid waste and public cleansing management laws and for related matters
5	National Marine Litter Policy and Action Plan 2021 - 2030	To reduce **marine plastic pollution** in Malaysia through strategic actions along the value chain. It has five pillars namely Policy Adoption and Implementation; Deployment of Technologies, Innovation and Capacity Building; Improve Monitoring and Data Collection on Marine Litter; Communication, Education & Public Awareness (CEPA) and Outreach; and Whole-Of-Nation and Multi-Stakeholders Approach. This Policy is substantiated with 17 action plans and 103 activities to be implemented in tandem with the Plastic Sustainability Roadmap 2021-2030 and the Roadmap Towards Zero Single-Use Plastic 2018-2030, in line with the 12th Malaysia Plan, which focuses on the implementation of circular economy as a catalyst for resource sustainability.

F. Mexico

No.	Regulation	Regulation Summary
1.	General Law on Ecological Equilibrium and Environmental Protection 1988 (LGEEPA) 1988-now	**The primary environmental law**, which provides a general legal framework for domestic legislation on the subject
2	The Law of Dumping in Mexican Marine Areas (Ley de Vertimientos en las Zonas Marinas Mexicanas) (LVZMM)	This new law substitutes a former **dumping** regulation and sets out the new requirements to obtain permits to dump specific substances and materials (solid, semi solid waste, organic material, fishing gear) to Mexican **marine areas**.
3	National Vision towards a Sustainable Management: Zero Waste (2019-now)	To transform the current waste management system into a circular economy scheme, promoting the rational use of natural resources and sustainable development. Include

		prohibited on **single-use plastic** shopping **bags** business sector, encourage recycle and remanufacturing.
4	An initiative to amend the General Law for the Prevention and Integral Management of Waste (LGPGIR) 2019-now	**Manufacturers** would be **responsible** for organizing, developing and financing the **integral management** of the **waste** generated as a result of the consumption of their products.

G. New Zealand

No.	Regulation	Regulation Summary
1.	Resource Management (Marine Pollution) Regulations (1998-now)	Control **dumping** and discharges **from ships** and off-shore installations in the **coastal marine** area. The regulations deal with the dumping of waste and discharges from vessels including oil, garbage and sewage
2	Resource Management Act 1991	For controlling the discharge of waste water including potential contaminants (**plastics**) to natural waterways (freshwater, **estuarine or coastal waters**) this regulation also provides the framework for the implementation of domestic Environmental Standards for Marine Aquaculture, which have the capacity to include further control on the use of **plastics in the aquaculture operations**. The act provides some **control over the discard of fishing gear**.
3	Litter Act 1979	Controls the discharge of **litter** to the **environment**
4	Waste Minimization (Microbeads) Regulations 2017	Prohibited to supply consumer products, such as cleaning products and hygiene products, that contain **plastic microbeads**
5	Waste Minimization (Plastic Shopping Bags) Regulations 2021	**Single-use plastic** shopping **bags** with handles that are made of plastic up to 70 microns in thickness are prohibited for supply.
6	Waste Minimization (Plastic and Related Products) Regulations 2022	Prohibited sale and manufacture **single-use** and **hard-to-recycle plastic** item
7	Fisheries Act 1996	Control over the **discard of fishing gear**

H. Peru

No.	Regulation	Regulation Summary
1.	Law #30884 on single use plastic (2018-now)	Prohibit use **single use plastic** and **polystyrene**

I. The Philippines

No.	Regulation	Regulation Summary
1	Republic Act No. 9003 - Ecological Solid Waste Management Act of 2000	To ensure the protection of public health and the environment though proper segregation, collection, transportation, storage, treatment, and disposal of solid wastes. This act also ensures the protection of the soil, surface and ground waters, and the ambient air quality from the effects of solid wastes. A domestic Solid Waste Management Commission was established to implement the objectives of the act.

No.	Regulation	Regulation Summary
2	Republic Act No. 9275 - Philippine Clean Water Act of 2004	A comprehensive program for water quality management that focuses on **pollution prevention** especially those coming from land-based sources which covers all water bodies including **marine waters**. Ultimately, it would provide safe and potable waters, and also help water bodies flourish for the improvement of our aquatic and marine resources.
3	Presidential Decree No. 979 - Marine Pollution Decree of 1976	Prevention and to control **marine pollution** from **waste dumping**. strengthens the responsibility of the Philippine Coast Guard to enforce the laws, rules, and regulations governing marine pollution
4	Presidential Decree 1152 - Philippine Environment Code, 1972	Establish environmental management policies and **standards** for air quality, **water quality**, land use, natural resources, and waste management
5	DILG Memorandum Circular 2020-147	Remind local government units to properly dispose of **waste**, especially those that are related to the management of COVID-19, such as **face masks(fibre plastic)**
6	Makati City Ordinance No. 03-095 s.2003	Makati City is a city within the National Capital Region and is considered a financial hub. The ordinance, which was passed in 2003, directs commercial establishments to transition and adopt biodegradable alternatives to packaging materials, cutlery, among others.
7	Los Baños Municipal Order 2008-752	Bans the use of plastic bags and polystyrene (expanded) to pack both dry and wet goods in the municipality of Los Baños, Laguna.
8	Muntinlupa City Ordinance No.10-109 s.2010	Muntinlupa City is a city located at the southern portion of the National Capital Region. The ordinance, which was passed in 2010, directs commercial establishments to prohibit the use of non-biodegradable materials to package dry goods, and regulate the use of non-biodegradable materials to package wet goods. Polystyrene (expanded)-based materials are also banned in the city.
9	Pasig City Ordinance No. 9, s.2010	Pasig City is a city within the National Capital Region and is located east of Manila. The ordinance, which was passed in 2010, prohibits commercial establishments in the city to use plastic bags and polystyrene (expanded)s to pack dry goods. The ordinance also aims to regulate the use of non-biodegradable materials to pack wet goods.
10	Bacolod City Order No. 562 s. 2011	Bacolod is located in Western Visayas. The ordinance was passed in 2011 but with a moratorium of 1 year was implemented in 2012. The ordinance prohibits the use of single-use plastics, with the exemption of biodegradable plastic bags. Plastic bags used as primary packaging for wet and dry food items are exempted on the basis of public hygiene.
11	Las Piñas City Ordinance No. 1036, s.2011	Las Piñas City is located in the southernmost part of the National Capital Region. The ordinance, which was passed in 2011, bans the use and selling of plastics bags and polystyrene (expanded)-based materials.
12	Marikina City Ordinance No. 18, s.2012	Marikina City is a city within the National Capital Region. The ordinance, which was passed in 2012, prohibits commercial establishments to use plastic bags to pack dry goods, and seeks to regulate the use of plastic bags to pack wet goods. The ordinance recommends the use of paper to pack dry goods. The ordinance bans the use of polystyrene (expanded)-based materials. The ordinance has a provision for exemption, which is evaluated on a case-to-case basis. Commercial establishments that violate provisions of the ordinance will be fined.

