

Submitted manuscript:

Mitigating marine plastic debris in Hong Kong: an action plan

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## Mitigating marine plastic debris in Hong Kong: an action plan

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<b>Abstract:</b>	<p>In Hong Kong, an astounding amount of marine litter is collected. With over 60% of discarded items originating from shoreline activities, policies aimed at reducing marine litter are urgent. In this action plan we seek to identify major impacts, characterise stakeholders and offer potential solutions to the problem. Producer responsibility schemes, legislation to ban commonly found items, development of alternative materials, enforcement of levy for rubbish and fines for littering, and improvement of wastewater and drainage systems are some of the measures to reduce the amount of debris in the environment. The major stakeholders of the issue are primarily the government, non-governmental organizations and businesses related to the plastic production chain. However, great relevance is attributed to invested citizens and researchers given their potential to influence decision makers. The competitive nature of industries in this area should also be taken advantage of, since companies can be champions of plastic reduction.</p>
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Mitigating marine plastic debris in Hong Kong: an action  
plan

## Abstract

The impact of marine debris ranges from ecological and social to economic, including ingestion by wildlife, loss of tourist potential and high costs of clean-ups and reallocation of collected litter. In Hong Kong, an astounding amount of litter is collected annually, encompassing plastic food packaging, bottles and bottle caps. With over 60% of discarded items originating from shoreline activities, policies aimed at reducing marine litter in the region are urgent. In this action plan we seek to introduce the issue of marine litter in Hong Kong, identify major impacts, characterise stakeholders and offer potential solutions to the problem. Producer responsibility schemes, legislation seeking to ban commonly found items, development of alternative materials, enforcement of levy for rubbish and fines for littering, and improvement of wastewater and drainage systems are some of the measures that could reduce the amount of discarded debris in the environment. The major stakeholders of Hong Kong's marine debris issue are primarily the local government, non-governmental organizations (NGOs) and businesses related to the plastic production chain. However, great relevance is attributed to invested citizens and researchers given their potential to influence decision makers. The competitive nature of industries in this area should also be taken advantage of, since companies may act as champions of plastic reduction. Finally, further cooperation with the Chinese government should be considered as marine litter is likely to affect - and originate from - mainland waters. In conclusion, collaboration between several actors is of critical importance if a successful reduction of plastic pollution is to be implemented, elevating Hong Kong to an aspiring position amongst global cities.

Keywords: marine litter, plastic, Hong Kong, policy, waste management, extended producer responsibility

# 1. Introduction

According to the *Honolulu Strategy*, marine debris (or marine litter) is defined as ‘any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned that ends up in the marine environment (UNEP/NOAA, 2011). Marine debris includes, plastics, paper and cardboard, metals, glass, concrete and other construction materials, textiles, timber and known harmful substances, including weaponries, asbestos and medical refuse (UNEP/NOAA, 2011). Marine litter is a global issue and the ecological, social and economic impacts of marine debris are widely recognised.

This proposed action plan aims to 1) assess Hong Kong’s marine debris problem including the impacts of Hong Kong on the global system, 2) propose strategies to reduce marine debris in Hong Kong, and 3) propose an implementation plan to maximise effectiveness of litter/plastic reduction strategies.

## 1.1. The issue of marine debris in Hong Kong

On average, 15,000 tonnes of marine litter is collected by the Hong Kong government annually (Yeung, Lam, Kwok, Leung, & Lee, 2016) and according to a 2015 report published by the Hong Kong Environmental Protection Department (EPD), quantity of marine refuse (including natural debris which comprised approximately 18%, by weight, of marine refuse) collected by the Government ranged from 16,767 tonnes in 2006 to 14,905 tonnes in 2013 (Environmental Protection Department, 2015). There was a slight decrease over time in the amount of shoreline refuse collected by Leisure and Cultural Services Department (LCSD) and the amount of floating refuse collected by the Hong Kong Marine Department (MD), however, the amount of shoreline refuse collected by Agriculture, Fisheries and Conservation Department (AFCD) showed no significant increase or decrease over the period examined (Environmental Protection Department, 2015).

There are seasonal variations in the amount of marine debris collected, with higher levels of debris during the wet season (May to October) and following severe weather such as typhoons. More litter is also collected during the summer months, peaking in August, when there are increased visitors to Hong Kong’s beaches and there is significantly more marine debris collected following

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festivals that have activities along Hong Kong's shorelines such as Dragon Boat and Mid-Autumn Festivals (Environmental Protection Department, 2015). There are also slight seasonal patterns in the spatial distribution of marine debris in Hong Kong, with more marine debris accumulating on the western and southern coastlines during the wet season due to the prevalence of south-westerly oceanic flow distributing the waters of southeast China. In the dry season, more marine debris accumulates on the eastern and north-eastern coastlines due to the primary influence of a north-easterly oceanic flow (Environmental Protection Department, 2015; Yeung, Lam, Kwok, Leung, & Lee, 2016). Despite the large amounts of marine debris collected by the government and non-governmental organizations (NGOs), thousands of tonnes of marine debris are also left uncollected and are accumulating on Hong Kong's shorelines and beaches.

Regarding litter composition in Hong Kong, 85% of shoreline refuse, 74 – 83.7% of floating refuse, and 65.5% of underwater refuse has been found to be plastic and foam plastic items and a large percentage of total debris amount consists of unidentifiable 'tiny refuse items' or 'tiny trash' (Environmental Protection Department, 2015; Yeung, Lam, Kwok, Leung, & Lee, 2016). Excluding tiny refuse items, single-use plastic items, in particular, food packaging, beverage bottles and caps make up the majority of marine litter found in Hong Kong. The most common items found on shorelines are single-use and food-related plastic packaging items, whilst the most common floating debris consists of foam plastic food containers, plastic drinks bottles and foam packaging (Environmental Protection Department, 2015).

The 2016 annual Hong Kong Cleanup, supported by the Ocean Conservancy's International Coastal Cleanup, comprised a 3-month litter collection period from September to December 2016 across 1,696 km of Hong Kong's shorelines, country park trails, and city streets (Hong Kong Cleanup, 2016). The items found in the coastal study were comparable with those from the EPD report, with food wrappers (17.55%), plastic/foam packaging (15.16%), plastic bottle caps (14.86%), and plastic beverage bottles (14.63%) making up the top 4 items recorded excluding 'tiny trash' (Hong Kong Cleanup, 2016). The Coastal Watch Project, which collected survey data between July 2014 and July 2016, also had similar results, with polystyrene food boxes and fragments, plastic packaging and film, and drinks bottles as the top 5 coastal floating litter items and fishing net pieces, plastic packaging and film, metal cans, fishing items and ceramics pieces as the top five underwater litter items (WWF Hong Kong, 2015).

4 Including 'tiny trash', amounts of foam pieces (33.88%) and plastic pieces (17.88%) were  
5 considerably higher than glass pieces (8.81%) and other items (Hong Kong Cleanup, 2016).  
6 Studies of marine debris conclude that the vast majority of collected debris in Hong Kong is 'tiny  
7 trash/refuse' items, which are items that have already broken down into small (less than 2.5 cm),  
8 hard to identify pieces. These 'tiny trash' items made up over 60% of items collected within the  
9 top 10 categories in the Hong Kong Cleanup (Hong Kong Cleanup, 2016). The high levels of  
10 micro-plastics pose a significant threat to marine and bird life, with possible further impacts on  
11 humans through ingestion of fish and filter feeders.  
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## 19 1.2. The sources of marine debris in Hong Kong 20 21

22 Sources of marine debris can be divided into land-based and sea-based. Though it is not possible  
23 to exactly estimate the litter types and amounts that come from these sources, it is widely  
24 suggested that 60 – 80% of marine litter comes from land-based sources, with the remaining 20  
25 – 40% of marine litter coming from sea-based sources (Faris & Hart, 1994; Yeung, Lam, Kwok,  
26 Leung, & Lee, 2016). The main land-based sources include shoreline and recreational activities,  
27 stormwater drainage systems, streams and rivers, whilst the main sea-based sources include  
28 commercial and recreational fishing, cruises, and shipping.  
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### 37 1.2.1. Land-based sources of marine debris in Hong Kong 38 39

40 Hong Kong has a vast amount of coastline, with a total length of 1178 km around Hong Kong  
41 and its 263 islands and the high population density results in a large amount of human-related  
42 litter which contributes to the land-based sources of marine debris (Environmental Protection  
43 Department, 2006). Unsustainable production and consumption, mismanagement or insufficient  
44 management of waste and littering behaviour all contribute to the issue of marine debris.  
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49 Recreational and shoreline activities are found to contribute the highest amounts of marine  
50 debris, with vast amounts of litter generated on beaches, shorelines and piers which can then  
51 enter the water due to wind, rain, or typhoons. The majority of this litter is single-use plastic  
52 (often food-related) packaging. Litter is found to enter the marine environment via stormwater  
53 drainage systems as although most drains are fitted with grates they are not fully effective in  
54 stopping Hong Kong's land generated water from entering the system during tropical storms and  
55 heavy rain (Environmental Protection Department, 2015).  
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6 Streams and rivers have also been found to be a potential carrier of land-based waste,  
7 particularly after heavy rain events, as shown by higher amounts of marine debris at Hong Kong  
8 beaches entered by streams (Environmental Protection Department, 2015). Other land-based  
9 activities found to contribute to Hong Kong's marine debris problem include smoking of  
10 cigarettes, dumping activities, and medical/personal hygiene activities (Environmental  
11 Protection Department, 2015).  
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### 19 1.2.2. Sea-based sources of marine debris in Hong Kong 20

21 Sea-based sources of marine debris are mostly traced back to fishing vessels and offshore  
22 fisheries, as shown by the prevalence of fishing net and fishing items, such as floats, lures,  
23 buoys and line, in underwater surveys (Yeung, Lam, Kwok, Leung, & Lee, 2016); as well as  
24 watersports activities, leisure boating, and merchant shipping (Environmental Protection  
25 Department, 2015; WWF Hong Kong, 2015)  
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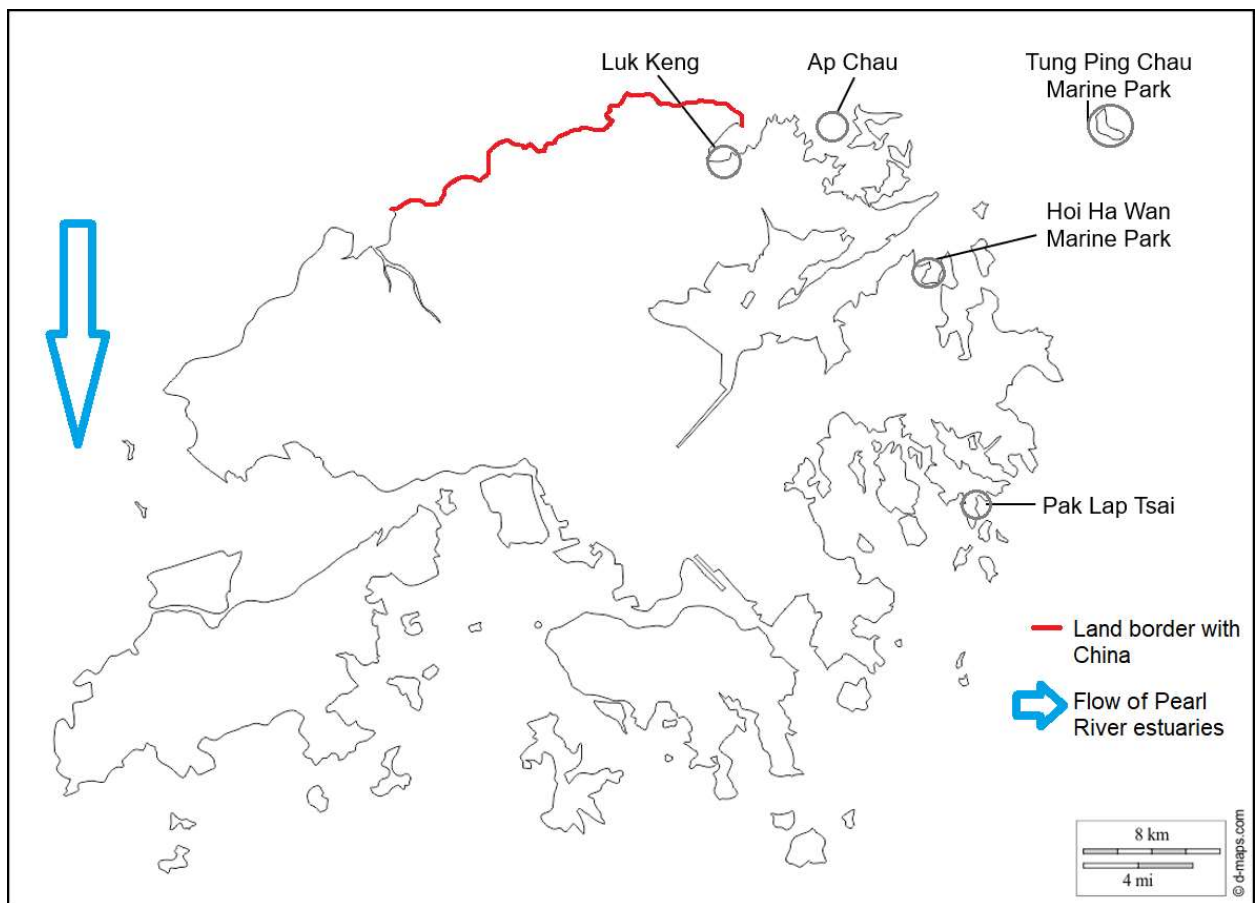
31 The effects of littering from merchant shipping can be seen in Aberdeen Typhoon Shelter,  
32 though the Marine Department state their regular contracted cleaning has alleviated the issue  
33 (Environmental Protection Department, 2015) it is argued that there is still a serious problem  
34 remaining (WWF Hong Kong, 2015). Improper littering by fishermen in the typhoon shelter is  
35 stated as the source, with polystyrene boxes frequently found (WWF Hong Kong, 2015). There  
36 have been further reports of illegal dumping of waste from vessels including yachts (WWF Hong  
37 Kong, 2015).  
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45 Rare events can also result in losses from cargo ships, resulting in huge amounts of marine  
46 debris. This was seen in July 2012 when Hong Kong suffered from a major spill of plastic pellets  
47 when six containers of over six billion polypropylene pellets packed in 6,000 sacks fell off a  
48 cargo ship during Typhoon Vicente (Hong Kong Cleanup, 2016). This pellet spill resulted in 150  
49 tonnes of plastic pellets spread across Hong Kong's southern coastline which took months to  
50 clear up, with pellets remaining to this day (Yeung, Lam, Kwok, Leung, & Lee, 2016). Cruise  
51 ships are another possible sea-based source of marine debris, however debris is often difficult  
52 to identify as it may often be similar to that from land-based sources.  
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4 1.2.3. Non-local sources of marine debris in Hong Kong

