



**Asia-Pacific
Economic Cooperation**

UPDATE OF 2009 APEC REPORT ON ECONOMIC COSTS OF MARINE DEBRIS TO APEC ECONOMIES



APEC Oceans and Fisheries Working Group

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of Marine Debris to APEC Economies**

APEC Project: **OFWG 01 2018A**

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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY	8
2 THE PURPOSE OF THIS REPORT	10
3 SUMMARY OF THE 2009 REPORT	11
4 INTRODUCTION	13
4.1 The problem	13
4.2 Risks to the Blue Economy and food security	14
5 THE COST OF INACTION – WHAT WE KNOW NOW	15
5.1 Direct damage costs	15
5.1.1 Direct damage.....	15
5.1.2 Remediation costs	20
5.1.3 Indirect costs.....	21
6 THE VALUE OF THE MARINE SECTOR TO APEC ECONOMIES.....	23
7 COST OF MARINE DEBRIS TO APEC ECONOMIES	28
7.1 The economic costs of marine debris – the 2009 direct damage approach	28
7.2 The economic capacity to deal with marine debris and the use of hot spots	31
7.3 Hot spots	31
7.4 Discussion.....	33
7.5 APEC and the trade in plastic waste.	35
7.6 Hot spots in the APEC region	36
8 MOVING FORWARD	42
8.1 The economic approach.....	43
8.2 Suggestions for enhancing policy levers	44
9 CONCLUSIONS.....	48
10 RECOMMENDATIONS.....	49
11 REFERENCES	51
12 APPENDICES	59
12.1 Appendix 1. Case Study 1. Inter-ministerial Co-operation: The Interagency Marine Debris Coordinating Committee (IMDCC) of the United States	59
12.1.1 Introduction.....	59
12.1.2 The Interagency Marine Debris Coordinating Committee (IMDCC).....	59
12.1.3 Recent amendments to the Save Our Seas Act	60
12.1.4 Reporting	60

12.2 Appendix 2. Case Study 2. Inter-ministerial Co-operation: River of Life – the Klang Valley in Malaysia.....	61
12.2.1 River of Life	61
12.2.2 Community engagement	63
12.2.3 In the top ten waterfronts.....	64
12.3 Appendix 3. Case Study 3. Female engagement: ReciclApp – Chile	64
12.3.1 Introduction.....	64
12.3.2 About ReciclApp	65
12.3.3 How the community benefits	65
12.3.4 Future developments	66
12.4 Appendix 4. Case Study 4. Marine debris control program (removal): Economics of a community fishing gear recycling scheme, Indonesia	67
12.4.1 Introduction.....	67
12.4.2 Figures and economics	68
12.4.3 Revenue.....	72
12.5 Appendix 5. Case Study 5. Marine debris control program (capture): Economics of a litter basket, Australia	73
12.5.1 Introduction.....	73
12.5.2 Figures and economics	74
12.5.3 Design and life expectancy	75
12.5.4 Data analysis, awareness and education.....	75
12.5.5 Repurposing collected plastic waste	78
12.6 Appendix 6. Actioning the APEC Policy and Practice Recommendations (PPRs).....	78
12.6.1 APEC policy and practice recommendation 1.....	78
12.6.2 APEC policy and practice recommendation 2.....	79
12.6.3 APEC policy and practice recommendation 3.....	79
12.6.4 APEC policy and practice recommendation 4.....	79
12.6.5 APEC policy and practice recommendation 5.....	80
12.6.6 APEC policy and practice recommendation 6.....	80
12.6.7 APEC policy and practice recommendation 7.....	80
12.6.8 APEC policy and practice recommendation 8.....	81
12.6.9 APEC policy and practice recommendation 9.....	81
12.7 Appendix 7. Stemming the tide, next wave: Summary of solutions.....	82
12.8 Appendix 8: Additional resources	83

TABLES

Table 1: Examples of direct damage to marine industry in the APEC region	16
Table 2: Examples of remedial costs of debris clean-up in the APEC region.....	17
Table 3: Examples of indirect cost impacts of marine debris in the APEC region	19
Table 4: Marine sectors and economic data availability for APEC member economies in 2015	23
Table 5: The APEC member economy GDP and marine economy GDP estimates in the APEC region in 2015 in USD (\$)	24
Table 6: The estimate of GDP by sector for each member economy in the APEC region (2015)	26
Table 7: Estimates of the direct damage cost from marine debris in the fisheries and aquaculture, transport and shipping and marine tourism sectors of APEC marine economies in 2015 in USD (\$) ..	29
Table 8: GDP added to waste estimates for APEC economies (adapted from Jambeck et al. 2015) ...	32
Table 9: A comparison of institutional waste aspects of economies in the APEC region	35
Table 10: Marine debris hot spots and remedial initiatives in the APEC region for discussion	36
Table 11: The projected net benefits (NB) from 21 policies (Ocean Conservancy 2015).....	37
Table 12: Policy levers proposed for five SE Asian economies to reduce marine debris (Ocean Conservancy 2016).....	38
Table 13: As summary of technical devices for stopping the ingress of marine debris	40
Table 14: Policy levers and activities to reduce marine debris	46
Table 15: Recommendations for reducing marine debris in the APEC region	49
Table 16: Operating costs for waste transport and cleaning	72
Table 17: Installation and servicing costs of litter baskets.....	74
Table 18: Stemming the tide, next wave: Summary of solutions.....	82

FIGURES

Figure 1: The marginal costs (MC) and marginal damage cost (MDC – the marginal benefit MB) of controlling marine debris at different levels of this pollutant (McIlgorm et al. 2008, 2011).....	11
Figure 2: Graph of the marine economy as a percentage of APEC member economy GDP	25
Figure 3: The predicted cost of marine debris damage in APEC member economies in 2015	30
Figure 4: The Kuznets curve relating environmental degradation and per capita income (Panayotou 2003)	34
Figure 5: The River of Life project area.....	62
Figure 6: Mapping of gross pollutant traps (Image credits: Cleanwater Group).....	75
Figure 7: ‘Heat map’ of an industrial area	77

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ACRONYMS

APEC	Asia Pacific Economic Cooperation
AUD	Australian dollar
Bn	Billion
CDS	Container deposit scheme
EPR	Extended producer responsibility
FAO	Food and agricultural organization of the United Nations
GDP	Gross domestic product
GVA	Gross value added
IDR	Indonesian rupees
IMO	International Maritime Organisation
MB	Marginal benefit
MC	Marginal cost
MD	Marine debris
MDC	Marginal damage cost
ME	Marine economy
MRF	Materials recovery facility
Mt	Million tonnes
NB	Net benefit
NGO	Non-government organisation
OFWG	Ocean and Fisheries Working Group (of APEC)
PPRs	Policy and practice recommendations
SDGs	Sustainable Development Goals of the United Nations
t	Tonne
Trn	Trillion
USD	United States dollar

Organizational initialisms are as presented in the report, when used and in the references.

1 EXECUTIVE SUMMARY

The need for remedial action on marine plastic debris in the APEC region is increasing. Many of the economies in APEC have had decades of strong economic growth and the production of consumer goods and services has created a legacy of plastic waste, which is now seen along the coasts and in the seas of the Asia-Pacific region.

The economic costs to industries from marine debris are the direct damage and associated lost economic opportunities. There are also remedial costs in cleaning up debris and the indirect costs of damage to the marine environment, that are not estimated here.

The value of marine economy GDP in 2015 in the APEC region was estimated to be US\$2.06 trillion dollars, approximately 4.7% of total APEC GDP in 2015. Global production of plastic has increased to 322mt in 2015 leading to higher levels of marine plastic pollution.

This report revises the previous 2009 APEC report which estimated there was \$1.26 billion of damage to fisheries and aquaculture, marine transport, shipbuilding and marine tourism industries from marine debris.

The current report finds that in 2015 there was an estimated US\$10.8 billion of damage per annum to industries in the marine economy attributable to marine debris. The estimate has risen by eight times since 2009, due to improved data, growth in the marine economy and in the amount of plastic waste in the oceans over the last decade.

At present rates of discarding of marine debris, the present value of the damage to these industries to 2050, is US\$216 billion (assuming a 3% discount rate). Global plastic production is predicted to triple by 2050 and this is not included in this projection. Business as usual is not an appropriate, or acceptable, outcome.

The literature review indicates that the capacity of an APEC economy to remediate and reduce marine debris is related to its total economic output (GDP), population, urbanization and a range of geographic factors, such as rivers, estuaries and length of coastline. All these vary within APEC member economies. The comparative ranking of total marine debris by volume by APEC economies has identified several Asian economies as having the highest levels of marine debris, a side effect of the thirty year “economic miracle” that has lifted a billion people out of poverty in Asia. Global economic history shows that rising GDP per capita eventually enables economies to transform environmental damage into remediation, though the predicted increases in the production and use of plastic to 2050 may counteract this.

Each APEC member economy should have a plan to address marine debris “hot spots” which will produce most economic benefits when remediated. Technical solutions, such as litter traps on rivers, are identified as being immediately applicable, while more strategic waste management approaches take longer to implement. It is these economic differences between APEC member economies that lead to plastic and other waste being traded from developed to less developed economies. This trade in waste is a current issue for most APEC member economies. Land based waste mismanagement leads to debris entering the ocean and requires management.

The lack of natural decomposition of plastic in the ocean, means that government has to create remedial frameworks, but this does not mean that government has to solve these waste issues alone. The private sector and the public as consumers, are beneficiaries of plastic; they create waste and are integral to the development and funding of the solutions to this waste issue, through models that extend both producer and consumer responsibility.

Every APEC member economy needs to improve waste governance at all levels of society and organize, cooperate and communicate “internally”, in order to improve marine debris control. Plastic producers in industry must limit mismanaged waste through extended producer responsibility. Fund raising to support a more environmentally responsible industry waste management system is taking place in some APEC economies. In the same way, the plastic consuming public must pay for recycling. For example, the purchase of garbage bags is a cost-effective way to reduce waste. To supplement these steps, the use of technical control devices can reduce debris entering the water course and then the ocean, where it is much more expensive to collect than at entry sites.

Five case studies from the APEC region are described in this report to illustrate current best practice for these “key steps”. New models of inter-ministerial cooperation on marine debris are seen in some economies as “top down” initiatives in APEC. There are also more organic “bottom up” developments in which citizens in poor communities, including women and marginalized groups, benefit from economic coordination via mobile phone technology for effective waste picking. Other projects involve recycling waste from fishing or innovating devices to stop litter entering water courses and hence the ocean. The economics of these solutions, including the re-use of polystyrene, are illustrated.

The report ends by making recommendations for moving forward and provides case studies that illustrate some of these recommendations with consideration of social aspects of measures to prevent and mitigate marine debris in the APEC region.



Photos (from left to right): TangaroaBlue.org (1) and National Oceanic and Atmospheric Administration (NOAA) (2, 3)

2 THE PURPOSE OF THIS REPORT

The report will:

- a) Provide an updated assessment of the economic impacts of marine debris in APEC economies;
- b) Identify major urban marine debris "hot spots" that may benefit from targeted control interventions;
- c) Evaluate the technical effectiveness of marine litter devices, such as river traps and harbor booms;
- d) Provide a cost-benefit analysis of potential solutions; and
- e) Provide policy recommendations that may lead to reductions in the amount of litter leaking into the ocean.

In the near term this project seeks to:

1. Increase the priority of marine debris and waste management programs by providing additional information regarding the costs of marine debris and the benefits of countermeasures; and
2. Improve coordination between marine and ocean ministries and ministries of environment.

In the medium term, this project seeks to:

1. Increase the number of APEC economies that incorporate marine debris considerations into solid waste management plans and waste management into marine and coastal plans; and
2. Promote the development of new partnerships and initiatives to address marine debris.
 - This will be assisted through sharing of contacts made during the project phase (where agreed by participants).

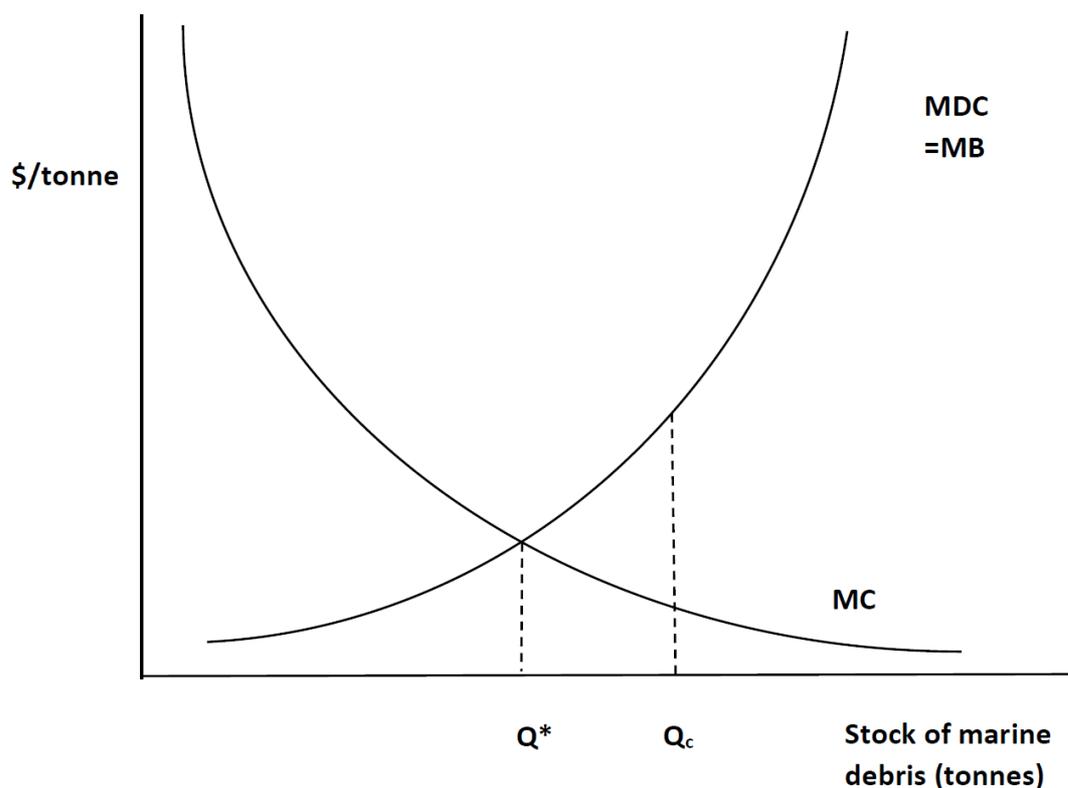
All dollar signs in the report are USD\$ unless otherwise specified. Weights are in tonnes (t).

3 SUMMARY OF THE 2009 REPORT

The 2009 report examined the available information and literature on the cost of damage to marine industries attributable to marine debris and made an estimate of this cost in the APEC region. This pollution was an avoidable cost and the economic benefits from controlling it were sizable. In 2009, it was noted an increasing proportion of marine debris was plastic and related both the costs and benefits of controlling marine debris in the ocean to the stock of marine debris.

It was estimated that the damage cost to marine industries in the APEC region in 2008 was \$1.26bn USD. This estimate was derived from the GDP of some of the industries in the marine economy most impacted by debris. The relationship between the marginal cost (damage) and the marginal benefit from prevention (cleanup costs saved) in proportion to the stock of marine debris is illustrated in Figure 1. High densities of debris merit expenditure, but prevention was proposed as being economically preferable to remedial costs.

Figure 1: The marginal costs (MC) and marginal damage cost (MDC – the marginal benefit MB) of controlling marine debris at different levels of this pollutant (McIlgorm et al. 2008, 2011).



In Figure 1 the point Q_c indicates the marginal net benefits from debris stock reduction back to the optimum level at Q^* (McIlgorm et al. 2008, 2011). Below the debris stock level Q^* , the marginal cost of collecting debris is high, with less marginal benefit.

The study made 12 recommendations that can be grouped under four themes:

Control – Joint action by governments at different levels; Biodegradable packaging to reduce marine debris (MD); Identify urban MD hot spots that could benefit from a workshop on control;

Measurement/data – APEC member economies identify the total cost of MD remediation; Cost per tonne for remediation; Estimate the environmental impacts by non-market value techniques; Work with the insurance industry on MD related impacts;

Technical approaches – MD return and low-cost re-cycling facilities at Ports and harbors; Make information on litter traps and devices available to APEC member economies;

Market instruments – Two studies of the use of different market-based instruments; Study cost sharing in ocean remediation between adjacent economies; Encourage municipalities to work with private enterprise in joint remediation. The study included two MD control workshops in Indonesia (Jakarta and Manado).

Since the 2009 report the growth of plastic production and its major contribution to waste and marine debris in the oceans has become more evident. There is also wider recognition that poor waste practices on land inevitably lead to marine debris. Albeit slowly, there has been an increasing recognition of the costs of marine debris, and plastic in particular, to industry and the marine environment. It also appears that while plastic breaks down, it does not decompose, leading to micro-plastics. Marine industries within APEC are now facing the annual and cumulative damage costs from marine debris. There are also the unmeasured impacts of plastic pollution on the marine environment and a realization of the cumulative ocean plastic legacy being left in the oceans for future generations.



Plastics and lighters gathered from beach clean ups. Photos: TangaroaBlue.org

4 INTRODUCTION

4.1 The problem

Plastic is an amazing product! It allows vast increases in design aesthetics, product range and packaging efficiency, lower transportation costs, extension of product life and efficient replication in production. The plastics industry has done what it supposed to have done in lowering the cost of production and maximizing consumption. However, it has a pecuniary externality effect on its competition, putting natural materials that were formerly used for many of the uses of plastic, out of business. Nevertheless, the plastics industry has also delivered positive economic and environmental benefits by reducing the potential over-exploitation of natural renewable resources, such as forests, and by making cars safer. Modern society's relationship with plastic is complicated.

The long-term problem of plastic lies in its nature as a synthetic material. Unfortunately, unlike many of the materials it replaced, plastic does not naturally breakdown into its chemical constituents. It currently has a limited recycling capacity and is disposed of through either burial, or incineration, with environmental and cost implications. The resultant plastic waste problem reveals gaps in the governance for its disposal and a lack of clarity in society as to the “end game” – should we recycle, bury or incinerate?

The plastics industry seems to have the capacity to supply the ever-increasing demand of our materially developing societies. The output of plastic producers is centralized and subject to economies of scale. Plastic producers in industry are not one entity, and they compete against each other, by product type and price. The volume of plastic production globally has risen from 100 million tonnes (mt) in 1989 to 322mt in 2015 (Statista 2019), but this increased production has not been matched by waste management. Future projections envisage plastic production are to reach 1,124mt by 2050 (World Economic Forum et al. 2016). The rate of growth in recycling and incineration over the last 40 years have led to predictions that by 2050 some 94% of all plastics will either be recycled (50%) or incinerated (44%) (Geyer et al. 2017).