No.	Regulation	Regulation Summary
13	Malay Municipal Order No. 320 s. 2012	Malay is known for Boracay Island, one of the world's best beaches. Malay is a municipality in Aklan, Central Philippines. The ordinance, which was passed in 2012, prohibits the use of plastic bags for packaging dry goods. Selling plastic bags is prohibited by the ordinance as well.
14	Manila City Ordinance No. 8282 s.2012	Manila City, the capital of the Philippines passed an ordinance in 2012 that prohibits the use of plastic bags for the packaging of dry goods, and restricts usage for wet goods. The ban also covers polystyrene-based packaging.
15	Quezon City Ordinance No. SP 2127 s.2012	Quezon City is the largest city in the National Capital Region. The above-mentioned ordinance was passed by the local council in 2012, and prohibits the use non non-biodegradable packaging in government buildings in the city, specifically in the Quezon City Hall Complex, Novaliches District Center, Quezon City General Hospital, and the Novaliches District Hospital. The ordinance directs government officials in these facilities for the implementation. Fines are imposed for the violations of the ordinance.
16	Quezon City Ordinance No. SP 2140 s.2012	The ordinance, which was passed in 2012, directs commercial establishments to charge 2 the Philippines pesos for every plastic bag that a customer will use (Plastic recovery system fee). In addition, the ordinance also provides incentives for using recyclable bags, such as a point system, "green lanes" for faster transactions, among others. Commercial establishments that violate the provisions of the ordinance will be fined.
17	Caloocan City Ordinance No. 0503 s.2013	Caloocan City is a city within the National Capital Region, and the ordinance, which was passed in 2013 prohibits commercial establishments from using plastic bags and other non-biodegradable materials as packaging materials. Biodegradable or oxo-biodegradable plastic bags that meet specifications are exempted from the ordinance. Commercial establishments that violate provisions of the ordinance will be fined.
18	Mandaluyong City Ordinance No. 523, s.2013	Mandaluyong City is a city within the National Capital Region, and the ordinance, which was passed in 2013 seeks to phase out plastic bags and polystyrene (expanded)-based materials in the city. According to the ordinance, total ban of plastic bags polystyrene (expanded)-based materials must be implemented in the city by 2014.
19	El Nido Municipal Ordinance No. 4 s. 2013	El Nido is a tourist destination known for its pristine beaches. It is a municipality located in Palawan, a large province in Southwest Philippines. The ordinance bans single-use plastics in the municipality.
20	Los Baños Municipal Order 2014-136	Bans the use of single-use plastics in the municipality of Los Baños, Laguna.
21	San Fernando City Order No. 008 s. 2014	The ordinance in San Fernando City, Pampanga, prohibits commercial establishments to use plastic bags as packaging materials for both dry and wet goods. The ordinance also encourages the use of recyclable bags.
22	Baguio City Ordinance No. 36 s. 2017	Baguio City is a tourist destination located in the mountainous region of Northern Philippines. The ordinance bans the use of single-use plastics, which includes biodegradable plastic materials.

No.	Regulation	Regulation Summary
		Biodegradable plastics will only be allowed once conclusive evidence regarding its degradation has been obtained. Exemptions to the ban of single-use plastics covers factory packaging of wet goods.
23	Paraňaque City Ordinance No. 40, s.2018	Paraňaque City is a city within the National Capital Region. The ordinance prohibits plastic for packaging dry goods and the use of single-use plastics.
24	Quezon City Ordinance No. SP 2876 s. 2019	The ordinance, which was passed in 2019, prohibits restaurants and hotels to distribute and use single-use plastics and cutlery for dine-in customers. In addition, hotels are prohibited to provide toiletries that are contained in single-use plastics, such as sachets. Commercial establishments that violate the provisions of the ordinance will be fined.
25	Pasay City Resolution No. 4873, s.2019	Pasay City is a city within the National Capital Region. The city has passed two legislations that aimed to regulate the utilization of plastic bags, Ordinance No. 4647 s. 2011 and Ordinance No. 5987 s. 2019. The resolution directs the Pasay City Environment and Natural Resources Office to strictly enforce the ordinance.
26	Davao City Ordinance No. 0500-21 s. 2021	Davao City is located in Mindanao, Southern Philippines. The ordinance regulates the use of plastics, wherein commercial establishments need to secure a permit before plastics can be used and sold. The ordinance also provides specifications on the plastics that can be used once a permit is issued.
27	National Plan of Action for the Prevention, Reduction and Management of marine Litter (NPOA-ML)	The objective is to provide a blueprint to enhance the current efforts of the economies in resource and waste management and to bring additional lens to **marine litter** issues and the control of additional leakage of waste into bodies of water. The goal is "**Zero waste to Philippine waters by 2040"** to support the Vision of " A Philippines free of marine litter through shared participation, responsibility, and accountability "

J. Russia

No.	Regulation	Regulation Summary
1.	Federal Law No. 167-FZ Water Code (does not separate marine environment)	**Protection** of water bodies in order to ensuring citizen's rights on having have pure water and a favorable **water environment**; maintaining optimal conditions for the use of water, and the quality of surface and subsurface waters in a state meeting sanitary and ecological requirements; protecting bodies of water from pollution, clogging and depletion; preventing or liquidating harmful effect of waters, and maintaining the biological diversity of water ecosystems
2	Order No. 87 of the Ministry of Natural Resources and Ecology validating the Regulation on calculation of damages caused to water bodies by the infringement of water legislation.2009	This Order establishes the modalities of calculation of damages caused to water bodies by the infringement of water legislation, including accidental oil spills, and, in particular, for the calculation of damages that have caused water pollution, clogging or exhaustion of water
3	Law on territorial sea and law on continental shelf	Do not cover environment protection, only one article on waste banned in terrestrial and sea. No legislative recognition of "single-use plastic", thus - no basis for separate waste collection and separation (it is voluntary)

No.	Regulation	Regulation Summary
4	Law on environmental protection (2002)	Includes first of all the legally approved list of contaminants, where microplastic is not included yet. Thus, since juridically microplastics in Russia l is not the contaminant, there is no legislative recognition of this term and of its threat and risk to the environment.
3	law on territorial sea and law on continental shelf	Do not cover environment protection only one article on waste banned in terrestrial and sea. No legislative recognition of “single-use plastic" thus no basis separate waste collection and separation (voluntary so far in some regions)
4	law on environmental protection (2002)	List of contaminants and microplastics juridical is not the contaminant, no legislative recognition of this term
5	Ministerial Decree No. 251 regarding validation of the list of hazardous substances the discharge from vessels. (2020)	The Government decrees to validate the list of hazardous substances that include all types of **plastic materials, including synthetic ropes, fishing nets and plastic bags** for waste collection, consumer waste materials, except for food remnants, fresh fish and its remnants, ammunition, explosives, biological and chemical weapons and the components for their production, substances which chemical composition is unknown and therefore the permissible concentration limits of which can’t be determined, chemical substances in accordance with **MARPOL 73/78** Convention.
6	Russia Government Ordinance No. 3722-r dated 31 December 2020	Which set the compulsory **recycling** targets for 2021 for various types of waste, including **packaging and plastic waste**

K. Singapore

In order to identify relevant and applicable regulations to this issue, we have considered the following potential sources of MP that could be regulated:

1. MP exported into aquaculture operation from the surrounding water.
2. Management of the farms: MP in fish-feed, in packaging of material use for the operation of the farm, composition of aquaculture nets/pens/ systems, sediment resuspension (can be triggered by farm-owned activities or outside natural. processes, such as ocean dynamics and climate condition-monitoring the presence of MP).
3. Water drainage and run-off (non-point source pollution).
4. Sewage.
5. Drainage or other seabed activities around the farm that could result in sediment resuspension.

No.	Regulation	Regulation Summary
1.	Sx Annexes of the International Maritime Organization’s (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL)	Prevention of pollution of the **marine environment by ships**. The following actions are carried out with the aim to reduce sea-based sources of marine litter. (Annex 1-6: Prevention of pollution by oil and oily water; control of pollution by noxious liquid substances in bulk; prevention of pollution by harmful substances carried by sea in packaged form; pollution by sewage from ships; pollution by garbage from ships; prevention of air pollution from ships)
	Environmental Public Health Act 1987 (“EPHA”)	The EPHA consolidates the law relating to environmental public health and in particular the regulation of waste generation, storage, collection, transport, and disposal

No.	Regulation	Regulation Summary
		(including treatment and recycling). For example, generators of toxic industrial waste must keep records of the toxic industrial waste generated and the manner of their disposal; waste collectors must be licensed; the regulator's approval is required for the transportation of toxic industrial waste beyond specified thresholds; and industrial waste must only be disposed at disposal facilities (including recycling facilities) established or licensed by the regulator. Under the Act, owners/occupiers of large commercial premises, hotels and malls, and industrial premises, and convention and exhibition centres to report on their waste generation and submit plans for waste minimisation. Littering and illegal dumping are also offences under the Act that attract significant maximum penalties.
	Prevention of Pollution of the Sea Act 1990 <https://sso.agc.gov.sg/Act/PPSA1990>	The PPSA was enacted to give effect to several international agreements relating to the protection of the marine environment, and provides for the prevention, reduction, and control of pollution of the sea and pollution from land and ships. It is an offence for any person to throw plastics into Singapore waters. It is also an offence for the owner, master, and agent of a ship if any plastics are disposed from the ship into Singapore waters. Any person who throws plastics into Singapore waters is liable for the costs of any measure taken by the regulator to remove it. Similarly, if any plastics is discharged from any ship into Singapore waters, the owner of the ship is liable to pay for the costs of any measure taken by the regulator to remove it or prevent or reduce any damage caused in Singapore by contamination from the discharge.
2	Fisheries Act 1996 <https://sso.agc.gov.sg/Act/FA1966>	Offshore fish farms are prohibited from **dumping waste** into **the sea** and routine farm inspections are carried out to ensure compliance
	Maritime and Port Authority of Singapore Act 1996 <https://sso.agc.gov.sg/Act/MPASA1996>	Under the MPAA, the consent of the regulator is required for the construction, alteration or improvement of any work on, over, or under any part of a river, waterway or the seashore (including seabed) lying below the high-water mark of ordinary tides; or the deposit or removal of any object or material on or from such part of a river, waterway or seashore.
	Sewerage and Drainage Act 1999 <https://sso.agc.gov.sg/Act/SDA1999>	The SDA regulates, amongst other things, the construction, maintenance, improvement, operation and use of sewerage and land drainage systems, and the discharge of sewage and trade effluent. Written approval from the regulator is required for the discharge of trade effluent into any public sewerage system.
	Environmental Protection and Management Act 1999 <https://sso.agc.gov.sg/act/epma1999>	The EPMA is the primary piece of legislation providing for air, water, and land pollution. Any occupier of any industrial or trade premises who carries on any trade industrial process must not allow the emission of air impurities in excess of the prescribed standard of concentration or rate of emission. The standard of concentration for particulate substances including solid particles of any kind has been prescribed. Air impurities or which standards of concentration have been