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6 In addition to the question of land-based and sea-based sources, there is also the question of  
7 the country of origin of the marine debris, a Hong Kong EPD study found that 95% of marine  
8 debris was local items, while 5% of marine litter was found to be non-local debris  
9 (Environmental Protection Department, 2015). Non-local debris was identified by counting items  
10 whose packaging labels contained simplified Chinese characters, and comparatively higher  
11 concentrations of non-local items were found at Ap Chau, Luk Keng, Tung Ping Chau Marine  
12 Park, Hoi Ha Wan Marine Park near Mirs Bay and Pak Lap Tsai (Figure 1) (Environmental  
13 Protection Department, 2015). Non-local items were mostly packaging materials such as plastic  
14 food wrappers, plastic or glass drinks bottles, metal food cans and metal cigarette tins  
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52 *Figure 1 Hong Kong's coastline and where non-local marine debris was found*

53 (Environmental Protection Department, 2015). The presence of non-local items however does  
54 not prove that the items come from outside of Hong Kong's territorial waters, as non-local items  
55 may have been purchased in local stores or brought into Hong Kong by local residents or  
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## 1.3. The Impacts of marine debris in Hong Kong

### 1.3.1. Ecological impacts

Though Hong Kong occupies only 0.03% of China's total marine area it has an exceptional amount of marine biodiversity – with over 6000 marine species recorded in Hong Kong's waters, it contains approximately 25% of China's total marine species (Astudillo, et al., 2021; Yeung, Lam, Kwok, Leung, & Lee, 2016). However, these species are under threat due to the large amounts of marine debris that accumulates in Hong Kong waters. Vast numbers of species are affected in many ways by the debris, most notably through entanglement and consumption of plastics. Although chemical transfer, aiding invasions of non-indigenous species and modification of the assemblages of species are other ecological impacts that need to be addressed (Yeung, Lam, Kwok, Leung, & Lee, 2016).

One type of marine organism that is affected by marine debris is sea turtles, most commonly by entanglement or consumption. As of 1997 records show evidence of entanglement for six of the seven species of sea turtle (Laist, 1997), with the marine pollution problem having worsened it is likely other sea turtle species will have been impacted. A study found two sea turtles, between 2011 and 2012, washed up in Hong Kong with plastic debris in their stomachs (Ng, Ang, Russell, Balazs, & Murphy, 2016). A green sea turtle was also found in 2013 with its death attributed to entanglement from a fishing net.

Seabirds are another group of marine organisms that are commonly impacted by their plastic consumption due to their feeding behaviour (Azzarello & van Vleet, 1987). Many are surface-feeders or plankton-feeding divers (Robards, Piatt, & Wohl, 1995), meaning plastics, particularly microplastics, are accidentally ingested. Researchers reported over a 14 year study, that plastic ingestion by procellariiformes, an order of seabirds, increased, likely due to an increased availability of plastic (Moser & Lee, 1992). Therefore, it can be deduced that, as there has been a further increase in plastic production and pollution since their study, plastic ingestion by seabirds passing through or inhabiting in Hong Kong may have increased further.

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Abandoned, lost or otherwise discarded fishing gear (ALDFG), also known as “ghost gear”, is another contributor to marine animal deaths. Eight cetaceans, found in Hong Kong waters, between 1993 and 1998 had evidence of entanglement from fishing gear (Parsons & Jefferson, 2000). In the years succeeding this study, an increase in fisheries and ALDFG will have exacerbated this issue. Studies have also shown cetaceans are heavily impacted through the ingestion of plastic (Baird & Hooker, 2000). Entanglement from ALDFG is also a threat to other marine species; there is an abundance of literature documenting the entanglement of sea turtles, seabirds and other marine mammals from a variety of fishing gear and other plastic debris (Laist, 1997; Sigler, 2014)

### 1.3.2. Social impacts

Not only are marine species impacted by debris found in the ocean, humans can be too. Popular tourist spots can be heavily influenced as ocean debris is washed up onto beaches or coastlines (Yeung, Lam, Kwok, Leung, & Lee, 2016) or the seascapes can become polluted, affecting the aesthetics of an area. This can then influence tourists’ decisions as to whether to visit somewhere or not. For business owners that rely on tourists, this has an impact on their income.

Seafood is a large part of Hong Kong’s trade and regular diet, with average annual per capita consumption rates of fish and molluscs at 32.1 kg and 19.1 kg respectively, some of the highest in the world (Ho & Leung, 2014). The west coast of Hong Kong and the surrounding area of the Pearl River estuaries (Figure 1) are hotspots for accumulation and distribution of microplastics (Fok & Cheung, 2015; Wu, Yang, & Criddle, 2017). Researchers reported the abundance of microplastics in Hong Kong is higher than the global average, suggesting locally caught and sold shellfish and bivalves contain higher concentrations of microplastics (Fok & Cheung, 2015). Sold and eaten in Hong Kong, one could infer Hong Kong locals that consume locally produced seafood frequently ingest more microplastic particles than the international average. Once consumed the toxicity of plastics and leaching of harmful chemicals (van Cauwenberghe & Janssen, 2014; Werner, et al., 2016) can have negative impacts on a person’s health.

### 1.3.3. Economic impacts

Marine debris in Hong Kong also has huge impacts economically, to the government, to businesses and to individuals. Over 15,000 tonnes of marine litter is collected annually by the

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Hong Kong government, by which contractors are hired, at a cost of USD \$3.85 million, to remove marine debris from Hong Kong's harbour (Yeung, Lam, Kwok, Leung, & Lee, 2016; McIlgorm, Raubenheimer, & McIlgorm, 2020). Transporting and disposing of collected marine debris appropriately incurs large costs and other clean up schemes in place for the outer lying regions of Hong Kong increases these annual costs of disposing of marine litter, heavily burdening the economy.

Hong Kong's ferry services have also reported not only time losses but also economic damage due to marine debris. It was estimated that between 2006 and 2007 the ferry service incurred losses of USD \$19,000 per vessel (McIlgorm, Raubenheimer, & McIlgorm, 2020). Along with the time losses of 12.36 hours, and therefore fewer customers, this too has a significant impact on the economy.

## 2. Proposed action plan

Excessive growth of plastic and other marine litter in coastal environments is not only a problem with the consumption of the materials, but also the management strategies to prevent and mitigate the issue (Rangel-Buitrago, et al., 2021). With reference to the Honolulu Strategy, the proposed, multifaceted action plan to combat marine litter in Hong Kong aims to address the following:

- A.** Reduce the amount of waste being produced
- B.** Reduce the amount and impact of marine debris introduced to the sea
- C.** Reduce the amount and impact of accumulated marine debris

### 2.1. Reduce the amount of waste being produced

With such a large population and high population density there is an urgent need for Hong Kong to reduce the amount of disposable products it is consuming, with its high and unsustainable levels of consumerism, in order to reduce its pressures on the environment. Hong Kong has seen its municipal solid waste (MSW) increase over 80 percent in the past three decades, when the population rose only 36% (Lo & Liu, 2018). To reduce the amount of waste being produced we propose the following strategies.

### 4 2.1.1. Waste levy 5

6 Since 2018, the Hong Kong government, at the strong encouragement from civil society, has  
7 explored the possibility of charging MSW disposal through a waste levy (Government of Hong  
8 Kong, 2018). The Waste Disposal (Charging for Municipal Solid Waste) (Amendment) Bill 2018  
9 designated two charging modes, one through the purchase of designated garbage bags for the  
10 disposal of rubbish at USD \$0.014 (HKD \$0.11) per litre, similar to the model implemented in  
11 Taipei, Taiwan, and another one through a “weight through gate-fee” which is administered  
12 when waste collectors pay for the disposal of truckloads of refuse that is weighed  
13 (Environmental Protection Department, 2018). With the bill drafted and widely supported by  
14 Hong Kong’s environmental NGOs, the passing of the bill faced an abrupt stop as the  
15 Legislative Council of Hong Kong has discontinued scrutiny of the bill, rendering plans to  
16 impose a waste levy at an abrupt halt in June 2020 (Government of Hong Kong, 2020). The  
17 waste levy is a classic example of the “polluter pays” principle and has seen drastic results in  
18 Taipei, where waste generation per capita decreased by approximately 65% after the  
19 implementation of the levy (Ecologic Institute, 2017). The introduction of a waste levy is  
20 expected to also reduce Hong Kong’s MSW.  
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### 33 2.1.2. Introduction of Producer Responsibility Schemes 34

35 Producer responsibility schemes (PRs) or extended producer responsibility (EPR) schemes  
36 have been widely implemented in developed regions of the world; in fact, twenty-six out of the  
37 28 European Union (EU) members states have EPR schemes for packaging waste in place, as  
38 recommended by the EU’s *Packaging and Waste Directive* (Watkins, et al., 2017). Hong Kong  
39 has introduced a PRS on Waste Electrical and Electronic Equipment in 2018 and plastic bag  
40 charges in 2009, however, there is yet no requirement or incentives for producers and first  
41 importers in Hong Kong to improve their recycling rates for plastic or glass products  
42 (Environmental Protection Department, 2019; Environmental Protection Department, 2019).  
43 PRS should be introduced for glass containers, plastic packaging and large packaging  
44 containers (such as polystyrene boxes) to give distributors, importers and/or producers  
45 increased responsibility for the collection, treatment and end-of-life disposal of products. Local  
46 environmental NGOs and manufacturer-funded organizations in Hong Kong have urged the  
47 Hong Kong government to expand PRS and establish value-on-return (deposit return) schemes  
48 for plastic packaging, especially for beverage containers (WWF Hong Kong, 2019; Drink  
49 Without Waste, 2020). In February 2021, the government of Hong Kong has launched a public  
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consultation on PRS on plastic beverage containers (Environmental Protection Department, 2021). Both PRS/EPR schemes and value-on-return/deposit return schemes should be introduced in Hong Kong as soon as possible to incentivize the reduction of packaging, especially those made of non-recyclable materials.

### 2.1.3. Education campaigns

The Hong Kong government has launched the Source Separation of Domestic Waste programme as early as 2005 with recycling being the central theme (Lo & Liu, 2018). There should be increased education on the issue of waste mis-management and the marine debris issue. This should target both individuals and corporations involved in the fishing industry, the general public, local producers and retailers, waste management companies and decision makers. Education campaigns are often run by NGOs however more government funding should be allocated for pollution education programs. World Wide Fund for Nature (WWF) Hong Kong has, since 2019, begun an educational and analytical initiative of ALDFG or ghost gear (WWF Hong Kong, 2019). By further educating the general public, local producers and retailers, and the fishing industry on the marine pollution issues and the effects of overconsumption and excessive packaging, it is hoped that they will have increased understanding of the effects their actions have on the issue of marine debris. This aims to result in reduced consumption and a notion of increased responsibility to dispose of waste with increased care.

