Asia-Pacific
Economic Cooperation

Advancing Free Trade
for Asia-Pacific Prosperity

Policy Brief on Trade in Marine Debris Collection Services

APEC Group on Services

November 2022

Asia-Pacific
Economic Cooperation

Policy Brief on Trade in Marine Debris Collection Services

APEC Group on Services

November 2022

This is a revised version of a paper submitted to the APEC Group on Services on Sustainable and Inclusive Growth and the APEC Chemical Dialogue, which met on 23 August 2022.

Written by:
Hildegunn Kyvik Nordås, Council on Economic Policies and Ronald Steenblik, International Institute for Sustainable Development

Acknowledgements:
The authors wish to thank Christine Schaeffer Assistant Director of the APEC Trade and Investment Section of Australia's Department of Foreign Affairs and Trade for her overall support for and guidance of the project. Kristen Bondietti, Briony Wood-Ingram and Hoa Tran from the Australian APEC Study Centre at RMIT University deserve special mention for their research and production support.

The authors also wish also to express appreciation for the time and information provided by the following individuals:

- Alexandre Dangis (Waste Free Oceans)
- Matthias Egger (The Ocean Cleanup)
- Lesley Ewing (California Coastal Commission)
- Christopher Kelly (H. Barber & Sons, Inc.)
- Michikazu Kojima (Economic Research Institute for ASEAN and East Asia)
- Cassie Layton (A/g Director, North Marine Parks and Ghost Nets, Australian Marine Parks, Parks Australia)
- Nikolai Maximenko, International Pacific Research Center at the School of Ocean and Earth Science and Technology, University of Hawaii)
- Tatjana Scroggie (The Ocean Cleanup)
- Andre Wirjo (APEC Secretariat)

The assistance of these individuals and organizations does not imply any endorsement of this report's contents, and any errors should be attributed solely to the authors.

Produced for
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace, Singapore 119616
Telephone Number: (65) 6891 9600 • Fascimile Number: (65) 6891 9419
Website: www.apec.org
Email: info@apec.org

APEC#222-CT-01.13

This report is supported by the Australian Government and implemented by the Australian APEC Study Centre, RMIT University

Australian Aid

Contents

Abbreviations and Acronyms used in the Paper

APEC	Asia-Pacific Economic Cooperation
ATA	Admission Temporaire / Temporary Admission
CPC	Central Product Classification of the United Nations
EEZ	exclusive economic zone
GATS	General Agreement on Trade in Services
GOOS	Global Ocean Observing System
GOS	Group on Services (of APEC)
GPS	Global Positioning System
ICC	International Coastal Cleanup® (of Ocean Conservancy)
ISO	International Organization for Standardization
NOAA	National Oceanic and Atmospheric Administration of the United States
NGO	non-governmental organization
PET	polyethylene terephthalate
SMEs	small and medium-sized enterprises
TEU	twenty-foot equivalent unit
UN	United Nations
W120	Services Sectoral Classification List of 10 June 1991
WFO	Waste Free Oceans
WWF	World Wildlife Fund

APEC Members:

AUS	Australia
BD	Brunei Darussalam
CDA	Canada
CHL	Chile
PRC	People's Republic of China (China also acceptable)
HKC	Hong Kong, China
INA	Indonesia
JPN	Japan
ROK	Republic of Korea
MAS	Malaysia
MEX	Mexico
NZ	New Zealand
PNG	Papua New Guinea
PE	Peru
PHL	The Republic of the Philippines
RUS	The Russian Federation
SGP	Singapore
CT	Chinese Taipei

APEC Group on Services Policy Brief on Trade in Marine-debris Collection Services

Key Messages

- Plastics in marine waters are a major environmental problem in APEC economies, and the situation is likely to get worse before it gets better.
- The first-best way to address the problem is to reduce plastics entering waterways and being discharged by ships, by reducing unnecessary use of plastics, where possible by substituting other materials, and improving waste-management services.
- Nonetheless, there remains a role for intercepting plastics from rivers, collecting it from shorelines and coastal waters, and monitoring the debris in the open ocean.
- Cleaning up marine debris can be considered a remediation service and a waste-management service as classified in CPC 2.1. and W120 (parts of 6B and 6D).
- Currently, the only truly commercial services within this sphere of activities relate to beach-cleaning. Intercepting plastics from river mouths is still in the demonstration stage, and in some places, fishers working in coastal waters are paid for plastic that they entrain in their nets and bring back to shore.
- Due to its remoteness and low density, the costs of cleaning up debris from the open ocean can be considerable, while the net environmental benefits are uncertain.
- Companies and non-profit organizations face several trade barriers. Customs procedures and tariffs may apply to temporary imports of equipment; crew and other staff on vessels may need visas, the collected debris cannot always be brought ashore and data localization requirements as well as restrictions on commercial association between different professionals may hamper the accumulation of knowledge.
- A prerequisite for furnishing effective solutions to cleaning up marine debris is knowledge about its sources, composition, movements and impact. Knowledge accumulation needs to be better coordinated among APEC economies.
- Research based on *in situ* sampling combined with observations from sensors, satellites and other remote sources is needed to fill the knowledge gap.

The environmental problem

Estimates of the amount of plastic waste that reaches the world's seas each year vary, but one recent study places it within the range of 5.5 to 14.5 million tonnes in 2018.[1] Of this, about 1% ends up floating on the surface of the open seas, and some is beached, but most ends up in the deep sea.[2] These are rough estimates as marine debris is still poorly mapped while the processes of beaching, sedimentation and fragmentation are not well understood — despite many decades of attention to the problem.[3] Plastics that accumulate on beaches degrade through exposure to sunlight and the action of wind, waves, foot and mechanized traffic. Some of that plastic washes up on shore, but much of it breaks up into smaller particles and either travels the seas for many years or settles to the ocean bed. Plastic that has remained at sea and gets caught up in currents can also spread non-indigenous marine species and pathogens into new habitats, raising concerns for biosecurity.[4]

About half of the plastic entering the marine environment is less dense than water and thus floats.[5] Surface currents, wind and waves lead to the convergence of floating debris into gyres, of which there are five basin-scale subtropical ones (two of which are located, respectively, in the eastern and western North Pacific Ocean, and two in the South Pacific Ocean). Together with sunlight, these forces also result in the fragmentation of debris into micro-plastics that are ingestible by marine life and thus can enter the food chain.

In the popular press the gyres have been described as garbage patches or even floating islands of plastics. In reality, the debris is dispersed over a huge surface even within the gyres. The density of plastic is about one item per 4 m^2 on average (1–10 items per m^2 in the densest part of the gyre) and plastic occurs from the surface to the sea bed. Furthermore, most items are a few millimetres or less.[6,7] Much of the plastic ultimately sinks from the gyres to the sea floor. Undercurrents and other oceanographic forces can then lead to some of the debris moving into submarine canyons and deep ocean trenches.[8]

The economic impacts of plastic on marine and coastal ecosystems, and even on tourism, are challenging to calculate and only rough estimates can be made. A 2020 study for APEC, for example, estimated that the direct impacts of marine litter on various industries had increased considerably in recent years and in 2015 imposed damage costs of around US$ 6.4 billion on marine tourism (59% of total damage costs), almost US$ 3 billion on transport and shipbuilding (27%), and almost US$ 1.5 billion on fisheries and aquaculture (13.4%).[9] With the cost of this environmental issue weighing heavily on APEC economies efforts to facilitate seamless supply chains for clean-up services are critical to enable and reduce the cost of clean-up activities

The aims of this Policy Brief are five-fold: (1) to increase awareness about the scale and importance of the marine plastic litter problem; (2) to describe the services, and associated technologies and occupational profiles, involved in removing such litter from river-mouths, beaches and near-coastal waters, and the open ocean; (3) to characterize the diverse roles played by various non-governmental, commercial, and governmental actors that are currently active in either carrying out or regulating these services; (4) to identify barriers to trade in these services; and (5) to suggest how best to facilitate growth in the (international) market for these much needed services.