In contrast to the initial centralized creation of virgin plastic, the plastic problem in the environment occurs because plastics end up scattered, mixed, decentralized and have significant transaction and search costs to re-centralize them into significant quantities that would make recycling economically viable. Currently, the technology to produce plastic is not sufficiently connected with recycling (World Economic Forum et al. 2016). Where recycling technology exists, it may not be viable due to dispersion of the potential raw material. Plastic recycling can be subject to patent access costs, and require finance to fund intensive capital costs. Financial markets prefer to invest in the known producer model and need to help innovate and restructure the disposal market as an entrepreneurial endeavor under current prices. The price of virgin plastic is low and does not encourage recycling (World Economic Forum et al. 2016).

Government has traditionally provided waste services to address generic waste needs. This may have inadvertently slowed the creation of private initiatives to help address the plastic recycling problem. For example, the price of landfill disposal is often less than the economic

benefits gained from plastic recycling. Even if the oil price does not rise, increasing the cost of landfill disposal can help drive solutions to the plastic problem, provided the waste system prevents illegal dumping. Several of the world's biggest cities do not have adequate landfill facilities and are running out of space for their waste. As the price of landfill increases, the incentive to recycle waste increases. The increasing complexity of capital required to facilitate recycling is expensive even to high-income per capita economies. Recycling opportunities should exist at any price equal to, or less than landfill costs.

The transport of plastic has extended global trade with many developed economies exporting their paper and plastic waste “offshore” to less developed economies with less stringent environmental protection policies for recycling. In 2018, China stopped taking imports of badly sorted plastic, causing the recent global “plastic waste crisis” with inherent waste trade issues (Financial Times 2018).

Plastics accumulate and remain perpetually in the environment, with annual waste inputs building the cumulative stock. The stock of plastic breaks down, but never truly decreases, as plastic has no decomposition or depreciation rate. The damage incurred is presumed to be proportional to the quantity of plastic, producing ever-increasing annual direct and indirect damages to society, though the damage functions have not been quantified. It is feasible, that as time passes and the actual costs of plastic pollution are recognized, they may reduce the “plastic advantage” in consumer markets. Even though plastic is now ahead of its product substitutes, the plastics industry has an incentive to ensure it contains its environmental impacts.

4.2 Risks to the Blue Economy and food security

The ocean is an environment in which human knowledge and understanding is limited and institutional development is slow. The Blue Economy idea has sought to capture the potential of economic growth, innovation and environmentally sustainable opportunities that can be realized from the oceans (EIU 2015, Ebarvia 2016). The Blue Economy also has equity and political stability considerations as a vast number of the world's poor rely upon the oceans for affordable protein and employment. The APEC economies have important marine economies and are potentially vulnerable to damage from marine debris, especially plastics.

Addressing marine plastic debris as a Blue Economy issue means we have to recognize that the marine environment complicates risks and expands the nature and breadth of damages. The international community has approached the marine debris problem as a marine issue. However, the UNEP Regional Sea Program has found regional seas are recipients of plastic waste due to governance failures on land as well as at sea. There is an increasing realization that the main policy priority is to address the plastic problem on land before it becomes a sea problem (UNEP 2017).

5 THE COST OF INACTION – WHAT WE KNOW NOW

In this section, we examine the information available on the current experience of costs and remediation of marine debris, using this as the “business as usual” proposition. The cost of inaction is higher costs than under improved waste management practices. Improved management of waste leakage can remediate the envisaged future cost impacts. Economic costs are opportunities foregone. For example, the costs of damage through marine debris can also have an opportunity cost as industry surrenders operational time to repairs.

In the 2009 APEC report, a range of different categories of costs arising from marine debris were identified: (i) Direct damage costs, (ii) Remediation costs and (iii) Indirect damage costs, such as environmental costs. Each of these are influenced by the inadequacies of waste disposal systems and waste mismanagement.

5.1 Direct damage costs

In the current literature, there are examples of how debris causes damage to marine industries such as fishing, shipping and transportation and marine tourism, in numerous ways as reported in Table 1.

5.1.1 Direct damage

Past studies internationally show that the fishing industry is directly impacted by marine debris (Takehama 1990, Hall 2000, Mouat 2010). Such damage includes accidents, collisions with debris, entanglement of floating objects with propeller blades and clogging of water intakes for engine cooling systems (McIlgorm et al. 2008). There have been few specific recent studies of the direct cost of marine debris damage to fishing boats in the APEC region.

Marine shipping and transport vessels can find that marine debris is an operational hazard. Floating freight containers are a navigational risk to coastal and ocean shipping, and derelict fishing gear and ropes can represent an entanglement threat to vessels, especially smaller vessels. Plastic ingestion can lead to clogging of water intakes for engine cooling systems, and ports are kept clean to reduce this impact. Entanglement with ropes has on occasions led to propeller damage and sinking of vessels via stern tube damage causing an influx of seawater (see McIlgorm et al. 2008). In Korea, Cho (2005) identified that marine debris was involved in 9% of all Korean shipping accidents in the 1996-98 period. Recently ships losing containers of plastic pellets have had a variety of impacts, including reducing the price of fish adjacent to an accident site (SCMP 2012). Small leisure boats are impacted by marine debris causing loss of operational time. There are records of wrecked propeller shafts, stern gear and flexible couplings on engines, putting vessels out of operation with economic losses and risk of injury (Johnson 2000).

Tourism is also directly impacted by marine debris. Debris on beaches and shorelines poses problems for tourism, wildlife and presents a hazard to the health of beach goers (Wagner 1989, Leggett et al. 2014). Loss of amenity on beaches and in shallow coastal habitats can cause significant economic impacts through both the reduction in tourist visits and in tourist activities (Jang et al. 2014).

Table 1: Examples of direct damage to marine industry in the APEC region

Sector	Type of damage/loss	Type of debris	APEC Economy	Estimated cost	Source
Fishing	Loss of fisheries production	Nets “ghost fishing”	US	Loss of \$250m in lobsters UNEP	Raaymakers (2007)
	Reduced catch from crab pots ghost fishing in Chesapeake Bay	Derelict fish pots	US	Removing 10% of the derelict pots from 10 heavily fished areas may increase blue crab harvest by 22 million pounds (14%)	Bilkovic et al. (2016)
	Loss of fishing gear and down time	Entanglement with derelict fishing gear	AUS/ NZ	\$10m for retrieval of nets	Slater (1994)
	To fishing boats	Floating objects	Japan	¥ 6.6 billion	Takehama (1990)
Shipping and transport	Damage to commercial leisure boats	General, entanglement of propellers and ingestion;	US	Cost of repairs, lost sales and downtime \$792m	Ofiara and Seneca (2006)
	Damage to ships	Rope entanglement with vessel	Korea	Vessel loss – 292 lives	Cho (2005)
	Loss of fishing product value from ship container spill of plastic pellets	Plastic pellets spill	Hong Kong, China; Chinese Taipei	Sinotech incident; 30-40% price reduction to fish farmers in area of plastic nurdle spill	SCMP (2012)
Marine tourism/ leisure	Estimate of the economic cost of marine debris on 31 Californian beaches	Marine debris on 31 California beaches	US	A 25% per capita reduction in marine debris for 31 beaches gave aggregate benefits of \$29.5m in 2013 dollars. (100% per capita reduction in marine debris gave \$148m aggregate benefits)	Leggett et al. (2014 and 2018)
	Flood litter impacts on Geoje island tourism area in 2011 episode	Litter and other waste washed down rivers onto beaches	Korea	Visitor count at the Island’s beaches decreased by 63%, with tourism revenue loss of US\$29-\$37m to the island	Jang et al. (2014)
	Mass marine litter wash up as random event – reducing tourism revenue in New Jersey and New York in 1988	Plastic and marine debris	US	Tourism expenditure loss of \$379m to \$3.6 billion in New Jersey	NRC (2009), Ofiara and Brown (1989)

Table 2: Examples of remedial costs of debris clean-up in the APEC region

Sector	Type of damage/loss	Type of debris	APEC Economy	Estimated cost	Source
Fishing	Removal of fishing nets and traps	Fishing nets and traps	US	\$4,960 per acre of net removed. removal of derelict pots/traps totalled \$193 per pot/trap	NRC (2007)
	Removal of Ghost nets in Northern Australia	Ghost nets	Australia	The average cost of ghost net recovery operation is US\$25,000; does not include the cost of Border Force surveillance activity or the costs of net disposal	Australian Senate (2016)
Shipping and Transportation	Cost to remove abandoned and derelict vessels in Queensland.	Wreckage/hull	Australia	\$6,000,000 for 250 vessels	Bailey (2018)
	Loss of a container of plastic pellets – Sinopec accident	Plastic pellet and container recovery and clean up	Hong Kong, China, Chinese Taipei	USD \$1.29 million to clean up 150 t plastic nurdle spill	DNEWS (2012)
Shoreline and ocean clean up and Shipping and Transportation	Contracted expenditure by Marine Department for floating refuse scavenging services, domestic refuse collection services and refuse disposal services (2017-2022)	Marine floating refuse and domestic refuse from vessels	Hong Kong, China	Marine cleansing contract HK\$447.38m (US\$11.5m p.a. in each of 5 years). For 16,045t of floating refuse collected in 2018, average of US\$ 716/t.	MD (2017, 2018)
	Subsidy to local government for coastal cleanup or reducing waste generation 2009-2016 program (8 years)	Marine litter and shoreline debris	Japan	Total cost of US \$451m to remove 214,711t of debris over 8 years. Cost of US \$2,102/tonne (range \$848-\$8,188/t). US\$30-90m p.a. collecting 35,000t p.a.	MOE (2018)
	Clean up under 2 nd National Marine Litter plan (2014-18). A total of 348,000t of debris removed	Marine litter – shoreline (63%) and floating (7%) and natural disaster (30%)	Korea	US\$282m spent over 5 years. Cost per tonne US\$810 (range \$733-\$1,149) across 21 programs	KOEM (2018) MOF (2018a)

Sector	Type of damage/loss	Type of debris	APEC Economy	Estimated cost	Source
Marine tourism/leisure	Annual cost of cleaning municipal beaches and waterways for New York city	Debris	US – East Coast	\$2,719,500 at a per capita cost of \$0.33	Kim et al. (2015)
	Cost of combatting litter and curtailing marine debris in Washington, Oregon and California	Litter	US – West Coast states	\$520m spent annually to combat litter and curtail marine debris. \$56,688 per city on beach and waterway clean ups	Stickel et al. (2012)
	Budget implications of marine litter for 30 Local government coastal councils	Litter and waste	Australia	Program costs were compared to leakage reduction rate. Any council that was spending more than 8% has an implied net benefit loss to members	Willis et al. (2018)
	Marine Litter leakage prevention	Macro plastic – storm water drains on Sydney beaches over various local government areas	Australia	Shows implicit cost of zoning failure due to missing knowledge of all participants and that "costs" to beach authorities can be traced back to identify risk factors for policy development, prevention measures needed and assigned to relevant authorities	Duckett and Repaci (2015)
	Examined benefits of reducing debris in six beaches near the mouth of Los Angeles River	Reduction of marine plastics from urban sources to urban beaches	US	Reducing debris by 75%, visitations to the beaches is estimated to increase 43% with a revenue of US\$53 million in benefits to communities	Leggett et al. (2014)
All sectors	Estimate of global cost of remediation over 10 years to 2030	Marine plastic debris	US/SE Asia	\$5 billion per annum \$550 per tonne of leakage prevented	Ocean Conservancy (2015)

Table 3: Examples of indirect cost impacts of marine debris in the APEC region

Sector	Type of damage/loss	Type of debris	APEC Economy	Estimated cost	Source
Fishing	Ghost net fishing losses	Ghost Net Fishing pot removals	US	Production increase by \$66m in 6 years due to derelict gear removal. (implied damage)	Bilkovic et al. (2016)
Shipping and transportation	Container spill of plastic pellets	Plastic pellets	New Zealand	MV Rena grounding with US\$600m spent on recovery	NZ History (2017)
Marine tourism/leisure	Loss of amenity to beaches and reefs	Plastics, fishing and general debris	US	US\$1-US\$28m/year	(Ofiara and Seneca 2006)
	Loss of recreational expenditure and regional economic effects	Marine debris	US (Alabama, California, Delaware, Ohio)	For Orange beach, CA. reducing MD to zero would add \$137m, while doubling MD would cost \$304m	Abt (2019) NOAA
Wildlife and Marine Ecosystem	Plastic damage of coral reefs via disease.	Plastic debris	US/Pacific Is.	The likelihood of disease increases from 4% to 89% when corals are in contact with plastic	Lamb et al. (2018)
Community	Clean Up Australia Day	Shore line and waterways, litter and marine debris	Australia	US\$26m million p.a. (Value of volunteers (1,052,536 volunteer hours at US\$23.33/hr, pro bono services (local government collection services) of \$0.75m, plus management and administration costs	Australian Senate (2016)

Old ropes and plastic waste can negatively impact the aesthetic values of the coastline and beaches for marine tourism visitors and for local residents also. Leggett et al. (2014) found that reducing marine debris by 75 percent from six beaches near the outflow of the Los Angeles River would benefit users of those beaches by \$5 per trip and increase visitation by 43 percent, for a total of \$53 million in benefits.

This loss in the amenity value of beaches for tourists, damages perceptions of resorts, and affects choice of holiday location, which brings an associated loss of revenue for the tourism industry in an area (Jang et al. 2014). The perceived loss of amenity can cause consumers to select other holiday regions, or to move to other beaches or coastal areas, with a consequent loss of tourism spending in a region (Abt 2019). The economic loss to the APEC member economy may be reduced by consumers choosing substitute sites within a region (Kirkley and McConnell 1997). However, marine debris becomes a concern for municipalities when tourists go elsewhere, representing a loss to the local economy (NRC 2009). On an international scale, tourists choose between holiday locations in different economies on available information and perceptions of aesthetic values such as a clean coast and clear seawater. Thus, marine debris can reduce tourism income in one APEC economy, with another less debris-affected economy being chosen instead (McIlgorm et al. 2008).

The importance of tourism expenditure in APEC economies (APEC 2017a) may provide the private sector with an incentive to contribute to keeping the beaches clean. Given the importance of marine tourism expenditure and industry investment to many APEC member economies, governments should recognize that beach litter and marine debris is prejudicing their marine tourism industries.

5.1.2 Remediation costs

Remedial, or remediation costs, are those associated with clean-up of marine debris and examples in the APEC region are reported in Table 2.

Remedial costs in fishing tend to focus on the costs of clean-up of derelict fishing gear and the associated benefits than can accrue from stopping ghost fishing by the lost gear (Bilkovic et al. 2016). Other studies, such as NRC (2007) indicate the cost of removing an acre of net, \$4,960 and of pot removal, \$193 each.

Shipping and transportation lead to remedial costs in dealing with wrecked and abandoned vessels of all sizes as seen in Queensland, Australia where \$6.0m was set aside by government to remove 250 wrecked or abandoned vessels (Bailey 2018). Shipping companies have had some cases of accidents where the costs of plastic nurdle spills can be substantial, such as \$1.29m for 150t in Hong Kong, China (DNEWS 2012).

The tourism industry in APEC has a GDP of \$1.278 trillion annually in 2016 (APEC 2017a), and we estimate that approximately \$400bn of this total (33%) can be considered as marine tourism. Local and municipal governments are involved in remedial clean-up of waste in many of the areas that attract tourists. Generally, municipalities can indicate remediation costs for marine debris experienced through keeping beaches clean, such as for beaches and municipal waterways in New York, which costs \$2.72million per annum (Kim et al. 2015).

All plastic in the ocean environment will be significantly more expensive to clean up than land-based plastic. The cost of collecting marine debris may exceed the revenue received from the plastic collected. Hence, high densities of plastic debris (e.g. nets, lobster or crab pots) are targeted in order to exceed the immediate costs of collection.



Marine waste gathered under “Reef Clean”, Australia.
Photo: TangaroaBlue.org



Fishing gear retrieval. Photo: NOAA

5.1.3 Indirect costs

Indirect costs are one-step removed from direct costs. They often impact in areas such as the marine environment where there are no markets, and hence any estimation of the costs of impacts requires non-market valuation techniques. Studies of indirect costs have most meaning when they are site-specific and can be related to the economic information on marine industry activities (McIlgorm 2016). The current literature has gaps and needs studies which estimate a damage function by linking levels of marine debris and damage to the marine environment. Economic costs can then be developed.

For a long time, it has been recognized that derelict fishing gear can cause entanglement with larger fauna such as seals and turtles, and damage sensitive habitats. Recently several shipping accidents have led to spills of containers full of plastic nurdles with environmental impacts. For the example, the recovery of MV Rena included estimated environmental remediation and salvage costs of \$600m (NZ History 2017).

More research is required on the damage by plastic marine debris on the environment to enable economic costs to be estimated. One recent study reports the likelihood of disease increases from 4% to 89% when corals are in contact with plastic and that structurally complex corals are eight times more likely to be affected by plastic (Lamb et al. 2018).

Other indirect costs can be to the community who will enjoy less leisure benefits and welfare when marine debris impacts leisure activities and environmental assets. Recent research in four US states (Alabama, California, Delaware, Ohio) involving non-market estimations, indicated that reducing marine debris to zero may increase added value in the economy by between \$29m-\$205m, and doubling marine debris may decrease added value by \$96m-\$304m in these regional economies annually (Abt 2019).

Discussion of costs

Any estimation of the costs associated with marine debris will inevitably reflect current waste mismanagement. The cost of inaction is the failure to take up more efficient waste management practices that will lower damage costs both now and in the future. This failure reflects that society having previously enjoyed apparently low-cost waste disposal, later finds it has high societal costs.



Harbor debris collection in Hong Kong, China.
Photo: Environment Protection Department, Hong Kong, China



Marine debris impacts animal life.
Photo: NOAA

Communities that build on poorly priced pollution will inevitably have to restructure at substantial cost. As we discuss later on in Chapter 8, within APEC this restructuring would have different degrees of economic and social pain, depending on the size and attributes of each economy.

6 THE VALUE OF THE MARINE SECTOR TO APEC ECONOMIES

The APEC region had a combined nominal Gross Domestic Product (GDP) of USD\$ 44.3 trillion in 2015, accounting for approximately 60% of the global GDP (APEC 2018).

Information gathering on the value of marine economies in APEC commenced with a 2003-04 project finding that for industrialized economies it was unusual for the marine economy to be more than 1.2%-3.6% of the APEC member economy GDP (McIlgorm 2004). However, in recent years a range of studies have indicated that the marine economy can be much larger for developing coastal and island economies, particularly in SE Asia (McIlgorm 2009; Ebarvia 2016). Much of the recently produced marine economy information has been produced by studies of “Ocean Accounts” with the contribution of Partnership for the Environmental Management of the Seas of East Asia (PEMSEA) being notable (Colgan 2016; Ebarvia 2016; Ebarvia in prep.).