### 2.1.4. Implementation of legislation for the most damaging items

Bringing in regional or national legislation which requires charges on single-use plastic items aims to cut consumption of the most harmful products. As seen throughout studies into Hong Kong's marine debris issue single-use disposable plastic items, namely food packaging, beverage bottles and caps, are Hong Kong's most common marine debris, alongside polystyrene (Styrofoam) pieces and boxes. Compulsory charging for single-use items has been seen to have successful results, with the United Kingdom's "five pence" (USD \$0.069) plastic bag charge resulting in an 86% reduction in plastic bag consumption per person since the charge was introduced in 2015 (Department for Environment Food & Rural Affairs, 2020). Hong Kong's neighbour, Macau, has already enacted a ban on Styrofoam takeaway food containers from January 2021 (TDM - Teledifusão de Macao, 2020). It is advisable that Hong Kong follows

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4 suit and imposes stricter regulations on the applications and disposal methods of damaging  
5 products such as polystyrene containers.  
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9 Although large retailers in Hong Kong must charge for plastic bags given, excessive amounts of  
10 plastic bags are still being used for packing fresh food and for 'food hygiene reasons' - such as  
11 to wrap cartons of milk and sealed, pre-packaged meat – there is also no enforcement of bag  
12 levies for wet market stalls. More policy to collect levy for single-use plastic items such as meal  
13 containers and cutlery could be efficacious in reducing overall plastic consumption in the Hong  
14 Kong. On the other hand, policies on mandatory “bring-your-own” reusable items to incentivise  
15 consumers to commit to reusable options would also be a culture-shifting action which could  
16 effectively reduce overall plastic consumption. A nominal rebate could spark the consumers'  
17 motivation to provide for themselves reusable alternatives.  
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26 In addition to charges or rebates on single-use items, banning harmful items ceases  
27 consumption and eventual input into the environment. Bans have already been implemented  
28 worldwide as seen with near-global bans on microbead-containing products and continue to  
29 target the world's most common polluting items such as France's ban on plastic cutlery  
30 (Schnurr, et al., 2018; Xanthos & Walker, 2017). Bans on polystyrene food containers would  
31 drastically reduce the marine pollution issue in Hong Kong and have been advocated for by civil  
32 society in the past.  
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### 39 2.1.5. Improvement of public facilities

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41 Improving public facilities such as public water fountains will reduce 'disposable lifestyles' and  
42 the purchasing of plastic bottles of water. Although some water fountains exist in public areas  
43 (set up by local charity 'Go Green Hong Kong' under the Water for Free initiative, some by the  
44 LCSD, and others are provided by independent restaurants and community centres) the  
45 provision of more water refill stations by the government in public spaces and mass transit  
46 railway stations will drastically cut plastic consumption (Water for Free, 2021). The mobile  
47 phone app and map launched by the Water for Free initiative allows residents of Hong Kong to  
48 find water dispensers in their vicinity to minimize the consumption of disposable plastic bottles in  
49 Hong Kong (Water for Free, 2021). The installation of more publicly accessible facilities, such as  
50 water fountains, for the reduction of single-use items and packaging could see further  
51 decreasing of MSW.  
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#### 4 2.1.6. Development of alternative sustainable packaging 5

6 Increased funding for the research, development and use of alternative sustainable packaging  
7 methods will result in reduced reliance on plastic as a packaging product. As 20% of Hong  
8 Kong's MSW is post-consumer plastics (Environmental Protection Department, 2021), the use  
9 of effective alternatives could have major impacts on the plastic marine debris issue.  
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15 Alternative packaging that can be biodegradable in natural conditions could be very attractive to  
16 the environmental conditions in Hong Kong as direct landfilling is the de facto waste disposal  
17 option for non-recyclables. Currently, there are numerous plant-based feedstock that could be  
18 promising for the conditions seen in Hong Kong. These types of feedstock, made of starchy  
19 materials such as tuber roots or corn, can be digested by many aquatic animals while still  
20 holding their intended shape throughout its shelf-life as would items made with petroleum-based  
21 feedstock (Bioplastic Feedstock Alliance, 2020). Singapore, a city-state with a similar capacity  
22 as Hong Kong, has found success in their researches for biodegradable packaging material  
23 made of sustainable feedstock, such as ones with durian rinds, a by-product of produce from  
24 the vicinity of the tropical nation (Zhao, Lyu, Lee, Cui, & Chen, 2019). With more research into  
25 this area, locally sourced alternatives to plastics could offer non-disruptive one-for-one  
26 substitution of plastic items with the advantage of not resulting in lasting marine litter in Hong  
27 Kong.  
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### 40 2.2. Reduce the amount and impact of marine debris introduced 41 to the sea 42 43 44

45 In addition to reducing the amount of waste produced at source it is vital that measures are  
46 taken to reduce the amount of debris entering the marine environment via littering behaviour,  
47 wind, rain and extreme weather events, waste mismanagement, and stormwater drainage  
48 systems.  
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#### 52 2.2.1. Effective enforcement of fines 53

54 Littering behaviour and illegal dumping of waste are major sources of Hong Kong's marine  
55 debris, however, low rates of prosecution offer little deterrence (on average 13.7 marine litter  
56 cases were prosecuted per year in 2012 to 2014) (Yeung, Lam, Kwok, Leung, & Lee, 2016).  
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## Mitigating marine plastic debris in Hong Kong: an action plan

Marine debris and littering hotspots may be identified through the use of study data and should be used as locations to target stricter enforcement of existing littering penalties by the AFCD, Food and Environment Hygiene Department (FEHD), LCSD, Marine Department (MD) and Hong Kong Police Force (HKFP).

### 2.2.2. Improvement of drainage systems

Measures should be taken to improve stormwater drainage systems to stop litter entering the sea in coastal areas and in extreme weather events. Studies found higher levels of marine debris during the wet season and following extreme weather events, as seen following Typhoon Mangkhut in 2018 where beaches were covered in micro and macro-plastic debris (Lo, et al., 2020). To reduce the amount of marine debris introduced by drainage systems there should be increased routine cleaning of stormwater drains before and during the wet season. Floating booms and traps should also be installed at drainage outputs to capture marine debris that gets through installed grates.

### 2.2.3. Improvement of waste management systems

Hong Kong is far behind in its recycling facilities and there is a severe need for an increase in government funding for recycling programmes. There is a lack of public awareness on the importance of recycling, lack of recycling bins for both households and corporations, and lack of a mechanised recycling process. Due to recycling in Hong Kong being processed by hand, contamination of recycling bins by landfill waste results in recycling not being processed. More recycling and rubbish bins should also be provided in coastal and recreational areas to limit the amount of marine debris from recreational and shoreline activities. In addition to more bins, there should be increases in frequency of litter collection in marine litter hotspots or areas of high recreational shoreline activity.

## 2.3. Reduce the amount and impact of accumulated marine debris

Despite strategies to reduce the amount of waste produced at source and to reduce litter output into the marine environment there are still large amounts of marine debris present in the environment. Reducing waste production and output through the suggested strategies will also not gain immediate results and thus it is essential for removal of marine debris to continue.

### 7 2.3.1. Increased efforts in marine debris removal 8 9

10 An increase in frequency of marine debris removal by the MD, LCSD, AFCD and FEHD is  
11 required to prevent accumulation of marine debris in Hong Kong. Locations of marine debris  
12 removal should be prioritised with regard to the level of ecological importance, including the  
13 amounts of marine and shoreline flora and fauna. Frequency of clean-ups should be adjusted to  
14 account for the seasonal patterns in spatial variations of marine litter, with increased removal on  
15 the western and southern coastline during the wet season and increased removal on the  
16 eastern and north-eastern coastline during the dry season. A team of researchers has, through  
17 a geostatistical interpolation mapping approach, proposed a prioritized area map to highlight  
18 particular areas in Hong Kong for marine debris mitigation (Coleby & Grist, 2019; Grist &  
19 Coleby, 2020).  
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28 There are additional benefits in promoting coastal clean-up events organized by civil society.  
29 The positive effects of these clean-up campaigns can be seen with events run by The Hong  
30 Kong Cleanup, Plastic Free Seas and other charitable organisations which have resulted in the  
31 involvement of numerous Hong Kong public groups and corporations in the removal of marine  
32 debris across Hong Kong (Hong Kong Cleanup, 2016). The events equip individuals with the  
33 knowledge of how to carry out safe and effective debris removal alongside the government's  
34 clean-up efforts. Moreover, the involvement of residents of Hong Kong in "citizen science"  
35 programmes linked to marine debris recovery can contribute to crowdsourcing of data, as seen  
36 in the University of Hong Kong's academic conferences investigating the use of citizen science  
37 and possible applications in local marine protection and WWF Hong Kong's initiatives  
38 (University of Hong Kong, 2019; WWF Hong Kong, 2020).  
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### 50 2.3.2. Implementation of a rapid response action plan 51

52 There is a need for a rapid response action plan following extreme weather events such as  
53 typhoons and tropical storms to minimise the effects of the increased amounts of marine debris.  
54 A variety of actors should be involved to allow a widespread response. By modelling the  
55 information collected from the case of Typhoon Vicente in 2012 and Typhoon Mangkhut in  
56 2018, authorities of Hong Kong can derive at projections of where along Hong Kong's coastline  
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4 would there be surges of marine debris and plan recovery efforts along with the assistance of  
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6 civil society and their volunteers accordingly.  
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### 10 11 12 2.3.3. Development and use of new technology 13

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15 Development of new technology is needed to allow efficient management of the marine debris  
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17 issue. Use of technology to locate areas of marine debris accumulation and remove debris from  
18  
19 the marine environment would help increase current debris removal rates. New technology such  
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21 as geographic information systems (GIS), artificial intelligence (AI) assisted detection  
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23 methods, drones and automated traps can also assist in preventing outflow of debris into the  
24  
25 marine environment (Schmaltz, et al., 2020).  
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## 28 29 2.4. Drivers, Pressures, State, Impacts and Responses (DPSIR) 30 31 framework 32

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34 In order to facilitate comprehension of the issue of marine litter in Hong Kong, we employed a  
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36 Drivers, Pressures, Impacts and Responses (DPSIR) framework (Figure 2) to summarise  
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38 section 2. Following its terminology, social and economic drivers (D) impose pressures (P) on a  
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40 given environment, which then undergoes a change of state (S), leading to impacts (I) on  
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42 society and in the environment itself, which may elicit a response (R) feeding back on the  
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44 previous categories (Smeets & Weterings, 1999). This is a tool for describing and analysing  
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46 environmental problems in a clear and holistic manner, which can be used to bridge  
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48 communication gaps between researchers, stakeholders, policy makers and the public  
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50 (Svarstad, Petersen, Rothman, Siepel, & Wätzold, 2008). While critics of the DPSIR framework  
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52 draw attention to its heavy reliance on a hierarchical (Carr, et al., 2007), overly simplistic nature  
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54 (Maxim, Spangenberg, & O'Connor, 2009), and lack of standardization when attributing  
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56 variables to a single category (Gari, Newton, & Icely, 2015), the framework has been  
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58 successfully applied in a myriad of studies (Tscherning, Helming, Krippner, Sieber, & Gomez y  
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60 Paloma, 2012; Gari, Newton, & Icely, 2015; Lewison, et al., 2016).  
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# Mitigating marine plastic debris in Hong Kong: an action plan

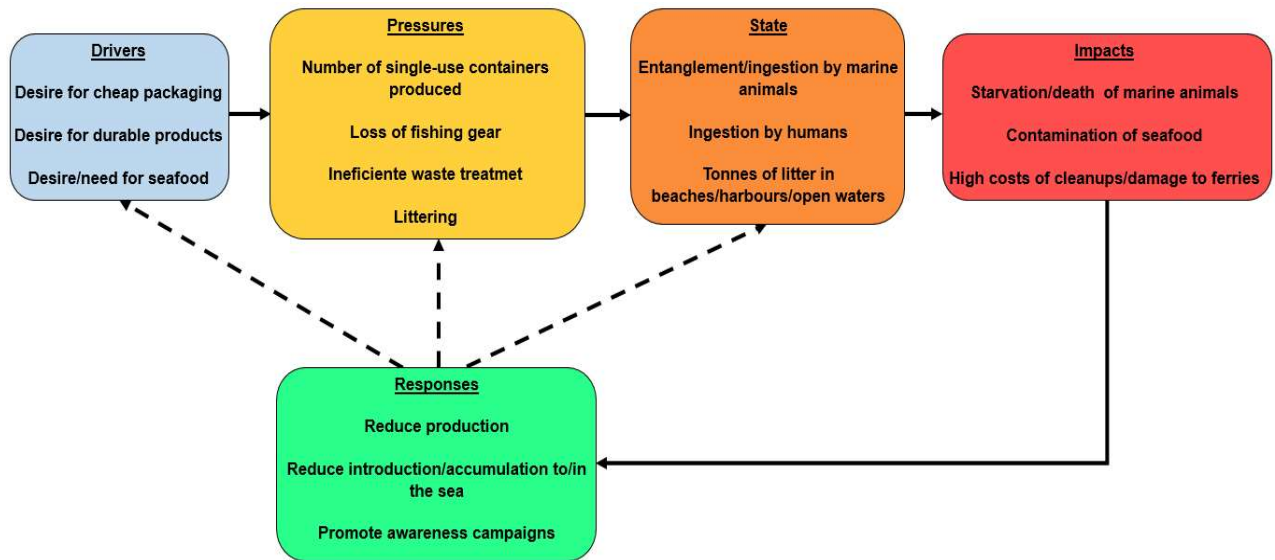


Figure 2 DPSIR framework of marine litter issues in Hong Kong. Each box stands for one of the elements of the scheme: Drivers (blue), Pressures (yellow), State (orange), Impacts (red) and Responses (green). Arrows represent connections between elements, while responses (dashed arrows) control drivers and pressures, and maintain/restore the state of the environment.