No.	Regulation	Regulation Summary
		prescribed include particulate substances. Where no standard is prescribed in respect of an air impurity, the occupier must carry on any trade or industrial process in or on the premises by the best practicable means available as may be necessary to prevent or minimise air pollution. Written permission is required before the discharge of (liquid) trade effluents and other polluting matters into drains (including surface and subsurface bodies of water and any part of sea abutting the foreshore). The discharge of toxic substances (any substance which Is noxious, injurious, or polluting) into inland waters such as to cause pollution of the environment is also an offense. The regulator is empowered under this Act to order the polluter who discharges pollutants into the land, drains, and sea to remove the pollutants and clean up the discharge. The EPMA also deals with hazardous substances (including some forms of plastics) control in Singapore through establishing a licensing scheme for the importation, manufacture, sale, and transport of such substances, as well as the requirement for impact analysis at sites where hazardous substances are stored, handled, or used.
3	Resource Sustainability Act (RSA) in 2019	Provides the legislative framework to impose upstream regulatory measures to address domestic priority waste streams, e-waste, food waste, packaging waste including **plastics**.
	Singapore Aquaculture Plan <https://www.ourfoodfuture.gov.sg/uplifting-aquaculture-industry/sg-aquaculture-plan>	Singapore plans to "uplift" its aquaculture industry in the coming years through its Singapore Aquaculture Plan, through, amongst other things, allocating more sea spaces for aquaculture and ensuring they are used optimally; supporting the aquaculture sector to be more productive, climate resilient, and resource efficient using technology and adopting appropriate farm management methods; and supporting research and innovation for sustainable tropical marine aquaculture through leveraging on the Singapore Food Agency's Marine Aquaculture Centre that has been established to deepen Singapore's expertise in the areas of aquaculture genetics, nutrition and health.
	Feeding Stuffs Act <https://sso.agc.gov.sg/Act/FSA1965>	The FSA provides for the control of feeding stuffs for animals and birds. The manufacture and production of animal feed, including aquaculture feed must be licensed. Feeding stuffs may be sampled and analysed, but it is not known if the analysis is done for microplastic content in the feed. SS 670:2021 Specification for Good Aquaculture Practice ("SS670:2021") SS670:2021 is intended to help farmers improve productivity and provide quality assurance, thus enhancing market access. It covers food safety and quality, animal health and welfare, environmental integrity the socio-economic aspects. The standard is used for the regulator's good practices certification for aquaculture. The standard requires that facilities provide effective physical separation of the farm cultivation areas from their

No.	Regulation	Regulation Summary
		surroundings to assure food safety, human health, safety and welfare, environmental integrity, and animal welfare. On feed and feeding management, while SS670:2021 provides for feed and feeding management and recommends that farms communicate with the feed supplier that various tests have been conducted, testing for microplastics is not one of the tests explicitly included in the recommendation. SS 689:2022 Specification for Clean and Green Urban Farms ("SS689:2022") SS689:2022 sets requirements for the operation of sustainable aquaculture in terms of techniques, practices, and management to ensure the quality and safety of products while minimising the impact on the environment. Iit provides, amongst other things, that the water used for aquaculture must be of a suitable quality for producing aquatic animals that are safe for human consumption and mandates the regular monitoring of basic water quality parameters in farming areas for the purpose of production. The presence of microplastics is not one of the parameters explicitly specified for monitoring. Farms must develop farm waste management plans to provide clear strategies in waste management, including of used packaging and transportation materials. All waste must be collected and disposed of regularly by licensed waste collectors.
	SS 670:2021 Specification for Good Aquaculture Practice	SS670:2021 is intended to help farmers improve productivity and provide quality assurance, thus enhancing market access. It covers food safety and quality, animal health and welfare, environmental integrity the socio-economic aspects. The standard is used for the regulator's good practices certification for aquaculture. The standard requires that facilities provide effective physical separation of the farm cultivation areas from their surroundings to assure food safety, human health, safety and welfare, environmental integrity, and animal welfare. On feed and feeding management, while SS670:2021 provides for feed and feeding management and recommends that farms communicate with the feed supplier that various tests have been conducted, testing for microplastics is not one of the tests explicitly included in the recommendation.
	SS 689:2022 Specification for Clean and Green Urban Farms	SS689:2022 sets requirements for the operation of sustainable aquaculture in terms of techniques, practices, and management to ensure the quality and safety of products while minimising the impact on the environment. Iit provides, amongst other things, that the water used for aquaculture must be of a suitable quality for producing aquatic animals that are safe for human consumption and mandates the regular monitoring of basic water quality parameters in farming areas for the purpose of production.

No.	Regulation	Regulation Summary
		The presence of microplastics is not one of the parameters explicitly specified for monitoring. Farms must develop farm waste management plans to provide clear strategies in waste management, including of used packaging and transportation materials. All waste must be collected and disposed of regularly by licensed waste collectors.
4	Marine litter policy landscape (2020)	Established the Interagency Taskforce on **Marine Litter**, to coordinate and implement marine litter policies across government agencies.
5	Zero waste Nation Act (2019-2030)	Increase overall waste recycling rate to 70 per cent and reduce waste-to-landfill per capita per day by 30 per cent by 2030 by: I. Reduction of Land-Based Sources of Litter II. **Reduction of Sea-Based Sources of Litter** III. Circular Economy Approach IV. Research and Development V. Maintaining and Strengthening Outreach

L. Chinese Taipei

No.	Regulation	Regulation Summary
1.	Action Plan of Marine Debris Governance (2018-2022)	To reduce the production of **marine debris** and its impact on ocean environment
	Followed by derivative regulation	
	a. Plastic bag restriction Phase 1 and II (2003&2018)	
	b. Limiting product over-packaging (2005)	
	c. Banned single-use utensil (2006&2019)	
	d. Restriction the use of plastic tray and package box (2007&2012)	
	e. Implementation of incentives for recycling beverage cups or using customers' cups (2011)	
	f. Restriction on straws – the first stage (2019)	
	g. Restriction on single-use beverage cups (2022)	
	h. Reduction of E-commerce's packaging (2023)	
2	Tribute to the Ocean – Plan of Coastal Cleanup and Management	1. Clearly define the authority responsible for coastal cleanup and management. 2. Decrease the **cleanup** volume of **coastal debris** through source control management. 3. Authorities should cleanup drifting woods and debris within 7 days after natural disasters. 4. Include: a. Define the coastal land to its authority institution clearly, and each authority should take responsibility of clean up for its own coastal area. b. **Gillnet marking measure**

No.	Regulation	Regulation Summary
		c. Fisheries Agency cooperates with local governments to manage the recycling of **oyster raft and aquaculture buoys** d. Ocean Conservation Administration draft a check scheme of fishers' gears on board e. Water Resources Agency and Environmental Protection Administration work together on blocking riverine litter with barriers f. Continuous monitoring of **coastal landfills** g. Source control of **single-use plastic** products h. Set storage areas for floating litter and **old nets** at fishing ports i. Encourage the recycling and reuse of **fishing nets** j. Increase the recycle rate of **plastic containers**
3	Eco-flotilla	Recruit Fishing board to removes **floating litter** and takes back their own litter on board for 800 tonnages every year
4.	Eco-Diver	Remove 25 tons of **underwater debris** and **ghost nets**