These international initiatives to estimate the structure of the marine economy have shown that National Accounts systems do not readily produce GDP data for the different sectors in the marine economy. Common marine sector categories were developed by APEC (McIlgorm 2004) and are shown in Table 4, which indicates the availability of marine value information that was available to this study across APEC economies in 2015.

Table 4: Marine sectors and economic data availability for APEC member economies in 2015

#	Sector of marine economy	Australia	Brunei Darussalam*	Canada	Chile**	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico*	New Zealand	Papua New Guinea**	Peru**	Philippines	Russia**	Singapore**	Chinese Taipei**	Thailand	United States	Viet Nam	Number out of 21
i	Oil and gas (Marine minerals)	X		X	X	X	X	X	X	X	X		X		Imp	X	X		X	X	X	X	16
ii	Fisheries/Aquaculture(Living resources)	X		X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	18
iii	Shipping (Transport and shipbuilding)	X		X	X	X	X	X	X	X	X		X		Imp	X	Imp	X	X	X	X	X	16
iv	Defense/Government (Government services)																						0
v	Marine Construction (Coastal defense/restor.)	X		X		X	X	X	X	X	X					X				X	X	X	12
vi	Marine Tourism (Leisure services)	X		X	Imp	X	X	X		X	X		X	Imp	Imp	X	Imp		Imp	X	X	X	12
vii	Manufacturing (Equipment, medicines etc).	X		X		X		X	X		X												6
viii	Marine Services (Maps, survey, consulting)					X	X	X	X	X			X										6
ix	Marine Research and Education					X		X			X												3
Key	*No data available; **Limited data available																						
	Green shading = no data; Imp.-Imputed data																						
	Blue shading = sectors in MD damage estimates																						

In Table 4, the differences are evident between the availability of data in each economy and in each marine sector. For many economies, the estimates for Marine oil/gas, fisheries/aquaculture, transportation/shipping and marine tourism are available, but data on other categories are not.

Since the APEC 2003-04 project, the development of a consistent way to measure marine economies has been progressing (Kildow and McIlgorm 2010, Park and Kildow 2015, Colgan 2016, Kildow et al. 2016). In some economies, the data for marine economy sectors is not readily dis-aggregated to reveal each marine industry category as it may be held by different government departments (McIlgorm 2016). For example, are oil and gas data in national accounts from marine or land sources? The Philippines, have a marine economy satellite account, China has a National Marine Data Information Service (NMDIS) and the USA has the National Ocean Economics Program (Virola et al. 2010; Talento et al. 2015; Wang 2016; Kildow et al. 2016). There is still an international need for the on-going production of marine economy data for each APEC economy based on internationally comparable and consistent standards, such as the System for National Accounts (SNA) Colgan (2016).

Marine economic studies in the international literature were reviewed and we draw on recent project work in East Asia (PEMSEA 2018c-j; Ebarvia in prep.). APEC Fisheries Working Group focal points were asked to provide links to data in each APEC member marine economy. Table 5 reports marine economy estimates made for the APEC region in 2015.

Table 5: The APEC member economy GDP and marine economy GDP estimates in the APEC region in 2015 in USD (\$)

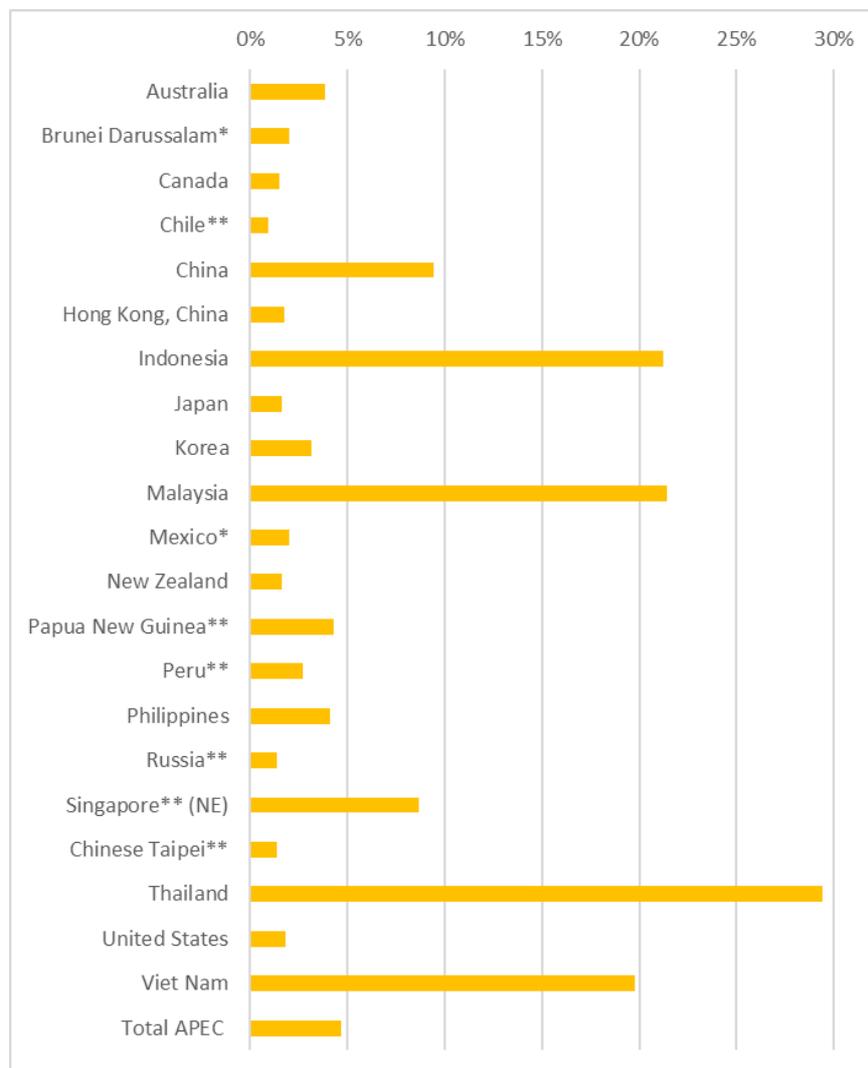
Economy	National GDP USD 2015 (APEC 2018) millions	Marine Economy GDP 2015 (USD millions)	ME as % of GDP	Reference - [qualifier]
Australia	\$1,349,034	\$ 52,095	3.9%	AIMS (2018)
Brunei Darussalam*	\$12,930	\$ 259	2.0%	*Assumed 2% of GDP
Canada	\$1,559,623	\$ 23,781	1.5%	DFO (2019)
Chile**	\$243,999	\$ 2,270	0.9%	Gov't. of Chile [M tourism data imputed]
China	\$11,064,666	\$ 1,041,758	9.4%	PEMSEA (2018b) and NMDIS (2018) [core & non-core]
Hong Kong, China	\$309,384	\$ 5,435	1.8%	AFCD (2019), THB (2018), CSD (2016)
Indonesia	\$860,854	\$ 182,540	21.2%	PEMSEA (2018c)
Japan	\$4,394,978	\$ 70,320	1.6%	1.6% in Nomura (2009); Nakahara (2009)
Korea	\$1,382,764	\$ 43,530	3.1%	PEMSEA (2018d)
Malaysia	\$296,434	\$ 63,600	21.5%	PEMSEA (2018e)
Mexico*	\$1,169,623	\$ 23,392	2.0%	*Assumed 2% of GDP
New Zealand	\$177,621	\$ 2,933	1.65%	NZ Statistics (2016)
Papua New Guinea**	\$20,639	\$ 881	4.3%	PNG Gov't [Fish sector, imputed Shipping & M tourism]
Peru**	\$189,927	\$ 5,127	2.7%	Gov't of Peru [Fish & Process., M tourism & Shipping imputed]
Philippines	\$292,774	\$ 11,910	4.1%	PEMSEA (2018f)
Russia**	\$1,368,401	\$ 18,334	1.3%	ROSSTAT(2018) [Mtourism & Shipping imputed]
Singapore** (NE)	\$304,098	\$ 26,286	8.6%	Author's estimate- Not endorsed
Chinese Taipei**	\$525,562	\$ 7,030	1.3%	C.Taipei Gov't [M tourism data imputed]
Thailand	\$401,399	\$ 118,190	29.4%	PEMSEA (2018h)
United States	\$18,120,714	\$ 327,176	1.8%	NOEP (2016)
Viet Nam	\$193,241	\$ 38,230	19.8%	PEMSEA (2018i)
Total APEC	\$44,238,665	\$ 2,065,077	4.7%	Marine Economy as % of total APEC GDP
Total World	\$74,842,734	\$3,493,685	4.7%	Pro rated estimate from APEC
Key: *Assumed 2% GDP ** Limited data available				(NE- not endorsed by member economy)

Footnote to Table 5: Some ME estimates are from specific studies and others are inferred as a proportion of the total APEC member GDP. Some studies record Gross Value Added (GVA) i.e. GDP less taxes plus subsidies (Eurostat 2019). The data records primary sector activity and only immediate secondary sector data e.g. seafood processing. Note: Imputed data should be treated with caution.

The results in Table 5 show that the total value of marine economies in the APEC region is USD \$2.06 Trillion (Trn) dollars in 2015. This represents 4.7% of the total APEC GDP. It is likely an underestimate, as not all economies can include data for the marine construction, marine services, or marine research and education sectors. Estimates do not include defense or government expenditure. By inference, assuming all other economies were similar to those in APEC, the global marine economy would have an estimated GDP of \$3.6 Trillion in 2015.

The Chinese marine economy is a large part of the APEC value (\$1.04 Trn), with the United States of America (\$0.32Trn). The marine economy GDPs expressed as a percentage of total APEC member economy GDP are reported in Figure 2.

Figure 2: Graph of the marine economy as a percentage of APEC member economy GDP



In Figure 2, many of the Asian economies are seen to have marine economies that contribute a higher percentage of GDP than in more industrial economies (McIlgorm 2009).

The marine economy data can then be disaggregated into each of the main marine sectors, such as fishing and aquaculture, shipping (transport and ship building), marine tourism and “others” (e.g. oil and gas, marine construction, manufacturing etc.), as reported in Table 6.

Table 6: The estimate of GDP by sector for each member economy in the APEC region (2015)

Economy	Marine Economy GDP (\$ 2015 (as Table 1))	Fisheries and Aquaculture	Shipping (transport and shipbuilding)	Marine Tourism (leisure services)	Other	Reference - [qualifier]
Australia	\$ 52,095,000,000	\$ 4,136,638,303	\$ 5,908,989,352	\$ 22,013,457,499	\$ 20,038,838,529	AIMS (2018)
Brunei Darussalam*	\$ 258,600,000	17,285,092	38,573,554	53,315,668	149,425,692	*Assumed 2% of GDP [<i>Imputed sector estimates</i>]
Canada	\$ 23,781,394,257	6,769,423,363	\$ 6,203,739,926	\$ 2,762,694,625	\$ 8,045,536,343	DFO (2019)
Chile**	\$ 2,270,000,000	\$ 921,000,000	\$ 316,000,000	\$ 3,224,941,200	\$ 1,033,000,000	Gov't. of Chile [<i>Imputed Marine tourism</i>]
China	\$ 1,041,758,000,000	\$ 68,490,000,000	\$ 89,540,000,000	\$ 172,630,000,000	\$ 711,098,000,000	PEMSEA (2018b) "Other" has non-core industries
Hong Kong, China	\$ 5,435,220,000	\$ 175,700,000	\$ 3,712,600,000	\$ 1,546,920,000	\$ -	AFCD (2019), THB (2018), CSD (2016)
Indonesia	\$ 182,540,000,000	\$ 14,702,520,000	\$ 2,200,000,000	\$ 19,304,040,000	\$ 146,333,440,000	PEMSEA (2018c)
Japan	\$ 70,320,000,000	\$ 4,700,261,672	\$ 10,489,142,771	\$ 14,497,903,261	\$ 40,632,693,853	1.6% in Nomura (2009) [<i>Imputed sector estimates</i>]
Korea	\$ 43,530,000,000	\$ 6,964,800,000	\$ 18,282,600,000	\$ 3,047,100,000	\$ 15,235,500,000	PEMSEA (2018d)
Malaysia	\$ 63,600,000,000	\$ 2,929,000,000	\$ 24,804,000,000	\$ 16,536,000,000	\$ 19,331,000,000	PEMSEA (2018e)
Mexico*	\$ 23,392,453,449	\$ 1,563,575,830	\$ 3,489,288,737	\$ 4,822,831,728	\$ 13,516,757,672	*Assumed 2% of GDP [<i>Imputed sector estimates</i>]
New Zealand	\$ 2,932,897,000	\$ 701,492,000	\$ 767,737,000	\$ 24,959,000	\$ 1,438,709,000	NZ Statistics (2017)
Papua New Guinea**	\$ 880,494,720	\$ 825,500,000	\$ 12,640,000	\$ 42,354,720	\$ -	Govt contact [<i>Fishing & imputed Mtourism & Shipping</i>]
Peru**	\$ 5,127,400,000	\$ 1,140,000,000	\$ 126,400,000	\$ 2,440,000,000	\$ 1,421,000,000	Gov't. Peru [<i>Imputed Shipping and other</i>]
Philippines	\$ 11,910,000,000	\$ 2,370,000,000	\$ 1,400,000,000	\$ 3,000,000,000	\$ 5,140,000,000	PEMSEA (2018f)
Russia*	\$ 18,334,000,000	\$ 3,140,000,000	\$ 2,734,754,601	\$ 3,779,928,305	\$ 5,470,000,000	ROSSTAT(2018) [<i>Imputed sector estimates</i>]
Singapore (NE)	\$ 26,285,760,603	\$ 47,060,000	\$ 21,286,860,000	\$ 4,951,840,603	\$ -	Author's estimate- Not endorsed
Chinese Taipei**	\$ 7,030,000,000	\$ 1,390,000,000	\$ 5,300,000,000	\$ 3,915,072,000	\$ 340,000,000	Gov't. of C. Taipei [<i>Imputed Marine tourism</i>]
Thailand	\$ 118,190,000,000	\$ 2,500,000,000	\$ 10,637,100,000	\$ 24,000,000,000	\$ 81,052,900,000	PEMSEA (2018h)
United States	\$ 327,176,325,000	\$ 8,117,760,000	\$ 83,507,298,000	\$ 119,244,152,000	\$ 116,307,115,000	NOEP (2016)
Viet Nam	\$ 38,230,000,000	\$ 15,292,000,000	\$ 3,823,000,000	\$ 5,352,200,000	\$ 13,762,800,000	PEMSEA (2018j)
Total APEC	\$ 2,065,077,545,029	\$ 146,894,016,260	\$ 294,580,723,942	\$ 427,189,710,608	\$ 1,200,346,716,088	Marine Economy [after imputations \$2.137tr]
Key: *Assumed 2% GDP	100%	7.1%	14.3%	20.7%	58.1%	[<i>Imputed data in italics - treat with caution</i>]
**Limited data available	(NE- not endorsed by member economy)					

The disaggregation by marine sector in Table 6 reveals that not all APEC economies are able to provide data for each sector. Estimates for fisheries and aquaculture, shipping/marine transport and marine tourism are available and form part of the marine debris damage estimation process. The other marine sectors such as oil and gas, marine construction, marine manufacturing (see Table 4), are not included in the estimation of the marine debris damage cost as explained in the next section of the report.

In some cases there are different interpretations of what is included in marine tourism, including recreation as “leisure services”. The GDP of marine tourism and recreation for 11 economies were compared with total tourism estimates (APEC 2017a) and found to be 33% of GDP for the total tourism sector. Where imputation was required, this factor was applied to the total tourism GDP.

7 COST OF MARINE DEBRIS TO APEC ECONOMIES

The direct costs of damage by marine debris are a reduction in the economic benefits that users can enjoy (McIlgorm et al. 2008). The section has two approaches to establishing the economic costs of marine debris.

The first is the extension of our 2009 approach to estimate the cost of damage to marine industries using data on the marine economy and then estimating the cost of damage to marine industries by marine debris as a fraction of marine economic activity (McIlgorm et al. 2008 and 2011).

The second is a highly aggregated benefit-cost approach that uses APEC member economy GDP (gross economic benefit), and mismanaged waste data (the cost), to compare the economic benefits that different APEC economies lever from their mismanaged waste discharges. This is a crude measure of the effectiveness of their waste management “institutional systems” and of the economic benefits accruing from their plastic waste discharges. This analysis gives longer-term direction to some of the economic development aspects of addressing marine debris control, changing it from a simple case of which economy is the producer of the largest volume or tonnage of debris, to consider the effectiveness of waste management institutions and the economic capacity available to address the pollution across the different APEC economies.

7.1 The economic costs of marine debris – the 2009 direct damage approach

Measuring the economic costs associated with marine debris can assess either the direct, remedial, or the indirect costs of damage. The 2009 report made an estimate of the direct damage to the value of marine industries in the marine economy of \$1.26bn. We have seen that the Marine Economy in APEC in 2015 has increased to an estimated value of \$2.07 trn dollars (Table 5 & 6).

The damage estimation method follows the work of Takehama (1990) who estimated that the damage to marine industries from marine debris in Japan was 0.3% of the annual gross value of the fish catch based on empirical insurance studies of the Japanese fishing and small vessel marine sector. We assumed in the 2009 study that the damage factor applies to fishery and marine sector GDP as a conservative damage factor estimate.

The Takehama (1990) study drew data from the late 1980s. Since that time, the level of global marine debris has grown substantially and has a much higher plastic composition than in the late 1980s. In the 1989 to 2015 period, the global production of plastic has increased from 100mt to 322mt (Statista 2019), a compounded annual increase rate of 4.5%. If we assume that damage is a linear function of increased plastic production¹, the damage function would have risen and is now 3.22 times Takehama’s value, i.e. 0.966%. In this study, we will assume the damage from marine debris to be 1% of the GDP of the fisheries and aquaculture, shipping

¹ Damage may be non-linear and increasing exponentially, making the linear case a conservative estimate. Further research on these damage cost-plastic production relationships is required, given the projected rise in plastic production by the year 2050.

and transportation value. Damage estimates for the marine tourism sector in recent studies have used a 2%-5% reduction in tourism revenue (Mouat, 2010; Trucost, 2016). A value of 1.5% of the marine tourism GDP was used in this study. Table 7 reports the estimates of damage to each marine economy.