## 3. Implementation plan

### 3.1. Necessary components of the implementation plan

If implementation of policies in Hong Kong is to be successful, several major actors should be taken into consideration. The ones with greatest interest and potential to act on our proposal are government agencies and non-governmental organizations (NGOs) (Figure 3A, second quadrant). From a political standpoint, the Hong Kong government should be capable of implementing litter policies on its own, but in order to do so it first requires feedback from local citizens while also being heavily affected by plastic lobbyists. A similar approach was seen in the *Marine Litter Action Plan of the Baltic Marine Environment Protection Mission*, where the stakeholders have been consulted through a bottom-up approach (HELCOM, 2015). In this regard, it is important to emphasize its intermediate position along the 'attitude' axis (Figure 3B), given the reliance on other actors. Government agencies can act in two distinct fronts – by organizing independent studies and by legislating. The former is achieved by setting up advisory groups, such as the *Interdepartmental Working Group on Clean Shorelines* organized following the plastic pellet disaster of 2012 (Environmental Protection Department, 2015). Working group

# Mitigating marine plastic debris in Hong Kong: an action plan

reports should offer an independent and thorough evaluation of current issues, constituting the scientific basis for decision-making. The latter is the legal outcome of this process.

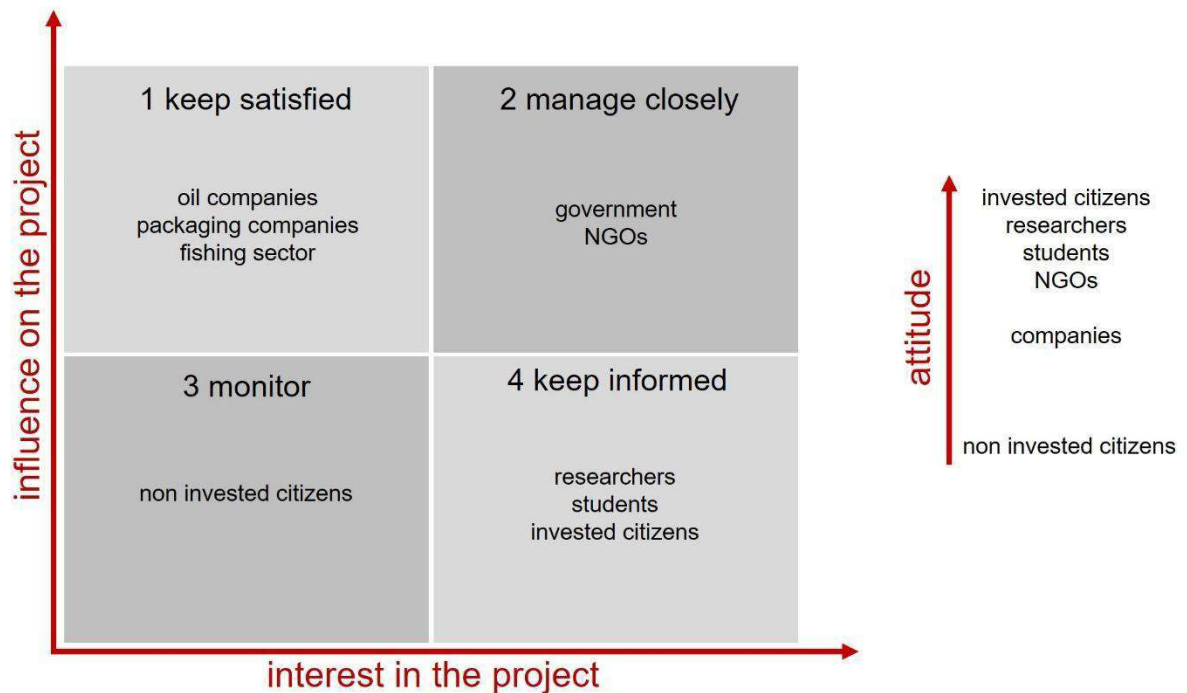


Figure 3 A. Actor analysis: the x-axis represents perspective on the project, while the y-axis represents power to act on the project. Quadrants depict the most appropriate action for each of the actor groups. B. Attitude meter: this axis indicates how likely each actor is to actively support the initiative in relation to one another.

Laws aimed at reducing consumption of single-use plastics, for instance, have been enacted in several countries. The European Commission adopted regulations in 2013 that would require member states to either start charging for plastic bags or ban them completely (European Commission, 2013); in 2019, the parliament successfully voted to ban plastic cutlery, cotton buds, straws and stirrers by 2021 (European Parliament, 2019), as part of a law against plastic waste in the marine environment. As for individual cities, the city of San Francisco became the first municipality in the United States to ban large retailers from distributing single-use plastic bags as early as 2007 (San Francisco Department of the Environment, 2007). In Brazil, the city of São Paulo and the state of Rio de Janeiro have also instituted charges on plastic bags since 2011 and 2018, respectively (Município de São Paulo, 2011; Assembleia legislativa do Rio de Janeiro, 2018).

## Mitigating marine plastic debris in Hong Kong: an action plan

Similar to governmental bodies, NGOs can provide additional data on plastic production, use and destination. Several local NGOs and WWF Hong Kong conducted the Coastal Watch initiative which surveyed marine habitats in Hong Kong and characterized the plastic litter found in such environments (Yeung, Lam, Kwok, Leung, & Lee, 2016). Likewise, environmental campaigns aimed at educating the general population and informing citizens are effective tools to pressure government officials and promote marine pollution literacy. NGOs are positioned relatively higher on the attitude scale, given they actively seek to influence decisions as opposed to relying on public perception alone.

Regarding institutions with low interest in discussing the proposal but otherwise significant power to act on it (or against it), oil and gas, fishing and packaging sectors are major actors (Figure 3A, first quadrant). Oil and gas companies in the value chain, though not necessarily based or manufacturing in Hong Kong, are responsible for extracting, refining and producing raw plastic particles, thus constituting the source of all petroleum-based plastic consumed; in some cases, however, these companies can be directly involved with clean-up events after spill events. The fishing industry is a major source of plastic debris in the form of discarded or lost fishing gear, notorious for continuously entangling several types of aquatic animals long after being abandoned; this phenomenon is also known as ghost fishing. Packaging companies, similarly, are the producers and distributors of single-use items, and are the sector most affected by a possible ban.

Invested citizens and education institutions in the form of researchers and students, on the other hand, show a great amount of interest while having little influence on implementation actions (Figure 3A, quadrant 4) (WWF Hong Kong, 2020). However, they are placed at the top of the attitude scale: their coordinated actions are capable of pressuring governments to change policies. It must also not be forgotten that researchers are constantly evaluating and publishing results that form public opinion, especially those on pollution impacts, ingestion of contaminants, and their physiological effects on biota. Citizens and schools/universities thus provide a much-needed feedback to decision-makers, while popular opinion on issues such as plastic bags and straws has culminated on several recent laws, as seen in the public consultations conducted by the Hong Kong government on plastic related legislations (Environmental Protection Department, 2021). Finally, non-invested citizens can be seen as potential actors, but lack of interest/information places them at an unfavourable position (Figure 3A, quadrant 3). It is

4 important to consider, however, that once such citizens become aware of their relevance, they  
5 can be a powerful source of change.  
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## 10 3.2. Business engagement 11 12

13 The role businesses play in Hong Kong on the topic of plastic or even on general waste  
14 reduction is crucial given Hong Kong's pro-business yet competitive commercial environment.  
15 Hong Kong hosts countless global companies which bring in the presence of products from all  
16 regions of the world. This attribute of Hong Kong is opportune in the strategy to engage  
17 businesses to take the lead on reducing plastic waste, thereby reducing plastic marine debris in  
18 Hong Kong.  
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### 26 3.2.1. Champions in plastic waste reduction 27 28

29 Businesses that have already undergone drastic consideration or action for the reduction of  
30 plastic waste should be recognised by the government. In addition, by celebrating best practices  
31 of champions, the rest of the industry would likely follow suit. WWF has launched an initiative,  
32 Plastic ACTION (PACT) in Asia that identifies champions in each plastic-heavy industry and  
33 redistributes their best practices and solutions across the region. PACT has been launched in  
34 Hong Kong for the food delivery service industry to induce a reduction on plastic food containers  
35 (WWF Hong Kong, 2020). Expected results from highlighting champions in the private sector  
36 would provide best practice references for the rest of the industry and even the region to follow.  
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### 45 3.2.2. Industry-wide action and goals 46 47

48 On top of individual businesses that are exemplary in demonstrating plastic reduction, the  
49 industries should also be encouraged to take synchronised action on plastics. This way, the  
50 industry-wide action provides "safety in numbers" for the individual businesses when the  
51 reduction work is disruptive for their regular operations. For example, the removal of straws or  
52 cutlery from fast food restaurants caused dissatisfaction and complaints from customers. If all  
53 fast-food restaurants in a city, for instance, cease to give out these single-use items together  
54 with an explanation on the environmental impact this action may bring, consumers can better  
55 comprehend the not economical but environmental motives behind the action. WWF's PACT  
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4 initiative also caters to this aspect and encouraged all prominent members of oligopolies to take  
5 part in a coordinated plastic reduction action, as seen in the continued dialogue with the food  
6 delivery sector, dominated by merely several key players (WWF Hong Kong, 2020). Expected  
7 impact from encouraging entire industries to act on plastic reduction could be new industry  
8 norms created with businesses, now conscious of the environmental impact the materials they  
9 use may bring in the form of marine debris.  
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### 18 3.3. Policy advocacy and change 19

20 The arguably most effective and impactful change drivers are well-enforced policy  
21 implementation that looks into all stakeholders. Policy work on eliminating marine debris should  
22 be a long-term strategy beginning with holding producers responsible with the “polluter pays”  
23 mindset. Enforcement of littering fines and prosecution, enactment of EPR/PRS laws,  
24 introduction of deposits under value-on-return schemes, and subsidizing sustainable alternative  
25 material applications are much needed policy changes that should be implemented in Hong  
26 Kong as soon as possible. Local recycling should also be monetarily supported by the Hong  
27 Kong government in order to resume recycling after China’s ban on waste imports, examined  
28 further in the section below.  
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### 39 3.4. Cross-border collaboration with China 40

41 Marine debris found in Hong Kong waters are not exclusively from Hong Kong alone, because a  
42 significant portion comes from its northern neighbour and fellow stakeholder, China  
43 (Environmental Protection Department, 2015). It is important for the Hong Kong government to  
44 work closely with China on debris prevention that physically stops marine debris from drifting  
45 past the Pearl River Delta and into the South China Sea, where it is more difficult to recover  
46 debris. While there already are policies and researches jointly executed and conducted by the  
47 Hong Kong and Chinese government, a closer partnership is expected to be greatly beneficial in  
48 understanding and reducing marine debris for the two territories. More importantly, China was  
49 previously the destination for plastic recyclables collected in Hong Kong and the Asia Pacific  
50 prior to the 2017/2018 “National Sword” policy of banning imports of post-consumer plastics  
51 (Tran, Goto, & Matsuda, 2021). Hong Kong, though often reasserted by China as an undeniable  
52 territory of the People’s Republic of China, is considered to be a foreign territory when it comes  
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4 to import/export definitions. The banning of Hong Kong's recyclables in China is  
5 counterproductive in supporting the programmes and policies Hong Kong has for circular  
6 economy and has greatly impacted recycling rates, as 99% of imported waste was re-exported  
7 to China prior to the "National Sword" policy (Tran, Goto, & Matsuda, 2021).  
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### 11 3.4.1. Waterway projects in Southern China 12 13

14 With the Guangdong province government, Hong Kong should work on waterway physical  
15 blockage and filtration systems that can trap marine debris that runs southerly on the Pearl  
16 River and other estuaries into the South China Sea. As previously described, Hong Kong's  
17 marine debris removal efforts have been ongoing within the territory. However, more  
18 partnerships to have physical blockage in place upstream in China would be more effective than  
19 to scavenge in the marine environment in Hong Kong. Partnerships with Hong Kong to invest in  
20 waterway infrastructure in Guangdong province would be beneficial for the two geographies and  
21 governments.  
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### 31 3.4.2. Innovation on marine debris tracking in the region 32 33

34 As an innovation hub of Asia, Hong Kong boasts a booming industry of startups and an  
35 excellent cradle for effective ideas for environmental protection. In the pursuit to remove marine  
36 debris in the vicinity, the Hong Kong government should invest into innovation and ideation in  
37 marine debris tracking, scavenging and reduction solutions. Hong Kong can much better track  
38 marine debris with the help of internet of things (IoT) devices, AI-assisted detection imaging,  
39 GIS technology, as well as citizen science, as investigated above. Expected impact from an  
40 increased investment in debris tracking would include better understanding of how marine  
41 debris travels in the region, how they build up and how they are linked to the plastic  
42 consumption in the vicinity.  
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## 52 Conclusion 53 54 55

56 From the literature review of this study, it is found that Hong Kong has a substantial level of  
57 awareness and interest in combatting the issue of marine debris, as seen with its numerous  
58 NGO-led activities and vehement criticism on the absence of waste-reduction policies that are  
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## Mitigating marine plastic debris in Hong Kong: an action plan

already seen in other regions. The proposed multifaceted strategy to implement the action plan for Hong Kong's marine debris mitigation involves a thorough understanding of stakeholders and how they respond to different initiatives and policies. The DPSIR framework, coupled with a holistic action plan to a) reduce the amount of waste being produced, b) reduce the amount and impact of marine debris introduced to the sea and c) reduce the amount and impact of accumulated marine debris are recommended to be considered together by authorities and civil society. Actors such as the Hong Kong government, plastic value chain decision-makers, NGOs and academia should work together with Hong Kong's invested citizens to further build on existing strategies to detect, monitor and reduce marine debris, as well as to reduce waste from source as long-term approaches.