M. Thailand

No.	Regulation	Regulation Summary
1.	Roadmap on Plastic waste management (2018-2030) and Phase I of the Action Plan on Plastic Waste Management (2020 until 2022)	A voluntary ban on the use of seven types of **single-use plastics** by 2020–2022 (oxo-degradable plastic, cap seal, microbeads, grocery bags less than 36 microns thick, straw, cups less than 100 microns thick, and polystyrene (expanded) for food container)
2	Thailand's Draft Action Plan on Marine Plastic Debris (2023-2027)	A framework for actions by relevant sectors in supporting the Roadmap on Plastic Waste Management 2018–2030, with 2 goals: 1. To reduce the amount of **plastic waste** from land-based and sea-based sources. 2. To reduce the impact of **marine plastic debris** on ecosystem

N. The United States

No.	Regulation	Regulation Summary
1.	The Microbead-Free Waters Act of 2015	Prohibits the manufacturing, packaging, and distribution of rinse-off cosmetics containing plastic microbeads. This new law also applies to products that are both cosmetics and non-prescription (also called "over-the-counter" or "OTC") drugs, such as toothpastes
2	Health and Safety Code section 116376 via Senate Bill No. 1422 in 2018	Adding **microplastics regulations** to California's Safe Drinking Water Act ("SDWA")
3	The Ocean Dumping Act. 1988	Amended the Marine Protection, Research, and Sanctuaries Act to **include plastics as a material prohibited from being dumped by vessels**
4	Clean Water Act's in 1972	**Effluent Guidelines** and Standards for Organic Chemicals, **Plastics, and Synthetic Fibers** (OCPSF) applies to industrial chemical facilities and **limits the discharge of plastics into certain waterways**
5	Senate Bill 54 in 2022	Aims to achieve a 25% reduction in single-use plastic by 2032 and utilizes an **extended producer responsibility structure**, where single-use plastic producers are required to contribute to the disposal of their products

No.	Regulation	Regulation Summary
6	US Marine Debris Act in 2006	Established a domestic **Marine Debris Program** within NOAA to identify, determine sources of, assess, prevent, reduce, and remove marine debris and address the adverse impacts of marine debris on the economy of the United States, marine environment, and navigation safety. The Act also set forth direction for the U.S. Coast Guard to address ship-based waste in accordance with MARPOL requirements.
7	Resource Conservation and Recovery Act (EPA)	**Protect human health and the environment** from potential **hazards of waste disposal**; conserve energy and natural resources; reduce the amount of waste generated; and ensure that wastes are managed in an environmentally sound manner by establishing minimum domestic criteria for solid waste facilities. Implemented by states and tribes and/or at the local level, with state, tribal or local governments having the option to put forth regulations that are more stringent than the domestic standards.
8	Save our seas 2.0 Act	1. Strengthening the United States' domestic marine debris response capability with a Marine Debris Foundation, a genius prize for innovation, and new research to tackle the issue. 2. Enhancing global engagement to combat **marine debris**, including formalizing U.S. policy on international cooperation, enhancing federal agency outreach to other economies, and exploring the potential for a new international agreement on the challenge. 3. Improving domestic infrastructure to prevent marine debris through new grants for and studies of waste management and mitigation.
9	Toxic Substances Control Act	1. Under TSCA, EPA has the authority to require testing of new and existing **chemical substances** such as those that may be **in plastic waste entering the environment**, and subsequently the authority to regulate these substances. 2. While TSCA can potentially be used for the purpose of addressing **risks specific to chemical substances that may be in plastic waste**, to date EPA has not used the authorities in the Act to regulate plastic waste.
10	Rivers and Harbors Appropriations Act	Authorizes the Army Corps of Engineers to issue **permits for the discharge of materials** of any kind into **navigable waters** under section 13.

O. Viet Nam

No.	Regulation	Regulation Summary
1.	Law on environmental protection no.72-2020-QH14 (2020)	Environmental protection activities; rights, obligations and responsibilities of agencies, organizations, residential communities, households and individuals involved in environmental protection activities.
	Article 64. Roadmap for production and import of **single-use plastic products, non-biodegradable plastic packaging and products and goods containing microplastics.**	Banned to produce and import plastic bag in early 2026, producer and importer of single-use or non-biodegradable plastic responsibility on recycle their product, stop production and import single-use plastic in the end 2030, local government banned use of single use and non-

No.	Regulation	Regulation Summary
		biodegradable plastic in retailer, hotel and tourism area at the end 2025.
	Article 66. Environmental protection during culture, sport and tourism activities	Obliges tourist area's visitor to reduce plastic waste
	Article 73. Reduction, reuse, recycling and treatment of plastic waste, prevention and control of **ocean plastic waste polution** l23	Prohibited plastic waste discharge in water bodies, collected and recycle plastic waste from marine area (include marine culture),provincial committees do 3R on non-biodegradable plastic and disseminate danger of plastic pollution in the ocean(including lost/dumping fishing gear), government road map on reducing production and import of non-biodegradable plastic product.
	Article 143. Services under environmental service development	Environmental remediation services for domestic solid waste landfills; services involving collection and treatment of **plastic waste floating in seas and oceans**.
2	Decree No. 08/2022/ND-CP (2022)	**Exporters and importers responsibility** for recycling and treating products and packages, **environmental information systems and database**, environmental emergency prevention and response plans.
	Article 64	**Roadmap for production and impor**t of single-use **plastic products**, non-biodegradable plastic packaging and products and goods containing microplastics
	Article 143	Services under environmental service development: Environmental remediation services for domestic solid waste landfills; services involving **collection and treatment of plastic waste floating in seas and oceans**.
3	Directive No. 33/CT-TTg on regarding strengthening of management, reuse, recycling, disposal and reduction of plastic waste. (2021-2026)	Regarding strengthening of management, reuse, **recycling, disposal and reduction of plastic waste.** (Issued by Decision No 2395/QD-BTMT)
4	Decision No. 1746-QD-TTg on introducing domestic action plan for management of marine plastics litter by 2030. (2019-2030)	Eliminate plastic litter from land-based and ocean-based sources, and strive to become a pioneering economies in **mitigation of marine plastic litter** in the region and circular economy. (Issued by Decision No 2395/QD-BTMT)
5	Decision No. 491/QD-TTg. 2018	Implementation of the **domestic strategy** for general management of **solid waste** by 2025 with vision towards 2050
6	Resolution No.36-NQ/TW on the strategy for sustainable development of Viet Nam's sea based economy by 2030, vision 2045	Become an economy with strong sea power; basically achieve the objectives of developing a sustainable sea-based economy; shape the marine ecosystem culture; actively adapt to climate change and sea rise level; **prevent pollution and degradation of the sea** environment, coastal landslides and coastal erosion; and recover and protect important marine ecosystems. The new, advanced and modern scientific achievements must become the direct factors in promoting the sustainable sea-based economy
7	Decision No. 28/QD-TTg-2020 dated January 7th ,2020 on approving the key point program for basic inspection of resources, sea and island environment by 2030.	A map of pollution risk zoning and bearing capacity of ecosystems, resources and environment has been established throughout Viet Nam's sea at a scale of 1:500,000 and a large proportion of coastal areas to a depth of up to 100m; identify the risks of pollution and **degradation**

No.	Regulation	Regulation Summary
		of the **marine environment due to plastic waste, microplastics**, radioactive waste, new pollutant compounds originating from human activities; identify sea areas favorable for sea dumping activities.
8	Decision No. 1316-QD-TTg on approving - Proposal for strengthened management of plastic waste in Viet Nam.2021-2026	Strengthening management of plastic waste from the central to local level, contributing to the successful implementation of the domestic strategy for comprehensive solid waste management by **2025, increasing the reuse, recycling and disposal of plastic waste**

Appendix 4. Identification result specific policies / regulatory framework related to coastal aquaculture and plastic / microplastics pollution in APEC economy.

No.	Economy	Specific Policies / Regulatory Framework related to Coastal Aquaculture and Plastic / Microplastics pollution
1	Chile	DECREE 64 year 2021, which regulate the waste from aquaculture activities. This decree approves the regulation that establishes the conditions on treatment and final disposal of wastes from aquaculture activities.
2	New Zealand	Working plastics in the sea: Resource Management Act 1991. The act establishes the framework for controlling the placement of structures into natural waterways (freshwater, estuarine or coastal waters). Government agency responsible is the Ministry for the Environment, with many powers for implementation devolved to local government agencies – regional and local councils. The targeted stakeholders are aquaculture operators. The domestic environmental standard framework is a relatively recent development in the sector and is still bedding in, with the major focus being on process for reconsenting aquaculture area allocations and biosecurity management, rather than the release of waste materials.
3	Chinese Taipei	(i) Tainan City Shallow Sea Oyster Aquaculture Management Autonomous Regulations; to achieve a better management system of the oyster aquaculture in Tainan City, (ii) Tainan City Floating Raft Oyster Aquaculture and Fishery Management Specification; with the objective is to enforce the management of the oyster aquaculture in Tainan City and to adjust the structure of fishery, (iii) Chiayi County Oyster Aquaculture Zoning and Fishery Right Management Autonomous Regulations; with the objectives are (a) to enhance the effective use of coastal waters, (b) to build the reasonable system of marine agriculture, and (c) maintain the normal development of shallow sea oyster aquaculture in Chiayi County, (iv) 2022 Chiayi County Floating Raft Oyster Aquaculture Environmental Protection Alternative Buoy Rewards and Subsidy Program; with the objective is to encourage fisherman using the environment friendly oyster aquaculture buoys, (v) Penghu County Government Subsidy for Container Nets and Oyster Aquaculture Buoys; with the objective is to prevent pollution of microplastic sheded by marine aquaculture Polystyrene (expanded) buoys. Peng Hu government encourages Peng Hu fisherman to replace with non-Polystyrene (expanded) buoys.

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
1	People's Republic of China	NA	
2	Japan*	Based on the "Osaka Blue Ocean Vision" formulated at the G20 Osaka Summit in June 2019, Japan have been formulating policies on marine plastics pollution. There are several policies regarding wastes relating fisheries, i.e.: . The number: Article 11, Act. No. 136 of 1970. Title: Act on Prevention of Marine Pollution and Maritime Disaster. This act Aims to prevent marine pollution and maritime disasters, ensure the proper implementation of international agreements on the prevention of marine pollution and maritime disasters, and contribute to the preservation of the marine environment and the protection of human life, limb and property (https://elaws.e-gov.go.jp/document?lawid=346CO0000000201). . The number: Article 3, Act No. 137 of 1970. Title: Waste Management and Public Cleansing Act. The law defines the definition of waste, the responsibilities of citizens, businesses, the state and local authorities, the treatment of general waste and the disposal of industrial waste, in order to reduce waste emissions and to protect the living environment and improve public health through proper separation, storage, collection, transport, recycling and disposal (https://elaws.e-gov.go.jp/document?lawid=345AC0000000137).	
3	Republic of Korea*	Act No.18065 "Management Of Marine Debris and Contaminated Sediment Act"	The purpose of this Act is to contribute to the continuous development of fisheries and to the income growth of fisherman by establishing plans for the management of fishery resources and efficiently managing fishery resources through the prescription of matters necessary for the protection, recovery, formation, etc. of fishery resources.
4	New Zealand	1. Marine Discharge: Resource Management (Marine Pollution) Regulations 1998 (https://www.legislation.govt.nz/regulation/public/1998/0208/latest/DLM253727.html?search=ts_regulation_Resource+Management+(Marine+Pollution)+Regulations_resel&p=1&sr=1).	1. The regulations control dumping and discharges from ships and off-shore installations in the coastal marine area. The regulations deal with the dumping of waste and discharges from vessels including oil, garbage and sewage. Government agency responsible is the Ministry for the Environment. Targeted stakeholders are vessel operators of all sizes. Implementation is variable as it relies on goodwill compliance of

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
		2. Waste Water Discharge: Resource Management Act 1991 (https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html). 3. Littering: Litter Act 1979 (https://www.legislation.govt.nz/act/public/1979/0041/latest/whole.html#DLM33423). 4. Working plastics in the sea: Resource Management Act 1991 (https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html). The Resource Management Act 1991 also provides the framework for the implementation of domestic Environmental Standards for Marine Aquaculture, which have the capacity to include further control on the use of plastics in the aquaculture operations. (https://www.mpi.govt.nz/fishing-aquaculture/aquaculture-fish-and-shellfish-farming/national-environmental-standards-for-marine-aquaculture/) 5. Fisheries Act 1996 (https://www.legislation.govt.nz/act/public/1996/0088/latest/whole.html?search=sw_096be8ed81c4a3bb_gear_25_se&p=1#whole). 6. General Controls on Plastics Use In New Zealand. Some plastic products are prohibited in New Zealand. Single-use plastic shopping bags with handles that are made of plastic up to 70 microns in thickness are prohibited for supply (Waste Minimization (Microbeads) Regulations 2017). Consumer products, such as cleaning products and hygiene products, that contain plastic microbeads are prohibited for supply (Waste Minimization (Plastic Shopping Bags) Regulations 2018). The manufacture and sale of, plastic drink stirrers that are single-use, plastic or synthetic cotton buds that are single-use, with some exceptions, any product that contains plastic with pro-degradants, PVC food trays or containers, specified polystyrene packaging for food or drink. (Waste Minimization (Plastic and Related Products) Regulations 2022). Targeted stakeholders are the manufacturers and outlets for these common plastic consumer products. These controls have all been introduced in the last few years and compliance is	vessel operators, while enforcement at sea is challenging and limited as a consequence. 2. This act establishes the framework for controlling the discharge of waste water including potential contaminants (plastics) to natural waterways (freshwater, estuarine or coastal waters). Government agency responsible is the Ministry for the Environment, with many powers for implementation devolved to local government agencies – regional and local councils. Targeted stakeholders are government agencies, companies and individuals involved in the discharge of waste water to the environment. Implementation is variable as it relies on the identification and permitting of waste water discharges which are vast in number, and with a wide range of sizes and waste discharge concerns. Compliance and enforcement are very patchy. 3. The act controls the discharge of litter to the environment. Government agency responsible is the Ministry for the Environment, with many powers for implementation devolved to a variety of local government agencies. Targeted stakeholders are individuals and entities involved in the discharge of litter to the environment. Extensive public education, some limited enforcement. 4. The act establishes the framework for controlling the placement of structures into natural waterways (freshwater, estuarine or coastal waters). Government agency responsible is the Ministry for the Environment, with many powers for implementation devolved to local government agencies – regional and local councils. The targeted stakeholders are aquaculture operators. The domestic environmental standard framework is a relatively recent development in the sector and is still bedding in, with the major focus being on process for reconsenting aquaculture area allocations and biosecurity management, rather than the release of waste materials. 5. The act provides some control over the discard of fishing gear. Government agency responsible is Fisheries New Zealand, within the Ministry for Primary Industries. Targeted stakeholders are mostly commercial operations in waterways, such as aquaculture

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
		being promoted by government agencies, rather than direct enforcement of breaches. The Ministry for the Environment is the government agency responsible for managing these regulatory restrictions (https://environment.govt.nz/acts-and-regulations/acts/waste-minimisation-act-2008/).	and marina operations. Relatively consistently applied to infrastructure development in aquatic areas, some enforcement.
5	Papua New Guinea	NA	
6	Chinese Taipei	Several general policies and regulations related to the management and or prevention of marine debris/marine plastic pollution: 1. Action Plan of Marine Debris Governance (2018). The objective is to reduce the production of marine debris and its impact on ocean environment. (https://bit.ly/3SoFMis). 2. Tribute to the Ocean – Plan of Coastal Cleanup and Management (2020). Objectives are: (1) Clearly define the authority responsible for coastal cleanup and management. (2) Decrease the cleanup volume of coastal debris through source control management. (3) Authorities should cleanup drifting woods and debris within 7 days after natural disasters (https://bit.ly/3CghFwD). 3. Eco-flotilla (2020). The objective is to recruit 2500 fishing boats joining eco-flotilla in 2020, and increase 5% in 2021. Eco-flotilla removes floating litter and takes back their own litter on board for 800 tonnages every year (https://bit.ly/3CdEyQr). 4. Eco-diver (2020). The objective is to remove 25 tons of underwater debris and ghost nets Specific regulations and policies to manage, prevent, reduce, and mitigate the distribution of plastics/microplastics in aquaculture systems with a specific interest in coastal aquaculture systems: 1. Tainan City Shallow Sea Oyster Aquaculture Management Autonomous Regulations; to achieve a better management system of the oyster aquaculture in Tainan City (https://law01.tainan.gov.tw/glrsnewsout/LawContent.aspx?id=GL000174). 2. Tainan City Floating Raft Oyster Aquaculture and Fishery Management Specification; with the objective is to enforce the management of the oyster aquaculture in Tainan City and to adjust	

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
		the structure of fishery (https://w3fs.tainan.gov.tw/Download.ashx?u=LzAwMS9VcGxvYWQvMzAvcmVsZmlsZS8xMDI0OC8yMzc1My9kNDY0Mzc1OC1hMDA1LTRjMjUtYWFjZS1lMzBiMDk0N2Y0NjgucGRm&n=MTEwMDUyNuato%2bW8j%2bWFrOWRiuS%2fruato%2beuoeeQhuimj%2bevhC5wZGY%3d). 3. Chiayi County Oyster Aquaculture Zoning and Fishery Right Management Autonomous Regulations; with the objectives are (a) to enhance the effective use of coastal waters, (b) to build the reasonable system of marine agriculture, and (c) maintain the normal development of shallow sea oyster aquaculture in Chiayi County (http://www.rootlaw.com.tw/LawArticle.aspx?LawID=B140200000000100-0990820). 4. 2022 Chiayi County Floating Raft Oyster Aquaculture Environmental Protection Alternative Buoy Rewards and Subsidy Program; with the objective is to encourage fisherman using the environment friendly oyster aquaculture buoys (https://agriculture.cyhg.gov.tw/News_Content.aspx?n=25C5947ECD01B1AF&sms=6F47E5EE8861247F&s=8C8AD15FDAF2955D). 5. Penghu County Government Subsidy for Container Nets and Oyster Aquaculture Buoys; with the objective is to prevent pollution of microplastics sheded by marine aquaculture Polystyrene (expanded) buoys. Peng Hu government encourages Peng Hu fisherman to replace with non-Polystyrene (expanded) buoys. Encourage fishermen to use alternative buoys instead of Polystyrene (expanded) buoys; with the objective is to decrease the pollution due to Polystyrene (expanded) along the coastline of Tainan City.	
7.	Indonesia*	1. Government Regulation Number 28 of 2017 on Fish Farming, dated 21 July 2017. 2. Minister of Marine Affairs and Fisheries Regulation No. 26 of 2021 on Pollution Prevention, Damage Prevention, Rehabilitation, and Improvement of Fish Resources and their Environment, dated 28 May 2021.	These three regulations do not specifically mention microplastics / plastic pollution, but describe the protection of the aquaculture environment from pollution in general

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
		3. Minister of Marine Affairs and Fisheries Regulation No. 25 of 2022 on Procedures for Rehabilitation of the Aquaculture Environment, dated 20 September 2022	
8.	Malaysia	These regulatory not specifically mention of microplastics /plastic pollution to coastal aquaculture but slightly correlate with marine pollution. 1. Fisheries Act 1985, Section 61 2. Local Government Act 1976 4. National Marine Litter Policy and Action Plan 2021 – 2030. Solid Waste Management and Public Cleansing Corporation Act 2007 (Act 673)	▪ Fisheries Act 1985, Section 61 main objective is to make suitable provisions with regards to the disposal of fishing gear and tackle. ▪ Local Government Act 1976 main objective is to empower all local government to address solid waste including marine debris. • National Marine Litter Policy and Action Plan 2021 – 2030 main objective is to reduce marine plastic pollution in Malaysia through strategic actions along the value chain of plastic life cycle. • Solid Waste Management and Public Cleansing Corporation Act 2007 (Act 673) main objective is to manage solid waste and public cleansing in public areas such as marine, this action will lead to minimize the quantity of plastic debris which enter marine ecosystem.
9.	The Philippines*	N.A. However, The Philippines has two Republic acts (issue by the senate and the house of and signed by the president) and more than twenty City ordinance (formulated and issued by the city council) which regulates and prohibits the use of certain types of plastic and is expected to indirectly reduce the quantity of plastic debris entering the sea	▪ Republic Act No. 9003 - Ecological Solid Waste Management Act of 2000 ▪ Republic Act No. 9275 – the Philippines Clean Water Act of 2004
10.	Russia*	N.A.	Most policies focus on marine oil spill pollution and calculation the damage on marine ecosystem
11.	Singapore	1. Fisheries act. 2. Marine litter policy landscape	▪ (Fisheries act) Offshore fish farms are prohibited from dumping waste into the sea and routine farm inspections are carried out to ensure compliance • (Marine litter policy landscape) established the Interagency Taskforce on Marine Litter, to coordinate and implement marine litter policies across government agencies.
12.	Thailand*	1. Thailand's Draft Action Plan on Marine Plastic Debris 2023–2027	• The Thailand's Draft Action Plan on Marine Plastic Debris 2023–2027 provides a framework for actions to reduce marine plastic debris impact to environment. The action is to take a systematically monitor the amount of marine plastic debris and the effect it has on the ecosystem. Furthermore, this action also mentions about fishing gear management system which state the issue of alternative material to plastic that can be used for fishing gear

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
			production, regulations to fishing boats, economic incentives for private operators and fishers, and information (public campaign) can support the system at production, consumption, and post-consumption of fishing gears and impact reduction when the fishing gear is lost.
13.	Viet Nam*	3. Decision on No. 687/QD-BNN-TCTS on Approval of the action plan on marine plastic waste management for the fisheries sector, 2020-2030 period. 4. Decision No. 911/QD-TTG on approving scheme for environmental protection in fishery sector in the 2021 – 2030 period	▪ Raise awareness of stake holder in reducing plastic wastes in fisheries sector ▪ Reduce use of materials and specialized equipment made of single-use plastic. • Increase percentage of collection, classification, reuse, and processing of plastic waste from fishery activities • All marine sanctuaries develop supervision plans and organize collection, classification of plastic waste and transport to processing entities • Developed database on marine plastic waste in fishery • Investigate into and assess sources of pollution and the volume of waste generated from fishery activities, and propose appropriate management solutions. • 6. Investigate into and assess existing technologies and application of technologies to treatment of waste generated from aquaculture, commercial fishing and processing of aquatic products, and propose technological solutions for treatment of waste generated from fishery activities
14.	Canada	NA	
15.	Chile*	1. DFL 725 Sanitary Code (DFL: *Decretos con fuerza de ley* / Decrees with force of law) published in 1968. 2. DFL 1; Law number 18.695, published in 2006. Organic of Municipalities. 5. DECREE - DTO 258 of 2008 from the Ministry of Foreign Affairs, enacting Annex V of the MARPOL 73/78 convention. 6. South Pacific Regional Fisheries Management Organization (SPRFMO) published in 2012. 5. Law 20.920 of 2016 related to extended producer responsibility (Spanish significate and Acronym: REP). 6. Law 21.100 year 2018 that prohibits the use of single-use plastic bags	○ It establishes the obligation of the municipalities to collect, transport and eliminate by appropriate methods the garbage, residues and waste that are deposited or produced in the urban road (article 11 letter b). For its part, in paragraph III of Title II (articles 78 to 81) it refers to “waste and garbage”; it establishes the sanitary authorizations of different waste management facilities • (https://www.bcn.cl/leychile/navegar?idNorma=5595). ○ It establishes the cleaning and adornment of the commune as the exclusive function of the municipalities (article 3 letter f) and attributes the garbage extraction service to the environment, cleanliness and adornment unit • (https://www.bcn.cl/leychile/navegar?idNorma=251693).

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
		7. Law 21.123 year 2018 8. Chilean Domistic Waste Policy (2018-2030), 9. DECREE 64 year 2021, which regulate the waste from **aquaculture activities** 10. Programa "Elijo Reciclar" ("I choose to recycle" Program) on year 2020, 11. Acuerdo de producción limpia: "Eco-Etiquetado" (Clean production agreement: "Eco-Labelling") in 2022. 12. Law 21.368 year 2021 which regulates the single use plastic and plastic bottles 13. Law 21.413 year 2022, 14. Hoja de Ruta de Economía Circular (Circular Economy Roadmap) from 2020 to 2040	○ It establishes regulations for the prevention of pollution by litter from ships. ○ This initiative aims to minimize pollution and waste originating from fishing vessels, discards or abandoned gear • (http://www.sprfmo.int/assets/Basic-Documents/Convention-web-12-Feb-2018.pdf). ○ This law establishes the regulation for six priority products including: lubricants, electric and electronic devices, containers and packaging, tires, car batteries, and alkaline batteries • (https://www.mondaq.com/waste-management/523220/law-n-20920-regarding-waste-management-extended-responsibility-of-the-producer-and-recycling-encouragement). ○ This law was enacted specifically to reduce the entry of plastic items into natural environments (https://www.bcn.cl/historiadelaley/nc/historia-de-la-ley/7567). ○ This law prohibits littering, throwing, or abandoning garbage on beaches, rivers, lakes, national parks, reserves, natural monuments or in other biodiversity conservation areas declared under official protection (http://extwprlegs1.fao.org/docs/pdf/chi182820.pdf). ○ This policy designated to achieve a sustainable management of natural resources, through the circular economy approach and the environmentally sound management of waste, hoping to increase the recovery rate of waste generated by economic activities and by those of household origin • (https://santiagorecicla.mma.gob.cl/wp-content/uploads/2020/02/Politica-Nacional-de-Residuos_final-V_sin-presentacion.pdf). ○ This decree approves the regulation that establishes the conditions on treatment and final disposal of wastes from **AQUACULTURE ACTIVITIES** (https://www.bcn.cl/leychile/navegar?idNorma=1157006). ○ This program seeks to provide clear information to consumers and promote recycling and the circular economy (https://elijoreciclar.mma.gob.cl/).

No.	Economy	Specific Policies/Regulatory Framework related to Coastal Aquaculture and Plastic/Microplastics pollution	Additional information
			○ It regulates products or services must provide labels, green seals or eco-labels, which give consumers information about the sustainability of its characteristics • (https://obtienearchivo.bcn.cl/obtienearchivo?id=repositorio/10221/33277/2/BCN_Ecoetiquetado_en_Chile_otros_paises_2022_FINAL.pdf). ○ This law was created to regulate the use of single use plastic and plastic bottles • (https://www.bcn.cl/leychile/navegar?idNorma=1163603). ○ This law prohibits smoking on sea, river or lake beaches, within a strip of 80 meters wide measured from the line of highest tide of the coast of the coast and of the coastal fiscal lands up to a distance of 80 meters measured from where the riverbank begins (https://www.bcn.cl/leychile/navegar?idNorma=1171984&idParte=10306205&idVersion=2022-02-01). ○ Domestic roadmap to the circular economy for a Chile without garbage (https://economiacircular.mma.gob.cl/wp-content/uploads/2020/12/Propuesta-Hoja-de-Ruta-Nacional-a-la-Economia-Circular-para-un-Chile-sin-Basura-2020-2040.pdf).
16.	Mexico*	N.A.	All the general policies and regulations are at the State level. There are no policies or regulations for the whole economies. In most cases these are projects under a specific law, however, these laws, which are referred to as Norms, are not yet published, and therefore the policies are not applicable.
17.	Peru*	Not available	The main Law that has been passed in Peru regarding plastic pollution is Law #30884 on single use plastic (https://busquedas.elperuano.pe/normaslegales/ley-que-regula-el-plastico-de-un-solo-uso-y-los-recipientes-ley-n-30884-1724734-1/)
18.	The United States*	NA	

* Presented the summary of the desk study's findings

Appendix 5. List of public discourse activities regarding plastic/microplastics input chain in coastal aquaculture in APEC economies

No.	Public Discourses to address Plastic/Microplastics issue in APEC economies	Economy	URL
1	Minister of the environment of Chile have developed and disseminate a “National strategy for the management of marine waste and microplastics” (*Estrategia nacional para la gestión de residuos marinos y microplásticos*)	Chile	https://mma.gob.cl/wp-content/uploads/2021/08/Estrategia-Nacional-para-la-gestion-de-residuos-marinos-y-microplasticos.pdf.
2	The Maritime authority Armada de Chile, DIRECTEMAR conducted a Symposium entitled "Plásticos y microplásticos en el medio marino y sus impactos en las actividades de acuicultura"	Chile	(https://www.directemar.cl/directemar/noticias-y-comunicaciones/noticias/2018/simposio-plasticos-y-microplasticos-en-el-medio-marino-y-sus-impactos)
3	The Ministry of Environment of Japan adjusts and manages the project relating to marine litter following an action plan against ocean litter.	Japan	https://www.env.go.jp/water/marine_litter/mpl.html
4	The Fisheries Agency has responsibilities on mitigate the distribution of microplastics or plastic debris in aquaculture sector	Japan	https://www.env.go.jp/water/marine_litter/mpl.html.
5	Launched a “Plastic smart” website maintained by the Ministry of Environment. Through this “plastic smart” action, the Ministry of Environment and private company try to proceed the activities toward a plastic-less society.	Japan	http://plastics-smart.env.go.jp/
6	The Fisheries Agency try to prevent or mitigate the distribution of microplastics or plastic debris, specifically in aquaculture; also supports activities relating to this topic. There are some informal collaborations among private companies, NGOs and/or local communities, where most parts are publicly supported.	Japan	https://www.jfa.maff.go.jp/j/sigen/action_sengen/190418.html
7	In the case of the aquaculture industry, fishery wastes in Japan are properly disposed of in accordance with the stipulated rules and guidelines. Also, new initiatives are being undertaken. Fisheries Agency is supporting the development of oyster pipes made of biodegradable materials. Other projects include the thermal recycling of floats in Hiroshima and Ehime.	Japan	• https://www.spf.org/opri/newsletter/447_2.html?latest=1 • https://www.ehime-np.co.jp/article/news201709221545 • https://www.maff.go.jp/j/plastic/attach/pdf/torikumi-93.pdf
8	GREEN SEA SETOUCHI Platform (GSHIP): A platform with companies and organizations as participating members for Hiroshima Prefecture, together with citizens and businesses, to consider and develop the necessary initiatives to achieve zero marine plastic litter.	Japan	https://gship.jp/initiative/about-us/
9	Japan Clean Ocean Material Alliance (CLOMA): A public-private partnership organization that promotes the development and introduction of sustainable use and alternative materials and accelerates innovation, involving relevant businesses and others in the supply chain for plastics and other products.	Japan	https://cloma.net/english/

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10	Japan Initiative for Marine Environment (JaIME): Companies and organizations participate in the councils, which work to accumulate scientific knowledge on plastic waste, provide assistance in the management of plastic waste in emerging Asian economies, and conduct awareness-raising activities both domesticly and internationally.	Japan	https://www.nikkakyo.org/upload_files/jaime/JaIME_jp.pdf
11	Establish The Marine Debris Management Committee and operated to promote comprehensive and systematic approach to marine debris problems with the participation of relevant ministries and agencies.	Republic of Korea	• https://www.meis.go.kr/mli/inform/agendaInfo.do
12	The Ministry of Oceans and Fisheries of Korea organized the 'Open forum for Zero Polystyrene (expanded) Buoy' inviting Government agencies, researchers, NGOs, and fishermen to participate in this forum	Republic of Korea	• https://eiec.kdi.re.kr/policy/materialView.do?num=221039&topic=
13	The Korea Environment Council held a press conference with 375 organizations calling for a solution to the plastic problem and the normalization of the single-use cup deposit system	Republic of Korea	• http://kfem.or.kr/?p=227361
14	Our Sea of East Asia Network (OSEAN) organized series of workshop to develop policy measures for reducing Polystyrene (expanded) buoys in aquaculture. This initiative also finds solutions for the Polystyrene (expanded) buoy debris problem through participatory workshops.	Republic of Korea	• https://www.sciencedirect.com/science/article/abs/pii/S0308597X14002243
15	"Polystyrene (expanded) buoy management policy in Korea" is currently in implementation phase. Through the tightened regulations and support policies, the cumulative supply of environment-friendly buoys reached 34.4% by 2021. The ban on the new installation of Polystyrene (expanded) buoys from 2023 was also the result of collaboration and coordination.	Republic of Korea	•
16	Various community outreach and public discourse activities have been conducted, and published in attached links	Malaysia	• https://www.pmo.gov.my/ms/2019/07/pelan-hala-tuju-malaysia-ke-arah-sifar-penggunaan-plastik-sekali-guna-2018-2030/ • https://www.kasa.gov.my/resources/malaysia-plastics-sustainability-roadmap-2021-2030/12/ • https://www.thestar.com.my/news/nation/2021/12/10/malaysia-plastics-sustainability-roadmap-2021-2030-launched • https://www.malaymail.com/news/malaysia/2019/12/28/mestecc-committed-to-addressing-environment-climate-change-issues/1822881

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			• https://www.thesundaily.my/home/call-for-more-anti-littering-action-XX9819606 • https://www.chemengonline.com/petronas-chemicals-announces-circular-plastics- • collaboration-project-in-malaysia/?printmode=1 • https://www.nst.com.my/lifestyle/bots/2022/05/799959/tech-grab-klean-and-mranti-team-tackle-plastic-pollution • https://themalaysianreserve.com/2022/06/07/sabic-committed-to-help-malaysia-in-minimising-plastic-waste/ • https://www.thestar.com.my/metro/metro-news/2021/10/28/mbsa-webinar-drives-home-message-on-single-use-plastics
17	Mexican government have conducted campaigns to address plastic litter/MP contamination by publishing articles in their official website	Mexico	• https://www.gob.mx/semarnat/acciones-y-programas/la-semarnat-informa-medidas-para-la-implementacion-de-las-enmiendas-de-basilea-sobre-residuos-plasticos • https://www.gob.mx/semarnat/articulos/contaminacion-por-plasticos-en-el-oceano-cifr as-alarmantes • https://www.gob.mx/salud/articulos/por-un-mundo-sin-contaminacion-por-plastico?idi om=es • https://www.gob.mx/cms/uploads/attachment/file/608513/ 89_2020_Documento_Plastico.pdf
18	The Ministry of the Environment (MINAM) has the competences in dealing with municipal solid waste (MSW). OEFA, its monitoring agency, is also in charge of mapping informal and illegal open dumpsters throughout the economies.	Peru	
19	Formal inter-agency coordination in Peru is yet to be implemented. There is currently a regulatory norm of what substances are prohibited in aquaculture, which includes antibiotics and pesticides, but plastics have not been added to the list as of October 2022.	Peru	https://rnia.produce.gob.pe/wp-content/uploads/2019/07/8_RD006-2017-SANIPES-DSNPA.pdf
20	Fishmeal companies have been alerted by clients (see Wang et al., 2022) that Peruvian fishmeal has relatively high MP content with respect to fishmeal produce in other parts of the Americas. In this sense, I am aware that at least Austral, one of the main fishmeal companies in Peru, is already working on	Peru	

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	issues linked to MP concentration in their fishmeal, analyzing its sources and typologies.		
21	Interview with local researcher talks about the presence of MPs in the Peruvian Pacific Ocean, and publication of MP status reports by Peruvian government. Peruvian society has gained more awareness in macro plastic waste in coastal environments, rather than MPs.	Peru	• https://rpp.pe/campanas/valor-compartido/conoce-el-impacto-que-tienen-los-microplasticos-ennuestra-salud-noticia-1397430 • https://elcomercio.pe/corresponsales-escolares/historias/microplasticos-una-amenaza-a-nuestra salud-y-al-medio-ambiente-microplasticos-contaminacion-pescado-ceviche-noticia/?ref=ecr • https://www.gob.pe/institucion/minam/noticias/563438-hallan-por-primera-vez-microplasticos-enorganismo-de-peces-de-la-amazonia-peruana
22	Coordination between the Philippiness APEC Study Center (PASCN) and Philippine Institute for Development Study (PIDS) led to the completion of a study about microplastics monitoring. PIDS study reveals 'abundance' of microplastics in Tañon Strait.	The Philippines	https://www.pids.gov.ph/details/pids-study-reveals-abundance-of-microplastics-in-taon-strait
23	A division of the Department of Environment and Natural Resources (a government agency) coordinates with the Central Visayas – Regional Development Research Council (it is the highest policy-making body in the region and serves as the counterpart of the National Economic and Development Authority (NEDA) Board at the subnational level) on their study about microplastics monitoring.	The Philippines	https://erdb.denr.gov.ph/2021/10/19/crerdecs-study-confirms-presence-of-microplastics-in-the-philippine-marine-waters-highest-density-in-tanon-strait-protected-seascape-in-badian-and-moalboal-cebu/
24	De La Salle University (a private higher education institution) and PerkinElmer (a private company) worked together for a series of information materials about microplastics pollution and analysis.The partnership has been completed and has made an impact in public discourse as demonstrated by social media engagements and video views.	The Philippines	https://www.youtube.com/watch?v=0hVnKR2UWjg
25	PlastiCount Pilipinas, an initiative from researchers from the University of the Philippines (a state university) with funding from the Department of Science and Technology (a government agency) was launched in order to monitor, map, and quantify micro and macroplastics in the Philippines. The project is ongoing, but is already making an impact in society as demonstrated by the number of people they have trained to analyze microplastics.	The Philippines	https://www.plasticount.ph/index.php/c_home/about.
26	Proctor and Gamble Philippines (a private company) partnered with the Asian Development Bank to undertake pilot studies on waste-to-energy plants.	The Philippines	https://www.adb.org/sites/default/files/project-documents/46927/46927-012-tcr-en.pdf

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27	A formal partnership was established among De La Salle University (a private higher education institution), GMA Network (a private news network), and DOST - ADMATEL (a government laboratory) to create a science-based news feature about microplastics. The goal of the news feature is to raise public awareness of the problem of microplastic pollution. The partnership has been completed and has made an impact in public discourse as demonstrated by social media engagements and video views. Tahong samples from PHL test positive for microplastics.	The Philippines	https://www.gmanetwork.com/news/scitech/science/697769/tahong-samples-from-phl-test-positive-for-microplastics/story/
28	A formal partnership between the Department of Education (a government agency) and Nestle Philippines (a private company) was established, wherein empty Bear Brand milk sachets were upcycled and turned into school chairs. 'Tibay' school chairs	The Philippines	• https://www.globalgiving.org/projects/give-chairs-for-public-schools-in-the-ph/report • https://www.nestle.com.ph/stories/pilot-ecobrick-hub/
29	De La Salle University (a private higher education institution) and GMA Network (a private news network) worked together for a short segment in one of GMA's shows about microplastics in salt samples. The goal of the segment is to raise awareness on microplastic pollution. The partnership has been completed and has made an impact in public discourse as demonstrated by social media engagements.	The Philippines	https://www.gmanetwork.com/news/lifestyle/healthandwellness/655063/salt-samples-from-phl-tested-for-microplastics-is-it-already-in-our-food/story/
30	Committee on Plastic Waste Management under the domestic environment board to promote effective and sustainable waste management by creating collaborations among all stakeholders from government, private, community, civil society. Furthermore, these multi-stakeholders have come together and initiated a network known as "Thailand Public Private Partnership for Sustainable Plastic and Waste Management" or PPP-Plastic. PPP-Plastic currently consists of over 30 governmental agencies, private companies, and civil society organizations and continues to grow. The Sub Committee and PPP-Plastic set out an ambitious goal to concentrate on single-used plastics of reducing plastic marine debris by at least 50% and all target plastic wastes in Thailand to be fully recycled by 2027.	Thailand	
31	Industrial manufacturers have formed a network under the name Alliance Plastic Circularity Thailand (APCT) to manage, reuse and recycle waste derived from manufacturing processes. At the same time, the Thailand Council for Sustainable Development (TBCSD) comprises 41 leading	Thailand	

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	companies and organizations in the economies all cooperating on plastic waste management.		
32	Thai companies have developed biodegradable containers and packaging from natural materials such as those made by Gracz.	Thailand	https://www.tei.or.th/th/blog_detail.php?blog_id=102
33	Four working networks have been established, including (1) independent organizations (academia, Chula Zero waste, solid waste management association, ect.), (2) social business groups and start-ups (Tact, Green2Get, GEPP, Trash Lucky, Yolo, Cirplas, Precious Plastic Bangkok, Food Loss Food Waste, Greenery), (3) private sectors (TIPMSE-FTI (led by Tetra Pak & SIG), PPP Plastics, I Love Asoke, TBIA, ect.), and (4) NGO (TEI, SOS, Less Plastics Thailand, Bangkaya, green world foundation, Rereef, Greenative, Little Big Green, Environman, etc.).	Thailand	