Table 7: Estimates of the direct damage cost from marine debris in the fisheries and aquaculture, transport and shipping and marine tourism sectors of APEC marine economies in 2015 in USD (\$)

Economy (\$)	Fisheries and Aquaculture	Shipping (transport and shipbuilding)	Marine Tourism (leisure services)	Total damage to Economy (\$) 2015
Australia	41,366,383	59,089,894	330,201,862	430,658,139
Brunei Darussalam*	172,851	385,736	799,735	1,358,321
Canada	67,694,234	62,037,399	41,440,419	171,172,052
Chile**	9,210,000	3,160,000	48,374,118	60,744,118
China	684,900,000	895,400,000	2,589,450,000	4,169,750,000
Hong Kong, China	1,757,000	37,126,000	23,203,500	62,086,500
Indonesia	147,025,200	22,000,000	289,560,600	458,585,800
Japan	47,002,617	104,891,428	217,468,549	369,362,593
Korea	69,648,000	182,826,000	45,706,500	298,180,500
Malaysia	29,290,000	248,040,000	248,040,000	525,370,000
Mexico*	15,635,758	34,892,887	72,342,476	122,871,122
New Zealand	7,014,920	7,677,370	374,385	15,066,675
Papua New Guinea**	8,255,000	126,400	635,321	9,016,721
Peru**	11,400,000	1,264,000	36,600,000	49,264,000
Philippines	23,700,000	14,000,000	45,000,000	82,700,000
Russia*	31,400,000	27,347,546	56,698,925	115,446,471
Singapore (NE)	470,600	212,868,600	74,277,609	287,616,809
Chinese Taipei**	13,900,000	53,000,000	58,726,080	125,626,080
Thailand	25,000,000	106,371,000	360,000,000	491,371,000
United States	81,177,600	835,072,980	1,788,662,280	2,704,912,860
Viet Nam	152,920,000	38,230,000	80,283,000	271,433,000
Total APEC	1,468,940,163	2,945,807,239	6,407,845,359	10,822,592,761
Key: *Assumed 2% GDP	13.6%	27.2%	59.2%	100%
** Limited data available	<i>Note: Imputation as per previous Table</i>			

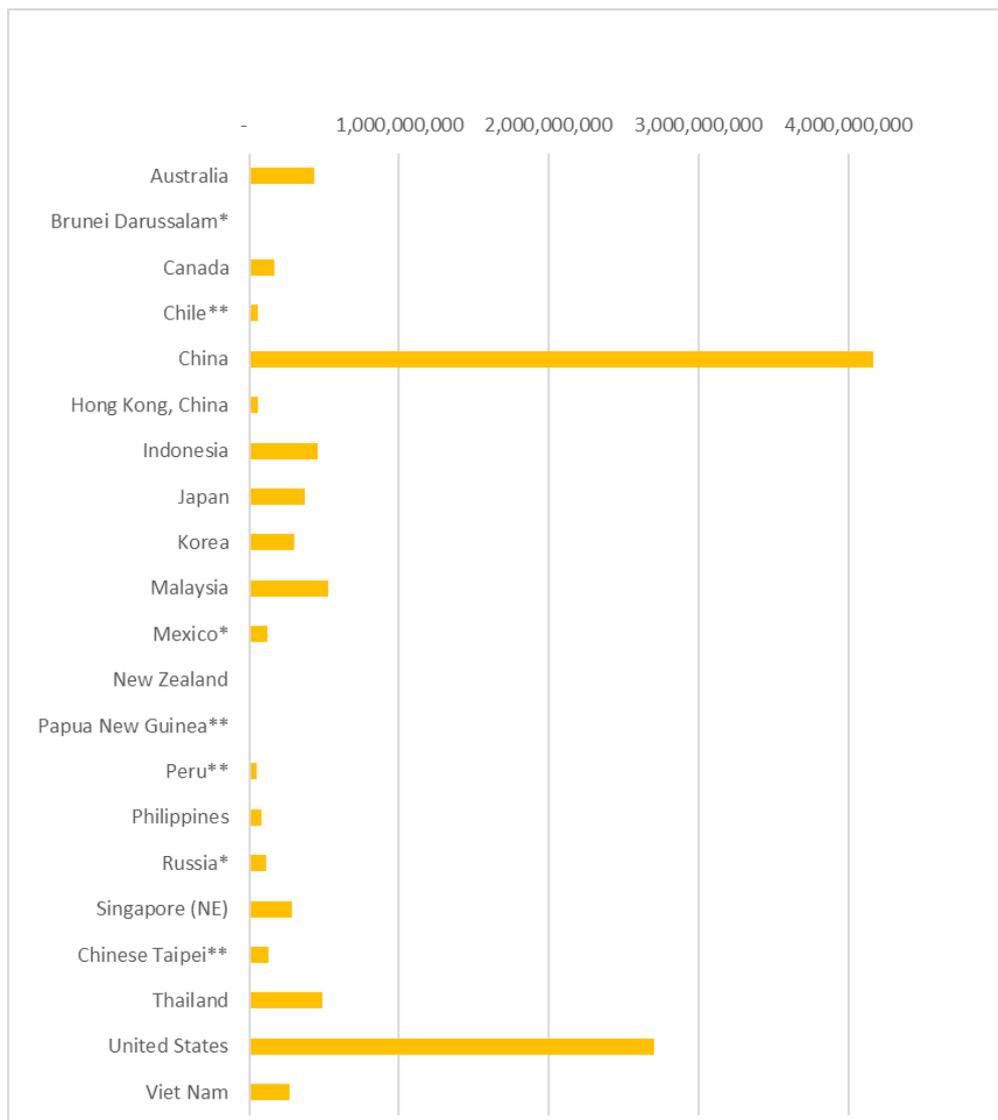
The total cost of damage to the marine economy in the APEC region in 2015 is an estimated \$10.8 billion dollars as reported in Table 7. The estimated direct cost impacts on each sector are \$1.47bn on fisheries and aquaculture (13.4% of the total damage cost), \$2.95bn (27.0%) on transport and shipbuilding and \$6.41bn (59.2%) on marine tourism.

These estimates are economic costs (lost opportunities) to these industries from marine debris damage, principally plastic. They do not include remediation, clean up, indirect damage to environment, or ecosystem value impacts. The estimates of damage to marine tourism generally reflect lost tourism expenditure and income due marine debris compromising

shorelines and beaches. The costs of remediation, such as cleaning beaches to regain visitors, are additional to this economic loss, and are not included in this damage estimate.

In Figure 3, the estimated cost of damage to fisheries and aquaculture, shipping and transportation and marine tourism are a fraction of the marine economy, and an even smaller fraction of each total economy. At present levels of debris, the present value of the damage projected to 2050 is \$216bn (assuming a 3% discount rate). Global plastic production is to triple by 2050, and will become a larger component of marine debris. Business as usual is not an appropriate or acceptable outcome.

Figure 3: The predicted cost of marine debris damage in APEC member economies in 2015



Summary

The estimates of damage costs in Figure 3 are proportional to the size of the fishing and aquaculture, shipping and transport and marine tourism sectors in each APEC member marine economy and should not be confused with waste discharge estimates. The intention of the

method is to identify the cost externalities attributable to marine debris that are being borne by these marine industries. These should be read as an “informed estimate” to enable each APEC member economy to discuss these costs internally in consultation with the respective industries. Economies need to promote measures to reduce the ingress of marine debris to watercourses and the sea, to reduce these economic losses, which are a deadweight loss across all APEC member economies.

However, not all economies in APEC are at the same level of economic capacity to take responsive measures. The larger relationship between marine debris, economic GDP and growth will be investigated next.

7.2 The economic capacity to deal with marine debris and the use of hot spots

The GDP of the APEC economies and the GDP associated with their marine economies has been estimated. In this section, we investigate the relationship between GDP and plastic waste, given that the use of plastics has been part of rapid economic growth in many APEC economies. The size of GDP will also have a bearing on the capacity of an economy to spend on remediating waste.

Relating GDP and mismanaged waste

Demographics, geographies and economic growth are the likely determinants of high levels of marine debris at the APEC member economy level. The following may need to be considered in waste and policy development within APEC:

- GDP in absolute terms;
- GDP per capita;
- Geographic topology – extensive internal waterways, island chain versus continental coasts, and length of coasts;
- The coastal population, as opposed to the total population: and
- The rate and speed of urbanization.

Economies also have differing internal institutional combinations of law, politics, and property rights schemes. There are differences between the capacities of existing infrastructures to manage waste, as well as differing economic structures (services, industrial goods production etc.) related to mismanaged plastic waste. The international plastic waste comparisons between economies are also complicated by the international trade in plastic waste in the past decade, when most of it went from developed economies to less developed economies in Asia (Financial Times 2018, Jambeck et al. 2018). The international trade in plastics is made more opaque by data not clearly evidencing the presence of plastic in many consumer goods in which it is resident (TVs, cars etc.), leading to unreconciled gaps between apparent production, consumption, recycling and disposal which one would ordinarily presume to be equal.

7.3 Hot spots

Marine debris is not distributed uniformly and higher density debris areas are referred to as “hot spots”. These hot spots can reduce the marginal costs of clean-up, reducing per unit

costs, but can produce high marginal benefits from clean up expenditure (McIlgorm et al. 2008). Hot spots can be either global, regional, national or local in nature.

In this new field where studies have been few, three recent papers have estimated the annual flow of land-based plastic contributing to global marine plastic pollution. The models use common mismanaged waste measures to estimate yearly marine plastic leakage into the marine environment:

- 4.8 to 12.7 million tonnes (Jambeck et al. 2015);
- 0.48 to 2.75 million tonnes (Schmidt et al. 2017); and
- 1.15 to 2.41 million tonnes (Lebreton et al. 2017).

The differences in estimates are that Jambeck et al. (2015) was based upon a proportional relationship between mismanaged waste, coastal proximity and population level. The model is based on aggregated World Bank data in 2010, a definition of mismanaged waste and not on observed marine debris levels. Schmidt et al. (2017) and Lebreton et al. (2017) interpreted the Jambeck et al. data set, but emphasized proximity to rivers, as opposed to coasts. Coasts and rivers are both important interfaces between land and ocean that are pathways for pollution. The papers estimated the total volume of waste, but also reveal a need to include other economic determinants of the levels of marine debris.

Demographics, geography and economic growth were also determining factors for high volumes of marine debris at APEC member economy levels. The estimated volumes of ocean leaked waste were highest in China, Indonesia, Philippines, Malaysia and Viet Nam (Jambeck et al. 2015). However, China and Viet Nam have two of the largest inland river systems in the world and have high population densities. China, Indonesia and Malaysia have had 50 years of 3.5% economic growth. Viet Nam has had 5% for the past 20 years and Philippines 5% for 2011-2016 (McKinsey 2018). These economies have been the prime movers in lifting over 850 million people out of extreme poverty in the last 25 years (World Bank 2018). The influence of these economic determinants is discussed below.

Economic data from the World Bank and estimates of the total volume of unmanaged waste as used in the Jambeck et al. (2015) paper have been added for the APEC economies. In Table 8, the data on APEC member economies are ranked in order of the total volume of plastic debris emissions per annum. The introduction of GDP indicates a link between economic output and plastic marine debris generation. For these economies 11%-15% of waste is plastic (Jambeck et al. 2015).

In Table 8 we see that the US economy in 2015 with \$16.67 trillion dollars of output in goods and services (in 2010 terms), has 112.9 million coastal citizens producing 2.58 kg of waste per citizen per day (of which 13% is plastic), but only have 0.04 to 0.11 million metric tonnes of plastic marine debris. The US has high per capita waste generation, but low marine plastic leakage indicating effective waste management systems. For every 1 kg of plastic leaked into the sea, the US economy generated over \$151,564 of GDP output.

Table 8: GDP added to waste estimates for APEC economies (adapted from Jambeck et al. 2015)

APEC Economy	China	Indonesia	Philippines	Vietnam	Thailand	Malaysia	United States
GDP (\$ trillion, 2010 Constant)	8.908	0.89	0.266	0.154	0.394	0.33	16.672
Coastal Population (m)	262.9	187.2	83.4	55.9	26	22.9	112.9
Waste Generation Rate (kg/p/day)	1.1	0.52	0.5	0.79	1.2	1.52	2.58
Mismanaged Waste (%)	76%	83%	83%	88%	75%	57%	2%
Mismanaged Plastic Waste (mt/year)	8.82	3.22	1.88	1.83	1.03	0.94	0.28
Global Mismanaged Waste (%)	27%	10%	6%	6%	3%	3%	1%
Plastic Marine Debris Output Range-Low to High (mt/year)	1.32-3.53	0.48-1.29	0.28-0.75	0.28-0.73	0.15-0.41	0.14-0.37	0.04-0.11
<i>GDP per Kg - Low estimate (\$)</i>	6,748	1,854	950	550	2,627	2,357	416,800
<i>GDP per kg -High estimate (\$)</i>	2,524	690	355	211	983	892	151,564

Other APEC member economies, such as Indonesia, generated \$890.8 billion of output in goods and services, has 187.2 million coastal citizens generating 0.52 kilograms of waste per person per day (of which 11% is composed of plastic), and yet has 0.48-1.29 million metric tonnes of plastic marine debris leakage. For every 1kg of plastic leaked into the sea there is only between \$690 to \$1,855 dollars of GDP output.

7.4 Discussion

The results in Table 8 above show that the US economy develops much more GDP per tonne of mismanaged plastic waste than Indonesia and other economies. We investigate this large scale relationship between GDP and mismanaged waste that impacts the oceans. Across the APEC member economies, there are different economic benefits being gained from marine debris emission as of 2010. For example:

- United States of America produces 1% of global mismanaged waste contribution, but contributed 25% of world economic output;
- China produces 27% of global mismanaged waste contribution, and 13% of world economic output;
- Indonesia contributed 10% of global mismanaged waste contribution, 1.1% of global GDP; and
- Viet Nam contributed 6% of global mismanaged waste contribution, but .03% of global GDP.

We see that the United States produces a high GDP, but “leaks” little mismanaged plastic waste. The US economy is large and its wealth has enabled it to develop good “institutional processes” that minimize mismanaged waste. These are regulations, waste controls at different levels of government and industry practices and include the export of waste. The challenge for the emerging economies of China, Indonesia and Viet Nam is to continue to upgrade the efficiency of their institutional processes to minimize waste mismanagement as their economies grow.

In environmental economics, the long-term relationship between increased growth in an economy and its environmental pollution is captured in the Kuznets curve (Figure 4).

Figure 4: The Kuznets curve relating environmental degradation and per capita income (Panayotou 2003)

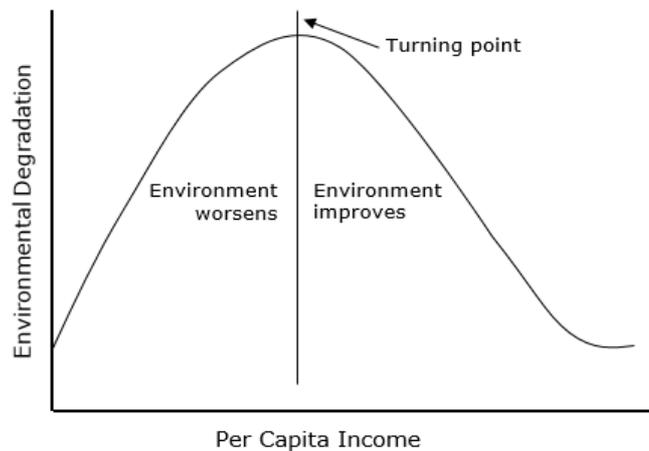


Figure 4 illustrates that when levels of GDP per capita are low, economies do not use their resources to treat waste, as they focus instead on creating GDP, hence externalizing environmental degradation. As GDP per capita grows, there is a turning point where a society becomes prosperous enough to apply its emerging economic wealth to reduce its pollution levels. Many developed economies, now on the right-hand side of the curve, went through this process during past periods of economic growth. The vertical height of the curve represents the total environmental degradation, but it varies with the institutional effectiveness of pollutant management at each level of income. For example, good management measures, such as equitable property rights or strong enforcement, can reduce the height of the curve for any economy. The preferred outcome for any economy is to have highest marginal economic benefit for each marginal unit of environmental damage (see Figure 1).

The curve is not only determined by per capita income. Policy responsiveness to growing demand for environmental quality also influences the transition to an improved environment (Panayotou 2003). High GDP economies use accumulated economic wealth to support the development of institutional processes and waste management infrastructure to deal with pollution on an on-going basis. Barnes (2019) empirically confirms the reduction in mismanaged plastic waste with increasing per capita income. However, he notes that past-published research papers help “issue awareness”.

Many of the economies within APEC are at different stages in this long-term economic growth and environmental quality relationship. This problem in plastics management can be seen in this context. The institutional arrangements for litter in any economy include capital, labor and technology, all of which are configured differently across APEC economies. These institutional aspects are presented in Table 9.

Table 9: A comparison of institutional waste aspects of economies in the APEC region

Institutional aspect	Type A	Type B
Legal	Waste regulations effective	Waste regulations, but not effective
Government waste system	High technology, high collection rate and cost	Less access to high technology or formal waste system
Private sector waste industry	Land dumping, incineration and some high-tech recycling in areas	Informal incineration, dumping and less available recycling sites.
Community involvement	Rate payers expect government to handle waste on user pays basis	Low tech community collection and sorting programs with potential for “waste startups”
Demographic	High GDP, low population density	Low GDP, high population density
Economy	Mature economic growth, high urbanization, service sector focus	Growing economies, high urbanization growth rates, production and manufacturing focus
Geographic	Large internal land mass to coast line ratio	Large internal rivers and coastlines with limited land area.

In Table 9 the conceptualized broad scale institutional aspects of waste management are contrasted between developed (Type A) and developing economies (Type B). Aspects differ significantly across capital investment in technology and labor rate fundamentals and may be thought of as a continuum. Low-income economies with high populations have less established waste systems, but waste remediation can be used to generate wages for waste pickers in poor communities. The contrast between the columns explains why Type A economies may export their waste to Type B economies. This trade can have mutual benefits if done in an orderly way, but otherwise can initiate political tensions (Financial Times, 2018).

7.5 APEC and the trade in plastic waste.

The section above has provided a background to the differences between the economies within APEC that have led to plastic waste being transported to less developed economies where wages rates are lower. In the decade prior to 2018, China was the major recipient of waste destined for recycling from many of the higher income APEC economies. The ban by China in early 2018 on importing some wastes has set in course various responses by industry and has seen low GDP per capita economies receiving waste that was formerly shipped to China (Financial Times, 2018). The correlation between destination and low labor rates occurs because waste containers require considerable low-cost labor to separate mixed waste material for recycling. The relationship between this recycling and plastic waste entering watercourses to become marine debris is poorly documented. Economies that choose to import this waste face a possible increase in their own marine debris levels.

At the center of the ban by China was the polluting mixed materials that emerged when shipped waste container contents were unloaded. This points to a need for more developed economies to improve the sorting and separation of different recyclable materials at every

level of the waste system if recycling operators, often in less developed economies with less institutional waste capacity, are to have economically viable “raw material”. Going some way to meet this need, recent amendments to the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (Basel Convention) aim to reduce the contamination levels of traded plastic wastes by requiring evidence of consent by importing economies to receiving bales of mixed waste.

In addition, a number of South East Asian economies have implemented waste import restrictions (Financial Times 2018). Further, many economies are developing circular economy strategies to encourage resource efficiency that may also affect the trade of virgin materials, secondary raw materials and recyclable waste (OECD, 2018).