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Mitigating marine plastic debris in Hong Kong: an action  
plan

## Abstract

The impact of marine debris ranges from ecological and social to economic, including ingestion by wildlife, loss of tourist potential and high costs of clean-ups and reallocation of collected litter. In Hong Kong, an astounding amount of litter is collected annually, encompassing plastic food packaging, bottles and bottle caps. With over 60% of discarded items originating from shoreline activities, policies aimed at reducing marine litter in the region are urgent. In this action plan we seek to introduce the issue of marine litter in Hong Kong, identify major impacts, characterise stakeholders and offer potential solutions to the problem. Producer responsibility schemes, legislation seeking to ban commonly found items, development of alternative materials, enforcement of levy for rubbish and fines for littering, and improvement of wastewater and drainage systems are some of the measures that could reduce the amount of discarded debris in the environment. The major stakeholders of Hong Kong's marine debris issue are primarily the local government, non-governmental organizations (NGOs) and businesses related to the plastic production chain. However, great relevance is attributed to invested citizens and researchers given their potential to influence decision makers. The competitive nature of industries in this area should also be taken advantage of, since companies may act as champions of plastic reduction. Finally, further cooperation with the Chinese government should be considered as marine litter is likely to affect - and originate from - mainland waters. In conclusion, collaboration between several actors is of critical importance if a successful reduction of plastic pollution is to be implemented, elevating Hong Kong to an aspiring position amongst global cities.

Keywords: marine litter, plastic, Hong Kong, policy, waste management, extended producer responsibility

# 1. Introduction

According to the *Honolulu Strategy*, marine debris (or marine litter) is defined as ‘any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned that ends up in the marine environment (UNEP/NOAA, 2011). Marine debris includes, plastics, paper and cardboard, metals, glass, concrete and other construction materials, textiles, timber and known harmful substances, including weaponries, asbestos and medical refuse (UNEP/NOAA, 2011). Marine litter is a global issue and the ecological, social and economic impacts of marine debris are widely recognised.

This proposed action plan aims to 1) assess Hong Kong’s marine debris problem including the impacts of Hong Kong on the global system, 2) propose strategies to reduce marine debris in Hong Kong, and 3) propose an implementation plan to maximise effectiveness of litter/plastic reduction strategies.

## 1.1. The issue of marine debris in Hong Kong

On average, 15,000 tonnes of marine litter is collected by the Hong Kong government annually (Yeung, Lam, Kwok, Leung, & Lee, 2016) and according to a 2015 report published by the Hong Kong Environmental Protection Department (EPD), quantity of marine refuse (including natural debris which comprised approximately 18%, by weight, of marine refuse) collected by the Government ranged from 16,767 tonnes in 2006 to 14,905 tonnes in 2013 (Environmental Protection Department, 2015). There was a slight decrease over time in the amount of shoreline refuse collected by Leisure and Cultural Services Department (LCSD) and the amount of floating refuse collected by the Hong Kong Marine Department (MD), however, the amount of shoreline refuse collected by Agriculture, Fisheries and Conservation Department (AFCD) showed no significant increase or decrease over the period examined (Environmental Protection Department, 2015).

There are seasonal variations in the amount of marine debris collected, with higher levels of debris during the wet season (May to October) and following severe weather such as typhoons. More litter is also collected during the summer months, peaking in August, when there are increased visitors to Hong Kong’s beaches and there is significantly more marine debris collected following

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festivals that have activities along Hong Kong's shorelines such as Dragon Boat and Mid-Autumn Festivals (Environmental Protection Department, 2015). There are also slight seasonal patterns in the spatial distribution of marine debris in Hong Kong, with more marine debris accumulating on the western and southern coastlines during the wet season due to the prevalence of south-westerly oceanic flow distributing the waters of southeast China. In the dry season, more marine debris accumulates on the eastern and north-eastern coastlines due to the primary influence of a north-easterly oceanic flow (Environmental Protection Department, 2015; Yeung, Lam, Kwok, Leung, & Lee, 2016). Despite the large amounts of marine debris collected by the government and non-governmental organizations (NGOs), thousands of tonnes of marine debris are also left uncollected and are accumulating on Hong Kong's shorelines and beaches.

Regarding litter composition in Hong Kong, 85% of shoreline refuse, 74 – 83.7% of floating refuse, and 65.5% of underwater refuse has been found to be plastic and foam plastic items and a large percentage of total debris amount consists of unidentifiable 'tiny refuse items' or 'tiny trash' (Environmental Protection Department, 2015; Yeung, Lam, Kwok, Leung, & Lee, 2016). Excluding tiny refuse items, single-use plastic items, in particular, food packaging, beverage bottles and caps make up the majority of marine litter found in Hong Kong. The most common items found on shorelines are single-use and food-related plastic packaging items, whilst the most common floating debris consists of foam plastic food containers, plastic drinks bottles and foam packaging (Environmental Protection Department, 2015).

The 2016 annual Hong Kong Cleanup, supported by the Ocean Conservancy's International Coastal Cleanup, comprised a 3-month litter collection period from September to December 2016 across 1,696 km of Hong Kong's shorelines, country park trails, and city streets (Hong Kong Cleanup, 2016). The items found in the coastal study were comparable with those from the EPD report, with food wrappers (17.55%), plastic/foam packaging (15.16%), plastic bottle caps (14.86%), and plastic beverage bottles (14.63%) making up the top 4 items recorded excluding 'tiny trash' (Hong Kong Cleanup, 2016). The Coastal Watch Project, which collected survey data between July 2014 and July 2016, also had similar results, with polystyrene food boxes and fragments, plastic packaging and film, and drinks bottles as the top 5 coastal floating litter items and fishing net pieces, plastic packaging and film, metal cans, fishing items and ceramics pieces as the top five underwater litter items (WWF Hong Kong, 2015).

## Mitigating marine plastic debris in Hong Kong: an action plan

Including 'tiny trash', amounts of foam pieces (33.88%) and plastic pieces (17.88%) were considerably higher than glass pieces (8.81%) and other items (Hong Kong Cleanup, 2016). Studies of marine debris conclude that the vast majority of collected debris in Hong Kong is 'tiny trash/refuse' items, which are items that have already broken down into small (less than 2.5 cm), hard to identify pieces. These 'tiny trash' items made up over 60% of items collected within the top 10 categories in the Hong Kong Cleanup (Hong Kong Cleanup, 2016). The high levels of micro-plastics pose a significant threat to marine and bird life, with possible further impacts on humans through ingestion of fish and filter feeders.

### 1.2. The sources of marine debris in Hong Kong

Sources of marine debris can be divided into land-based and sea-based. Though it is not possible to exactly estimate the litter types and amounts that come from these sources, it is widely suggested that 60 – 80% of marine litter comes from land-based sources, with the remaining 20 – 40% of marine litter coming from sea-based sources (Faris & Hart, 1994; Yeung, Lam, Kwok, Leung, & Lee, 2016). The main land-based sources include shoreline and recreational activities, stormwater drainage systems, streams and rivers, whilst the main sea-based sources include commercial and recreational fishing, cruises, and shipping.

#### 1.2.1. Land-based sources of marine debris in Hong Kong

Hong Kong has a vast amount of coastline, with a total length of 1178 km around Hong Kong and its 263 islands and the high population density results in a large amount of human-related litter which contributes to the land-based sources of marine debris (Environmental Protection Department, 2006). Unsustainable production and consumption, mismanagement or insufficient management of waste and littering behaviour all contribute to the issue of marine debris.

Recreational and shoreline activities are found to contribute the highest amounts of marine debris, with vast amounts of litter generated on beaches, shorelines and piers which can then enter the water due to wind, rain, or typhoons. The majority of this litter is single-use plastic (often food-related) packaging. Litter is found to enter the marine environment via stormwater drainage systems as although most drains are fitted with grates they are not fully effective in stopping Hong Kong's land generated water from entering the system during tropical storms and heavy rain (Environmental Protection Department, 2015).

6 Streams and rivers have also been found to be a potential carrier of land-based waste,  
7 particularly after heavy rain events, as shown by higher amounts of marine debris at Hong Kong  
8 beaches entered by streams (Environmental Protection Department, 2015). Other land-based  
9 activities found to contribute to Hong Kong's marine debris problem include smoking of  
10 cigarettes, dumping activities, and medical/personal hygiene activities (Environmental  
11 Protection Department, 2015).  
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### 19 1.2.2. Sea-based sources of marine debris in Hong Kong 20

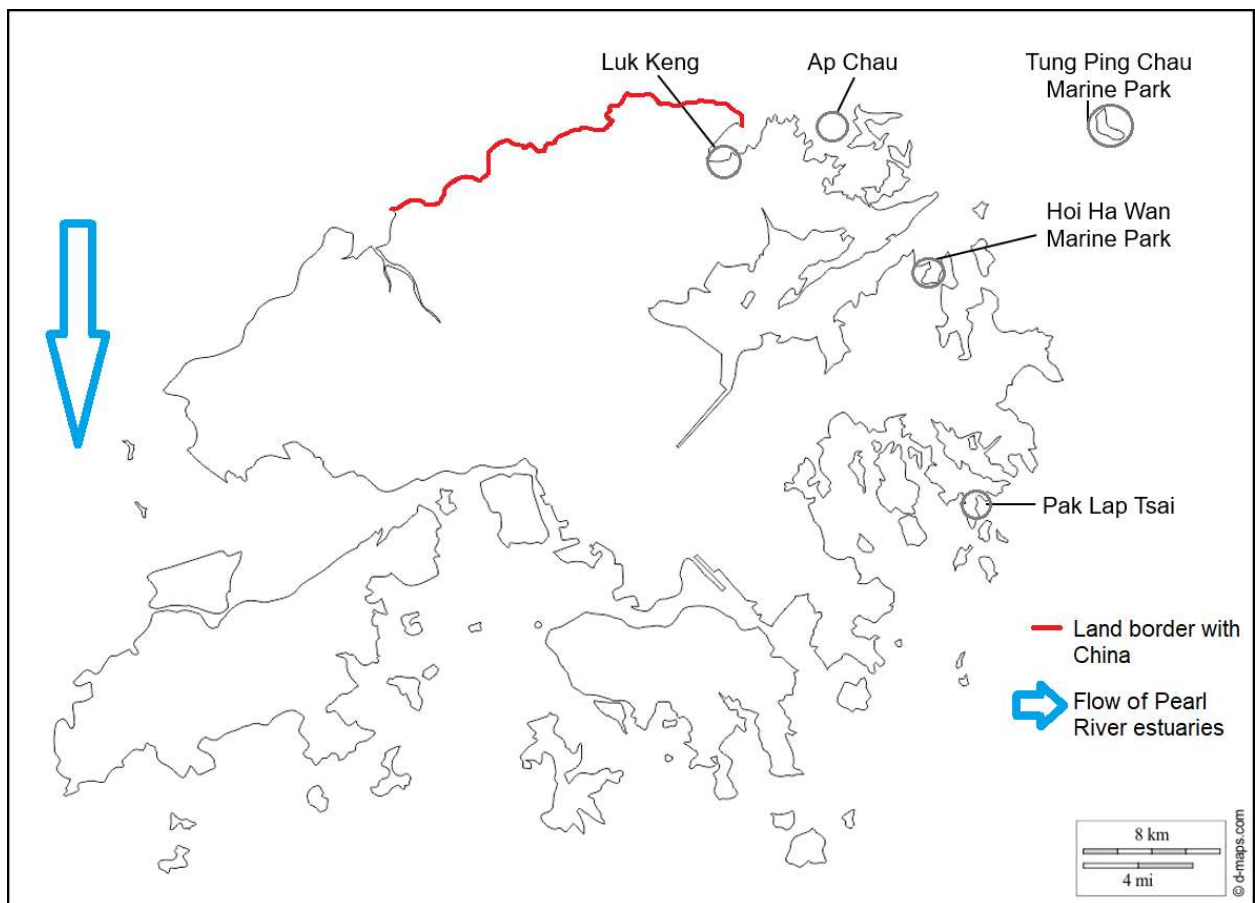
21 Sea-based sources of marine debris are mostly traced back to fishing vessels and offshore  
22 fisheries, as shown by the prevalence of fishing net and fishing items, such as floats, lures,  
23 buoys and line, in underwater surveys (Yeung, Lam, Kwok, Leung, & Lee, 2016); as well as  
24 watersports activities, leisure boating, and merchant shipping (Environmental Protection  
25 Department, 2015; WWF Hong Kong, 2015)  
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31 The effects of littering from merchant shipping can be seen in Aberdeen Typhoon Shelter,  
32 though the Marine Department state their regular contracted cleaning has alleviated the issue  
33 (Environmental Protection Department, 2015) it is argued that there is still a serious problem  
34 remaining (WWF Hong Kong, 2015). Improper littering by fishermen in the typhoon shelter is  
35 stated as the source, with polystyrene boxes frequently found (WWF Hong Kong, 2015). There  
36 have been further reports of illegal dumping of waste from vessels including yachts (WWF Hong  
37 Kong, 2015).  
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45 Rare events can also result in losses from cargo ships, resulting in huge amounts of marine  
46 debris. This was seen in July 2012 when Hong Kong suffered from a major spill of plastic pellets  
47 when six containers of over six billion polypropylene pellets packed in 6,000 sacks fell off a  
48 cargo ship during Typhoon Vicente (Hong Kong Cleanup, 2016). This pellet spill resulted in 150  
49 tonnes of plastic pellets spread across Hong Kong's southern coastline which took months to  
50 clear up, with pellets remaining to this day (Yeung, Lam, Kwok, Leung, & Lee, 2016). Cruise  
51 ships are another possible sea-based source of marine debris, however debris is often difficult  
52 to identify as it may often be similar to that from land-based sources.  
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4 1.2.3. Non-local sources of marine debris in Hong Kong