Addressing the plastics problem through marine-debris collection services

Avoiding plastic reaching the marine environment is the first-best solution to the problem of ocean plastic pollution, along with shifting away from non-biodegradable plastics to materials that biodegrade into innocuous compounds.

However, current efforts to prevent marine plastic pollution are far from perfect and are unlikely to be for many years. In its business-as-usual case, one study predicts that the volume of plastics that will enter aquatic environments could rise 2.6 fold by 2040.[10] That creates a need to intercept the plastic drifting down rivers before it reaches the open sea (the source of more than 80% of plastic reaching the ocean[11]), and to collect and properly dispose of or recycle the plastic (and other floating debris) from the marine environment and its littoral before it becomes uncollectible. Downstream cleaning can thus be considered a necessary adjunct to upstream prevention and improved waste management.

The "markets" for these marine debris services are nascent, however, involving many different types of actors, and governed by a complex set of local, domestic and possibly international regulations. As described in an earlier study for APEC, APEC economies have implemented a wide range of programs and measures to manage marine debris pollution, both regulatory and non-regulatory, and funding to support community-led activities.[12] The following focuses more on the non-governmental organizations and businesses engaged marine-debris collection.

Basically, four types of services intercept marine plastic litter in or around the ocean: (1) beach cleaning; (2) river cleaning; (3) coastal waters cleaning; and (4) open-ocean cleaning. The boundaries between these activities are not always distinct. In the following we describe the supply-chain activities and the regulatory framework within which they operate, as well as the environmental costs and benefits of each activity.

Beach cleaning

Beach cleaning — also sometimes called beach grooming when it is done with machines — is a service that has existed for decades in some localities, in large part because of its clear commercial value for tourism. At the least sophisticated and least commercial end of the spectrum are periodic litter collections carried out by volunteers with rakes and other simple hand tools. The largest effort, the International Coastal Cleanup® (ICC), is conducted every September by the Ocean Conservancy, which over the course of more than 35 years has collected around 350 million pounds [160,000 tonnes], mainly from beaches, with the help of some 17 million volunteers.[13] The Ocean Conservancy is based in the United States, but its annual clean-up involves volunteers in over 150 economies.

In addition to mass collective clean-ups, in some locations individuals in the informal economy recover plastic bottles and aluminium cans from beaches and then sell them to recyclers for cash. Those individuals also serve as intermediaries between clean-up volunteers and recyclers, as documented in an account of a clean-up effort involving 130 community volunteers that took place in August 2021 near Koh Libong, Thailand.[14]

At the more mechanical and formal end of the spectrum, some municipalities and beach resorts carry out clean-ups of designated stretches of beaches according to a set schedule (anywhere from daily to seasonal), usually by dragging sifting machines behind low-compaction tractors.[15]

Others contract with independent commercial entities to perform the service. Specialized beach-cleaning equipment is manufactured by at least eleven companies around the world, three of which are headquartered in an APEC economy.[16] The skill level required to operate these machines is not high, but their maintenance requires some mechanical aptitude.

River cleaning

River cleaning is a less-developed activity than beach cleaning, and is carried out on a quasi-commercial basis.[17] Apart from very informal clean-ups by people collecting floating debris directly in small boats, more sophisticated river cleaning can range from setting up booms to deploying automatic skimmers.[18] The Ocean Cleanup, a non-profit foundation based in I Netherlands, has been working to develop several divert-and-collect river-cleaning systems since 2016, and has carried out demonstration projects in four rivers across three APEC member economies (Indonesia, Malaysia, and Viet Nam), plus the Dominican Republic and Jamaica.[19] Other companies have also developed novel passive technologies for capturing debris floating down rivers, such as the floating cogged wheel system developed by River Cleaning (Italy).[20]

The Clean Currents Coalition (CCC), a collaborative network co-funded by the Benioff Ocean Science Laboratory and the Coca-Cola Foundation, has been supporting the deployment of such technologies in a number of rivers around the world, including several in APEC economies:

- *Indonesia* (Citarum River) — The Citarum River provides water, electricity, and irrigation for over 25 million people on the island of Java, but in many places the surface of the water is obscured by waste. The Greeneration Foundation has partnered with Riverrecycle, Waste4Change, and Deltares to install a plastic-capture device in the river, which has been in place since December 2021. The project plans recycles what it can of the captured plastics, turns non-recyclable plastics into fuel, and composts any collected organic matter.[21]
- *Mexico* (Tijuana River) — The Tijuana River Estuary, which straddles the U.S.-Mexico border, is home to ten endangered species and is a critical staging point for migratory birds. With help from the CCC, the regional environmental organization, WILDCOAST, recently installed a plastic capture device — the “Brute Boom” — in Los Laureles Canyon, a tributary stream of the Tijuana River, in order to stop mainly plastic debris from spilling into the estuary and ultimately the Pacific Ocean.[22]
- *Thailand* (Lat Phrao Canal) — This 1.5 km canal forms part of a network of over 1,600 canals and waterways that pass through Bangkok. Since June 2020, the TerraCycle Thai Foundation has been operating several plastic-capture devices in the canal, providing employment for 15 people in the local community. TerraCycle is also partnering with schools to implement recycling programs, and educating residents in the area on the issue of plastic pollution.[23]
- *Viet Nam* (Song Hong) — The Song Hong (Red River) runs from northern Viet Nam to the South China Sea. Since 2020, Ocean Conservancy has been working with the Centre for Marinelife Conservation and Community Development, a leading Vietnamese NGO in the field of coastal and marine ecosystem conservation, to install trash traps along rivers in Viet Nam and improve local-waste management infrastructure.[24]

Collecting plastic waste from coastal waters

The collection of waste from coastal waters involves similar approaches as river-cleaning but has so far been mainly confined to bays and other marine areas in which debris accumulates. This activity appears to be dominated more by voluntary efforts than commercial services. In the United States, for example, the Ocean Conservancy operates a program it calls "Good Mate Watercraft Cleanups", and reports that in 2019 those clean-ups involved more than 9,000 volunteers and collected 83.5 tonnes of floating debris, mainly plastics.[25] Such clean-ups carried out by volunteers usually involve simple equipment, such as hand nets. At the commercial level, they may deploy draggers. No special skill other than the ability to navigate a watercraft safely is required, though in some coastal waters through which large ships pass, harbor authorities may require that groups engaging in debris collecting obtain a permit in advance.[26]

Operators of fishing vessels are employed in several parts of the world in helping to remove plastics from coastal waters. In the Republic of Korea, for example, the Government has in the past paid fishermen for specific types of debris collected in their nets during the course of fishing, per kilogram or bagful of debris they bring ashore.[27] The main aim of this program and similar programs has been to discourage fishermen from simply throwing the debris back into the ocean after removing it from their nets.

Fishing nets that have been discarded or lost at sea (so-called "Ghost Nets") are the focus of the Australian government's A$14.8 million, three-year Ghost Nets Initiative, launched in 2021. Roughly half of the funding is supporting work with Indigenous ranger groups, who collect data on the sources of ghost nets and coordinate the nets' retrieval, as well as conducting beach clean-ups in the Gulf of Carpentaria, a global marine debris "hot spot". More than A$5 million will be invested in new technologies to better detect, collect and dispose of ghost nets, which could include mobile recycling plants, GPS tracking devices and databases. The remainder of the funds is being invested in proactive steps to address the sources of the problem, and enable further research and coordination with stakeholders.[28]

A somewhat different and quasi-commercial approach has been taken by Waste Free Oceans (WFO), a charitable foundation based in Brussels, Belgium. WFO has collaborated with fishermen and local communities to collect waste present in their fishing areas.[29] Using collection trawls ("Trash Catchers") capable of being towed by fishing vessels of varying sizes, the WFO pays fishermen to collect ocean plastic exclusively on their idle fishing days, collecting between 2 and 8 tonnes of marine litter on each journey. Once a trash catcher is full, the fishermen bring it to a station, from where it is hauled off the boat with a crane. In one project in Hong Kong, China, WFO Asia worked with WWF [World Wildlife Fund] Hong Kong, China to carry out a feasibility study to demonstrate how marine litter can be collected from the surrounding bay. The collected waste was then shipped to its partners in the plastics industry to recycle and reuse in the production of new plastic products.