The APEC member economies should monitor these waste trade policy developments. Where appropriate, domestic policies can provide for trade in secondary materials, waste and related services to promote resource efficiency and prevent mismanaged waste that may otherwise become marine debris.

7.6 Hot spots in the APEC region

In selecting hotspots for the current study, international comparisons have less significance than initiatives taken by each APEC member economy within institutional and economic conditions that influence the control of marine debris. Ultimately, each APEC member economy should estimate the marine debris waste stock in its waters, apply limits on the quantity of debris that can be added and recognize the economic costs of having excess debris levels.

Our selection of five hotspots in the APEC region that could be the focus of policy initiatives reflects the available literature on the total volume of plastic waste by member economy (Table 10). Each of these five high-volume marine debris producing APEC economies are aware of specific marine debris hot spots.

Table 10: Marine debris hot spots and remedial initiatives in the APEC region for discussion

Economy	Area/ demographics	Cities	Current initiatives
China	Three major rivers and internal water ways, Yellow sea	Inland and coastal cities	Member economy and provincial programs
Indonesia	West Java, major rivers with growth cities	Jakarta and other cities	Member economy initiative
Philippines	Islands with highly populated urban centers	Manila and other cities	Proposed Member economy program
Malaysia	Coastal cities with high growth	Kuala Lumpur and other cities	Member economy initiative
Viet Nam	Inland water ways and coastal cities with high growth	Inland and coastal cities	Member economy Maritime Strategy initiative

In each of these economies, there are waste management initiatives in place or being trialed involving technical devices to reduce litter that may be translatable to other APEC economies. The central need is to strengthen the institutional waste management systems in each economy. For less developed economies, there may be translatable institutional approaches as qualified by geographies and demographics. The GDP differences across APEC suggest that transfer payments from developed economies to less developed economies to deal with waste is one potential mechanism. Transfer through aid projects already provide some funding to achieve global environmental objectives in relation to waste management (Raubenheimer and McIlgorm 2017, 2018b).

The Stemming the Tide report (Ocean Conservancy 2015) identified 21 policies and their associated net benefits/costs (per tonne of marine plastic reduction) and implementation difficulty, as reported in Table 11.



Debris clean-up and sorting for recycling by a community NGO, Tangaroa Blue. Photo: TangaroaBlue.org



Strapping bands from shipping waste. Photo: TangaroaBlue.org

Table 11: The projected net benefits (NB) from 21 policies (Ocean Conservancy 2015)

Net Benefit	Easy – implementation	Harder: Implementation	Hardest Implementation
Positive + Net Benefit per tonne	- Some Gasification (<i>Not always</i>)	- Industry product fees - Advance disposal fees	- Littering fines - Product bans - Pay as you go taxes, Waste disposal fees
Zero NB			
Net Cost per tonne	- Some Gasification (<i>Not always</i>) - Incineration* - Recycling: Materials Recovery Facility (MRF <i>manual/mech./optical</i>) - Optimize waste hauler system - Close/cover/mine dump sites - Increased collection services - Sufficient street refuse bins - Sanitary Land fill - Waterway infrastructure	- Dump site ban (hazardous dump sites) - Container deposit schemes - Waste ex-change program - Drop-off waste centers - Low-value plastic subsidy	- Household separation bins

**this was in the original report, but has been contested by some NGOs.*

The Ocean Conservancy (2015) report identifies five policy levers that may be used in the five hot spot economies with high marine debris output, as reported in Table 12.

Table 12: Policy levers proposed for five SE Asian economies to reduce marine debris (Ocean Conservancy 2016)

Services	China	Indonesia	Philippines	Viet Nam	Thailand
Collection Services	Yes	Yes		Yes	
Close leakage points in collection system	Yes	Yes	Yes	Yes	Yes
Gasification		Yes	Yes		
Incineration*	Yes			Yes	Yes
MRF-based recycling	Yes	Yes	Yes	Yes	Yes

*Note: Incineration was in the original report, but has been contested by NGOs.

The average estimated net cost for each of the five policy levers would be \$550 per tonne of marine debris leakage reduced, envisaging a 65% reduction in waste leakage. These efforts were inter-dependent, depending on efficient collection machines, securing waste in dumps with lower leakage rates, increasing the amount dumped and diverting valuable resources. However, this automated system would perform functions traditionally done manually by the very poor who may be excluded from a future waste supply chain.

Technical solutions

There are a range of policy and technical tools that are used to control the marine debris problem. We start by examining the policy approaches and then the different types of technical solutions to prevent the ingress of marine debris to the oceans that are being applied in the economies in the APEC region.

Calls on government to address the leakage of debris into the oceans tend to under estimate the institutional vacuum in coastal environment, where government may not have a unified agency approach. Conversely, there is no natural market or supply chain in place for marine debris in the ocean commons.

The absence of established property rights, price signals or market competition reduces the options open to policy makers. The solutions require the creation of a new order of rights, responsibilities, business models and “market-like” mechanisms that would place a price on marine debris, hence giving an incentive to remove it.

Given these institutional and market misalignments, attention focuses on technical solutions that can be readily applied to address the waste as it enters waterways and oceans. The combination of sources and debris volumes makes estuaries and river exits key points for concentration of effort to control debris, before it enters the ocean.

Technical solutions are a practical and cost-effective tool to apply to “hot spots”. Over the longer term, it will take time for high-level waste policy and systems to reduce mismanaged waste.

The study has reviewed technical devices and approaches and will divide them as follows:

Technologies and Solutions

There are physical remediation technologies to address of marine plastic pollution such as Nets, Booms, Traps, Skimmers, and Filters. Other technologies can involve side scan sonar and diving and purpose designed vessels. These are described in Table 13.

There are also other technologies can be applied to different parts of the marine debris problem, for example:

- (i) End of plastic lifecycle technologies (bacteria, pressure, chemical and heat);
- (ii) Advances in technical recycling knowledge, reducing cost via waste separating technologies and catalyst advancement; and
- (iii) Information Technology:
 - Such as mobiles, personal computers and the cloud, including block chain technology;
 - Cloud and central data base create solution to information asymmetry to decrease the cost of collection, and increase the price received per unit of effort;
 - Creating a verified transaction record for individuals and income for third parties;
 - Allowing competitors to coordinate for mutual benefit (increased productivity) by creating a neutral third-party coordinator; and
 - Helping price signals amongst market participants for recyclable plastics with low diffusion costs and quick response times.

In summary, the most readily applicable measure for any APEC economy is technical litter reduction. However, these devices have capital and maintenance costs and do not directly address the systemic land and sea origins of the marine debris problem.

Table 13: As summary of technical devices for stopping the ingress of marine debris

Name of technical device	Description and operational effectiveness	Reference and Source link
Nets	<p>(i) Nets that can be set across streams and rivers/estuaries to intercept debris.</p> <p>Require regular clearing to stop litter blocking water flows, especially during peak flow events. Functional design of nets can trap aquatic life along with plastics. Lost nets could constitute a ghost fishing threat.</p>	Korea – MOF (2018 a, b) and KOEM (2018)
Booms	<p>(ii) Booms floating on the surface of rivers and estuaries to intercept and retain surface floating marine debris. Booms can also be made on a smaller scale from nets tubes and recycled plastics for small tasks (see link).</p> <p>Require regular clearing of retained litter to keep the boom effective, especially during peak flow events.</p>	<p>Korea – MOF (2018a, b) and KOEM (2018)</p> <p>https://southcoastsun.co.za/130486/recycled-plastic-boom-aid-river-litter-fight/</p>
Gross Pollutant Traps	<p>(iii) Gross pollutant traps (GPTs) are used by councils and are generally large grids that catch larger litter items flowing along waterways such as storm water drains and rivers. E.g. In San Francisco Bay GPTs capture 44% of litter.</p> <p>Liverpool Council, Sydney has 150 GPTs valued at US\$16million in capital investment, spending US\$240k on new GPT installation, not including maintenance.</p> <p>Most effective when significant proportion of marine debris in a catchment area comes from suburban streets through storm water systems.</p> <p>Only effective within its capacity range between servicing.</p>	Australian Senate (2016)
Traps for litter	<p>(iv) Wire cages or net bags, placed over water outfalls to intercept litter.</p> <p>Require scheduled clearing of trapped litter to keep operational. Can be overwhelmed by peak flow events.</p>	Korea – MOF (2018a, b) and KOEM (2018) Australia Senate (2016)

Name of technical device	Description and operational effectiveness	Reference and Source link
Skimmers	<p>(v) Floating devices than can collect and store litter. Most useful in calmer harbor settings.</p> <p>Have to be maintained to keep collecting effectively.</p>	Australian Senate (2016)
Filters	<p>(vi) Sand filters can be used to sieve out smaller plastics and micro-plastics.</p> <p>Washing Machines can have micro plastic and lint filters installed.</p>	<p>http://www.environmentalenhancements.com/index.html</p> <p>https://www.septicsafe.com/filtrol-160-lint-filter-with-1-filter-bag/</p>
Recycling ocean plastics – (boats nets and recycling)	<p>In 2017 recycled 459 tonnes of recyclable trash. 85 tonnes was ocean plastic. This cost \$120,500 in staff and plastic purchase costs from collectors. This cost about \$261 per tonne for collection, processing and disposal/selling. Plastic is sold for recycling up value chain to offset this.</p> <p>Established group of 9 women to make handicrafts from plastics. Has 100 informal waste collectors, over 3,700 Bank Sampah members (2/3 women), 40/67 Bank Sampah managers women and Misool run Sampah has 5/5 women employees.</p> <p>In 2018 – Ocean based plastics recovered was 175t.</p>	<p>Misool Foundation, West Irian, Indonesia, US AID</p> <p>https://www.misoolfoundation.org/misool-community-recycling</p>

8 MOVING FORWARD

The fundamental issue obstructing better management of marine debris is the lack of a market and price for plastic and other wastes to drive economic remediation activity. The market and price will not be generated at sea, but will come from economic systems on land. The “demanders” will be consumers wanting less plastic entering the oceans and assurances that plastic is being managed in an environmentally acceptable way. These public preferences then translate into demand for plastics as a resource for recycling.

The “suppliers” will be waste producers and handlers who collect waste to produce aggregate amounts of plastic waste that merit recovery. Not all plastic will be recycled or burnt, and burial will remain an option, but should decrease in an effective recycling market.

Connecting supply and demand will require the use of various instruments, legal, economic and social. For example, extended producer responsibility (EPR) encourages producers to align with recyclers, and for producers to incorporate these costs in their business model to make consumers pay. In many economies, the very poor in communities can become waste collectors and pickers who locate, gather and aggregate plastic to ensure supply for recycling.

A recovered plastic market needs to be profitable, but the increasing amount and low cost of virgin plastic resin subverts the formation of a recovered plastic market. Therefore, taxation of virgin plastic may be required (Raubenheimer and McIlgorm 2017).

In 2016, APEC Member Economies endorsed the document titled *Overcoming Barriers to Financing Waste Management Systems and Reducing Marine Litter: APEC Policy and Practice Recommendations*. The purpose of the document was to incentivize investment in waste management solutions in APEC economies by private investors, multilateral development banks and other sources of capital.

Methods for achieving the APEC policy and practice recommendations were further elaborated in two reports titled *Stemming the Tide* (Ocean Conservancy, 2016) and *The Next Wave. Investment Strategies for Plastic Free Seas* (Ocean Conservancy, 2017). The priority areas and solutions identified in these reports are summarized in Appendix 7.

In 2019, APEC endorsed the OFWG’s *APEC Roadmap on Marine Debris* (APEC 2019) which has the following vision.

“Recognizing the pressing need for a collective and coordinated vision and long-term strategy with high-level endorsement, the present document aims to encourage member economies to take voluntary and concrete steps while taking into account their respective internal circumstances. Recognizing further that marine debris is a global and multidisciplinary challenge, APEC will take action, based on scientific evidence and lessons learned from regional efforts, to significantly contribute to addressing this urgent issue through the following areas:

- *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;*

- *Fostering research and innovation for the development and refinement of new methodologies and solutions for monitoring, preventing, and reducing marine debris;*
- *Promoting sharing of best practices and lessons learned and enhancing cooperation; and*
- *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” (APEC 2019).*

This report aims to build on the priority actions and solutions identified by the above reports and provides economic perspectives for considering the policy interventions appropriate to APEC member economies. A list of further resources is provided in Appendix 8.

8.1 The economic approach

This report has presented the costs of marine debris to APEC economies, justifying further investments in prevention and mitigation. However, cost efficiency must be considered by governments to ensure the desired results are achieved when spending public funds.

The identification of marine debris ‘hot spots’ can assist in solutions that may achieve the most visible and impactful results. There are a range of studies in different economies where mapping of marine debris and hot spots has been used to co-ordinate clean up action (KOEM 2018; MOF 2018a and b; Willis et al. 2018).

Another approach distinguishes between “top down” and “bottom up” approaches. Efforts to reduce marine litter can be initiated by government (total economy and local) in a top-down approach, or by citizens in a bottom-up approach. Industry responds to building plastic pollution into product risk profiles.

Top-down government approaches can be implemented at total economy, provincial and local levels. To be successful at any of these levels, cooperation is needed between multiple government agencies. Inter-ministerial cooperation is therefore discussed in this report, which provides two best practice examples. The Interagency Marine Debris Coordinating Committee (IMDCC) in the United States of America has marine debris reduction as its main objective, whereas the River of Life program in Malaysia aims to accelerate economic development along a riverfront, in part by reducing pollution inputs and thereby reducing contributions to marine debris via the river.

Refer to:

- Case Study 1. Inter-ministerial Co-operation: The Interagency Marine Debris Coordinating Committee (IMDCC) of the United States (Appendix 1);
- Case Study 2: Inter-ministerial Co-operation: River of Life – the Klang Valley in Malaysia (Appendix 2); and
- APEC policy and practice recommendation 1, 4 (Appendix 6).

Bottom-up initiatives are increasingly making use of technology to facilitate and expand waste collection for recycling. In particular, mobile phone applications have proved successful in engaging communities, fostering new partnerships, creating jobs for vulnerable communities and reducing costs by eliminating the ‘middle man’. The advantage of such technologies is the ease with which they can be expanded, replicated and tailored to suite local needs. ReciclApp was developed in Chile and has expanded to Bolivia, connecting disadvantaged members of the community with recyclers and providing new or improved sources of income.

Refer to:

- Case Study 3: Female engagement: ReciclApp – Chile (Appendix 3); and
- APEC policy and practice recommendation 7, 8 (Appendix 6).

Whether a top-down or a bottom-up approach is taken, most initiatives will need to consider the economics of implementation if they are to remain feasible in the long-term. An example of the costings for plastic marine debris removal efforts through a fishing gear buy-back scheme in Indonesia is provided in Appendix 4. A litter basket that prevents debris entering waterways is costed, providing additional value as a tool for data analysis and education. Although costs will vary greatly in different contexts, these examples outline budgets for consideration by those wishing to implement similar projects.

Refer to:

- Case Study 4: Marine debris control program (removal): Economics of a community fishing gear recycling scheme, Indonesia (Appendix 4);
- Case Study 5: Marine debris control program (capture): Economics of a litter basket, Australia (Appendix 5); and
- APEC policy and practice recommendation 1, 2, 5 (Appendix 6).

8.2 Suggestions for enhancing policy levers

Economies vary in their capacity to adopt and implement measures to prevent and reduce marine debris. Measures may be mandatory, co-regulatory or voluntary. Policy levers will also depend on the actors targeted. Incentivizing activities will be shared by the actors.

Actors can be categorized into the following categories:

1. Member economies (and provincial administrative regions);
2. Producers (manufacturers and importers of plastic products);
3. Consumers (households, small businesses, public institutions);
4. Key sectors; and
5. Research institutions.

This report has not aimed to provide an exhaustive list of policy levers and activities, but rather a selection to consider. The suggested policy levers and activities also provide

opportunity for prioritizing investment in research to determine the best fit for each economy. In the context of each member economy to determine socio-economic variables as well as cost-effectiveness.

The suggested activities will assist to various degrees in achieving the *APEC Policy and practice recommendations* endorsed in 2016 by APEC member economies (APEC 2016) which were:

- #1 Set ambitious attainable targets;
- #2 Measure and reward progress;
- #3 Determine shared terms;
- #4 Streamline decision-making;
- #5 Increase funding and improve outcomes by financing all phases of integrated waste management systems;
- #6 Enable innovative, transparent funding approaches;
- #7 Reward recycling and innovative, environmentally sound waste treatment;
- #8 Incentivize entrepreneurial waste pickers;
- #9 Enforce strong environmental standards to guide innovation (APEC 2016).

These are presented in Table 14 against potential policy levers. Further suggestions are listed for consideration in Appendix 6.

The APEC Roadmap on Marine Debris (APEC 2019) proposed guidelines on:

- A. Policy development and co-operation;
- B. Capacity building;
- C. Research and innovation; and
- D. Financing and private sector engagement.

The proposed policy levers are reconciled with the APEC Roadmap Guidelines on Marine Debris and are reflected in Table 14.

Baseline information is required to progress measuring the effectiveness of policy interventions. Where information is limited, rapid assessment methodologies have been used to create baselines. These assessments can provide some level of surety that activities in the short- to medium-term are cost-effective.

The comparisons in Table 14 attempt to reconcile APEC policies and guidelines with policy levers and initiatives this report has identified based on current international approaches to addressing marine debris pollution. While recognizing the complexity in applying APEC guidelines in member economies, an obvious output from the Table is the need for each APEC member economy to strengthen legislation and engagement with the private sector and the community to gain the desired policy outcome – i.e. the reduction of marine debris to acceptable levels.

Table 14: Policy levers and activities to reduce marine debris

Actor	Policy levers and activities	Policy Practice & Recommendations (1-9) & APEC Roadmap (A-D)
Member economy and provincial administrative regions	<ol style="list-style-type: none"> 1. Establish national and local waste committees. 2. Adopt national waste policy/strategy/action plan: <ul style="list-style-type: none"> • Define roles and responsibilities. • Set timelines for deliverables. • Allocate funding. 3. Adopt legislative support for end-markets: <ul style="list-style-type: none"> • Recycled content, procurement policies, landfill fees. • Legislate requirements for council collection services, composting. 4. Adopt legislation for Extended Stakeholder and Consumer Responsibility: <ul style="list-style-type: none"> • Design EPR legislation, approve co-regulatory arrangements, ensure compliance, certify contractors, monitor outcomes. • Design consumer deposit and pay-as-you-throw legislation. 5. Adopt legislation that reduces plastic consumption: <ul style="list-style-type: none"> • Product bans. • Excessive packaging prohibitions. 6. Implement differential taxes for plastics: <ul style="list-style-type: none"> • Higher taxes for avoidable and unnecessary products and packaging. • Medium-low taxes for products that provide societal benefit and are reused or recycled. 7. Adopt environmental regulations for all sectors in lifecycle of plastics. 8. Implement economic incentives to engage private sector: <ul style="list-style-type: none"> • Tax rebates/reductions for back loading and reverse logistics to reduce costs of waste transportation, particularly in rural and remote areas. 	<p>4; A</p> <p>1, 2; A,D</p> <p>2, 7, 8; A,D</p> <p>5, 6; A,D</p> <p>1, 2; A,D</p> <p>1, 2, 7; A,D</p> <p>9; A,C,D</p> <p>1, 7; A,D</p>
Producer	<ol style="list-style-type: none"> 1. Design and manage EPR schemes in compliance with legislation: <ul style="list-style-type: none"> • Awareness raising (impacts, sorting, how-to-recycle, collection points). 2. Product design: <ul style="list-style-type: none"> • Reduce material used. • Design for recycling. • Reduce/eliminate associated additives and substances of concern. 3. Waste reduction: <ul style="list-style-type: none"> • Reduce pre-consumer waste generation. 	<p>5, 6, 7; A,D</p> <p>3, 7; A,B,C,D</p> <p>1, 2; A,C,D</p>

Actor	Policy levers and activities	Policy Practice & Recommendations (1-9) & APEC Roadmap (A-D)
	<ul style="list-style-type: none"> • Reduce post-consumer waste through recycled content targets. • Reduce packaging. • Product take-back schemes for recycling. <p>4. Labelling to encourage sorting for recycling and inform consumers of recyclability of products and packaging.</p> <p>5. Operationalize reverse logistics for products placed on markets and back loading opportunities for other wastes.</p> <p>6. Research effective end-of-life treatment of products placed on markets, particularly in context of destination market capacity.</p>	<p>3, 7; A,B,D</p> <p>5, 6, 7; A,D</p> <p>3, 8, 9; C,D</p>
Consumer	<p>1. Behavior change:</p> <ul style="list-style-type: none"> • Product choices. • Anti-littering. • Sorting wet, dry and recyclable wastes (refer to Ocean Conservancy (2017), Next Wave report). <p>2. Participate in pay-as-you-throw schemes.</p> <p>3. Pay and recover deposits for returnable items.</p> <p>4. Transport to collection (drop-off points).</p> <p>5. Political engagement: lobby policymakers and local council members.</p>	<p>2, 8; A,B,C</p> <p>2, 5, 6; A,B,D</p> <p>2, 5, 6; A,B,D</p> <p>2, 5, 6; A,B,D</p> <p>9; A,B,D</p>
Key sector engagement (contributor and recipient)	<p>1. Work with sectors to design and implement standards, guidelines and regulations, e.g.</p> <ul style="list-style-type: none"> • Packaging (manufacturers, retailers). • Retail outlets. • Tourism. • Construction and demolition. • Transportation, including shipping (IMO). • Fisheries and aquaculture (FAO) • Agriculture. 	<p>1, 2, 3, 7, 9; A,B,C,D</p>
Investment in Research	<p>1. Decoupling plastic production from fossil fuels (including removing subsidies for fossil fuels).</p> <p>2. Depolymerization, chemical recycling.</p> <p>3. Policy interventions – economic incentives and policy readiness.</p> <p>4. Socio-economic impacts of marine debris, benefits of preventive and cleanup activities.</p> <p>5. Economic incentives for back loading and reverse logistics to reduce costs of transporting waste.</p>	<p>1, 7; A,B,C,D</p> <p>5, 7, 9; A,C,D</p> <p>5,6,7,8; A,C,D</p> <p>8; C</p> <p>1, 7; A,C,D</p>

9 CONCLUSIONS

The economic costs of marine debris damage to industries in the APEC region is estimated to be US\$10.8bn per annum and business as usual to 2050, has an estimate present value of \$216bn. Given plastic production will treble by 2050, business as usual is not acceptable, as plastic is predicted to form an increasing proportion of marine debris.

The international governance of marine waste has many gaps. The ocean is a victim of the failure of land waste management. Future policy needs to address waste mismanagement on land and reduce marine debris from sea-based sources.

The void between institutions that manage land-based sources versus sea-based sources will take time and commitment to fill. In the interim, the use of technical devices to contain debris before it reaches the ocean is a key intercept point that APEC economies can use. However, this stopgap solution is less effective than modifying waste systems on land to prevent debris and litter.

Waste remediation clean-up costs borne local government seem inevitable, diverting funds that could be employed to fix the land waste mismanagement issue. In this situation, the role of government is to apply coercive power for improving domestic waste government arrangements, coordinating departmental approaches to this issue, or establishing one agency to have an economy wide respected mandate to coordinate them. Information systems, such as databases on marine debris hot spots and mapping of sources and pathways are required to support communication, coordination and decision tools by the many parts of government at different levels.

The private sector needs to be included more broadly in extended producer responsibility programs particularly to provide funds to help cover the costs of improved waste practices and disposal, as well as the design of products placed on the market. APEC member economy governments should create an enabling environment for this, through regulations as appropriate.

The report has indicated that the GDP within APEC developing economies have successfully raised many citizens out of poverty through rapid economic growth and are increasingly likely to invest in waste treatment for an improved environment for their citizens. Given the disparities in per capita GDP levels across APEC, transfer of technical, regulatory and economic assistance can assist these less developed economies and the trade in waste should be monitored within the APEC region.

It is important that market forces be harnessed to address the marine debris price vacuum. To enable this, APEC has to create an enabling environment for plastic recycling and this may require policy instruments to create increased demand for recycled plastics. “Bottom up” waste enterprises can deliver benefits to many poor and socially marginalized groups.

10 RECOMMENDATIONS

The following recommendations are made to provide towards a harmonized approach by APEC member economies to prevent marine debris in the region through:

- 1) Providing an **enabling environment**;
- 2) Improving knowledge of the **economic impacts** of marine debris;
- 3) Using this knowledge to inform **risk and damage costs** to marine industries; and
- 4) Translating the resulting economic factors into **effective long-term policy**.

By relating data to economic value, and context-appropriate policy interventions, economies can build robust waste management systems that autonomously deal with the lifecycle of plastics to prevent marine debris.

Table 15: Recommendations for reducing marine debris in the APEC region

CREATE AN ENABLING ENVIRONMENT	Recommendation 1 Given that most marine debris is from land sources, a high level APEC response is needed to address land-based waste management practices across APEC economies, hence reducing mismanaged waste, marine debris and its economic impacts.
	Recommendation 2 Encourage cleaner production of plastics and related resource efficiency, facilitating policies and frameworks with the private sector that will increase investment in plastic recycling and waste collection.
IMPROVE UNDERSTANDING OF ECONOMIC RISKS TO MARINE INDUSTRIES AND ASSETS	Recommendation 3 Given the projected damage costs to marine industries by 2050, APEC needs to recognize the GDP impacts of mismanaged waste and prioritize the reduction of these costs. This includes further research into the total expenditure on marine debris remediation costs by APEC economies and the estimation of the damage to the marine environment by marine debris.
	Recommendation 4 APEC OFWG promote improved measurement of the value of the marine economy through harmonized national accounting standards. APEC OFWG can monitor the UN ESCAP ² developments in Ocean Accounting.

² www.unescap.org - Global Ocean Accounts Partnership (GOAP)

	<p>Recommendation 5 Recognize marine debris as a risk to marine economies, particularly to coastal tourism and fishing (from micro plastics in particular). Research can further assess the costs and benefits of controlling marine debris at the member economy level.</p>
	<p>Recommendation 6 Each APEC economy should estimate the quantity of marine debris entering the marine environment from land and sea, to monitor and control MD stock levels. Global assessment methodologies³, including rapid assessment, can standardize data and assist in spatial identification of hotspots.</p>
<p>IMPROVE KNOWLEDGE</p>	<p>Recommendation 7 Identify the pathways that enable marine debris to enter the oceans, with a focus on marine sectoral contributions and impacts, e.g. coastal tourism, fisheries.</p>
	<p>Recommendation 8 There is a need to improve and standardize reporting on the production, consumption, treatment and trade of plastics and plastic waste in the APEC region.</p>
<p>INSTITUTIONAL AND POLICY INFRASTRUCTURE</p>	<p>Recommendation 9 Assess institutional arrangements, particularly inter-governmental cooperation and involvement of the private sector, in each member economy to develop more effective and holistic policy interventions to prevent marine debris, including policy that promotes the supply (volume and quality), demand and, where appropriate, the trade of recyclable plastics, and informed by the knowledge gained through implementing Recommendations 1-5. Consider assistance to low GDP per capita economies to improve institutional and policy frameworks for waste management.</p>
	<p>Recommendation 10 Assess the contribution of existing trade agreements and other relevant international agreements to regulate the trade of plastic products and waste to improve resource recovery in all APEC member economies.</p>

³ GESAMP 2016

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12 APPENDICES

12.1 Appendix 1. Case Study 1. Inter-ministerial Co-operation: The Interagency Marine Debris Coordinating Committee (IMDCC) of the United States

12.1.1 Introduction

Various components of marine litter prevention, mitigation and removal can fall under the mandate of a number of government agencies. Good practice in the governance of the issue therefore relates to the facilitation of these agencies in enacting their roles and responsibilities towards minimizing the impacts of marine debris to the environment and to society in a cost-effective manner.

In the United States, the National Oceanic and Atmospheric Administration (NOAA) is the primary agency within the US Government tasked with addressing the issue of debris found in both inland (Great Lakes) and the marine environment. The agency was established in 2006 through the *U.S. Marine Debris Research, Prevention and Reduction Act (2006)*. The Act was superseded by the *Save our Seas Act*, which reauthorized the NOAA Marine Debris Program⁴ in both 2012 and 2018. The latter assigned \$10 million per year to the program, through to 2022.

In addition to establishing NOAA, the initial Act of 2006 also stipulated the establishment of a single national marine debris committee, leading to the formation of the **Interagency Marine Debris Coordinating Committee (IMDCC)** in 2006.⁵

12.1.2 The Interagency Marine Debris Coordinating Committee (IMDCC)

Inter-ministerial coordination is exemplified in the IMDCC. As the committee states, its mandate is to share information, assess and implement best management practices, coordinate interagency responses to marine debris, including severe events, as well as coordinate research priorities, monitoring techniques, educational programs and even regulatory measures. In addition to this coordination at the Federal agency level, the IMDCC also acts internationally on priorities and strategies for all aspects of marine debris.

The IMDCC reports to the US Congress every two years and participation by various government agencies is legislated, thus guaranteeing the relevant government agencies that have the mandate to manage the different components of marine debris are present at meetings. Inter-ministerial cooperation is therefore ensured as a key element in making progress on the issue.

⁴ <https://marinedebris.noaa.gov/>

⁵ <https://marinedebris.noaa.gov/IMDCC>

The IMDCC is made up of the following Federal agencies:

1. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) – **Chair**
2. United States Environmental Protection Agency (EPA) – **Vice-Chair**
3. Department of Defense, United States Army Corps of Engineers (USACE)
4. Department of Defense, United States Navy (Navy)
5. Department of Homeland Security, United States Coast Guard (USCG)
6. Department of the Interior, Bureau of Safety and Environmental Enforcement (BSEE)
7. Department of the Interior, National Park Service (NPS)
8. Department of the Interior, United States Fish and Wildlife Service (USFWS)
9. Department of Justice, Environment and Natural Resources Division (DOJ)
10. Department of State, Office of Ocean and Polar Affairs (DOS) and
11. Marine Mammal Commission (MMC)⁶.

12.1.3 Recent amendments to the Save Our Seas Act

The Save Our Seas Act was amended to provide for the following:

- Require the National Oceanic and Atmospheric Administration (NOAA) to work with:
 - Other agencies to address both land- and sea-based sources of marine debris; and
 - The Department of State and other agencies to promote **international action** to reduce the incidence of marine debris.
- Allow NOAA to provide funding to assist in clean-up and other responses post **‘severe marine debris events.’**
- Expand the IMDCC to include a senior official from the State Department and from the Department of the Interior.

In addition, the US President was urged to:

- Work with foreign economies that contribute the most to the global marine debris problem in order to find a solution to the problem;
- Study issues related to marine debris, including the economic impacts of marine debris; and
- Encourage consideration of the impact of marine debris in relevant future trade agreements.⁷

12.1.4 Reporting

The 2006 Marine Debris Act required reporting on the following:

- A summary of the marine debris inventory to be maintained by NOAA;
- A review of the NOAA Marine Debris Program (MDP), including projects funded and accomplishments relating to reduction and prevention of marine debris;
- A review of the US Coast Guard program and accomplishments relating to marine debris removal, including enforcement and compliance with MARPOL requirements; and
- Estimated Federal and non-Federal funding provided for marine debris.

⁶ 2016-2017 Interagency Marine Debris Coordinating Committee Biennial Report, available at <https://marinedebris.noaa.gov/IMDCC>

⁷ <https://www.congress.gov/bill/115th-congress/senate-bill/756>

In 2008 a report was produced titled “*Interagency Report on Marine Debris Sources, Impacts, Strategies, and Recommendations*”. In this report, 25 recommendations were grouped into eight focus areas, namely:

- Education and Outreach;
- Legislation/Regulation/Policy;
- Incentive Programs;
- Enforcement;
- Cleanups, Research;
- Technology Development; and
- Fostering Coordination.

The IMDCC biennial report to Congress outlines the recommendations of the 2008 report under each focus area. A summary is then provided on progress made by the individual IMDCC ministerial agencies for each focus area since the previous report to Congress. The 2017 IMDCC report noted work on evaluating the economic costs of marine debris within the US, emergency response planning for extreme marine debris events and potential marine debris impacts of opening arctic shipping routes. This was in addition to the overall focus on coordination of efforts to prevent marine debris, research and monitoring, as well as removal, while expanding efforts to engage at the international level.

12.2 Appendix 2. Case Study 2. Inter-ministerial Co-operation: River of Life – the Klang Valley in Malaysia

The Klang River in Malaysia is 30km from the coastline and has 11 major tributaries, flowing into the Straits of Malacca. The river is 120km long and flows through the heavily populated Klang Valley, receiving pollutants from various sources, such as wet markets, landfills and municipal sewers, amongst others. In addition, rapid economic growth has seen an increase in urbanization and the development of commercial and industrial centers. An estimated 80 tonnes of solid wastes is discharged from the Klang Valley in this river daily, some originating from squatters settled along the river dumping items. The valley itself has a population of over 4 million people and the river flows through the densely populated Kuala Lumpur, the capital city of Malaysia.

12.2.1 River of Life

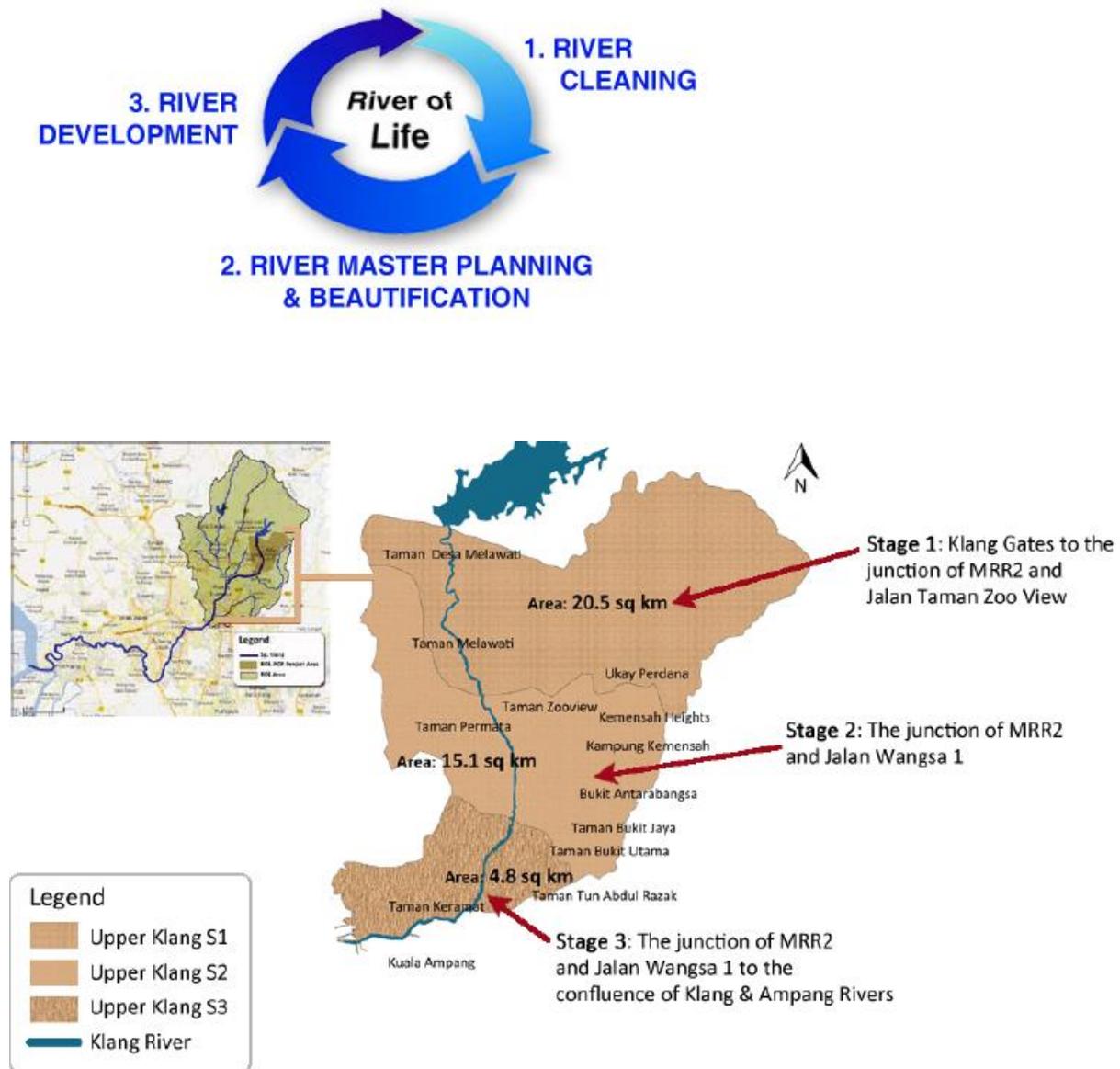
The River of Life project is a seven-year project, launched in 2012 and provides an example of upstream activities in a river catchment that result in reduced flow of marine debris to the ocean. The project forms part of the Economic Transformation Program, an initiative of the Malaysian government to stimulate economic activity in the area. The project was therefore not initiated with the specific objective of reducing marine debris, but illustrates the integrated nature of the problem. The US\$1.3billion project⁸ includes three components managed by different government agencies. These are:

1. River Cleaning – led by the Department of Irrigation and Drainage (DID) Malaysia;
2. River Beautification – led by the Kuala Lumpur City Hall (DBKL); and
3. Commercialization and Tourism – led by the Ministry of Territories (KWP).⁹

⁸ <https://www.aecom.com/projects/river-life-klang-river-malaysia/>

⁹ <http://www.klriver.org/index.cfm?&menuid=8>

Figure 5: The River of Life project area¹⁰



As part of the River Cleaning phase, 110km of the Klang River basin was cleaned, aiming to raise the water quality of the river from Class III/IV (not suitable for recreational use or harmful for body contact) to Class IIB (suitable for recreational use/not dangerous for body contact) by 2020. In addition, it was hoped the cleaned environment would dissuade dumping of garbage into the river.¹¹

¹⁰ <http://www.klriver.org/index.cfm?&menuid=4>

¹¹ Market Based Instruments Practices for Pollution Control in Malaysia: River of Life Project. www.asa.gov.eg/attach/261_wg16_mbi%20-%20malaysia.pdf

Under the River Cleaning component of the River of Life project, 12 key initiatives were implemented. These are:

1. **Sewerage Services Department** – Upgrade existing sewerage facilities as it is the most impactful and important initiative to reduce Klang river pollution.
2. **Sewerage Services Department** – Expand existing regional sewage treatment plants to cater for future growth.
3. **Kuala Lumpur City Hall** – Install wastewater treatment plants at five wet markets to reduce rubbish and pollutants.
4. **Department of Irrigation and Drainage Selangor and Kuala Lumpur City Hall** – Install additional gross pollutant traps to improve the river aesthetics and water quality.
5. **Department of Irrigation and Drainage Kuala Lumpur** – Utilise retention pond to remove pollutants from sewage and sullage.
6. **Selangor Chief Minister's Office/Ampang Jaya Municipal Office (MPAJ)** – Relocation of squatters to reduce sewage, sullage, and rubbish in the Klang River.
7. **Department of Irrigation and Drainage** – Implement the Drainage and Stormwater Management Master Plan to upgrade drainage systems.
8. **Department of Irrigation and Drainage** – Conduct hydrological study and rehabilitation of the river for flow control.
9. **Department of Irrigation and Drainage** – Promote, enforce, and manage river cleanliness and health – erosion from urban development.
10. **Department of Housing and Local Government** – Promote, enforce, and manage river cleanliness and health – restaurants, workshops, and other commercial outlets.
11. **Department of Environment** – Promote, enforce, and manage river cleanliness and health – industries that generate wastewater/ effluent.
12. **National Solid Waste Management Department** – Promote, enforce, and manage river cleanliness – general rubbish disposal.¹²

Efforts by the Department of Environment under the River of Life project are coordinated by the Water and Marine Division. As per initiative 10 above, the Division ensures compliance to the Environmental Quality Act, 1974, but also monitors 35 stations to report on the quality status of the river in order to track progress towards the 2020 target.¹³

12.2.2 Community engagement

As part of the River Cleaning Component, the River of Life Public Outreach Program (ROLPOP) developed a 'Citizen's Eye' application that enables public reporting of any issues relating to river management, including pollution. The objective is to reduce pollution by fostering behavior change through awareness and ownership of the area.¹⁴

¹² <https://www.doe.gov.my/portalv1/wp-content/uploads/2018/09/iv-River-Of-Life-Eng.pdf>

¹³ <https://www.doe.gov.my/portalv1/wp-content/uploads/2018/09/iv-River-Of-Life-Eng.pdf>

¹⁴ <http://www.klriver.org/index.cfm?&menuid=8>

Klang is also one of the locations across Malaysia that participates in the Ocean Conservancy's International Coastal Cleanup activities¹⁵ and local participants also took part in a 'World Oceans Day: Coastal cleanup in South Port Klang from Plastic Pollution.'¹⁶

In addition to the general public, the River Cleaning component also aimed to engage educational institutions, local communities, food establishments (hawkers, wet markets and workshops), as well as industries, corporations and developers, on the issues of solid waste management, sewage wastewater discharges and construction waste.

12.2.3 In the top ten waterfronts

As a result of the efforts and cooperation by the Malaysian government agencies, Kuala Lumpur's River of Life was voted in the world's top ten waterfronts to visit by the United Kingdom's Independent news portal.¹⁷

12.3 Appendix 3. Case Study 3. Female engagement: ReciclApp – Chile

12.3.1 Introduction

An estimated 2 billion people do not have access to adequate waste collection facilities. This commonly impacts vulnerable communities, who are left with limited solutions beyond dumping, incineration and burying their waste. In the Latin America and Caribbean region, municipal solid waste management has not kept pace with the rapid economic growth experienced in recent years. As a result, informal waste recyclers collect much of this waste and efforts have been made to integrate this sector in formal waste management systems.¹⁸ By doing this, information can be gathered on the amount of waste recovered by the informal sector.¹⁹

Mobile applications are being used in a number of contexts to facilitate connectivity between diffuse sources of waste and local solutions. These dispersed small-scale systems allow disadvantaged communities, often women, to enter the workforce or increase their earning capacity. International examples include Gringgo, in Bali, providing opportunity to some of Indonesia's most disadvantaged communities by putting waste collectors in direct contact with recyclers. Although not servicing a disadvantaged community, ShareWaste in Australia diverts organic waste from landfill by connecting residents with household composters, providing another example that could be replicated across communities globally.

¹⁵ <https://reefcheck.org/reef-news/reef-check-malaysia-participates-in-nationwide-coastal-clean-up>

¹⁶ <https://www.worldoceansday.org/events-2018/world-oceans-day-coastal-cleanup-in-south-port-klang-from-plastic-pollution>

¹⁷ <https://www.nst.com.my/news/nation/2019/01/448345/life-good-kls-river-life-makes-list-worlds-10-best-waterfront-districts>

¹⁸ Zohoori, M. and A. Ghani. Municipal solid waste management challenges and problems for cities in low-income and developing countries. *Int. J. Sci. Eng. Appl.* 2017

¹⁹ Ailyn Rojas C., et al, 2018, The Potential Benefits of Introducing Informal Recyclers and OrganicWaste Recovery to a Current Waste Management System: The Case Study of Santiago de Chile. *Resources* 2018, 7, 18. doi:10.3390/resources7010018

12.3.2 About ReciclApp

ReciclApp²⁰ is a social enterprise started by a group of engineering students, lead by Cristián Lara, from innovation center at the Catholic University in Santiago. The team developed a phone application that allows local authorities, individuals, businesses and public institutions to connect directly with waste collectors, removing the middle-tier transporters.

The mobile application is available at no charge and can be downloaded from App Store or Play Store. After adding their location to their account, users upload the amount of material they have available for collection by type (glass, cans, plastic, paper or cardboard). This information allows recycling companies to plan efficient pickup routes that are printed out for the collectors, who then make the rounds to the advertised locations at the times allocated and designate a convenient time for pickup.

The effort of the collectors is reduced and they can be sure a guaranteed volume of recyclables is available. This material is then delivered to the recycling company or designated drop-off facilities where it can be stored for collection by trucks owned by recycling companies.



ReciclApp available for free download

12.3.3 How the community benefits

Residents generate waste and by participating in the scheme can accumulate points that can then be exchanged for discounts and products in the program's incentive scheme.

Waste collectors are connected with a guaranteed source of sorted waste. This resource is then sold on to recyclers and collectors retain all payment for the waste they deliver. In many cases, waste collectors have more than doubled their income. Many recyclers also approached households by foot in the hope there would be recyclable material available.

²⁰ <http://reciclapp.cl/>

Within the first year of operation, ReciclApp was facilitating approximately 200 collections by 1,000 participants throughout Chile. Waste collectors have increased their income from an estimated US\$100 per month to US\$250 per month.



Marcela Puchi Fuentes collecting waste in Chile²¹

Many of the waste collectors employed are women. They have reported improved income as well as being socially accepted within the communities they service. Their sense of pride and well-being has improved significantly. Where previously they felt inferior picking through household waste and begging for donations, they are no longer feel ashamed to provide a service now recognized as valuable to the community and the environment.²²

12.3.4 Future developments

Local councils are now paying ReciclApp US\$1,200 to operate in their municipalities and peri-urban regions in recognition of the savings to their waste management budgets. The management team are hoping to employ waste collectors directly on a monthly salary with guaranteed daily schedules and incentive-based schemes to further improve the stability of their livelihoods. These incentives may be based on volumes collected and number of households and business serviced. ReciclApp is now operating in Bolivia and intends to expand into Mexico.

²¹ https://motherboard.vice.com/en_us/article/jpaqn8/chiles-uber-of-recycling-is-sparking-a-recycling-revolution

²² https://www.vice.com/en_us/article/jpaqn8/chiles-uber-of-recycling-is-sparking-a-recycling-revolution

12.4 Appendix 4. Case Study 4. Marine debris control program (removal): Economics of a community fishing gear recycling scheme, Indonesia

12.4.1 Introduction

There were no net recycling programs in Indonesia before the initiation of the TierraMar – Yayasan ATSEF Lestari project established in Merauke. Merauke is a large town in Papua, Indonesia with a long history of gillnet fishing.

As a result of poor management of end-of-life gear, many monofilament nets have accumulated along the banks of the Maro River and in many other areas within the region. After consultation with fishers in the region, it was agreed to establish a waste-net recycling program based on the Net-Works programs operating in the Philippines and Cameroon since 2012. These consultations with the fishing community led to some tailoring of the Net-Works program to local requirements.

With over 10 tonnes of waste fishing nets collected, cleaned and sold, the project has provided a significant increase in income for participants in Merauke. The initial one-year feasibility project was completed in December 2018 and part of the broader SeaNet Indonesia project funded by the Australian Government and run by TierraMar and the Coral Triangle Centre. The project has since received funding to continue for a second year into 2019, as well as expand it and include other plastics. The second year is funded by World Animal Protection and run by TierraMar with ATSEF as the on-ground partner to facilitate implementation. The intention is for the project to become self-funding.

The project has not only benefited the community financially through creation of alternate livelihoods and access to microfinancing, but an area that was no longer fished due to the hazards presented by these waste-nets is now safe for the community to fish again.

12.4.1.1 About Net-Works

Net-Works is a model that provides a partnership between Interface and the Zoological Society of London that promotes the collection of end-of-life and discarded fishing nets by coastal communities. Participation is incentivized through the sale of the cleaned and baled nets for recycling into yarn by Aquafil, Slovenia. This yarn is then used in the manufacture of carpet tiles by Interface.

12.4.1.2 Collection, cleaning and baling

Prior to the initiation of this project, end-of-life fishing nets presented no value to fishers. Nets are now collected by fishers and the community and brought to collection points.

The community has established a formal group to undertake cleaning activities, promoting the inclusion of women. Nets are cleaned to Aquafil specifications. Equipment for cleaning operations was provided by the program support team (see costs below).



Women sorting nets

12.4.1.3 Community benefits through waste banks

Money received from the sale of baled nets is deposited in a community bank established under the TierraMar – ATSEF Lestari program, providing some of the poorest communities with convenient and localized opportunities for savings and access to loans. Many of the community bank members are women. In addition, environment funds have commonly been established by the community banks to support local conservation projects.

The project in Merauke aimed to establish a Village Savings and Loan Association as per the Net-Works model used in existing projects. It was decided with the Merauke community to make use of an existing micro-finance institution, Baitul Maal Wat Tamwil (BMT), which operates on a profit-sharing basis and has a history in the community of growing micro and small businesses.

Three community groups participated in the initial program, electing to operate from a single community account. The intention of these community groups is to split the account into three to allow each to control the income and expenditure for their particular communities. Currently, the funds collected by the community from the sale of the cleaned nets are deposited in an account held at BMT. These funds are then used by the community for individual micro-loans or collective projects. This differs from the community banking system used in existing Net-Works projects in the Philippines and Cameroon, which did not suit local conditions.

12.4.2 Figures and economics

A business model was proposed by SeaNet Indonesia that outlined fixed costs, operational costs and expected revenue. The intention is to wean the project into a self-funding model within each community. Additional funding has been sought to assist in the second year, but this includes scoping of other communities and the feasibility of including other plastic waste into the current model.

The **fixed costs** were funded through the Australian Government Department of Environment and Energy through its Coral Triangle Support Program as part of the larger project to promote sustainable fishing practices in pilot communities. The funding of AUD30,000

covered the initial setup costs that include community assessments, support for establishing end-markets, mapping logistical requirements, negotiating contracts and community training on various financial, logistical and administrative aspects of the project.

The goal was to provide a self-funding model to cover the **operational costs**, which is dependent on revenue received from Aquafil for the waste nets. These costs include the ongoing costs of collection, cleaning, shipping and general administrative costs. During the first year, the services of a third-party local baler were used to reduce training requirements. The current cost of baling is IDR 1,000,000 (~AUD100) per tonne of net. However, the monofilament nets have presented problems with the equipment. As a result, a hydraulic baling machine was purchased in 2019 using profits from the scheme. In addition, domestic net recyclers are being investigated to reduce the significant international shipping costs and provide greater benefits to the community.

As the project progressed, international shipping costs that were initially covered by Interface were transferred to the community project, but incorporated in the buying price. This has shifted the risk from Interface to the community. These costs are significant and a potential barrier to the ongoing success of the project should costs escalate. As a result, alternate local recyclers are being identified.

To determine **revenue potential**, an assessment of the expected weight of monofilament gillnets in use was made at the initiation of the project. This was based on the history of gillnet fishing in the area, the average number and weight of gillnets per vessel, fishing intensity per boat and the frequency of maintenance or replacement of nets.

An estimated forecast of possible gillnets available for collection was based on the sale of these nets from local stores. This amounted to more than 15 tonnes per year.

Estimation for annual use of gillnets in Merauke:

20 fishing groups x 100 nets per year x 7.5kg per net = 15,000kg per year.

Note: These were end of life nets and did not include the significant numbers of nets already discarded along the banks of the rivers and port areas.

Calculations projected 50 tonnes of nets available for collection over a 5-year period. This calculation did not include the approximately 150 small-scale gillnet boats. Recent regulatory changes are expected to result in fleet increases, adding to the expected sales of monofilament gillnets in the area.



Cooperative officer weighing nets

12.4.2.1 Fixed costs

The fixed costs covered by the AUD30,000 grant are broken down as follows:

Initial assessment

Identifying a potential community group and market for waste-nets and undertaking a brief assessment on the feasibility of a community cooperative:

1. Identify willing participants for the program (60% female participation achieved);
2. Conduct a market study for waste-nets in Merauke and Surabaya;
3. Establish a community saving and loan cooperative or possibility of a hybrid using existing mechanisms; and
4. Provide field officer to coordinate the collection and recycling program in Merauke.

TOTAL: AUD 14,105

Support – Initial setup

Support the community group and cooperative's capacity to manage waste fishing net market in Merauke through training and mentoring:

1. Conduct a workshop on management of the cooperative;
2. Conduct training on the handling of waste fishing nets to ensure compliance with Net-Works shipping standards (ongoing throughout the project in both years);
3. Provide equipment for cleaning, sorting and packing of waste fishing nets;
4. Conduct weekly mentoring to the cooperative and community group to identify issues and provide solutions; and
5. Conduct saving and loan training for SeaNet officer and designated community member.

TOTAL: AUD 5,315

Support – Collection and domestic shipping

Support the community groups to collect waste fishing nets and prepare for domestic shipping (to Surabaya):

1. Ascertain the expected volume of 2 target villages (kg of collected waste fishing nets, number of nets that can be processed, potential supply of waste-nets by fishing industry);
2. Establish regular a pick-up schedule; and
3. Collect waste fishing nets and pack according to national and international shipping standards.

TOTAL: AUD 5,315

Support – International shipping

Support and ensure an international shipping of waste fishing net from Surabaya or other city to interface manufacturing factory:

1. Support the international shipping paperwork and document its procedure;
2. Analyze the gap and provide a solution for better shipping procedure and effective processing time; and
3. Ensure the international shipping of waste fishing net is occurring.

TOTAL: AUD 5,315

12.4.2.2 Fixed costs not included

The Net-Works project was initiated under a larger project funded by the Australian Government, called 'Building a Sustainable Seafood Industry to Support Coastal Communities in the Arafura Sea'. This program ran from December 2016 to October 2018 and funded pilot programs in the region. Under this project, feasibility of the project was investigated. Some first-year costs have therefore not been specifically included in this project, namely:

- Salary of 1 staff member at the Coral Triangle Centre (CTC);
- On-ground office to manage various aspects of the sub-projects;
- Establishment of legal agreement between Zoological Society of London, TierraMar and the Coral Triangle Centre; and
- Establishment of Aquafil-Yayasan ATSEF Lestari legal agreement (international shipping).

As noted above, additional costs have been included in the second-year budget to scope additional communities suitable for expansion of the project.

12.4.2.3 Operating costs

The operating costs are based on per annum costs for 10 tonnes of waste nets. This is the volume collected in the first year of the project and expected to continue through the second year.

Table 16: Operating costs for waste transport and cleaning

Quantity	Items	Expenses (IDR)
10 tonnes	Tonnage of waste nets	(Confidential)
1 container	Shipping to Surabaya	19,000,000
10 tonnes	Baling cost	10,000,000
40 trips	Local transportation cost to the baling station (plus 1 trip from Kumbe)	5,000,000
20 trips	Local transportation cost to storage facility	2,000,000
1 payment	Storage rental in Merauke	2,000,000
10 tonnes	Net cleaning cost	10,000,000
30 litres	Laundry detergent	600,000
1	Contingency	1,000,000
TOTAL COSTS (excl. purchase price of 10 tonnes of waste nets)		49,600,000 (AUD 4,960)

12.4.3 Revenue

The price paid by Aquafil is calculated per metric ton and is based on an expected export weight of 10 tonnes of cleaned and bailed nets. This price was negotiated with the community, amounting to a figure that the community felt was worth participating in the project long-term. The purchase price offered by Aquafil has not been disclosed for commercial reasons.

International shipping costs were initially not included in the fixed purchase price as these costs were paid by Aquafil. Since the cost of international shipping was shifted to the community project, the price paid for the nets has been adjusted to reflect these costs.

The project supporters are currently investigating the possible impact of amendments to the Basel Convention regarding international trade of plastic waste. Initial reaction is that the current sorting and cleaning processes would not trigger prior informed consent procedures under the convention. The additional administrative activities would result in additional costs to the project.²³

²³ Further information available from SeaNet Indonesia Final Report. Building a Sustainable Seafood Industry to Support Coastal Communities in the Arafura Sea. January 2018; Business Case – Net-Works project for SeaNet Indonesia in Merauke, Papua.

12.5 Appendix 5. Case Study 5. Marine debris control program (capture): Economics of a litter basket, Australia

12.5.1 Introduction

Public storm water networks are a source of marine debris where infrastructure is commonly not fitted with capture mechanisms that prevent debris entering waterways and the ocean. Inadequately serviced storm water networks can also risk property and safety should blockages lead to flooding, costing local councils valuable resources.

In Australia, the Cleanwater Group devised a solution for existing infrastructure where no source reduction exists that is often of non-standard design. The 'Drain Buddy' device provides a primary treatment solution at or closer to the source of pollution, reducing the possibility of in-system blockages as well as marine debris. These litter baskets are installed in drain entry points to storm water networks, such as on the roadside or in carparks.

The litter baskets are not only preventive, but also provide diagnostics on the types, quantities, flows and distribution of land-based sources of marine debris from urban areas. Where storm water networks were installed prior to the 1980s, infrastructure is difficult to upgrade and there are commonly no preventive measures in place. This is despite such areas connecting the highest population densities with waterways. In some regions of the United States, a storm water utility payment has been included in rates to fund maintenance of ageing storm water infrastructure.

The Cleanwater Group has a vision of a 90% reduction of litter entering storm water networks across Australia by 2030. In addition to reducing marine debris, the team aims to address two additional questions:

- How to bring more value to storm water assets by effectively preventing plastic and other gross pollutants from reaching the marine environment?; and
- How to improve the value of beach cleanup data by identifying local sources of marine debris that can be targeted for effective and efficient source reduction measures?

To achieve these three goals, the at-source litter baskets are used:

1. *As an assessment tool* – to determine the load and spatial distribution of pollutants;
2. *As an evaluation tool* – to calculate the effectiveness of management interventions comparing data from before and after assessments; and
3. *As a communication and source reduction tool* – to develop relevant evidence to establish and inform community-led source reduction plans.

The Cleanwater Group has partnered with Tangaroa Blue to provide a repeatable and reproducible methodology for data collection, underpinned by Tangaroa Blue's long-standing and successful Australian Marine Debris Initiative (AMDI). This online database allows for upload of cleanup data from around Australia captured according to well-established protocols, as well as analysis of data.

12.5.2 Figures and economics

The Cleanwater Group operate in groups of two field technicians that install and service the litter baskets. Activities are based on approximately 20 installations for a typical trial, with the majority of trials leading to larger-scale installation numbers. Charges for servicing depend on travel distance and the number of litter baskets to be serviced. Fuel, equipment and minor repairs are included in the servicing fee.

In some cases, the local council has opted to service the litter traps. The group has found this to have limited success, relying on a ‘champion’ in the management team. Some councils have also engaged their maintenance team to service as well as analyze the captured debris.

Table 17: Installation and servicing costs of litter baskets

Item	Cost (AUD)	Notes
Supply and install	\$500 / basket	Average installation = 20 traps for a typical trial. Includes customized measurements, travel to site.
Service	\$25 per pit	Typically, on a monthly, 12 weekly or quarterly basis, depending on volume captured. Average is 50 litres per pit. Includes disposal (waste levies can vary in different locations). Includes minor maintenance and repairs. Two staff to clean. Based on volume and travel distance.
High Pressure, Low Volume Vacuum System	\$30,000	Capital cost. System is transferrable onto boat if cleaning rivers.
Vehicle	\$40,000+	Small pickup vehicle
Net replacement	\$200	Frames are very durable and do not typically require replacement.
Data analysis	\$75-\$85 per pit	For complete analysis. Can sort approx. 20 samples in one day if completed as community event.



Mobile vacuum system for servicing litter baskets

12.5.3 Design and life expectancy

Many councils are concerned about the litter basket's ability to deal with high-volume water flows. For this reason, an overflow mechanism has been fitted to allow water to bypass the litter basket if needed. In most cases, the overflow mechanism is not triggered where litter baskets are adequately serviced according to the average volume of debris captured. For this reason, the Cleanwater Group has a policy to install only where councils have a service plan in place to prevent blocking, including under normal water flow conditions.

Storm water pits in older infrastructure tend to vary in size and design. The litter basket is therefore modular, allowing for quick customization, along with ten types of bags that can be adjusted to fit the frame. Frames can be made from steel or plastic. Some drains have also been designed with lids, which can also be accommodated. All customizations are included in the AU\$500 installation fee.

Most litter baskets are durable, but this does depend on the location and behavior of those in the vicinity of the pits. For example, at some shopping malls, cleaning detergents and hot oils and fat are poured down drains which degrades the nets rapidly, requiring replacement after a year. Cigarette butts that are still alight also create holes in the net. Vermin also occasionally eat at the net, requiring small repairs.

On average, the life expectancy of a net 7-10 years if serviced and maintained. For the support and frames (main infrastructure), the life expectancy is 15-20 years.

12.5.4 Data analysis, awareness and education

Many councils are not fully aware of where all storm water pits are located. For this, the Cleanwater Group uses a geographic information system (GIS) tool to map all the gross pollutant traps and provides this information to councils.

Figure 6: Mapping of gross pollutant traps (Image credits: Cleanwater Group)



Analysis of the debris captured at various locations has shown clear consumption patterns, providing valuable guidance on tackling behavior change at the source. For instance:

- at shopping centers, confectionary packaging and shopping docket are commonly found;
- traps outside gyms accumulate energy drinks, cigarette butts and chewing gum packaging;
- department store loading stations accumulate larger quantities of polystyrene foam packaging; and
- plastics manufacturing facilities leak pre-production pellets into waterways (the Cleanwater Group is now working with the plastic industry to reduce leakage prior to reaching the basket).



Polystyrene captured at loading docks



Cigarette butts captured outside gyms

The litter baskets are also a valuable tool for measuring the success of policy interventions. An example is container deposit schemes where the number of PET bottles and cans captured prior to the rollout of the scheme can be measured against capture rates post-implementation.



Litter baskets before CDS



Bottle tops captured alongside CDS deposit facilities

‘Heat maps’ are used to indicate litter hotspot areas and identify spatial distributions of different types of litter found. They are also used to illustrate changes in capture rates based on tenancy. For example, debris captured at industrial sites varies during construction to established occupancy and with a change in tenants.

The response on social media for councils that have implemented the litter baskets has been extremely positive. In addition, shopping malls are using the litter baskets as a cost-effective tool to enhance their corporate social responsibility perception within the community.

The Cleanwater Group and Surfrider Foundation Australia (an NGO) have partnered to run an education program in schools. The intention is to engage schoolchildren in marine debris and storm water related education, data analysis and source reduction programs. Schools can also assist with data collection outside of school areas where, for example, debris can be identified from retailers, and can promote best practice in waste management to these facilities.

Figure 7: ‘Heat map’ of an industrial area



12.5.5 Repurposing collected plastic waste

Cleanwater Group in conjunction with Newtecpoly are taking the commingled plastic collected from the litter baskets along with plastics from beach cleanup and making wheel stops for parking areas. These applications can make use of plastic that would otherwise not have been repurposed due to contamination with sand, etc. and would therefore have been landfilled.

A cheap, hollow wheel stop retails for approximately AU\$50 and AU\$100 for a solid stop. Using repurposed plastic waste, solid wheel stops can be made for AU\$109. A shopping center that has contracted Cleanwater Group wheel stops has found the positive social response gained by paying an extra \$9 per car stop to be more beneficial than paying for the synthetic version imported from overseas and without sustainability benefits. With larger volumes, these prices can be reduced and be market competitive.

Additionally, Cleanwater Group have successfully trialed using waste beach plastic collected and converting it into the support frames for their Drain Buddy Litter Basket. This now allows plastic collected from beach cleanups to go into a product that prevents the plastic getting onto the beach in the first place.

12.6 Appendix 6. Actioning the APEC Policy and Practice Recommendations (PPRs)

In 2016, the document titled *Overcoming Barriers to Financing Waste Management Systems and Reducing Marine Litter: APEC Policy and Practice Recommendations* was adopted. The purpose of the document was to incentivize investment in waste management solutions in APEC economies by private investors, multilateral development banks, and other sources of capital.

12.6.1 APEC policy and practice recommendation 1

Set ambitious attainable targets: Set ambitious yet attainable waste management targets at the economy-wide and municipal levels in consultation with affected stakeholders, consistent with the Sustainable Development Goals (SDGs) and, as appropriate, The Paris Agreement on Climate Change, and encourage regions or provinces to develop detailed action plans to reach agreed targets:

1. Targets for EPR schemes for particular problem items (e.g. batteries, e-waste, packaging);
2. Collection targets, particularly informal settlements and rural areas (e.g. pre-paid garbage bags);
3. Domestic recycling targets (excluding export of waste);
4. Market restrictions on unnecessary and avoidable items at risk of becoming marine debris (single-use/disposable: straws, take-away containers, cutlery, etc.);
5. Studies
 - a. Legislative reviews at economy-wide and municipal levels, with a focus on inclusion of marine litter, duty to collect waste separately and legislative-readiness to implement EPR schemes (e.g. inclusion of polluter pays, user pays principles);
 - b. Studies on implementation of 3R waste hierarchy and inclusion in regulations;

6. Adoption of economy-wide waste policies that strongly target marine debris or economy-wide marine litter action plans (e.g. Indonesia).
7. Establishment of economy-wide funds specifically for improving waste management (subsidising collection, sorting, recycling; awareness-raising; administration of certifications and monitoring – see outputs of Chinese Taipei waste management fund – https://recycle.epa.gov.tw/en/aboutus_01.html); and How-2-recycle labelling (<https://how2recycle.info/>), APCO/PlanetArk labelling (<https://www.packagingcovenant.org.au/who-we-are/packaging-recycling-label-program>).

12.6.2 APEC policy and practice recommendation 2

Measure and reward progress: Build waste management performance indicators and methodology to track progress against economy-wide and municipal waste targets, maintain an economy-wide waste database, and encourage and acknowledge frontrunner cities for their overall waste and sanitation achievement through competitive award and certification.

1. Environmental regulations and certification schemes in place for collectors, sorters, recyclers.
2. Number of certified collectors, sorters, recyclers.
3. Open tender process in place for contracts to collect, sort, and recycle (to prevent monopolies and escalating prices).
4. Design and implementation of monitoring programs – see GESAMP monitoring guidelines (ref)
5. Identification of hotspots – see Indonesia marine debris hotspots (Shuker and Cadman 2018).
6. Waste profile studies to identify trends and target items.
7. Implementation of regular clean-ups; Adopt-a-Beach programs.

12.6.3 APEC policy and practice recommendation 3

Determine shared terms: Issue APEC guidelines on the development of definitions related to sustainable materials management (SMM) that facilitate trade in new technologies, and investment in recycling, recovery and other related SMM solutions:

1. Working definitions of recyclable, reusable, biodegradable, compostable;
2. Agree point of measuring recycled waste (i.e. not include exported materials; measured at the point of entry to recycling facility vs real recycled outputs);
3. Agree accounting methodologies for measuring recycled content; and APR guidelines – design for recycling (<https://plasticsrecycling.org/apr-design-guide/apr-design-guide-home>).

12.6.4 APEC policy and practice recommendation 4

Streamline decision-making: Concentrate the majority of municipal solid waste responsibilities within a single government entity or independent department or agency, while clearly defining the waste-related roles and responsibilities of remaining institutions.

1. Adopt economy-wide waste management policies/action plans which define roles, targets, definitions (with strong integration of marine debris measures);
2. Establishment of economy-wide and local municipal committees to deal with waste management and marine debris, identifying roles and responsibilities, timelines for deliverables and assigned budgets, integrating marine debris activities and deliverables; and
3. See case studies 1 and 2 for examples (Appendix 1 and 2).

12.6.5 APEC policy and practice recommendation 5

Increase funding and improve outcomes by financing all phases of integrated waste management systems: Increase dedicated financial support from domestic governments and encourage other stakeholders including the domestic and international financial community and other private sector actors to invest in local waste management.

1. See recommendations suggested in Next Wave Report (Ocean Conservancy) recommendations – first identify gaps and most efficient interventions.
2. Conduct rapid baseline assessments and identify hot spots.
3. Develop action plans that identify priorities, knowledge gaps and institutional support, as well as member economy and regional goals to be targeted.
4. Build capacity for developing and submitting funding applications.

12.6.6 APEC policy and practice recommendation 6

Enable innovative, transparent funding approaches: Where appropriate, enable the establishment of innovative, transparent funding approaches. These might include independent, blended pooled funding entities, and pay for performance delivery models.

1. See EPR schemes for PPR1.
2. Investigate Green Dot licensing scheme in Europe (<https://www.pro-e.org/the-green-dot-trademark>).
3. Investigate extended consumer responsibility (consumer pays) schemes.
4. Investigate green taxes and clean tax cuts (for e.g. <https://www.greenbiz.com/article/clean-tax-cuts-and-global-free-market-plastic-solutions>).

12.6.7 APEC policy and practice recommendation 7

Reward recycling and innovative, environmentally sound waste treatment: Develop end-of-life incentive policy to stimulate recycling market demand and increase product recyclability; create conditions that encourage investments in waste collection, sorting and environmentally sound waste treatment.

1. Implement landfill bans and taxes, composting programs and procurement policies for recycled content.
2. Refer to additional resources listed in Appendix 7.
3. Include design criteria in EPR legislation (see examples in Canada, Norway).
4. Implement differential taxes for recycled content in products, recyclability of products and volumes of product recycled (see Norway example for PET bottles).

5. APR guidelines – design for recycling (<https://plasticsrecycling.org/apr-design-guide/apr-design-guide-home>).

12.6.8 APEC policy and practice recommendation 8

Incentivize entrepreneurial waste pickers: Encourage the waste picker sector to assume new service roles in waste collection, recycling, composting, and treatment through facilitation by NGOs and municipalities to improve health and safety while improving economic livelihoods.

1. Include enhanced waste picker working conditions in waste management performance indicators as per PPR2.
2. Subsidise payments to waste pickers through EPR schemes (see outputs of Chinese Taipei waste management fund – https://recycle.epa.gov.tw/en/aboutus_01.html).
3. Create end-markets to support collection by waste pickers
4. Expand on models that cut out the “middle man” and put waste pickers in direct contact with recyclers, on-demand transport model. See case study 3 (Appendix 3).
5. Investigate back loading and reverse logistics to support collection from waste pickers, particularly in informal settlements, peri-urban and remote areas

12.6.9 APEC policy and practice recommendation 9

Enforce strong environmental standards to guide innovation: Set strong environmental standards with reliable and transparent monitoring; consider community engagement strategies for transparency and accountability.

1. Establish/review certification schemes for collectors, transporters, recyclers, other treatment facilities
2. Develop design guidelines for various applications of plastics.
3. Establish Product Stewardship Associations to provide a platform for government, industry, NGO, academia and other stakeholders to work towards sustainable product development and end-of-life treatment.
4. Support NGO marine debris monitoring activities, methodologies and databases (using GESAMP guidelines on monitoring).

12.7 Appendix 7. Stemming the tide, next wave: Summary of solutions

Table 18: Stemming the tide, next wave: Summary of solutions

<p>Stemming the Tide (2016)</p>	<ol style="list-style-type: none"> 1. Ensure political leadership and commitment. Obtain real and meaningful commitments from national governments, governors and mayors to set and achieve ambitious waste management targets. 2. Secure on-the-ground wins. Provide local “proofs of concept” for integrated waste management approaches in a number of carefully selected “beta” cities. 3. Get critical mass. Use lessons learned in beta cities to enable stakeholders to build a “best practice” transfer mechanism that can accelerate the transfer of global expertise to high priority cities. 4. Pave the way for funding. Ensure that required project investment conditions are in place in the private, public and multi-lateral sectors. Work with industry strategically on an innovative mechanism to reduce capital costs and investment risks. 5. Facilitate technology implementation. Equip state-of-the-art waste management technology providers with the detailed data on waste composition, volume, and pathways; local infrastructure; wage structure; scavenger systems; feedstock supply security; energy prices, feed-in tariffs and off-take agreements to enable implementation at scale. 6. Intensify the priority. Bring leadership and strategic focus on solutions to the ocean plastic challenge as part of the global policy agenda on the ocean.
<p>The Next Wave (2017)</p>	<p>Opportunistic solutions</p> <ol style="list-style-type: none"> 1. Beach and waterway cleanups. Expand these efforts, with more frequent cleanups, “adopt-a-beach programs” and more formal involvement at varying levels of government. 2. Waterway infrastructure. The use of traps for plastic near shores and in rivers is maintenance intensive and can be overwhelmed by surges of trash has proven effective. 3. Local monitoring and blocking of leakage points. These initiatives can be sponsored and organized in key metropolitan areas by consumer packaged goods companies, plastic producers, hospitality and tourism industries and other businesses using their considerable marketing and analytical capacity. <p>Systemic solutions</p> <ol style="list-style-type: none"> 4. Whole waste stream collection and separation infrastructure. Collection and separation should be regarded by governments and investors as setting the stage for technological innovation on the treatment and recycling side. Plastic producers, consumer brands, cities and

international development finance institutions can collaborate on developing and financing these systems, at least for an initial period long enough to provide attractive feedstock security for a new generation of treatment and recycling technologies.

5. **Traditional waste management: sanitary landfills, reuse, repurpose, and small-scale waste-to-energy.** There are a number of situations in which traditional waste management systems are the preferred solution.
6. **Vertically integrated waste management systems using emerging technologies to process low-value plastics.** Ultimately, this may be a transformative solution for big cities: well-integrated waste management systems designed to reduce costs and serve high-technology treatment options that are sufficiently profitable to pay for most, if not all, of the waste management system.

12.8 Appendix 8: Additional resources

An alphabetical list of reports and assessments to consider when implementing the APEC 2016 Policy and Practice recommendations and the APEC Roadmap on Marine Debris (APEC 2019).

APEC, USAID (2017). Facilitating Trade and Investment in Sustainable Materials Management Solutions in the APEC Region: Promoting an Enabling Regulatory Environment. <https://www.apec.org/-/media/APEC/Publications/2017/11/CTI-Annual-Report-2017/TOC/Appendix-7-Facilitating-Trade-and-Investment-in-SMM-Solutions-in-the-APEC-Region.pdf>

Moss, et al (2017). Sea of Opportunity: Supply Chain Investment Opportunities to Address Marine Plastic Pollution. <https://www.oceanactionhub.org/sea-opportunity-supply-chain-investment-opportunities-address-marine-plastic-pollution>

Ocean Conservancy (2016). Stemming the Tide: Land-based strategies for a plastic-free ocean. <https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf>

Ocean Conservancy (2017). THE NEXT WAVE: Investment Strategies for Plastic Free Seas. <https://oceanconservancy.org/wp-content/uploads/2017/05/the-next-wave.pdf>

OECD (2016). Extended Producer Responsibility - Updated Guidance for Efficient Waste Management. <https://www.oecd.org/development/extended-producer-responsibility-9789264256385-en.htm>

OECD (2017). Policy Highlights: Improving Markets for Recycled Plastics - Trends, Prospects and Policy Responses. <https://www.oecd.org/environment/improving-markets-for-recycled-plastics-9789264301016-en.htm>

**Update of 2009 APEC report on Economic Costs
of Marine Debris to APEC Economies**

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