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6 In addition to the question of land-based and sea-based sources, there is also the question of  
7 the country of origin of the marine debris, a Hong Kong EPD study found that 95% of marine  
8 debris was local items, while 5% of marine litter was found to be non-local debris  
9 (Environmental Protection Department, 2015). Non-local debris was identified by counting items  
10 whose packaging labels contained simplified Chinese characters, and comparatively higher  
11 concentrations of non-local items were found at Ap Chau, Luk Keng, Tung Ping Chau Marine  
12 Park, Hoi Ha Wan Marine Park near Mirs Bay and Pak Lap Tsai (Figure 1) (Environmental  
13 Protection Department, 2015). Non-local items were mostly packaging materials such as plastic  
14 food wrappers, plastic or glass drinks bottles, metal food cans and metal cigarette tins  
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52 *Figure 1 Hong Kong's coastline and where non-local marine debris was found*

53 (Environmental Protection Department, 2015). The presence of non-local items however does  
54 not prove that the items come from outside of Hong Kong's territorial waters, as non-local items  
55 may have been purchased in local stores or brought into Hong Kong by local residents or  
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## 1.3. The Impacts of marine debris in Hong Kong

### 1.3.1. Ecological impacts

Though Hong Kong occupies only 0.03% of China's total marine area it has an exceptional amount of marine biodiversity – with over 6000 marine species recorded in Hong Kong's waters, it contains approximately 25% of China's total marine species (Astudillo, et al., 2021; Yeung, Lam, Kwok, Leung, & Lee, 2016). However, these species are under threat due to the large amounts of marine debris that accumulates in Hong Kong waters. Vast numbers of species are affected in many ways by the debris, most notably through entanglement and consumption of plastics. Although chemical transfer, aiding invasions of non-indigenous species and modification of the assemblages of species are other ecological impacts that need to be addressed (Yeung, Lam, Kwok, Leung, & Lee, 2016).

One type of marine organism that is affected by marine debris is sea turtles, most commonly by entanglement or consumption. As of 1997 records show evidence of entanglement for six of the seven species of sea turtle (Laist, 1997), with the marine pollution problem having worsened it is likely other sea turtle species will have been impacted. A study found two sea turtles, between 2011 and 2012, washed up in Hong Kong with plastic debris in their stomachs (Ng, Ang, Russell, Balazs, & Murphy, 2016). A green sea turtle was also found in 2013 with its death attributed to entanglement from a fishing net.

Seabirds are another group of marine organisms that are commonly impacted by their plastic consumption due to their feeding behaviour (Azzarello & van Vleet, 1987). Many are surface-feeders or plankton-feeding divers (Robards, Piatt, & Wohl, 1995), meaning plastics, particularly microplastics, are accidentally ingested. Researchers reported over a 14 year study, that plastic ingestion by procellariiformes, an order of seabirds, increased, likely due to an increased availability of plastic (Moser & Lee, 1992). Therefore, it can be deduced that, as there has been a further increase in plastic production and pollution since their study, plastic ingestion by seabirds passing through or inhabiting in Hong Kong may have increased further.

## Mitigating marine plastic debris in Hong Kong: an action plan

Abandoned, lost or otherwise discarded fishing gear (ALDFG), also known as “ghost gear”, is another contributor to marine animal deaths. Eight cetaceans, found in Hong Kong waters, between 1993 and 1998 had evidence of entanglement from fishing gear (Parsons & Jefferson, 2000). In the years succeeding this study, an increase in fisheries and ALDFG will have exacerbated this issue. Studies have also shown cetaceans are heavily impacted through the ingestion of plastic (Baird & Hooker, 2000). Entanglement from ALDFG is also a threat to other marine species; there is an abundance of literature documenting the entanglement of sea turtles, seabirds and other marine mammals from a variety of fishing gear and other plastic debris (Laist, 1997; Sigler, 2014)

### 1.3.2. Social impacts

Not only are marine species impacted by debris found in the ocean, humans can be too. Popular tourist spots can be heavily influenced as ocean debris is washed up onto beaches or coastlines (Yeung, Lam, Kwok, Leung, & Lee, 2016) or the seascapes can become polluted, affecting the aesthetics of an area. This can then influence tourists’ decisions as to whether to visit somewhere or not. For business owners that rely on tourists, this has an impact on their income.

Seafood is a large part of Hong Kong’s trade and regular diet, with average annual per capita consumption rates of fish and molluscs at 32.1 kg and 19.1 kg respectively, some of the highest in the world (Ho & Leung, 2014). The west coast of Hong Kong and the surrounding area of the Pearl River estuaries (Figure 1) are hotspots for accumulation and distribution of microplastics (Fok & Cheung, 2015; Wu, Yang, & Criddle, 2017). Researchers reported the abundance of microplastics in Hong Kong is higher than the global average, suggesting locally caught and sold shellfish and bivalves contain higher concentrations of microplastics (Fok & Cheung, 2015). Sold and eaten in Hong Kong, one could infer Hong Kong locals that consume locally produced seafood frequently ingest more microplastic particles than the international average. Once consumed the toxicity of plastics and leaching of harmful chemicals (van Cauwenberghe & Janssen, 2014; Werner, et al., 2016) can have negative impacts on a person’s health.

### 1.3.3. Economic impacts

Marine debris in Hong Kong also has huge impacts economically, to the government, to businesses and to individuals. Over 15,000 tonnes of marine litter is collected annually by the

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Hong Kong government, by which contractors are hired, at a cost of USD \$3.85 million, to remove marine debris from Hong Kong's harbour (Yeung, Lam, Kwok, Leung, & Lee, 2016; McIlgorm, Raubenheimer, & McIlgorm, 2020). Transporting and disposing of collected marine debris appropriately incurs large costs and other clean up schemes in place for the outer lying regions of Hong Kong increases these annual costs of disposing of marine litter, heavily burdening the economy.

Hong Kong's ferry services have also reported not only time losses but also economic damage due to marine debris. It was estimated that between 2006 and 2007 the ferry service incurred losses of USD \$19,000 per vessel (McIlgorm, Raubenheimer, & McIlgorm, 2020). Along with the time losses of 12.36 hours, and therefore fewer customers, this too has a significant impact on the economy.

## 2. Proposed action plan

Excessive growth of plastic and other marine litter in coastal environments is not only a problem with the consumption of the materials, but also the management strategies to prevent and mitigate the issue (Rangel-Buitrago, et al., 2021). With reference to the Honolulu Strategy, the proposed, multifaceted action plan to combat marine litter in Hong Kong aims to address the following:

- A.** Reduce the amount of waste being produced
- B.** Reduce the amount and impact of marine debris introduced to the sea
- C.** Reduce the amount and impact of accumulated marine debris

### 2.1. Reduce the amount of waste being produced

With such a large population and high population density there is an urgent need for Hong Kong to reduce the amount of disposable products it is consuming, with its high and unsustainable levels of consumerism, in order to reduce its pressures on the environment. Hong Kong has seen its municipal solid waste (MSW) increase over 80 percent in the past three decades, when the population rose only 36% (Lo & Liu, 2018). To reduce the amount of waste being produced we propose the following strategies.

### 4 2.1.1. Waste levy 5

6 Since 2018, the Hong Kong government, at the strong encouragement from civil society, has  
7 explored the possibility of charging MSW disposal through a waste levy (Government of Hong  
8 Kong, 2018). The Waste Disposal (Charging for Municipal Solid Waste) (Amendment) Bill 2018  
9 designated two charging modes, one through the purchase of designated garbage bags for the  
10 disposal of rubbish at USD \$0.014 (HKD \$0.11) per litre, similar to the model implemented in  
11 Taipei, Taiwan, and another one through a “weight through gate-fee” which is administered  
12 when waste collectors pay for the disposal of truckloads of refuse that is weighed  
13 (Environmental Protection Department, 2018). With the bill drafted and widely supported by  
14 Hong Kong’s environmental NGOs, the passing of the bill faced an abrupt stop as the  
15 Legislative Council of Hong Kong has discontinued scrutiny of the bill, rendering plans to  
16 impose a waste levy at an abrupt halt in June 2020 (Government of Hong Kong, 2020). The  
17 waste levy is a classic example of the “polluter pays” principle and has seen drastic results in  
18 Taipei, where waste generation per capita decreased by approximately 65% after the  
19 implementation of the levy (Ecologic Institute, 2017). The introduction of a waste levy is  
20 expected to also reduce Hong Kong’s MSW.  
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### 33 2.1.2. Introduction of Producer Responsibility Schemes 34

35 Producer responsibility schemes (PRs) or extended producer responsibility (EPR) schemes  
36 have been widely implemented in developed regions of the world; in fact, twenty-six out of the  
37 28 European Union (EU) members states have EPR schemes for packaging waste in place, as  
38 recommended by the EU’s *Packaging and Waste Directive* (Watkins, et al., 2017). Hong Kong  
39 has introduced a PRS on Waste Electrical and Electronic Equipment in 2018 and plastic bag  
40 charges in 2009, however, there is yet no requirement or incentives for producers and first  
41 importers in Hong Kong to improve their recycling rates for plastic or glass products  
42 (Environmental Protection Department, 2019; Environmental Protection Department, 2019).  
43 PRS should be introduced for glass containers, plastic packaging and large packaging  
44 containers (such as polystyrene boxes) to give distributors, importers and/or producers  
45 increased responsibility for the collection, treatment and end-of-life disposal of products. Local  
46 environmental NGOs and manufacturer-funded organizations in Hong Kong have urged the  
47 Hong Kong government to expand PRS and establish value-on-return (deposit return) schemes  
48 for plastic packaging, especially for beverage containers (WWF Hong Kong, 2019; Drink  
49 Without Waste, 2020). In February 2021, the government of Hong Kong has launched a public  
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## Mitigating marine plastic debris in Hong Kong: an action plan

consultation on PRS on plastic beverage containers (Environmental Protection Department, 2021). Both PRS/EPR schemes and value-on-return/deposit return schemes should be introduced in Hong Kong as soon as possible to incentivize the reduction of packaging, especially those made of non-recyclable materials.

### 2.1.3. Education campaigns

The Hong Kong government has launched the Source Separation of Domestic Waste programme as early as 2005 with recycling being the central theme (Lo & Liu, 2018). There should be increased education on the issue of waste mis-management and the marine debris issue. This should target both individuals and corporations involved in the fishing industry, the general public, local producers and retailers, waste management companies and decision makers. Education campaigns are often run by NGOs however more government funding should be allocated for pollution education programs. World Wide Fund for Nature (WWF) Hong Kong has, since 2019, begun an educational and analytical initiative of ALDFG or ghost gear (WWF Hong Kong, 2019). By further educating the general public, local producers and retailers, and the fishing industry on the marine pollution issues and the effects of overconsumption and excessive packaging, it is hoped that they will have increased understanding of the effects their actions have on the issue of marine debris. This aims to result in reduced consumption and a notion of increased responsibility to dispose of waste with increased care.