Collecting plastic waste from the open ocean

The collection of plastics floating on the open ocean is the most costly and capital-intensive activity per tonne of plastic collected and is still at an experimental stage. Such collections have so far mainly targeted what are colloquially called "garbage patches", particularly those in the North Pacific Ocean.

Ocean collection of debris from the gyres are dominated by a few not-for-profit organizations. They operate in international waters, outside economies' exclusive economic zones (EEZs), and thus the activity itself is not governed by domestic rules regulating trade.

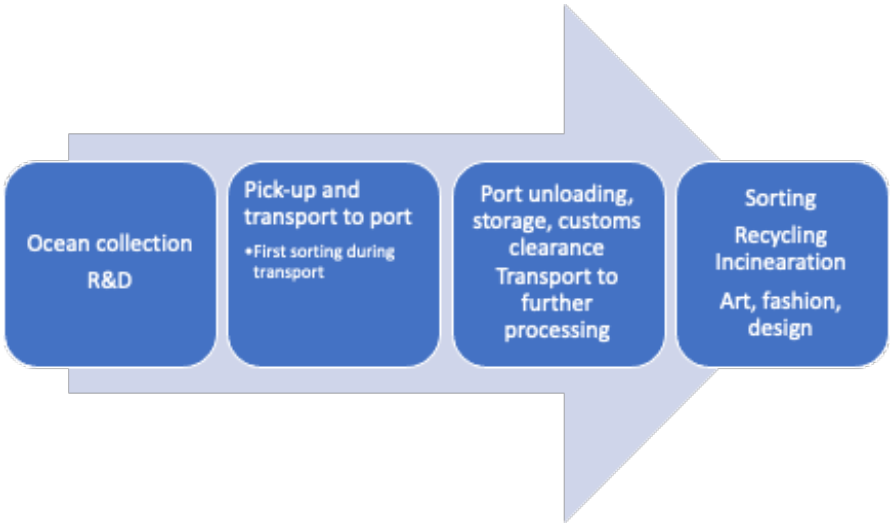
The leading organizations combine clean-up with *in-situ* sampling in collaboration with academic and citizen research. Combining *in situ* observations with remote sensing and other observations — e.g., by the UN-led Global Ocean Observing System (GOOS) and the US National Oceanic and Atmospheric Administration (NOAA) Global Drifter Program — allows calibration and validation of information from satellite sensors. Importantly, the collaboration between research and cleaning also supports the development of numerical models to better understand the sources, composition, movements, and impact of marine debris, which in turn guide more effective clean-up methods.

The Ocean Cleanup is one example of efforts to clean up floating debris from the open ocean. Its latest approach involves towing a long, U-shaped barrier behind two powerful trawler-sized boats. The barrier then acts as an "artificial coastline" that guides the plastic into a retention zone (basically, a large pouch made of netting) at its far end. Once the retention zone becomes full, it is sealed off, detached from the system, and emptied on board the vessel.[30]

The scale of existing operations is tiny. According to a recent study, the plastic collection rate of The Ocean Cleanup is 65m^3 per day.[31] To put this number into perspective, a day's plastic collection would fill slightly more than two standard 20-foot containers (twenty-foot equivalent unit, or TEU). The smallest feeder container ship takes up to 1000 TEU, so it would take more than a year of continuous collection to fill a ship. Finally, according to another recent study, the average capacity of waste incineration plants in China is about 1200 tonnes a day. Thus, it would take The Ocean Cleanup about 18 days to fill one day of incineration capacity at an average plant in China, if it so wished.[32]

The full supply chain of ocean clean-up activities is described in Figure 1, assuming they involve a floating installation, and vessels pick-up and transport the debris to a port at regular intervals. The distance to the nearest port from the North Pacific Subtropical Gyre (San Francisco) is about 2000 km. In some cases, a first sorting of material can be done on the vessel during transport. Marine debris in the open ocean consists of between 45% and 50% ghost nets[33] and ropes while the rest is mainly solid plastics. Mechanical sorting of the debris is difficult, so the task is typically done manually.[34] An example of which services are involved in cleaning maritime debris is taken from the collaboration between The Ocean Cleanup and Maersk. The latter provides the logistics supply chain consisting of worldwide shipment, airfreight, container and special transport, customs clearance and warehouse and storage management.[35]

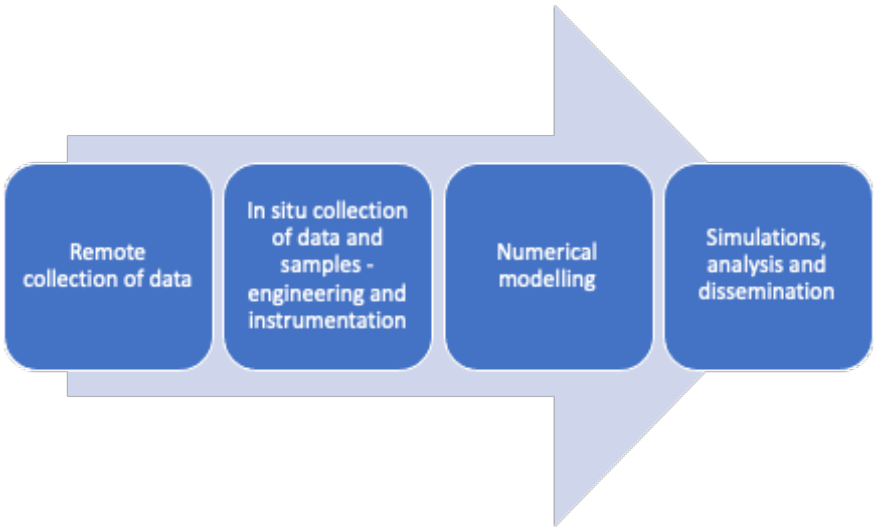
Figure 1. The supply chain of cleaning up plastic from the open ocean



Source: Authors' elaborations.

Remote sensing of plastics in the ocean is still in its infancy[36], and involves placing sensors for the collection of data on vessels, aircraft, drifters, and installations. Together with imaging from satellites, data are processed and made available to researchers and others. Technical solutions for imaging, distinguishing debris from the sea surface and distinguishing different types of debris (including partly submerged items) are still under development. *In situ* data and samples of seawater can be collected by specialized research vessels, but also the marine debris collection entities themselves engage in collecting and analysing samples of seawater. Given remaining technical challenges related to remote sensing, *in situ* sampling observations and sampling remain essential.

Figure 2. The supply chain for R&D services provided in association with ocean plastics collection



Source: Authors' deliberations; Maximenko et al. (2019).

Modelling frameworks have been developed based on scientific knowledge and new empirical techniques including machine learning for analysing big data collected by the sensors and from samples. The analyses aim at filling the huge knowledge gap on the sources, composition, movements, and impact of marine debris to inform future clean-up efforts.[37]

Bringing the waste ashore

Collecting plastic waste is only the first stage of marine plastics waste management. A crucial adjunct to all of these services is some way to dispose of the collected debris. If it is not already pre-sorted by those collecting the plastic, or during its transport, the debris needs to be transported to a sorting facility and next to a recycling plant, incinerator, or landfill site. That is typically the fate of plastic collected from river mouths, beaches, and from within an economy's EEZ.

Debris from the open ocean is also brought to shore. To which shore depends on several factors. First, the shipping distance contributes substantially to the clean-up cost. Second, in which economy the clean-up services provider is registered or located matters. If debris is brought from international waters to the home economy of the clean-up service, it is not considered imports and therefore should not be subject to customs procedures or other import restrictions. Third, how the economy in which the port is located implements the Basel convention on trade in toxic waste determines whether and what kind of debris can be brought ashore. Fourth, access to waste management infrastructure at or close to the port is needed to safely dispose of the collected debris.

The business models

Except for a few commercial businesses cleaning beaches under contract, funding for marine-debris cleaning so far has generally involved some combination of funding from voluntary donations of money and in-kind labour, equipment or materials.

Waste Free Oceans began with its founder creating a foundation funded largely by the plastics industry. Many others obtain funding more broadly. One of the largest, the Ocean Conservancy, receives donations not just from individual and corporate donors, but also from charitable foundations and even a few government agencies, such as Environment and Climate Change Canada, and the United States' National Oceanic and Atmospheric Administration (NOAA).[38] For small non-profit organizations, however, applying for competitive grants from local or regional governments to fund their activities can constitute a considerable administrative burden.[39]

An important and growing recent means for financing activities targeting the collection and treatment of plastic, especially from beaches and coastal waters, are organizations offering so-called plastic credits or offsets. The WWF-World Wide Fund For Nature defines a plastic credit

as a "transferable unit representing a specific quantity of plastic that has been collected and possibly recycled from the environment."[40] Basically, an organization collects plastic litter (or pays others to do it); has the origin, weight and ultimate fate (e.g., recycling or conversion to fuel) of the collected plastic certified; and then sells that credit to a company seeking to offset an equal weight of the plastics it uses in its products, such as beverages or cosmetics (i.e., its plastic footprint). Some credit generators, such as Indonesia's Waste4Change, allow the client to specify what type of waste it wants to ensure is recycled, often PET plastic.[41]

Besides Waste4Change, APEC economies are home to at least four other organizations that issue plastic credits: Plastic Credit Exchange (the Philippines), rePurpose Global and RIO Ocean Integrity (both based in the United States), and TONTOTON (Viet Nam). Some of the organizations collect, sort and recycle plastic from diverse locations, while others, such as RIO Ocean and TONTOTON concentrate on plastic littering the marine environment.[42] Verra, which is based in the United States, acts as the Secretariat for organizations that adhere to its guidelines.[43] To facilitate tracking the generation, retirement and cancellation of plastic credits, it maintains a database of projects that register with their program.[44]

Plastic credits, like carbon credits, are not without their critics. In the view of Lauren Phipps, of the GreenBiz Group, for example, "to build a circular economy for plastics ... the whole point is to reduce or eliminate plastic waste, not offset it".[45] She and other observers point to inadequate project transparency, and a lack of consistent reporting and industry standards, concluding that there remains a high potential for double-counting plastic credits. Nonetheless, many of the projects generating plastic credits also pursue social objectives in the communities in which they work, such as employing local waste collectors and generating new job opportunities in recycling.

A business model common for clean-up services in the open oceans combines clean-up with research. As noted, The Ocean Cleanup frequently works with researchers to monitor and analyse the movement of marine debris and the impact of the clean-up services. Other models place the research activity in the driving seat. For example, an ongoing project managed by a research network led by the University of Hawaii works with two vessels, one for research (Robert Seamans) and one for ocean cleaning (Kwai). The research ship is owned by the Sea Education Association and is equipped with laboratories and computer labs. It is used for summer sailing semesters with students engaged in the *in-situ* sampling and analysis. The clean-up ship is charted from the Marshall Island Government by the Ocean Voyages Institute, a not-for-profit organization. The vessel collects garbage with the help of satellite beacons that have been placed on nets by crowd-sourced volunteer yachts and commercial vessels.[46]

With the exception of some beach-cleaning, none of these business models are market-based. A key question for APEC is whether a market could or should be created, and what it would take to establish a market for marine debris clean-up. No firm conclusions can be drawn at this stage, but experience from the emergence of markets for remediation services could give some cues. In the United States, for example, the market for remediation services developed in the 1970s following the discovery of toxic chemicals in landfills, brownfield sites and in ground water. The Environmental Protection Agency was given the authority to identify sites of priority for clean-up, order the site owner to clean it up, or clean it up itself. These regulatory requirements created business opportunities that were taken up by new firms as well as new departments of existing firms.[47]

Unlike site-specific remediation services, marine debris is not stationary and is dispersed across jurisdictions both within and across economies. Clean-up at a commercial scale would therefore probably require coordination of regulation across major APEC economies combined with open markets for clean-up services providers. Clean-up of river mouths, which account for most of the debris that reaches the ocean, may be the activity most likely to reach a commercial scale under such circumstances. More work and market analysis are needed to further explore this option, bearing in mind that a side effect could be to formalize some of the activities hitherto performed by volunteers and informal workers in local communities.

The environmental effects of marine debris collection

The reasons for removing debris, especially plastic debris, from the marine environment include improving the aesthetic appeal of beaches, rivers and the sea, and reducing costs to the fishing industry, but the main motivation is environmental improvement or remediation. Nonetheless, debris collection, in certain areas and under certain circumstances, can also be harmful. The balance between help and harm depends in large part on how, and how often, the cleaning is conducted.

The environmental effects of removing floating debris from river mouths and coastal zones are generally benign, as the plastic is typically intercepted before it has a chance to become habitat for marine fauna, and the techniques used to collect the debris usually minimize bycatch.

By contrast, the effects on marine ecosystems of mechanically cleaning, or grooming, sandy beaches are controversial. Mechanical cleaning removes not just unwanted debris, but also organic materials, like algae, seaweed, and terrestrial plants and their seeds, which provide nutrients critical to the intertidal food chain.[48] Removing them from a beach can thus reduce its biodiversity and species abundance. Screening beach sand also aerates it, which dries it out, thus making it more susceptible to wind erosion. And it can disturb or destroy the habitats of turtles and birds, and the isopods on which birds feed.[49]

A growing consensus is that the best-practice approach to beach cleaning combines both mechanical and non-mechanical methods. A guidance document produced for the French Government in 2011, for example, classifies beaches into several categories. It finds that mechanical cleaning is most suitable for beaches with high levels of human traffic and low ecological value, whereas manual cleaning is best for the most environmentally sensitive areas, especially those on which salt-tolerant vegetation can be established.[50] A more recent review of the literature notes that studies of the effects of different beach-cleaning methods have often failed to separate out the effects of other factors — such as foot traffic, dune destruction, shore armouring, and artificial lighting — from the impacts of beach cleaning itself, and calls for more research.[51]

The case for cleaning up marine debris from the open ocean is also debated. Due to the remoteness and the low density of the targeted plastic, the costs of cleaning it up can be considerable, while the net environmental benefits are uncertain. On the one hand, marine debris, if left alone, may enter critical habitats, and cause substantial environmental damage. Moreover, marine debris can itself become a habitat for marine life, sometimes transporting invasive species to new areas.[52] To what extent and how fast maritime debris in the open ocean

reaches such habitats is uncertain, and the transport of marine debris collected from the open ocean for processing on land can raise biosecurity issues for the economy importing such waste. Clean-up activities also have environmental costs both directly related to by-catch and more broadly in terms of their carbon footprint.

Barriers to trade in marine-debris collection services

Marine debris collection services can probably be classified within Version 2.1 of the United Nations' Central Product Classification (CPC 2.1) under remediation services (code 944), and possibly waste-collection services (code 942), which correspond to parts 6B and 6D of the Services Sectoral Classification List (commonly referred to in short as "W120").[53] Only 51 economies have made commitments under the General Agreement on Trade in Services (GATS) in these services, including nine APEC economies.[54]

The CPC definition specifies that remediation services are, e.g., "services involved in implementing approved plans for the remediation of surface water on a contaminated site, that meet requirements specified by legislation or regulation". A similar formulation is found for soil and groundwater. The definition thus indicates that the demand for remediation services stems from government regulation.

The above analysis suggests that marine debris clean-up would be the most cost-effective if services suppliers could deploy equipment, staff and technology seamlessly across domestic boundaries as well as disposing of the collected debris to local waste-management systems anywhere around the Pacific. Furthermore, synergies exist between clean-up, monitoring and research. Such synergies could be fully exploited within open innovation and open information systems. The major barriers to open markets and open innovation and information systems are described and identified in five areas (see Annex Table 1 for details):

Barriers to the movement of people

Clean-up services are typically project-based and thus temporary, with the exception of some beach-cleaning services under contract. Cross-border trade in such services inevitably involves deploying staff to the clean-up site. Vessels engaged in clean-up and research also carry researchers and their equipment, and possibly volunteers and other staff for sorting of the debris. Both crew members and researchers may need a transit visa or a crew visa to enter the economy and board the ship. Lengthy, costly and unpredictable visa requirements and lack of multiple-entry visas can significantly hamper clean-up projects. The cleaning up of marine debris, particularly combined with research and monitoring, also requires inputs from engineers, research staff, lawyers and students. Different qualification requirements, lack of recognition of qualifications, as well as the reservation of certain activities for licensed professionals and restrictions on commercial association between regulated professions are major barriers to cross-border and multidisciplinary work on monitoring and cleaning up marine debris.

Restrictions in ports

Bringing the debris to ports can also be subject to trade barriers, including discriminatory access to port facilities and services as well as discriminatory taxes and fees for foreign ships. It may also be a requirement that companies establish a local office to operate from the port.

Restrictions on vessels

Ocean clean-up services as well as coastal clean-up may face restrictions on the chartering of vessels.

Restrictions on access to essential waste management facilities

Waste management services consist of a supply chain from collection, transport, and sorting, to treatment, landfill, incineration or recycling. Some of the links in the chain may constitute essential facilities or bottlenecks that cannot easily be duplicated by marine debris clean-up services providers. Exclusion from or discriminatory access to such essential facilities may render maritime debris clean-up infeasible.

Restrictions on dataflows

Developing knowledge on which to base clean-up services for marine debris relies on data on the sources, composition, movements, and impact of the debris. Such data are collected by governments, the UN, volunteers, researchers, and ships — sometimes using drones. Access to such data, including through open government databases, is essential for generating new knowledge. Coordinating data collection would also be of great value.

Barriers to the movement of goods

Clean-up services providers, whether commercial or not-for-profit, bring equipment for clean-up and temporary storage, instruments for scientific measurements and other necessary equipment. Several reports as well as interviews with stakeholders indicate that temporary imports of equipment into domestic territories are subject to customs procedures and sometimes tariffs have to be paid, albeit usually refunded upon exit. A common requirement is that the goods are presented to customs upon entry; the tariffs applicable to the goods are then paid or a guarantee provided. The unchanged equipment must be presented again to customs when exiting the economy's territory and the tariff may be fully or partly refunded if the conditions — i.e., the time allowed between imports and exports of the equipment — are met. The A.T.A (*Admission Temporaire in French*, Temporary Admission in English) Carnet system offers a standardized way of administering temporary imports, which could lower the administrative costs and reduce the burden on liquidity, particularly for SMEs. Other trade barriers related to the equipment that clean-up services use are different and non-interoperable product and process standards. Finally, many economies prohibit imports of waste, including plastic debris.

Recommendations

We recommend that APEC economies:

Services trade policy

- *Waste management services:* Ensure that marine debris clean-up services have access to local waste-management systems and infrastructure.
- *Remediation services:* Consider removing barriers to trade and investment in remediation services, including making technical standards interoperable.
- *Mode 4:* Because marine debris knows no borders and the clean-up services providers must also be able to cross borders as needed, facilitate such movements of persons by:

    - Making all staff involved in cleaning up and analysing marine debris eligible for temporary entry and stay to deliver these services.
    - Recognizing the qualifications of engineers and other regulated professions involved in marine debris clean-up, monitoring and research, in all APEC economies, for instance building on the APEC Engineer Register & International Professional Engineer Agreement
    - Removing restrictions on regulated professionals engaging in multidisciplinary, cross-border projects related to research, monitoring, and clean-up of marine debris.
- *Maritime transport services:*
    - Consider easing restrictions on the chartering of vessels used for cleaning up, monitoring or research on marine debris.
    - Ensure non-discrimination in access to and payment for port services for foreign vessels engaged in cleaning up, monitoring or research of marine debris.

Trade policy measures supporting trade in services — data

- Remove all data-localization requirements for data gathered from remote sensing, including from drones and satellites, for the purpose of monitoring marine debris.
- Contribute to integrating and coordinating data gathered from monitoring marine debris.
- Make data gathered on marine debris available through open government data policies.

Trade policy measures complementing marine debris cleaning services

- Allow duty-free temporary imports of equipment and instruments for clean-up and research on marine debris. The A.T.A Carnet system offers a standardized way of administering temporary imports.
- Consider — within the limitations of the Basel convention —allowing imports of marine debris.

Market creation

- Consider developing common voluntary standards for both the desired minimum condition of beaches and coastal waters, and the performance of organizations that remove debris from these locations. The ISO 13009:2015 standard, “Tourism and related services — Requirements and recommendations for beach operation” could provide a basis for such a voluntary standard.
- Consider further analyses of the feasibility of creating a market for marine debris clean-up services through coordinated domestic regulation building on existing regulation for remediation services for soil and groundwater.

International co-ordination

- Follow closely developments relating to an international legally binding instrument to end plastic pollution, to ensure that any proposed actions align with and support the goals of the instrument

Annex 1: Regulatory barriers to clean-up services of marine debris

Movement of goods	**AUS**	**BD**	**CDA**	**CHL**	**HKC**	**INA**	**JPN**	**MAS**	**MEX**	**NZ**	**PE**	**PHL**	**PNG**	**PRC**	**ROK**	**RUS**	**SGP**	**CT**	**THA**	**USA**	**VN**
Customs declarations can be submitted in electronic format	yes	yes	yes	yes	yes		yes		yes	yes	yes				yes	yes			yes	yes	yes

Movement of people	**AUS**	**BD**	**CDA**	**CHL**	**HKC**	**INA**	**JPN**	**MAS**	**MEX**	**NZ**	**PE**	**PHL**	**PNG**	**PRC**	**ROK**	**RUS**	**SGP**	**CT**	**THA**	**USA**	**VN**
Certificates or permits are required for:																					
a) Crew	yes		no*	yes	yes	yes	yes	yes	yes	yes			yes	yes	yes	no*	yes	yes	yes	yes	yes
b) Research staff (engineers)	no		yes	yes	yes	yes	no	yes	yes	yes			yes	yes	yes	no	yes	yes	yes	yes	yes
Foreign certificates and permits are recognized subject to objective criteria:																					
a) Crew	yes		no	yes	yes	yes	yes	no	yes	yes			yes	no	yes	no	yes	yes	no	no	yes
b) Research staff (engineers)	yes		yes	yes	yes	yes	yes	yes	yes	yes			yes	yes	yes	yes	yes	yes	yes	yes	yes
Visas on arrival are available for temporary entry or transit of crew	no		yes	yes	no	yes	yes	yes	yes	yes	no	yes	no	no	yes	no	no	no ^	no	no	yes
Multiple entry visas are allowed for:																					
a) Crew	yes		yes	yes	no	yes	yes	no	yes	yes	no	no "		yes	yes	yes	yes		no	yes	yes
b) Researchers	yes		yes	yes	yes	yes	yes	yes	yes	yes	yes	no "		yes	yes	no	yes	yes	yes	yes	yes

Restrictions at ports	AUS	BD	CDA	CHL	HKC	INA	JPN	MAS	MEX	NZ	PE	PHL	PNG	PRC	ROK	RUS	SGP	CT	THA	USA	VN
Discriminations in the use of marine services	no		no	no	no	no	no	no	no	no	no			no	no	no	no		no	no	no
Discriminations in the use of port terminal services	no		no	no	no	no	no	no	no	no	no			no	no	no	no		yes	no	no
Discriminations in the use of ancillary services	no		no	no	no	no	no	no	no	no	no			no	no	no	no		no	no	no
Discriminatory port tariffs and other port-related fees	no		no	no	no	no	no	no	no	no	no			no	no	no	no		no	no	no
Discriminatory environmental and/or security standards	no		no	no	no	no	no	no	no	no	no			no	no	no	no		no	no	no

Restrictions on the chartering of vessels:	AUS	BD	CDA	CHL	HKC	INA	JPN	MAS	MEX	NZ	PE	PHL	PNG	PRC	ROK	RUS	SGP	CT	THA	USA	VN
a) Bareboat	no		no	no	no	no	no	yes	no	no	no			no	no	yes	no		no	no	no
b) With crew	no		no	no	no	no	no	yes	no	no	no			no	yes	yes	no		no	no	no

Data	AUS	BD	CDA	CHL	HKC	INA	JPN	MAS	MEX	NZ	PE	PHL	PNG	PRC	ROK	RUS	SGP	CT	THA	USA	VN
Certain data must be stored locally	no	no	no	no	no	yes	no	no	yes	yes	no	no		yes	yes	yes	yes		no	no	yes

Notes:

* Certificates are required for pilots

^ visa upon arrival is only available at Taoyuan International Airport

" Visa is not required for visits shorter than 30 days for visitors from 154 economies

Sources General: OECD STRI database, OECD Digital services restrictiveness index, OECD trade facilitation indices

Sources HKC:

- The Merchant Shipping (Seafarers) Ordinancehttps://www.elegislation.gov.hk/hk/cap478
- MERCHANT SHIPPING (SEAFARERS) (CERTIFICATION OF OFFICERS) REGULATION T-2 Cap. 478J , accessed at https://www.elegislation.gov.hk/hk/cap478J
- https://www.mardep.gov.hk/en/pub_services/pdf/coc_gl4.pdf
- https://www.hkatc.gov.hk/HK_AIP/AIP/GEN/HK_GEN1.3.pdf
- https://www.immd.gov.hk/eng/services/index.html
- https://www.elegislation.gov.hk/hk/cap409
- https://www.immd.gov.hk/pdf/Information%20Leaflet%20on%20Immigration%20Clearance%20of%20Visiting%20Pleasure%20Vessels%20(ENG).pdf
- https://hkie.org.hk/en/quali/international_agreement/
- https://www.elegislation.gov.hk/hk/cap409
- https://www.immd.gov.hk/eng/services/visas/GEP.html
- https://www.mardep.gov.hk/en/pub_services/exam1.html

Sources CT:

- Regulations on authorisation and employment of foreign crew members https://law.moj.gov.tw/ENG/LawClass/LawParaDeatil.aspx?pcode=M0050061&bp=3
- Regulations on temporary entry for foreigners https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=D0080139
- Seafarers Services Regulations https://law.moj.gov.tw/ENG/LawClass/LawParaDeatil.aspx?pcode=K0070023&bp=10
- Seafarer Act https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=K0070042
- Regulations governing management and employment of foreign seafarers https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=K0070040
- Quality and criteria standards for foreigners undertaking jobs specified under the Employment Service Act https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=N0090031
- Employer Services Act https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=N0090001
- Professional and Technologists Examinations Act https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=R0040001
- Senior professional and technical examinations regulations for engineers https://wwwc.moex.gov.tw/english/content/wfrmContent.aspx?menu_id=3608
- https://www.onlinevisa.com/visa-policy/taiwan/
- https://www.roc-taiwan.org/ch_en/post/2971.html
- https://en.motcmpb.gov.tw/Information/Detail/e33df038-dd40-48f2-9520-6a0345c4c514?SiteId=2&NodeId=10014
- https://www.boca.gov.tw/cp-220-5081-c06dc-2.html

- https://ezworktaiwan.wda.gov.tw/en/cp.aspx?n=602D9CE3DD72F51C&s=243D7E993A404388
- explanation of consultation mechanism, work flow and Ref. Lao-Dong-Fa-Guan-Zi-11005116391 dated August 18, 2021.)

Sources PNG:

- https://pngcanberra.org/visas/
- https://www.findaport.com/country/papua-new-guinea
- https://ica.gov.pg/visa-information/visa-on-arrival
- https://ica.gov.pg/uploads/media/post_file_1730343-entry-permit-booklet-dubai.pdf
- https://ica.gov.pg/visa-information/immigration-and-entry-permit-information
- https://www.nmsa.gov.pg/shipping/
- https://www.nmsa.gov.pg/conventions-and-national-legislations/national-legislations/
- Merchant Shipping Act http://nmsa.gov.pg/wp-content/uploads/2017/02/Merchant-Shipping-Act-1975.pdf
- Merchant Shipping STCW Convention http://nmsa.gov.pg/wp-content/uploads/2017/02/Merchant-Shipping-STCW-Convention-Regulation-2002.pdf
- https://iepng.org/expatriates

Professional Engineers Registration Act (Amended) 2007 https://iepng.org/images/resources/Registration-Act-2007.pdf

Sources PHL:

https://dfa.gov.ph/list-of-countries-for-21-day-visa

Annex 2. Private companies and non-governmental institutions currently engaged in marine debris clean-up, monitoring or research

Table A2.1 Selected companies and organizations engaged in or that organize beach-cleaning in the APEC region

Name of company or organization (cleaning activity)	Headquarters	Type of entity
Beach Raker LLC	Pompano Beach, FLA, USA	Local, private company
#EUBeachCleanUp	Brussels, Belgium	Global inter-governmental
Ocean Conservancy (International Coastal Cleanup®)	Washington, D.C., USA	Global NGO
Ocean Crusaders Foundation Ltd.	Manly, QLD, Australia	Local foundation
Plastic Oceans International	Malibu, CAL, USA, with affiliates in Canada, Chile, and Mexico	Regional NGO, focused on economies bordering the Pacific Ocean
Riviera Co., Ltd. (Riviera Beach Clean, Zaimokuza coast, Japan)	Tokyo, Japan	Local, private media & leisure company
Surfrider Foundation	San Clemente, CAL, USA	Economy-wide foundation
Sustainable Coastlines	Auckland, NZ	Economy-wide charitable trust
Sustainable Coastlines Hawai ‘i	Hawaii, USA	Local NGO
Tangaroa Blue Foundation (Australian Marine Debris Initiative)	Dunsborough, Western Australia, Australia	Local NGO

Table A2.2 Manufacturers of mechanical beach-cleaning equipment

Name of company (brand)	Headquarters
Beach Trotters (Unicorn)	Torredembarra, Tarragona, Spain
D’Hooghe machinebouw (dhooghe beachcleaners)	Moorslede, Belgium
H. Barber & Sons, Inc. (Surf Rake; Sand Man)	Naugatuck, Connecticut, USA
Kässbohrer Geländefahrzeug AG (BeachTech®)	Laupheim, Germany
Mavi Deniz Çevre Hiz A.Ş.	Istanbul, Turkey
Metaljonica s.n.c. (Scorpion Beachcleaner S.R.L.)	Roseto degli Abruzzi (TE), Italy
P.F.G.	Longiano (FC), Italia
Qingzhou Rio Environment Technology Co., Ltd. (RIO Beach Cleaner)	Qingzhou City, Shandong Province, China
Ram Europe group	Orchomenos, Greece
Rockland Manufacturing Co. (Beach King®)	Bedford, Pennsylvania, USA
Tuareg S.r.l.	Mandatoriccio Mare (CS), Italy

Table A2.3 Selected organizations in the APEC region that engage in or organize river-mouth or coastal collection of plastic debris

Name of company or organization (program)	Headquarters	Type of entity
Clean Currents Coalition (a project of the Benioff Ocean Science Laboratory)	Santa Barbara, California, USA	Non-profit collaborative network
Ghost Diving NZ	Newlands, Wellington, NZ	Community non-profit
Ocean Conservancy (Good Mate watercraft cleanups)	Washington, D.C., USA	Global NGO
Ocean Crusaders Foundation Ltd.	Manly, Queensland, Australia	Local foundation

Table A2.4 Designers or manufacturers of systems for collecting floating marine debris in rivers, harbours, or coastal regions

Name of company or organization (brand)	Headquarters	Type of entity
Aquarius Systems (Aquatic Trash Skimmer)	North Prairie, Wisconsin, USA	Private company, selling globally
Clearwater Mills LLC	Pasadena, Maryland, USA	Private company, selling locally
Mavi Deniz Çevre Hiz A.Ş.	Istanbul, Turkey	Private company, selling globally
River Cleaning	Cassola (Vi), Italy	Private company
The Ocean Cleanup (Interceptor)	Rotterdam, Netherlands	Dutch NGO operating internationally
Waste Free Oceans	Brussels, Belgium	Non-profit, operating internationally
Water Witch Waterway Maintenance Solutions	Liverpool, UK	Private company, selling globally

Table A2.5 Selected organizations that engaged in or organize the cleaning up of floating marine debris in the open ocean

Name of company or organization (brand)	Headquarters	Type of entity
Ocean Voyages Institute	Honolulu, Hawaii, USA	Non-profit research and educational organization
The Ocean Cleanup (Interceptor)	Rotterdam, Netherlands	NGO operating globally

Annex 3: Research-oriented programs and international collaborative initiatives

The **Global Partnership on Marine Litter** (GPML)[55] is a multi-stakeholder partnership working on reduction and prevention of marine debris as stated in the Sustainable Development Goals 14.1. The United Nations Environment Programme (UNEP) provides secretarial services to the partnership which runs a digital platform, develops action plans and organizes the International Marine Debris Conference (the 7th was held in Seoul, Korea September 2022).

The 2017 **G20 Action Plan on Marine Litter**, which has since been elaborated in the 2019 G20 Implementation Framework for Actions on Marine Plastic Litter[56] includes a section (6) on removal and remediation of marine litter.

The 2018 **G7 Innovation Challenge to Address Marine Plastic Litter**, an initiative of the Group of Seven forum, aims to in developing economies "stimulate innovations, raise awareness of how to address marine plastic litter or facilitate much needed improvements to the management of plastic, especially plastic waste".[57]

The **US National Oceanic and Atmospheric Administration** (NOAA) Marine Debris Program was established in 2006 and engages in and funds research, prevention and reducing the impact of marine debris.

The **5 Gyres Institute** is a non-profit organization in special consultative status with the United Nations Economic and Social Council. Founded in 2009, it conducts expeditions that bring citizen scientists, corporate executives, representatives of brands, and celebrities to the gyres, as well as lakes and rivers, to conduct first-hand research on plastic pollution. It also engages in community outreach and citizen science to promote data-driven solutions.[58]

Sea Education Association was established in 1971 and is a teaching and research not-for-profit with university accreditation. It owns and operates vessels that are deployed to marine research projects, including on marine debris.

The Global Ocean Observing System (GOOS) is an Intergovernmental Oceanographic Commission (IOC)-led programme. The IOC is part of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It was established in 1991 and aims at developing a global ocean observation system by 2030.

The **Integrated Marine Debris Observing System** (IMDOS) is a network of interdisciplinary research, using available data from NOAA, GOOS and others, including in situ observations from citizen researchers on ships and yachts for modelling the sources, composition, movements and impact of marine debris. The initiative is currently in a prototype phase.

Endnotes

[1] Wayman, C. and Niemann, H., "The fate of plastic in the ocean environment – a minireview", *Environmental Science: Processes & Impacts* 23 (2021): 198-212.
[2] See Cózar, A., Echevarría, F., González-Gordillo, J., Irigoien, X., Úbeda, B., Hernández-León, S. and Duarte, C., "Plastic debris in the open ocean," *Proceedings of the National Academy of Sciences*, 111(28), (2014): 10239-44. Eriksen, M., Lebreton, L., Carson, H, Thiel, M., Moore, C., Borerro, C. and Reisser, J. "Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea", *Plos One*, 9(12) (2014): e111913. Kane, I., Clare, A., Miramontes, E., Wogelius, R., Rothwell, J., Garreau, P. and Pohl, F., "Seafloor microplastic hotspots controlled by deep-sea circulation", *Science*, 368(6495) (2020): 1140-45. Among the 10 largest sources of marine debris reported by Jambeck et al. (2015) study were six APEC economies (China (1), Indonesia (2), the Philippines (3), Viet Nam (4), Thailand (6), and Malaysia (8)). See Jambeck, J., Geyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., "Plastic waste inputs from land into the ocean", *Science*, 347(6223) (2015): 768-71.
[3] See, for example, Colton J., Burns, B. and Knapp, D., "Plastic particles in surface waters of the Northwestern Atlantic", *Science*, 185(4150), (1974): 491-97.
[4] Audrézet, F., Zaiko, A., Lear, G., Wood, S., Tremblay, L. and Pochon, X., "Biosecurity implications of drifting marine plastic debris: Current knowledge and future research," 162 *Marine Pollution Bulletin*, (2021): 111835-39.
[5] Andrady, A., "Microplastics in the marine environment," *Marine Pollution Bulletin*, 62(8) (2011): 1596-1605.
[6] Van Sebille, E., Aliani, S., Law, K., Maximenko, N., Alsina, J., Bagaev, A., and Wichmann, D., "The physical oceanography of the transport of floating marine debris," *Environmental Research Letters*, 15(2), (2020): 023003.
[7] Scientific research on marine debris often distinguishes between four size classes: 0.33–1.00 mm (small microplastics), 1.01–4.75 mm (large microplastics), 4.76–200 mm (mesoplastic), and larger than 200 mm (macroplastic). See Eriksen et al., 2014, *op cit*.
[8] Kane, I., Clare, M., Miramontes, E., Wogelius, R., Rothwell, J., Garreau, P., and Pohl, F., "Seafloor microplastic hotspots controlled by deep-sea circulation," *Science*, 368(6495), (2020):1140-45.
[9] McIlgorm, A., Raubenheimer, K., and McIlgorm, D., (2020), *Update of 2009 APEC report on Economic Costs of Marine litter to APEC Economies*, Report to the APEC Ocean and Fisheries Working Group by the Australian National Centre for Ocean Resources and Security (ANCORS), University of Wollongong, Australia.
[10] Lau. W., Shiran, Y., Bailey, R., Cook, E., Stuchtey, M., Koskella, J., Velis, C., Godfrey, L., Boucher, J. and Murphy, M., "Evaluating scenarios toward zero plastic pollution," *Science*, 369(6510), (2020): 1455–1461.
[11] Meijer, L., Van Emmerik, T., Van der Ent, E., Schmidt C., and Lebreton, L., "More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean", *Science Advances* 8(18), (2000).
[12] APEC Policy Support Unit (2019), *Compendium of Policies and Preventive Measures to Reduce Land-based Marine Debris in APEC Economies*, Singapore, APEC Secretariat.
[13] See Ocean Conservancy, "Fighting for Trash Free Seas" accessed at <https://oceanconservancy.org/trash-free-seas/international-coastal-cleanup/>.
[14] IUCN, "2,023 kilograms of wastes collected at Koh Libong Sub-district beach cleanup", 05 Oct, 2021, accessed at https://www.iucn.org/news/thailand/202110/2023-kilograms-wastes-collected-koh-libong-sub-district-beach-cleanup.
[15] See, for example, the explanation at <http://longislandbeachcleaning.com>
[16] Data source accessed at <https://www.environmental-expert.com/companies/keyword-beach-cleaning-machine-9180>
[17] Authors' interviews with Waste Free Oceans (June 2022) and The Ocean Cleanup (May 2022).
[18] A review of 12 approaches to intercepting floating plastic can be viewed at "Designed Conscious" accessed at <https://designedconscious.com/plastics-in-the-ocean/sustainability-news-stories/12-river-plastic-cleanup-projects/>.
[19] See "The Ocean Cleanup" accessed at <https://theoceancleanup.com/rivers/>
[20] See "River Cleaning" accessed at <https://rivercleaning.com/river-cleaning-system/>
[21] Saraswati, A., *Trash Barrier: Block River Waste to Ocean*, Greeneration Foundation, July 2022, accessed at <https://greeneration.org/en/publication/green-info/trash-barrier-block-river-waste-to-ocean/>.
[22] Wildcoast, "*Wildcoast Stops The Tsunami Of Trash At The US/Mexico Border*", 19 April 2022, accessed at https://wildcoast.org/wildcoast-stops-the-tsunami-of-trash-at-the-us-mexico-border/.
[23] RYT9, "*Lat Phrao Canal Cleanup project moving forward through 2nd Year*", 7 January 2022, accessed at <https://www.ryt9.com/en/prg/255369>

[24] Tran, V.,"*Meet Vietnam's New Trash Trapper*", 9 September 2022, accessed at <https://oceanconservancy.org/blog/2022/09/09/meet-vietnams-new-trash-trapper>
[25] Ocean Conservancy, accessed at <https://oceanconservancy.org/trash-free-seas/boating-community/marina-cleanup-day/>
[26] Authors' interviews with Waste Free Oceans (June 2022).
[27] APEC Policy Support Unit (2019), *Compendium of Policies and Preventive Measures to Reduce Land-based Marine Debris in APEC Economies*, Singapore, APEC Secretariat.
[28] Parks Australia, "*Ghost Nets Initiative launch*", 3 May 2021, accessed at https://parksaustralia.gov.au/news/ghost-nets-initiative-launch/.
[29] See "Waste Free Oceans", accessed at <https://www.wastefreeoceans.org/collecting>
[30] Van Giezen, A. and Wiegmans, B. (2020) present a case study of The Ocean Cleanup, a Dutch not-for profit organization with a mission to clean up the ocean gyres and more recently also river mouths. See Van Giezen, A., and Wiegmans, B., "Spoilt-Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation," *Transportation Research Interdisciplinary Perspectives*, 5 (2020): 100115.
[31] *Ibid.*
[32] Lee, R., Meyer, B., Huang, Q. and Voss, R. "Sustainable waste management for zero waste cities in China: potential, challenges and opportunities". *Clean energy*, 4(3): 169-201. The estimate is based on a rough assumption that the density of plastic debris is about 1g/cm3.
[33] Fishing nets that have been lost or cutaway at sea and often continue floating on or near the ocean surface for many years.
[34] According to a case study of The Ocean Cleanup, the floating installation collects about 65 m^3 plastic per day, which requires transport to port every 45 days. The total amount of debris each year is 7000 tonnes. See Van Giezen, A. and Wiegmans, B., "Spoilt-Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation," *Transportation Research Interdisciplinary Perspectives*, 5 (2020): 100115.
[35] See The Ocean Cleanup, **"***The Ocean Cleanup, A.P. Moller – Maersk Extend Relationship with new Three-Year Partnership*", 13 January 2021, accessed at < https://theoceancleanup.com/press/press-releases/the-ocean-cleanup-a-p-moller-maersk-extend-relationship-with-new-three-year-partnership/>.
[36] Maximenko, N., et al, (2019), *op cit.*
[37] Examples of models are statistical observation driven models, mathematical models, and multidimensional particle tracking models. See for instance, Maximenko, N., Hafner, J. and Niiler, P., "Pathways of marine debris derived from trajectories of Lagrangian drifters", *Marine pollution bulletin*, *65*(1-3), (2012): 51-62 or Van Sebille, E., et al, "The physical oceanography of the transport of floating marine debris", *Environmental Research Letters*, *15*(2), (2020): 02300.
[38] Ocean Conservancy, "2021 Annual Report", *Splash*, Spring (2022): 6.
[39] Author's interview with Ocean Crusaders (July 2022).
[40] WWF, (2021), "Plastic crediting and plastic neutrality", WWF Position Paper, accessed at <https://c402277.ssl.cf1.rackcdn.com/publications/1429/files/original/newWWF_Position_on_Plastic_Crediting_and_Plastic_Neutrality_.pdf?1611957221>
[41] See Waste4Change, "Waste Credit", accessed at <https://waste4change.com/service/waste-credit?lang=en>
[42] See RIO, "Programs to Heal our Planet", accessed at <https://oceansintegrity.com/our-program> and Tonto Ton, accessed at <https://tontoton.com>
[43] See Plastic Collective, accessed at <https://www.plasticcollective.co/how-do-plastic-credits-work/>
[44] See Verra, accessed at <https://verra.org/project/plastic-program/>
[45] Phipps, L., "The Wild West of plastic credits and offsets", *Circularity Weekly*, (2021), accessed at <https://www.greenbiz.com/article/wild-west-plastic-credits-and-offsets>
[46] Author's interview with Nicolai Maximienko, University of Hawaii and coordinator of the Integrated Marine Debris Observing System.
[47] See Ellis, D. and Hadley, P., "Sustainable remediation white paper—Integrating sustainable principles, practices, and metrics into remediation projects", *Remediation Journal*, *19*(3), (2009): 5–114.
[48] Malm, T., Råberg, S., Fell S. and Carlsson, P., "Effects of beach cast cleaning on beach quality, microbial food web, and littoral macrofaunal biodiversity", *Estuarine, Coastal and Shelf Science* 60(2) (2004): 339–347.
[49] Thorson, B., "Beach Grooming: Raking beach life from the sand", *The Swim Guide*, 24 August 2016, accessed at <https://www.theswimguide.org/2016/08/24/beach-grooming/>
[50] Conservatoire du littoral et Rivages de France (2011), *Guide du nettoyage des plages* [Beach-cleaning guide], Le Bourget-du Lac: Bayard Nature et Territoires.
[51] Zielinski, S., Botero C. and Yanes, A., "To clean or not to clean? A critical review of beach cleaning methods and impacts", *Marine Pollution Bulletin* 139, (2019): 390-401.

[52] Mace, T., "At-sea detection of marine debris: overview of technologies, processes, issues, and options", *Marine Pollution Bulletin*, 65(1-3), (2012): 23-27.
[53] General Agreement on Tariffs and Trade, "Services Sectoral Classification List", GATT document No. MTN.GNS/W/120 of 10 July 1991.
[54] Australia, Canada, China PRC, Japan, the Republic of Korea, Russia, Thailand, the United States, and Viet Nam.
[55] See Global Partnership on Marine Litter, accessed at <https://www.gpmarinelitter.org>
[56] See G20 (2019), *G20 Implementation Framework for Actions on Marine Plastic Litter*, accessed at <https://www.mofa.go.jp/policy/economy/g20_summit/osaka19/pdf/documents/en/annex_14.pdf>
[57] See Government of Canada (2019), *G7 innovation challenge to address marine plastic litter*, accessed at < https://www.international.gc.ca/world-monde/international_relations-relations_internationales/g7/documents/2018-09-19-marine_plastic_litter-dechets_plastique_marins.aspx?lang=eng >
[58] See 5 Gyres, *Science to Solutions*, accessed at <https://www.5gyres.org/about-us>

Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace, Singapore 119616
Telephone Number: (65) 6891 9600
Fascimile Number: (65) 6891 9419
Website: www.apec.org
Email: info@apec.org

APEC#222-CT-01.13