### 2.1.4. Implementation of legislation for the most damaging items

Bringing in regional or national legislation which requires charges on single-use plastic items aims to cut consumption of the most harmful products. As seen throughout studies into Hong Kong's marine debris issue single-use disposable plastic items, namely food packaging, beverage bottles and caps, are Hong Kong's most common marine debris, alongside polystyrene (Styrofoam) pieces and boxes. Compulsory charging for single-use items has been seen to have successful results, with the United Kingdom's "five pence" (USD \$0.069) plastic bag charge resulting in an 86% reduction in plastic bag consumption per person since the charge was introduced in 2015 (Department for Environment Food & Rural Affairs, 2020). Hong Kong's neighbour, Macau, has already enacted a ban on Styrofoam takeaway food containers from January 2021 (TDM - Teledifusão de Macao, 2020). It is advisable that Hong Kong follows

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4 suit and imposes stricter regulations on the applications and disposal methods of damaging  
5 products such as polystyrene containers.  
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9 Although large retailers in Hong Kong must charge for plastic bags given, excessive amounts of  
10 plastic bags are still being used for packing fresh food and for 'food hygiene reasons' - such as  
11 to wrap cartons of milk and sealed, pre-packaged meat – there is also no enforcement of bag  
12 levies for wet market stalls. More policy to collect levy for single-use plastic items such as meal  
13 containers and cutlery could be efficacious in reducing overall plastic consumption in the Hong  
14 Kong. On the other hand, policies on mandatory “bring-your-own” reusable items to incentivise  
15 consumers to commit to reusable options would also be a culture-shifting action which could  
16 effectively reduce overall plastic consumption. A nominal rebate could spark the consumers'  
17 motivation to provide for themselves reusable alternatives.  
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26 In addition to charges or rebates on single-use items, banning harmful items ceases  
27 consumption and eventual input into the environment. Bans have already been implemented  
28 worldwide as seen with near-global bans on microbead-containing products and continue to  
29 target the world's most common polluting items such as France's ban on plastic cutlery  
30 (Schnurr, et al., 2018; Xanthos & Walker, 2017). Bans on polystyrene food containers would  
31 drastically reduce the marine pollution issue in Hong Kong and have been advocated for by civil  
32 society in the past.  
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### 39 2.1.5. Improvement of public facilities

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41 Improving public facilities such as public water fountains will reduce 'disposable lifestyles' and  
42 the purchasing of plastic bottles of water. Although some water fountains exist in public areas  
43 (set up by local charity 'Go Green Hong Kong' under the Water for Free initiative, some by the  
44 LCSD, and others are provided by independent restaurants and community centres) the  
45 provision of more water refill stations by the government in public spaces and mass transit  
46 railway stations will drastically cut plastic consumption (Water for Free, 2021). The mobile  
47 phone app and map launched by the Water for Free initiative allows residents of Hong Kong to  
48 find water dispensers in their vicinity to minimize the consumption of disposable plastic bottles in  
49 Hong Kong (Water for Free, 2021). The installation of more publicly accessible facilities, such as  
50 water fountains, for the reduction of single-use items and packaging could see further  
51 decreasing of MSW.  
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#### 4 2.1.6. Development of alternative sustainable packaging 5

6 Increased funding for the research, development and use of alternative sustainable packaging  
7 methods will result in reduced reliance on plastic as a packaging product. As 20% of Hong  
8 Kong's MSW is post-consumer plastics (Environmental Protection Department, 2021), the use  
9 of effective alternatives could have major impacts on the plastic marine debris issue.  
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15 Alternative packaging that can be biodegradable in natural conditions could be very attractive to  
16 the environmental conditions in Hong Kong as direct landfilling is the de facto waste disposal  
17 option for non-recyclables. Currently, there are numerous plant-based feedstock that could be  
18 promising for the conditions seen in Hong Kong. These types of feedstock, made of starchy  
19 materials such as tuber roots or corn, can be digested by many aquatic animals while still  
20 holding their intended shape throughout its shelf-life as would items made with petroleum-based  
21 feedstock (Bioplastic Feedstock Alliance, 2020). Singapore, a city-state with a similar capacity  
22 as Hong Kong, has found success in their researches for biodegradable packaging material  
23 made of sustainable feedstock, such as ones with durian rinds, a by-product of produce from  
24 the vicinity of the tropical nation (Zhao, Lyu, Lee, Cui, & Chen, 2019). With more research into  
25 this area, locally sourced alternatives to plastics could offer non-disruptive one-for-one  
26 substitution of plastic items with the advantage of not resulting in lasting marine litter in Hong  
27 Kong.  
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### 40 2.2. Reduce the amount and impact of marine debris introduced 41 to the sea 42 43

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45 In addition to reducing the amount of waste produced at source it is vital that measures are  
46 taken to reduce the amount of debris entering the marine environment via littering behaviour,  
47 wind, rain and extreme weather events, waste mismanagement, and stormwater drainage  
48 systems.  
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#### 52 2.2.1. Effective enforcement of fines 53

54 Littering behaviour and illegal dumping of waste are major sources of Hong Kong's marine  
55 debris, however, low rates of prosecution offer little deterrence (on average 13.7 marine litter  
56 cases were prosecuted per year in 2012 to 2014) (Yeung, Lam, Kwok, Leung, & Lee, 2016).  
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## Mitigating marine plastic debris in Hong Kong: an action plan

Marine debris and littering hotspots may be identified through the use of study data and should be used as locations to target stricter enforcement of existing littering penalties by the AFCD, Food and Environment Hygiene Department (FEHD), LCSD, Marine Department (MD) and Hong Kong Police Force (HKFP).

### 2.2.2. Improvement of drainage systems

Measures should be taken to improve stormwater drainage systems to stop litter entering the sea in coastal areas and in extreme weather events. Studies found higher levels of marine debris during the wet season and following extreme weather events, as seen following Typhoon Mangkhut in 2018 where beaches were covered in micro and macro-plastic debris (Lo, et al., 2020). To reduce the amount of marine debris introduced by drainage systems there should be increased routine cleaning of stormwater drains before and during the wet season. Floating booms and traps should also be installed at drainage outputs to capture marine debris that gets through installed grates.

### 2.2.3. Improvement of waste management systems

Hong Kong is far behind in its recycling facilities and there is a severe need for an increase in government funding for recycling programmes. There is a lack of public awareness on the importance of recycling, lack of recycling bins for both households and corporations, and lack of a mechanised recycling process. Due to recycling in Hong Kong being processed by hand, contamination of recycling bins by landfill waste results in recycling not being processed. More recycling and rubbish bins should also be provided in coastal and recreational areas to limit the amount of marine debris from recreational and shoreline activities. In addition to more bins, there should be increases in frequency of litter collection in marine litter hotspots or areas of high recreational shoreline activity.

## 2.3. Reduce the amount and impact of accumulated marine debris

Despite strategies to reduce the amount of waste produced at source and to reduce litter output into the marine environment there are still large amounts of marine debris present in the environment. Reducing waste production and output through the suggested strategies will also not gain immediate results and thus it is essential for removal of marine debris to continue.



### 7 2.3.1. Increased efforts in marine debris removal 8 9

10 An increase in frequency of marine debris removal by the MD, LCSD, AFCD and FEHD is  
11 required to prevent accumulation of marine debris in Hong Kong. Locations of marine debris  
12 removal should be prioritised with regard to the level of ecological importance, including the  
13 amounts of marine and shoreline flora and fauna. Frequency of clean-ups should be adjusted to  
14 account for the seasonal patterns in spatial variations of marine litter, with increased removal on  
15 the western and southern coastline during the wet season and increased removal on the  
16 eastern and north-eastern coastline during the dry season. A team of researchers has, through  
17 a geostatistical interpolation mapping approach, proposed a prioritized area map to highlight  
18 particular areas in Hong Kong for marine debris mitigation (Coleby & Grist, 2019; Grist &  
19 Coleby, 2020).  
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28 There are additional benefits in promoting coastal clean-up events organized by civil society.  
29 The positive effects of these clean-up campaigns can be seen with events run by The Hong  
30 Kong Cleanup, Plastic Free Seas and other charitable organisations which have resulted in the  
31 involvement of numerous Hong Kong public groups and corporations in the removal of marine  
32 debris across Hong Kong (Hong Kong Cleanup, 2016). The events equip individuals with the  
33 knowledge of how to carry out safe and effective debris removal alongside the government's  
34 clean-up efforts. Moreover, the involvement of residents of Hong Kong in "citizen science"  
35 programmes linked to marine debris recovery can contribute to crowdsourcing of data, as seen  
36 in the University of Hong Kong's academic conferences investigating the use of citizen science  
37 and possible applications in local marine protection and WWF Hong Kong's initiatives  
38 (University of Hong Kong, 2019; WWF Hong Kong, 2020).  
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### 50 2.3.2. Implementation of a rapid response action plan 51

52 There is a need for a rapid response action plan following extreme weather events such as  
53 typhoons and tropical storms to minimise the effects of the increased amounts of marine debris.  
54 A variety of actors should be involved to allow a widespread response. By modelling the  
55 information collected from the case of Typhoon Vicente in 2012 and Typhoon Mangkhut in  
56 2018, authorities of Hong Kong can derive at projections of where along Hong Kong's coastline  
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4 would there be surges of marine debris and plan recovery efforts along with the assistance of  
5 civil society and their volunteers accordingly.  
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### 10 11 2.3.3. Development and use of new technology 12 13

14 Development of new technology is needed to allow efficient management of the marine debris  
15 issue. Use of technology to locate areas of marine debris accumulation and remove debris from  
16 the marine environment would help increase current debris removal rates. New technology such  
17 as geographic information systems (GIS), artificial intelligence (AI) assisted detection  
18 methods, drones and automated traps can also assist in preventing outflow of debris into the  
19 marine environment (Schmaltz, et al., 2020).  
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## 28 2.4. Drivers, Pressures, State, Impacts and Responses (DPSIR) 29 framework 30 31 32

33 In order to facilitate comprehension of the issue of marine litter in Hong Kong, we employed a  
34 Drivers, Pressures, Impacts and Responses (DPSIR) framework (Figure 2) to summarise  
35 section 2. Following its terminology, social and economic drivers (D) impose pressures (P) on a  
36 given environment, which then undergoes a change of state (S), leading to impacts (I) on  
37 society and in the environment itself, which may elicit a response (R) feeding back on the  
38 previous categories (Smeets & Weterings, 1999). This is a tool for describing and analysing  
39 environmental problems in a clear and holistic manner, which can be used to bridge  
40 communication gaps between researchers, stakeholders, policy makers and the public  
41 (Svarstad, Petersen, Rothman, Siepel, & Wätzold, 2008). While critics of the DPSIR framework  
42 draw attention to its heavy reliance on a hierarchical (Carr, et al., 2007), overly simplistic nature  
43 (Maxim, Spangenberg, & O'Connor, 2009), and lack of standardization when attributing  
44 variables to a single category (Gari, Newton, & Icely, 2015), the framework has been  
45 successfully applied in a myriad of studies (Tscherning, Helming, Krippner, Sieber, & Gomez y  
46 Paloma, 2012; Gari, Newton, & Icely, 2015; Lewison, et al., 2016).  
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# Mitigating marine plastic debris in Hong Kong: an action plan

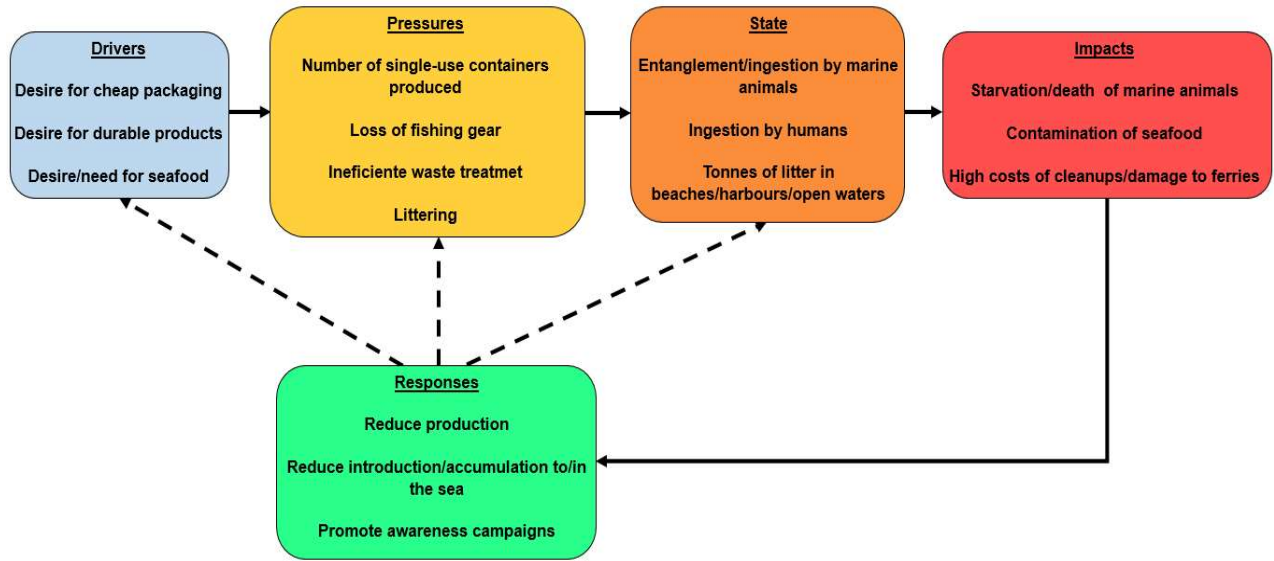


Figure 2 DPSIR framework of marine litter issues in Hong Kong. Each box stands for one of the elements of the scheme: Drivers (blue), Pressures (yellow), State (orange), Impacts (red) and Responses (green). Arrows represent connections between elements, while responses (dashed arrows) control drivers and pressures, and maintain/restore the state of the environment.

## 3. Implementation plan

### 3.1. Necessary components of the implementation plan

If implementation of policies in Hong Kong is to be successful, several major actors should be taken into consideration. The ones with greatest interest and potential to act on our proposal are government agencies and non-governmental organizations (NGOs) (Figure 3A, second quadrant). From a political standpoint, the Hong Kong government should be capable of implementing litter policies on its own, but in order to do so it first requires feedback from local citizens while also being heavily affected by plastic lobbyists. A similar approach was seen in the *Marine Litter Action Plan of the Baltic Marine Environment Protection Mission*, where the stakeholders have been consulted through a bottom-up approach (HELCOM, 2015). In this regard, it is important to emphasize its intermediate position along the 'attitude' axis (Figure 3B), given the reliance on other actors. Government agencies can act in two distinct fronts – by organizing independent studies and by legislating. The former is achieved by setting up advisory groups, such as the *Interdepartmental Working Group on Clean Shorelines* organized following the plastic pellet disaster of 2012 (Environmental Protection Department, 2015). Working group

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reports should offer an independent and thorough evaluation of current issues, constituting the scientific basis for decision-making. The latter is the legal outcome of this process.

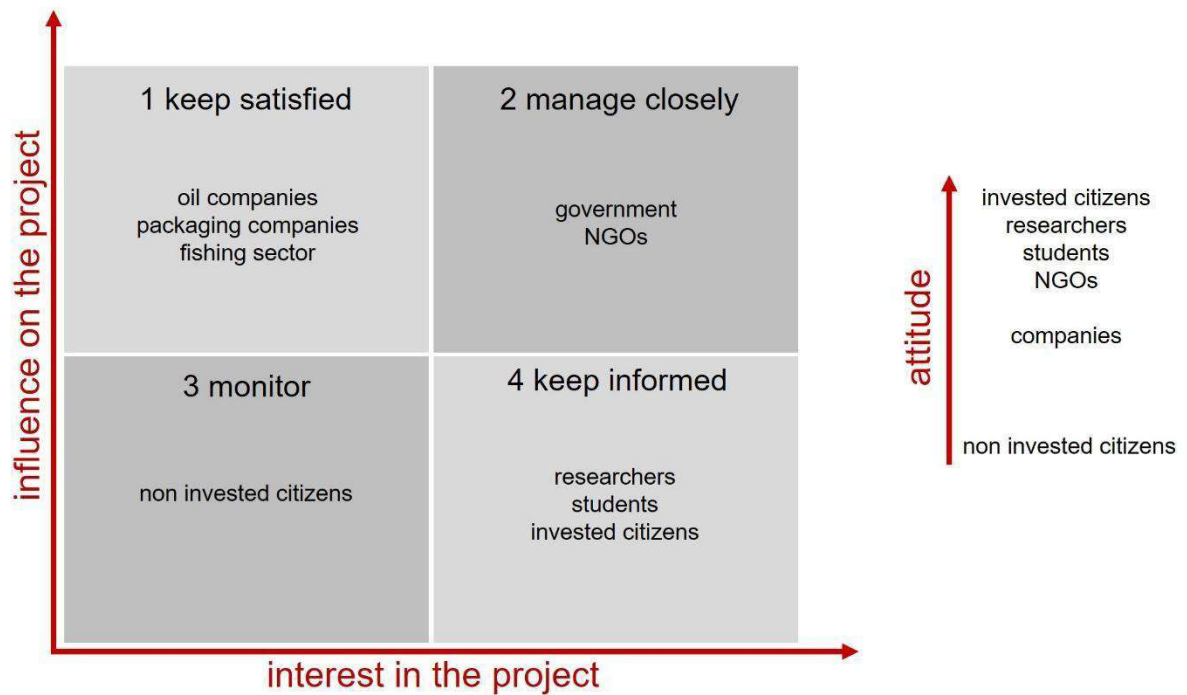


Figure 3 A. Actor analysis: the x-axis represents perspective on the project, while the y-axis represents power to act on the project. Quadrants depict the most appropriate action for each of the actor groups. B. Attitude meter: this axis indicates how likely each actor is to actively support the initiative in relation to one another.

Laws aimed at reducing consumption of single-use plastics, for instance, have been enacted in several countries. The European Commission adopted regulations in 2013 that would require member states to either start charging for plastic bags or ban them completely (European Commission, 2013); in 2019, the parliament successfully voted to ban plastic cutlery, cotton buds, straws and stirrers by 2021 (European Parliament, 2019), as part of a law against plastic waste in the marine environment. As for individual cities, the city of San Francisco became the first municipality in the United States to ban large retailers from distributing single-use plastic bags as early as 2007 (San Francisco Department of the Environment, 2007). In Brazil, the city of São Paulo and the state of Rio de Janeiro have also instituted charges on plastic bags since 2011 and 2018, respectively (Município de São Paulo, 2011; Assembleia legislativa do Rio de Janeiro, 2018).

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Similar to governmental bodies, NGOs can provide additional data on plastic production, use and destination. Several local NGOs and WWF Hong Kong conducted the Coastal Watch initiative which surveyed marine habitats in Hong Kong and characterized the plastic litter found in such environments (Yeung, Lam, Kwok, Leung, & Lee, 2016). Likewise, environmental campaigns aimed at educating the general population and informing citizens are effective tools to pressure government officials and promote marine pollution literacy. NGOs are positioned relatively higher on the attitude scale, given they actively seek to influence decisions as opposed to relying on public perception alone.

Regarding institutions with low interest in discussing the proposal but otherwise significant power to act on it (or against it), oil and gas, fishing and packaging sectors are major actors (Figure 3A, first quadrant). Oil and gas companies in the value chain, though not necessarily based or manufacturing in Hong Kong, are responsible for extracting, refining and producing raw plastic particles, thus constituting the source of all petroleum-based plastic consumed; in some cases, however, these companies can be directly involved with clean-up events after spill events. The fishing industry is a major source of plastic debris in the form of discarded or lost fishing gear, notorious for continuously entangling several types of aquatic animals long after being abandoned; this phenomenon is also known as ghost fishing. Packaging companies, similarly, are the producers and distributors of single-use items, and are the sector most affected by a possible ban.

Invested citizens and education institutions in the form of researchers and students, on the other hand, show a great amount of interest while having little influence on implementation actions (Figure 3A, quadrant 4) (WWF Hong Kong, 2020). However, they are placed at the top of the attitude scale: their coordinated actions are capable of pressuring governments to change policies. It must also not be forgotten that researchers are constantly evaluating and publishing results that form public opinion, especially those on pollution impacts, ingestion of contaminants, and their physiological effects on biota. Citizens and schools/universities thus provide a much-needed feedback to decision-makers, while popular opinion on issues such as plastic bags and straws has culminated on several recent laws, as seen in the public consultations conducted by the Hong Kong government on plastic related legislations (Environmental Protection Department, 2021). Finally, non-invested citizens can be seen as potential actors, but lack of interest/information places them at an unfavourable position (Figure 3A, quadrant 3). It is

4 important to consider, however, that once such citizens become aware of their relevance, they  
5 can be a powerful source of change.  
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## 10 3.2. Business engagement 11 12

13 The role businesses play in Hong Kong on the topic of plastic or even on general waste  
14 reduction is crucial given Hong Kong's pro-business yet competitive commercial environment.  
15 Hong Kong hosts countless global companies which bring in the presence of products from all  
16 regions of the world. This attribute of Hong Kong is opportune in the strategy to engage  
17 businesses to take the lead on reducing plastic waste, thereby reducing plastic marine debris in  
18 Hong Kong.  
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### 26 3.2.1. Champions in plastic waste reduction 27 28

29 Businesses that have already undergone drastic consideration or action for the reduction of  
30 plastic waste should be recognised by the government. In addition, by celebrating best practices  
31 of champions, the rest of the industry would likely follow suit. WWF has launched an initiative,  
32 Plastic ACTION (PACT) in Asia that identifies champions in each plastic-heavy industry and  
33 redistributes their best practices and solutions across the region. PACT has been launched in  
34 Hong Kong for the food delivery service industry to induce a reduction on plastic food containers  
35 (WWF Hong Kong, 2020). Expected results from highlighting champions in the private sector  
36 would provide best practice references for the rest of the industry and even the region to follow.  
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### 45 3.2.2. Industry-wide action and goals 46 47

48 On top of individual businesses that are exemplary in demonstrating plastic reduction, the  
49 industries should also be encouraged to take synchronised action on plastics. This way, the  
50 industry-wide action provides "safety in numbers" for the individual businesses when the  
51 reduction work is disruptive for their regular operations. For example, the removal of straws or  
52 cutlery from fast food restaurants caused dissatisfaction and complaints from customers. If all  
53 fast-food restaurants in a city, for instance, cease to give out these single-use items together  
54 with an explanation on the environmental impact this action may bring, consumers can better  
55 comprehend the not economical but environmental motives behind the action. WWF's PACT  
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4 initiative also caters to this aspect and encouraged all prominent members of oligopolies to take  
5 part in a coordinated plastic reduction action, as seen in the continued dialogue with the food  
6 delivery sector, dominated by merely several key players (WWF Hong Kong, 2020). Expected  
7 impact from encouraging entire industries to act on plastic reduction could be new industry  
8 norms created with businesses, now conscious of the environmental impact the materials they  
9 use may bring in the form of marine debris.  
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### 18 3.3. Policy advocacy and change 19

20 The arguably most effective and impactful change drivers are well-enforced policy  
21 implementation that looks into all stakeholders. Policy work on eliminating marine debris should  
22 be a long-term strategy beginning with holding producers responsible with the “polluter pays”  
23 mindset. Enforcement of littering fines and prosecution, enactment of EPR/PRS laws,  
24 introduction of deposits under value-on-return schemes, and subsidizing sustainable alternative  
25 material applications are much needed policy changes that should be implemented in Hong  
26 Kong as soon as possible. Local recycling should also be monetarily supported by the Hong  
27 Kong government in order to resume recycling after China’s ban on waste imports, examined  
28 further in the section below.  
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### 39 3.4. Cross-border collaboration with China 40

41 Marine debris found in Hong Kong waters are not exclusively from Hong Kong alone, because a  
42 significant portion comes from its northern neighbour and fellow stakeholder, China  
43 (Environmental Protection Department, 2015). It is important for the Hong Kong government to  
44 work closely with China on debris prevention that physically stops marine debris from drifting  
45 past the Pearl River Delta and into the South China Sea, where it is more difficult to recover  
46 debris. While there already are policies and researches jointly executed and conducted by the  
47 Hong Kong and Chinese government, a closer partnership is expected to be greatly beneficial in  
48 understanding and reducing marine debris for the two territories. More importantly, China was  
49 previously the destination for plastic recyclables collected in Hong Kong and the Asia Pacific  
50 prior to the 2017/2018 “National Sword” policy of banning imports of post-consumer plastics  
51 (Tran, Goto, & Matsuda, 2021). Hong Kong, though often reasserted by China as an undeniable  
52 territory of the People’s Republic of China, is considered to be a foreign territory when it comes  
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4 to import/export definitions. The banning of Hong Kong's recyclables in China is  
5 counterproductive in supporting the programmes and policies Hong Kong has for circular  
6 economy and has greatly impacted recycling rates, as 99% of imported waste was re-exported  
7 to China prior to the "National Sword" policy (Tran, Goto, & Matsuda, 2021).  
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### 11 3.4.1. Waterway projects in Southern China 12 13

14 With the Guangdong province government, Hong Kong should work on waterway physical  
15 blockage and filtration systems that can trap marine debris that runs southerly on the Pearl  
16 River and other estuaries into the South China Sea. As previously described, Hong Kong's  
17 marine debris removal efforts have been ongoing within the territory. However, more  
18 partnerships to have physical blockage in place upstream in China would be more effective than  
19 to scavenge in the marine environment in Hong Kong. Partnerships with Hong Kong to invest in  
20 waterway infrastructure in Guangdong province would be beneficial for the two geographies and  
21 governments.  
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### 31 3.4.2. Innovation on marine debris tracking in the region 32 33

34 As an innovation hub of Asia, Hong Kong boasts a booming industry of startups and an  
35 excellent cradle for effective ideas for environmental protection. In the pursuit to remove marine  
36 debris in the vicinity, the Hong Kong government should invest into innovation and ideation in  
37 marine debris tracking, scavenging and reduction solutions. Hong Kong can much better track  
38 marine debris with the help of internet of things (IoT) devices, AI-assisted detection imaging,  
39 GIS technology, as well as citizen science, as investigated above. Expected impact from an  
40 increased investment in debris tracking would include better understanding of how marine  
41 debris travels in the region, how they build up and how they are linked to the plastic  
42 consumption in the vicinity.  
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## 52 Conclusion 53 54 55

56 From the literature review of this study, it is found that Hong Kong has a substantial level of  
57 awareness and interest in combatting the issue of marine debris, as seen with its numerous  
58 NGO-led activities and vehement criticism on the absence of waste-reduction policies that are  
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## Mitigating marine plastic debris in Hong Kong: an action plan

already seen in other regions. The proposed multifaceted strategy to implement the action plan for Hong Kong's marine debris mitigation involves a thorough understanding of stakeholders and how they respond to different initiatives and policies. The DPSIR framework, coupled with a holistic action plan to a) reduce the amount of waste being produced, b) reduce the amount and impact of marine debris introduced to the sea and c) reduce the amount and impact of accumulated marine debris are recommended to be considered together by authorities and civil society. Actors such as the Hong Kong government, plastic value chain decision-makers, NGOs and academia should work together with Hong Kong's invested citizens to further build on existing strategies to detect, monitor and reduce marine debris, as well as to reduce waste from source as long-term approaches.

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**Declaration of interests**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: