A project entitled

*The origin of stranded shoreline macroplastic debris in Hong Kong*

Submitted by

*Tsui Ka Mei*

submitted to The Education University of Hong Kong

for the degree of *Bachelor of Education (Honours) (Geography)*

in *April 2021*

Declaration

I, *Tsui Ka Mei* declare that this research report represents my own work under the supervision of *Dr. Lincoln Fok,* and that it has not been submitted previously for examination to any tertiary institution.

*Tsui Ka Mei*

*19$^{th}$ April 2021*

Table of Contents

List of Tables

List of Figures

Abstract

In recent years, macroplastic debris (> 25 mm) in the aquatic ecosystem has aroused public concern, both locally and globally. In this study, macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters, other languages or no label was counted in five transects of three channelized rivers and on six sandy beaches located at the inner and outer bay in Hong Kong during a wet summer season (May–September 2020).

The results showed that the mean proportion of macroplastic debris labelled with traditional Chinese characters in channelized rivers was 85.6% by number, suggesting that locally generated macroplastic debris is likely to be labelled with traditional Chinese characters in Hong Kong. Meanwhile, the Independent-Samples T Test revealed that the mean proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on the two sandy beaches located at inner bay by number was significantly higher ($p < 0.05$) than that on the four sandy beaches located at outer bay, suggesting that stranded shoreline macroplastic debris on inner sandy beaches tend to has a local origin — channelized river, whereas that on outer sandy beaches tend to has a non-local origin in Hong Kong. The low proportion of stranded shoreline macroplastic debris contributing from local sources on Lung Kwu Tan located on the west coast suggested that the Pearl River may be a potential source of macroplastic debris. Apart from it, of the many kinds of labelled macroplastic debris found, plastic beverage bottles were the most prevalent type of macroplastic debris and followed by food wrappers, constituting 66.2% of the total abundance by number in Hong Kong. Additionally, particular attention should be given to the blooming threat brought by improperly disposed face masks under the coronavirus disease 2019 (COVID-19). Further research on the spatial-temporal variation of the stranded shoreline macroplastic debris will help formulate strategic policies to address this problem in Hong Kong.

## 1. Introduction

Marine debris is a transboundary global environmental issue, which presents in marine habitats worldwide, from densely populated to remote islands or polar regions and from shallow waters to the deep-ocean trenches (Wang et.al., 2016). According to the United Nations Environment Programme (UNEP) (2009), marine debris is defined as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment" (p.13). It can be classified into plastics, metal, glass, processed timber, paper, rubber or cloth (Galgani et al., 2010). It is estimated that the total input of marine debris into the oceans and seas was approximately 8 million per day (UNEP, 2005). Among all categories, plastic debris was the main component of marine debris on a global scale, which constituted up to 95% of the waste on shorelines, the sea surface and the seafloor (Galgani, Hanke & Maes, 2015). The continuous growth of marine debris, mainly plastics is of significant concern since plastics have a very slow rate of degradation from initial embrittlement to fragmentation and eventually complete chemical decomposition, which leads to a gradual increase and accumulation in the marine and coastal environment over time (STAP, 2011). Also, most plastics having low specific gravity (less than l.03g $cm^{-3}$ of sea water) are positively buoyant in the seawater-air interface (Kanehiro, Tokai & Matsuda, 1995). They can be transported over considerable distances via prevailing winds and ocean currents and consequently washed ashore on beaches, producing a wide spectrum of environmental, economic and social impacts along the way (Barnes et al., 2009).

For environmental impacts, plastic marine debris entanglement restricts the movement of marine wildlife, leading to starvation, suffocation, laceration and possible mortality in species; ingestion of indigestible plastic marine debris causes gastrointestinal obstruction of marine organisms, leading to nutrient deficiency, starvation and eventual mortality in species; plastic marine debris leads to physical interference including sunlight obstruction and surface scoring of marine and coastal habitats; plastic marine debris serves as a transport medium of invasive species, leading to biodiversity loss and changes to habitat structure and ecosystem functions (Sheavly & Register, 2007).

For economic impacts, plastic marine debris reduces tourism revenue on the ground of the aesthetic degradation of coastal areas; plastic marine debris removal results in substantial cleansing costs; plastic marine debris damages vessels and fishing equipment, increasing fisheries' and aquaculture operators' monetary and time costs of repair or replacement; ghost fishing reduces potential catches, leading to economic losses of commercial fisheries (Mouat, Lopez Lozano & Bateson, 2010).

For social impacts, plastic marine debris diminishes the intrinsic values — non-use value (knowledge that the quality of aquatic ecosystems is maintained) and option value (ability to use the beaches, coasts or seas) and social values — aesthetic value associated with the marine and coastal environment; plastic marine debris poses a public health risk in terms of consumption of hydrophobic contaminated seafood, navigational hazards caused by fouling and damage of a vessel's propeller or equipment and injuries to recreational users in-water situations as people being entangled in plastic submerged debris and minor cut or abrasion injuries on shore caused by beach washed plastic marine debris (Cheshire et.al., 2009).

The Hong Kong Special Administrative Region (HKSAR) is a densely populated coastal city composed of a peninsula and 263 islands with a dense population of over 7.5 million people inhabited in a land area of 1 107 $km^2$ in 2019 (Census and Statistics Department, 2020). It has a sea area of 1 648 $km^2$ and a relatively long coastline of 1 197 km (with 95 % of its land boundaries surrounded by the sea) (Environmental Protection Department, 2018). Despite being a small city that occupies only 0.03% of the total marine area of China, Hong Kong supports a rich marine biodiversity of 5943 marine species, accounting for ~26% of China's total number of marine species (Ng et.al., 2016).

According to the Environmental Protection Department, over 14,800 tonnes of marine debris which was mostly made of plastic was collected annually by the Hong Kong government between 2010 and 2019 (Clean Shorelines, 2021). Nevertheless, thousands of tonnes of marine debris remain uncollected and accumulate in situ, especially in areas that are not cleaned up regularly by government departments or community groups (Yeung, Lam, Kwok, Leung & Lee, 2016). To review existing measures and formulate strategic policies to address the marine debris problem, the Hong Kong government has appointed the Mott MacDonald Hong Kong Limited to conduct a study to investigate the origin, sources, composition and geographical distribution of marine debris in Hong Kong waters from April 2013 to March 2014.

For the origin of marine debris, stranded shoreline debris and floating debris originating from the Mainland accounted for a relatively small portion (5%) of all the marine debris sampled, which was counted by referring to the simplified Chinese characters labelled on the packaging labels of the debris at 32 coastal locations (Mott MacDonald Hong Kong Limited, 2015). Meanwhile, marine debris with packaging labels in traditional Chinese characters was counted as a local item. Nonetheless, marine debris labelled with other languages was overlooked in the classification method for reporting the origin of marine debris. Also, trade globalization and the increasing ethnic diversity within population centers imply that marine debris labelled with simplified Chinese characters may or may not has a non-local origin, whereas those labelled with traditional Chinese characters may or may not originate from the local. Therefore, this study aims to assess the origin of shoreline debris, particularly macroplastic debris stranded on sandy beaches in Hong Kong regarding the sources, composition and geographical distribution of marine debris identified in previous studies in Hong Kong waters. In this paper, macroplastic debris refers to plastic debris with a diameter larger than 25 mm (Romeo et al., 2015).

For the sources of marine debris, most of the stranded shoreline debris and floating debris was generated from land-based sources (84%) when compared with that from marine-based sources (16%) (Mott MacDonald Hong Kong Limited, 2015). This matches with a research finding revealing that a large amount (80%) of plastic debris in the marine environment was from densely populated onshore areas (Derraik, 2002). Improperly disposed land-based anthropogenic debris is believed to be transported directly or indirectly by wind and surface runoff during rainstorms into river systems or stormwater drainage systems and finally to coastal waters and beaches in Hong Kong (Araújo & Costa, 2007; Lima, Costa & Barletta, 2014; Fok & Cheung, 2015). In other words, debris found in Hong Kong's river channels can serve as an indicator of locally generated macroplastic debris.

For the composition of marine debris, the majority (over 70%) of stranded shoreline debris and floating debris was plastic debris, in which food-related packaging debris was the most common type (Mott MacDonald Hong Kong Limited, 2015). According to the Food and Drugs (Composition and Labelling) Regulations, name of the food, list of ingredients, indication of "use by" or "best before" date, statement of special conditions for storage or instructions for use, name and address of manufacturer or packer and count, weight or volume of food should be labelled on the label of prepackaged food in either English or Chinese language, apparently in traditional Chinese characters or in both languages unless there is an exemption in Hong Kong (Department of Justice, 2016). Meanwhile, according to the Standard for Nutrition Labelling of Prepackaged Foods, energy, core nutrients content value and percentage in the nutrient reference values (NRV) are mandatory to be labelled on the nutrition label of prepackaging foods in Chinese, apparently in simplified Chinese characters or foreign languages in correspondence with Chinese in China (Ministry of Health of the People's Republic of China, 2011). These regulations suggest that a vast amount of macroplastic debris found in Hong Kong's river channels should be labelled with traditional Chinese characters.

For the geographical distribution of marine debris, seasonal variation was identified as in general a higher amount of stranded shoreline debris and floating debris was collected during the wet season (Mott MacDonald Hong Kong Limited, 2015). Also, more stranded shoreline debris and floating debris was collected at the western and southern coasts of Hong Kong during the wet season, whereas more of that was collected at the eastern coasts of Hong Kong during the dry season under the influence of monsoon winds (Mott MacDonald Hong Kong Limited, 2015). These observations were corroborated with a study result showing that the abundances and weights of plastic marine debris were significantly higher in the wet season than in the dry season and the Pearl River on the west of Hong Kong plays a crucial role in the distribution of plastic debris in Hong Kong (Cheung, Cheung & Fok, 2016).

With reference to the sources, composition and geographical distribution of marine debris in Hong Kong waters, this study will examine the origin of stranded shoreline macroplastic debris in Hong Kong during a wet summer season by analysing the proportion of macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters, other languages or no label in channelized rivers and on sandy beaches. The following hypotheses were tested in this study: (1) most of the macroplastic debris in the channelized rivers is labelled with traditional Chinese characters; (2) more stranded shoreline macroplastic debris on inner sandy beaches is labelled with traditional Chinese characters than on outer sandy beaches; and (3) more stranded shoreline macroplastic debris on outer sandy beaches is labelled with simplified Chinese characters and other languages than on inner sandy beaches. Hypothesis (2) and (3) can only be tested if hypothesis (1) is accepted.

## 2. Methodology

### 2.1. Sample site — Channelized Rivers

Five transects were selected from three channelized rivers, namely Tuen Mun River, Kam Tin River and Shan Pui River (Fig. 1). The length of the transect at Tuen Mun River is about 3481 m; the length of transects at Kam Tin River 1, Kam Tin River 2 and Kam Tin River 3 are about 3747 m, 3748 m and 2405 m respectively and the length of the transect at Shan Pui River is about 3853 m. These transects were identified from Google Maps, where the channelized river flows through dense settlements downstream and enters Castle Peak Bay (Tuen Mun River) and Deep Bay (Kam Tin River and Shan Pui River). Improper disposal of macroplastic debris generated by intense human activities along the channelized rivers is likely to enter these channelized rivers during the rainfall-runoff process as a local source of debris.


Fig. 1. Routes of the five sampling transects along three channelized rivers in Hong Kong. At Tuen Mun River, one transect from Siu Hong Station Exit F to Siu Hong Court Glorious Garden was selected (marked in red). At Kam Tin River, three transects were selected: one from Kam Tin Low Flow Pumping Station to Kam Tai Road to the end of Wang Toi Shan Shan Tsuen Road (marked in yellow), one from Kam Tin Low Flow Pumping Station to Kam Po Road to Kam Shek Road to Kam Shui North Road to Kam Shui Road to the end of Kam Shui South Road (marked in blue), one from Yeung Uk Tsuen Garden along Long Ho Road to Shung Ching Road to Sham Chung Tsuen Road to the end of Sham Chung Road to Lung Tin Sewage Pumping Station (marked in orange). At Shan Pui River, one transect from Chung Hau Tsuen Public Toilet along Wang Lok Street to Po Fai Path to Hi Lee Path to Cheung Shing Path to Ma Tin Road to Kung Um Road to Pak Sha Tsuen RCP (YL-24), Shap Pat Heung was selected (marked in purple).

2.2. Sample site — Sandy Beaches

Six sandy beaches were selected from the inner and outer bay of Hong Kong. Two sandy beaches, namely Ma Shi Chau and Wu Kai Sha Beach are located at inner bay and four sandy beaches, namely Lung Kwu Tan (western part of Hong Kong), Pui O Beach and Stanley Back Beach (southern part of Hong Kong) and Sai Wan Beach (eastern part of Hong Kong) are located at outer bay (Fig. 2). All of the selected sandy beaches are non-gazetted beaches where beach maintenance does not carry out frequently on a daily basis by the Food and Environmental Hygiene

Department and shark prevention nets are not equipped, which prevent the shoreline debris from being collected before data collection or being blocked off the beach and enhance the measurement validity of the research findings, except Pui O Beach. For Pui O Beach, samplings were conducted at the two ends of the beach to minimize the error caused by the shark prevention net installed around the middle section of the beach.

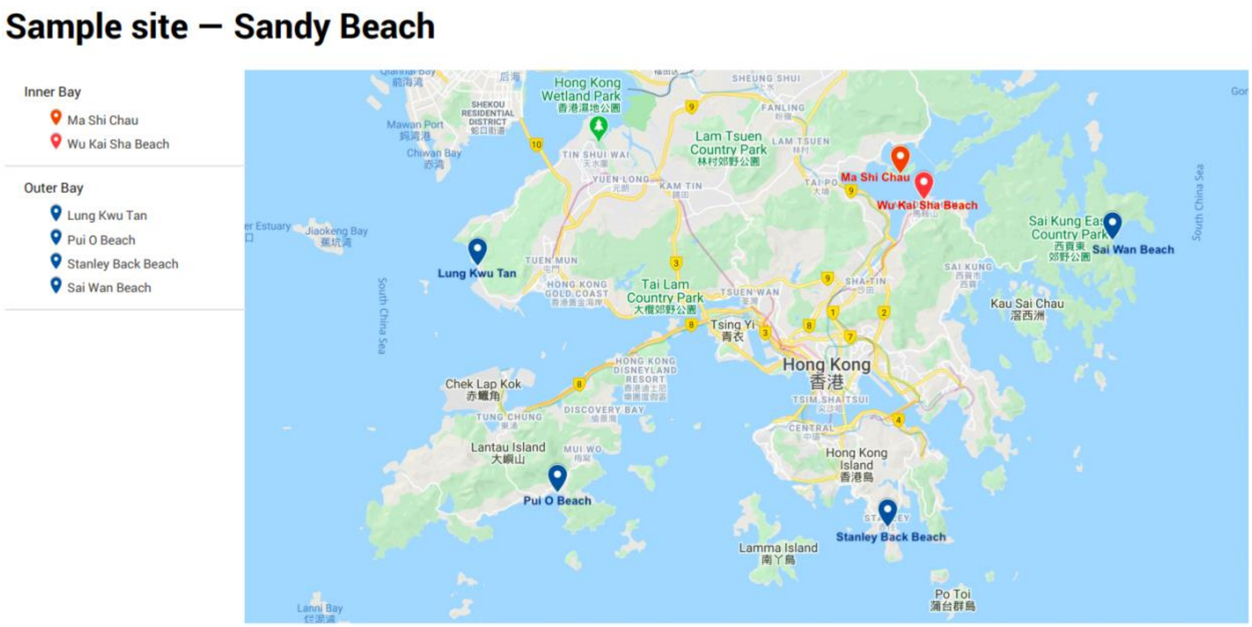


Fig. 2. Locations of the six sampling sandy beaches in Hong Kong. Two sandy beaches were selected in the inner bay (marked in red): Ma Shi Chau and Wu Kai Sha Beach. Four sandy beaches were selected in the outer bay (marked in blue): Lung Kwu Tan (western part of HK), Pui O Beach and Stanley Back Beach (southern part of HK) and Sai Wan Beach (eastern part of HK).

2.3. Data collection

Sampling was conducted during a wet summer season (May-September 2020), a period when the sum of the monthly mean of rainfall accounted for over two-thirds of Hong Kong's annual total rainfall (mean annual rainfall (1997 - 2020) = 2419 mm) (Hong Kong Observatory, 2021). The amount of macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters, other languages or no label was counted visually by the naked eye with a binocular along each transect of the channelized rivers and from the water edge to the back across the sandy beaches within a week after a rainfall event. The rainfall amount was large enough with a Red

Rainstorm Signal (heavy rainfall exceeding 50 millimetres in an hour), Black Rainstorm Signal (heavy rainfall exceeding 70 millimetres in an hour), Announcement on Localized Heavy Rain (rainfall of 70 millimetres or more is recorded in an hour in individual districts of Hong Kong) or Special Announcement on Flooding in the northern New Territories (heavy rain affects the area and flooding is expected to occur or is occurring in the low-lying plains of the northern New Territories) to ensure a substantial amount of macroplastic debris to be observed and counted at the sample sites, which enhanced the reliability of the findings (Hong Kong Observatory, 2021). The data was recorded on a debris survey form (Appendix — Debris Survey Form) which was designed with reference to the ocean trash data form of the International Coastal Cleanup with new columns (traditional Chinese characters, simplified Chinese characters, other languages and no label) indicating the origin of the debris added next to the name of the most commonly found debris like food-related packaging items (Ocean Conservancy, 2019). Natural debris like tree branches, dead leaves, seagrass or algal wrack, etc. was explicitly excluded in the debris survey.

2.4. Statistical Analysis

The abundance of macroplastic debris labelled with traditional Chinese characters at each sampling site was calculated by dividing the number of distinguishable macroplastic debris labelled with traditional Chinese characters by the total number of distinguishable macroplastic debris excluding those with no label. The values of macroplastic debris labelled with traditional Chinese characters were expressed in terms of proportion (%). The proportion of macroplastic debris labelled with traditional Chinese characters at each sampling site was calculated by the formula as follows:

Proportion of TCC macroplastic debris ($P_{TCC}$) = [illegible]

where TCC = Traditional Chinese Characters

Afterward, a source-apportionment study given the assumption that all stranded shoreline macroplastic debris labelled with traditional Chinese characters on each sampling sandy beach came from channelized rivers only was performed to quantify the proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on each sampling sandy beach. It was calculated by dividing the proportion of stranded shoreline macroplastic debris labelled with traditional Chinese characters on each sampling sandy beach by the mean proportion of macroplastic debris labelled with traditional Chinese characters in the five sampling transects of the three channelized rivers and used to perform statistical analysis (modified from Peart & Walling, 1986). The proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on each sampling sandy beach was calculated by the formula as follows:

Proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) $= \frac{\text{[illegible]}}{\text{[illegible]}}$

All statistical tests were performed using SPSS software, version 26.0. The results were reported using descriptive statistics. The Shapiro–Wilk test was adopted prior to further statistical analysis to assess the normality of the data. As the data approached a normal distribution (proportion of macroplastic debris labelled with traditional Chinese characters in channelized rivers: $p = 0.821$; proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on sandy beaches: $p = 0.542$), the parametric tests were applied. Independent-Samples T Test was used to detect the difference of the proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on sandy beaches located at inner bay and outer bay. In all cases, the results obtained with p levels $< 0.05$ were considered statistically significant.

## 3. Results

### 3.1. Quantity and composition of debris

A total of 68649 distinguishable debris was counted by number from five transects of three channelized rivers (12002 items) and six sandy beaches (56647 items) in this study. Among these, macroplastic debris represented the vast majority (64469 items; 82.1%), whereas non-plastic debris including metal, glass, paper, cloth, rubber and wood constituted only a minor proportion (4180 items; 17.9%). Within the macroplastic debris, those labelled with traditional Chinese characters, simplified Chinese characters and other languages only made up a small proportion (2629 items; 19%), whereas the vast majority (61500 items; 81%) was no labelled. Of the many kinds of labelled macroplastic debris found, beverage bottle was the most abundant items (37.6%), followed by food wrapper (28.6%).

### 3.2. Proportion of macroplastic debris labelled with traditional Chinese characters in channelized rivers

Table 1
Statistical summary of the proportion of macroplastic debris labelled with traditional Chinese characters (TCC) in channelized rivers by number

| | TCC macroplastic debris Proportion (%) |
|---|---|
| Mean | 85.564 |
| Median | 85.388 |
| SD | 6.571 |
| IQR | 10.714 |
| Minimum | 73.826 |
| Maximum | 95.054 |

A total of 2296 distinguishable macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters and other languages was counted by number from five transects of three channelized rivers — Tuen Mun River (924 items), Kam Tin River 1 (473 items), Kam Tin

River 2 (295 items), Kam Tin River 3 (327 items) and Shan Pui River (277 items). By number, the mean proportion (± SD) of macroplastic debris labelled with traditional Chinese characters in channelized rivers was 85.6 ± 6.6% (Table 1). This proved that most of the macroplastic debris in the channelized rivers was labelled with traditional Chinese characters (Hypothesis 1) and indicated that locally generated macroplastic debris (with label) is likely to be labelled with traditional Chinese characters in Hong Kong.

### 3.3. Proportion of stranded shoreline macroplastic debris contributing from local sources on inner and outer sandy beaches

Table 2
Statistical summary of the proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on inner sandy beaches and outer sandy beaches by number

| n | Macroplastic debris contributing from local sources (channelized rivers) Proportion (%) | |
|---|---|---|
| | Inner | Outer |
| | 4 | 7 |
| Mean | 62.857 | 39.535 |
| Median | 59.479 | 44.686 |
| SD | 12.197 | 10.985 |
| IQR | 21.695 | 17.258 |
| Minimum | 52.118 | 18.825 |
| Maximum | 80.349 | 46.749 |
| p[a] | 0.010 | |

[a] An Independent-Samples T Test was used to test the mean proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on inner sandy beaches and outer sandy beaches. A significant difference ($p < 0.05$) was found in the comparisons of the proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on inner sandy beaches and outer sandy beaches by number.

A total of 673 distinguishable stranded shoreline macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters and other languages was counted by number from six sandy beaches — Ma Shi Chau (106 items), Wu Kai Sha Beach (88 items), Lung Kwu Tan (363 items), Pui O Beach (39 items), Stanley Back Beach (49 items) and Sai Wan Beach (28 items). Using the proportion of stranded shoreline macroplastic debris labelled with traditional Chinese characters on each sampling sandy beach and the mean proportion of macroplastic debris labelled with traditional Chinese characters in the five sampling transects of the three channelized rivers, the source-apportionment study revealed that the mean proportion (± SD) of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) by number was higher on two sandy beaches located at inner bay (62.9 ± 12.2%) when compared with that on four sandy beaches located at outer bay (39.5 ± 11%) (Table 2). The Independent-Samples T Test revealed that the mean proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on two sandy beaches located at inner bay by number was significantly higher than that on the four sandy beaches located at outer bay ($p = 0.010$). This proved that more stranded shoreline macroplastic debris on inner sandy beaches was labelled with traditional Chinese characters than on outer sandy beaches and more stranded shoreline macroplastic debris on outer sandy beaches was labelled with simplified Chinese characters and other languages than on inner sandy beaches (Hypothesis 2 & 3). This indicated that stranded shoreline macroplastic debris on inner sandy beaches is likely to has a local origin, whereas that on outer sandy beaches is likely to has a non-local origin in Hong Kong.

### 3.4. Proportion of stranded shoreline macroplastic debris contributing from local sources on outer sandy beaches

The source-apportionment study revealed that the mean proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) by number on Lung Kwu Tan (western part of Hong Kong) (24.2%) was almost one half lower than that on Pui O Beach and Stanley Back Beach (southern part of Hong Kong) and Sai Wan Beach (eastern part of Hong Kong) (45.7%).

3.5. Face masks in macroplastic debris

A total of 320 face masks were counted by number from five transects of three channelized rivers (296 items) and six sandy beaches (24 items). Of the many kinds of non-labelled macroplastic debris found (61500 items), face masks accounted for 0.5%.

# 4. Discussion

## 4.1. Dominant categories of labelled macroplastic debris — beverage bottles & food wrappers

Of all the categories counted by number, a large proportion of labelled macroplastic debris consisted of beverage bottles and food wrappers in this study. This resembled the research findings on the types of marine debris in Hong Kong (Mott MacDonald Hong Kong Limited, 2015). Also, partial coincident results were found during the international coastal cleanup in 2020, which showed that food wrappers were the most common debris collected from the coastlines and waterways around the globe, followed by cigarette butts and plastic beverage bottles (Ocean Conservancy, 2021). Based on the Standard Practice for Coding Plastic Manufactured Articles for Resin Identification, the main resin used in beverage bottles was polyethylene terephthalate (PET) (specific gravity range: 1.38-1.41g $cm^{-3}$), whereas that used in food wrappers were polypropylene (PP) (specific gravity range: 0.85-0.91g $cm^{-3}$) and polystyrene (PS) (specific gravity range: 1.04-1.08g $cm^{-3}$) (ASTM International, 2020; Guo et al., 2016). Therefore, PP food wrappers having a lower specific gravity than sea water (l.03g $cm^{-3}$) tend to float on the sea surface. Meanwhile, PET beverage bottles which hold air when their caps on are positively buoyant in the seawater-air interface despite their higher specific gravity when compared with sea water. PP and PET are naturally resistant to degradation including photodegradation, thermal degradation and biodegradation under normal conditions (Fotopoulou & Karapanagioti, 2017). The low density and durability enable these macroplastic debris to travel for long distances and to accumulate along the coastline, on the sea surface, in the water column and on the seafloor over a long period of time, which can lead to varied hazardous environmental, economic and social concerns in Hong Kong.

4.2. A temporary sink for macroplastic debris — river

An increasing body of evidence reflects that macroplastic debris can be a new form of river sediment load along with organic and mineral types because of its ubiquity and longevity in the environment (Gabbott, Key, Russell, Yonan & Zalasiewicz, 2020). The route of macroplastic debris through a fluvial system can be conceptualized into five phases starting with input, transport, storage, remobilization and output (Liro, Emmerik, Wyżga, Liro & Mikuś, 2020). The input of macroplastic debris to the fluvial system is highly dependent on anthropogenic factors (e.g. population density and waste management) and natural factors (e.g. wind and surface runoff) (Hurley, Horton, Lusher & Nizzetto, 2020; Nihei, Yoshida, Kataoka & Ogata, 2020). This explains why most of the macroplastic debris in the five sampling transects of three channelized rivers flowing through dense settlements in Hong Kong recorded in this study was labelled with traditional Chinese characters. Meanwhile, the transport, storage, remobilization phases are controlled by the energy of a river (Van Emmerik, 2019). This statement is supported by the observation that deposition of macroplastic debris occurred in riparian vegetation and on the river sediments (Photos — Deposition of macroplastic debris in riparian vegetation and on river sediments) in the five sampling transects of three channelized rivers when rivers' energy declined after peak discharge of a large rainfall event. Finally, the output of macroplastic debris from the fluvial system to the estuary or ocean is affected by both artificial factors (e.g. river cleanup) and natural factors (e.g. fluvial processes) (Winton, Anderson, Rocliffe & Loiselle, 2020). River cleanup by the Food and Environmental Hygiene Department (FEHD) as identified during data collection reduce the amount of macroplastic debris being transported out of the rivers to Castle Peak Bay and Deep Bay in Hong Kong.

4.3. Efficiency in data collection — indicator items

Table 3
Paired Samples Correlations between the proportion of plastic beverage bottles, food wrappers and both plastic beverage bottles and food wrappers contributing from local sources (channelized rivers) and the proportion of all macroplastic debris contributing from local sources (channelized rivers) on inner sandy beaches and outer sandy beaches

| | Inner | Outer |
|---|---|---|
| Plastic beverage bottles | 0.113 | 0.381 |
| Food wrappers | 0.206 | 0.176 |
| Plastic beverage bottles & Food wrappers | 0.087 | 0.263 |

The average duration of data collection along each sampling transect of the channelized rivers and from the water edge to the back across each sampling sandy beach were 5 hours and 2 hours respectively. With a view to improving the efficiency of data collection, the Paired-Sample T Test was employed to determine correlations among the proportion of dominant categories of labelled macroplastic debris (plastic beverage bottles, food wrappers and both plastic beverage bottles and food wrappers) contributing from local sources (channelized rivers) and that of all macroplastic debris on inner sandy beaches and outer sandy beaches for identifying indicator items to assess the origin of stranded shoreline macroplastic debris in Hong Kong (Lippiatt, Opfer & Arthur, 2013). Nevertheless, none of the comparisons showed a significant correlation (plastic beverage bottles and all macroplastic debris: $p^{inner} = 0.113$, $p^{outer} = 0.381$; food wrappers and all macroplastic debris: $p^{inner} = 0.206$, $p^{outer} = 0.176$; plastic beverage bottles and food wrappers and all macroplastic debris: $p^{inner} = 0.087$, $p^{outer} = 0.263$; Table 3). Therefore, all macroplastic debris labelled with traditional Chinese characters, simplified Chinese characters and other languages in channelized rivers and on sandy beaches should be counted for statistical analysis to avoid overestimating or underestimating the proportion of stranded shoreline macroplastic debris contributing from local sources (channelized rivers) on inner sandy beaches and outer sandy beaches in Hong Kong.

4.4. The role of Pearl River — inputs of macroplastic debris

In China, plastic production has increased drastically from 102 million tonnes accounting for 29.4% of the global plastics production in 2017 to 254 million tonnes accounting for 31% of the global plastics production in 2019 (PlasticsEurope, 2020). Of all the provinces in China, the Guangdong Province ranked first in plastic manufacturing, which constituted 16.59% of the total plastic production in 2018 (Guangdong Plastics Industry Association, 2019). Meanwhile, China contributed the highest share (~28%) of the global mismanaged plastic debris (Jambeck, et al., 2015). These improperly managed plastic debris can potentially be washed into the waterways and eventually the oceans (Cheung, Fok, Hung & Cheung, 2018). The Pearl River at the northwest of Hong Kong, which has a catchment area larger than 796300 $km^2$ covering nine populous cities in the Guangdong Province (Dongguan, Foshan, Guangzhou, Huizhou, Jiangmen, Shenzhen, Zhaoqing, Zhongshan and Zhuhai) was believed to be the third-largest source of land-derived plastic debris in oceans (Lebreton et al., 2017; Pearl River Water Resources Commission of the Ministry of Water Resources China, 2019). In other words, it plays an important role in transporting macroplastic debris to the South China Sea, which resulted in the spatial variations in the stranded shoreline macroplastic debris in Hong Kong, especially during the wet season (Cheung, Cheung & Fok, 2016). It is compatible with this study on the proportion of stranded shoreline macroplastic debris contributing from local sources on outer sandy beaches. According to the findings, Lung Kwu Tan located at the western part of Hong Kong is subject to a stronger influence of the macroplastic debris inputs from the Pearl River coupled with the south-westerly prevailing wind in wet season since more stranded shoreline macroplastic debris on it tended to has a non-local origin when compared with that on beaches (Pui O Beach, Stanley Back Beach and Sai Wan Beach) located at the southern and eastern part of Hong Kong.

4.5. Coronavirus waste — face masks

Under the Prevention and Control of Disease (Wearing of Mask) Regulation, a mandatory mask-wearing requirement is imposed for every individual over the age of two in all public place in Hong Kong unless with a reasonable excuse for reducing the probability of airborne transmission of coronavirus disease 2019 (COVID-19) (Department of Justice, 2020). It is estimated that 1.56 billion face masks have entered oceans in 2020 (OceansAsia, 2020). Face masks are mostly made of petroleum-based non-renewable plastic material that is non-biodegradable and may take up to 450 years to decompose (Dharmaraj et al., 2021). These single-use personal protective equipment can be highly contagious since traces of the SARS-CoV-2 virus causing the COVID-19 disease were detectable on the face mask's outer surface after 7 days (Van Doremalen et al., 2020). If not properly disposed of, face masks pose a public health risk, especially to trash collectors or cleaners who are more prone to waste exposure. Apart from this, increasing improperly discarded face masks transporting from their sources via river systems to the marine environment further exacerbate the macroplastic debris pollution, causing deleterious effects to that surrounding ecosystem. Therefore, data regarding face masks should be recorded in the future coastal cleanup event, which can serve as the basis for evidence-informed policymaking on stranded shoreline macroplastic debris management in Hong Kong.

4.6. Limitations

The major limitation of this study was lacking spatially and temporally extensive samples. Owing to human resource constraints, a limited number of samples were collected from five transects of three channelized rivers (Tuen Mun River, Kam Tin River and Shan Pui River) and six sandy beaches (Ma Shi Chau, Wu Kai Sha Beach, Lung Kwu Tan, Pui O Beach, Stanley Back Beach and Sai Wan Beach). Also, the sample collection time was restricted by the occurrence of large rainfall event (Red Rainstorm Signal, Black Rainstorm Signal, Announcement on Localized

Heavy Rain or Special Announcement on Flooding in the northern New Territories) to ensure a substantial amount of macroplastic debris to be observed and counted at the sample sites. A more comprehensive picture regarding the origin of stranded shoreline macroplastic debris in Hong Kong over space and time can be drawn in future studies by increasing the sample size and continuous data collection during both wet and dry seasons.

## 5. Conclusion

Macroplastic debris is a global crisis attributing to both anthropogenic activities and environmental influences, which deserves particular attention in Hong Kong. Comparing the proportion of macroplastic debris marked with traditional Chinese characters, simplified Chinese characters, other languages or no label in channelized rivers and on sandy beaches provided some clues for the origin of stranded shoreline macroplastic debris in Hong Kong. The results of this study can serve as a basis for assessing future changes in the characteristics of stranded shoreline macroplastic debris in this city.

In summary, locally generated macroplastic debris is likely to be labelled with traditional Chinese characters and stranded shoreline macroplastic debris on inner sandy beaches tend to has a local origin — channelized river, whereas that on outer sandy beaches tend to be transported from non-local origins via ocean currents and the prevailing wind in Hong Kong.

The identification of the origin of stranded shoreline macroplastic debris in Hong Kong points to the need for both the formulation of local strategies and regional collaboration measures with Macau and Guangdong Province to effectively tackle this cross-border pollution problem in Hong Kong. Locally, for instance, increasing the frequency of collection and cleansing at the refuse collection points in rural villages, particularly during the wet season to prevent debris from washing into the river systems. Meanwhile, cross-sectoral collaboration can be initiated by a governmental organization like the Hong Kong-Guangdong Joint Working Group on Sustainable Development and Environmental Protection. Besides, the private sector like the plastics industries in Hong Kong should be accountable for the end-of-life of their plastic products, notably beverage bottle which was the most abundant macroplastic debris found in this study through investing in waste collection and recycling programmes.

In the light of the adverse effects of mismanaged face masks on people and the environment, an effective waste management system starting with the sorting of infected or non-infected waste, collection, transportation to treatment and safety precautions for the waste management handlers should be established under the elevated practice of wearing face masks by people from different walks of life when confronted with the coronavirus pandemic. Additionally, environmentally friendly non-toxic biodegradable alternatives like natural fiber and natural rubber should be promoted as recyclable substitutes of plastics in the production of face masks to minimize their impacts in Hong Kong.

The present study represents a snapshot of the origin of stranded shoreline macroplastic debris in Hong Kong. Further long-term research should be conducted to fully examine the spatial-temporal variation of the stranded shoreline macroplastic debris problem and thereby mitigate the environmental, economic and social impacts brought by it, contributing to the sustainable development of Hong Kong.

(6028 words)

Appendix — Debris Survey Form

| (Date: ) (Time: ) | | | | |
|---|---|---|---|---|
| Item | Traditional Chinese characters | Simplified Chinese characters | Other languages | No label |
| Food Wrappers (Candy, Chips, etc.) | | | | |
| Beverage Bottles (Plastic) | | | | |
| Beverage Bottles (Glass) | | | | |
| Beverage Cans | | | | |
| Beverage Cartons (紙包飲品盒) | | | | |
| Other Plastic Bottles (Oil, Shampoo, Medicine bottle, etc.) | | | | |
| Bottle Caps (Plastic) | | | | |
| Bottle Caps (Metal) | | | | |
| Cups (Plastic) | | | | |
| Cups (Paper) | | | | |
| Take Away Containers (Polystyrene) | | | | |
| Take Away Containers (Other plastic) | | | | |
| Straws/ Stirrers/ Cutlery (Plastic) | | | | |
| Plastic Bags | | | | |
| Paper Bags | | | | |
| Other Plastic Packaging (Tissue packets, netting) | | | | |
| Large polystyrene box (Whole) | | | | |
| Polystyrene box (Identifiable pieces) | | | | |
| Tobacco Packaging/Wrap | | | | |
| Cigarette Lighters | | | | |
| Cigarette Butt | | | | |
| Clothing (Jeans, Gloves, etc.) | | | | |
| Cloth fragments | | | | |
| Shoes/ Flip flops/ Insole | | | | |
| Fishing Items (Net/ Line/ Buoys/ Traps) | | | | |
| Rope/ Strapping Bands/ Cable Ties | | | | |
| Personal Hygiene Items (Tissues paper, Wet wipe) | | | | |
| Construction Materials | | | | |
| Metal cans | | | | |
| Paper (Newspaper, Cardboard packaging, etc.) | | | | |
| Car components (Tyres, Hood, License plate, etc.) | | | | |
| Mask | | | | |
| Plastic container (Buckets, Trays) | | | | |
| Glass fragments/ Ceramics pieces | | | | |
| Hard plastic fragments | | | | |
| | | | | |
| Total | | | | |

Photos — Deposition of macroplastic debris in riparian vegetation and on river sediments

## End-of-text references

Araújo, M. C., & Costa, M. (2007). An analysis of the riverine contribution to the solid wastes contamination of an isolated beach at the Brazilian Northeast. *Management of Environmental Quality: An International Journal*, *18*(1), 6–12. doi: 10.1108/14777830710717677

ASTM International. (2020). *ASTM D7611 / D7611M-20, Standard Practice for Coding Plastic Manufactured Articles for Resin Identification.* West Conshohocken, PA. Retrieved from https://www.astm.org/COMMIT/d7611.pdf

Barnes DK, Galgani F, Thompson RC, et al. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society of London B: Biological Sciences 364*(1526): 1985–1998.

Census and Statistics Department. (2020). *Population - Overview.* Retrieved from https://www.censtatd.gov.hk/hkstat/sub/so20.jsp

Cheshire, A.C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B., Westphalen, G. (2009). *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter.* UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83: xii + 120 pp. Retrieved from https://www.nrc.govt.nz/media/10448/unepioclittermonitoringguidelines.pdf

Cheung, P. K., Cheung, L. T. O., & Fok, L. (2016). Seasonal variation in the abundance of marine plastic debris in the estuary of a subtropical macro-scale drainage basin in South China. *Science of The Total Environment*, *562*, 658–665. doi: 10.1016/j.scitotenv.2016.04.048

Cheung, P. K., Fok, L., Hung, P. L., & Cheung, L. T. (2018). Spatio-temporal comparison of NEUSTONIC microplastic density in Hong KONG waters under the influence of the Pearl River estuary. *Science of The Total Environment, 628-629*, 731-739. doi:10.1016/j.scitotenv.2018.01.338

Clean Shorelines. (2021). *Annual amount of marine refuse collected in 2010-2019.* Retrieved from https://www.epd.gov.hk/epd/clean_shorelines/files/01-Annual%20amount%20of%20marine%20refuse%20collected%20in%202010-2019/01-EN_.pdf

Department of Justice. (2016). *Cap. 132W FOOD AND DRUGS (COMPOSITION AND LABELLING) REGULATIONS.* Retrieved from https://www.elegislation.gov.hk/hk/cap132W

Department of Justice. (2020). *Cap. 599* PREVENTION AND CONTROL OF DISEASE (WEARING OF MASK) REGULATION. Retrieved from https://www.elegislation.gov.hk/hk/cap599I

Derraik, J. G. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin*, *44*(9), 842–852. doi: 10.1016/s0025-326x(02)00220-5

Dharmaraj, S., Ashokkumar, V., Hariharan, S., Manibharathi, A., Show, P. L., Chong, C. T., & Ngamcharussrivichai, C. (2021). The COVID-19 Pandemic face Mask WASTE: A blooming threat to the marine environment. *Chemosphere, 272*, 129601. doi:10.1016/j.chemosphere.2021.129601

Environmental Protection Department. (2018). *Marine Water Quality in Hong Kong in 2018.* Hong Kong: The Government of the Hong Kong Special Administrative Region. Retrieved from https://www.epd.gov.hk/epd/sites/default/files/epd/english/environmentinhk/water/hkwqrc/files/waterquality/annual-report/marinereport2018.pdf

Fok, L., & Cheung, P. (2015). Hong Kong at the Pearl River Estuary: A hotspot of microplastic pollution. *Marine Pollution Bulletin*, *99*(1-2), 112–118. doi: 10.1016/j.marpolbul.2015.07.050

Fotopoulou, K. N., & Karapanagioti, H. K. (2017). Degradation of various plastics in the environment. *The Handbook of Environmental Chemistry,* 71-92. doi:10.1007/698_2017_11

Gabbott, S., Key, S., Russell, C., Yonan, Y., & Zalasiewicz, J. (2020). The geography and geology of plastics. *Plastic Waste and Recycling,* 33-63. doi:10.1016/b978-0-12-817880-5.00003-7

Galgani, F., Fleet, D., Van Franeker, J., Katsavenakis, S., Maes, T., Mouat, J., Oosterbaan, L., Poitou, I., Hanke, G., Thompson, R., Amato, E., Birkun, A. & Janssen, C. (2010). *Marine Strategy Framework Directive Task Group 10 Report Marine litter,* JRC Scientific and technical report, ICES/JRC/IFREMER Joint Report (no 31210 – 2009/2010), Editor: Zampoukas, N., pp. 57. doi: 10.2788/86941

Galgani, F., Hanke, G., & Maes, T. (2015). Global Distribution, Composition and Abundance of Marine Litter. *Marine Anthropogenic Litter*, 29–56. doi: 10.1007/978-3-319-16510-3_2

Guangdong Plastics Industry Association. (2019). *2018 Guangdong Plastics Processing Operation Report.* Retrieved from http://www.gdpia.com/xt/gg/2019/0417/35498.html

Guo, J., Li, X., Guo, Y., Ruan, J., Qiao, Q., Zhang, J., . . . Li, F. (2016). Research on Flotation technique of Separating pet from plastic Packaging Wastes. *Procedia Environmental Sciences*, *31*, 178-184. doi:10.1016/j.proenv.2016.02.024

Hong Kong Observatory. (2021). *Monthly Meteorological Normals for Hong Kong.* Retrieved from http://www.hko.gov.hk/en/cis/normal/1981_2010/normals.htm#

Hong Kong Observatory. (2021). *Rainstorm Warning System.* Retrived from https://www.hko.gov.hk/en/wservice/warning/rainstor.htm

Hurley, R., Horton, A., Lusher, A., & Nizzetto, L. (2020). Plastic waste in the terrestrial environment. *Plastic Waste and Recycling,* 163-193. doi:10.1016/b978-0-12-817880-5.00007-4

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., . . . Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*(6223), 768-771. doi:10.1126/science.1260352

Kanehiro, H., Tokai, T., & Matsuda, K. (1995). Marine litter composition and distribution on the sea-bed of Tokyo Bay. *Journal of Fisheries Engineering, 31*(3), 195-199.

Lebreton, L. C., Van der Zwet, J., Damsteeg, J., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature Communications, 8*(1). doi:10.1038/ncomms15611

Lima, A., Costa, M., & Barletta, M. (2014). Distribution patterns of microplastics within the plankton of a tropical estuary. *Environmental Research, 132,* 146–155. doi: 10.1016/j.envres.2014.03.031

Lippiatt, S., Opfer, S., & Arthur, C. (2013). *Marine debris monitoring and assessment: recommendations for monitoring debris trends in the marine environment.* NOAA Technical Memorandum NOS-OR&R-46. Retrieved from https://repository.library.noaa.gov/view/noaa/2681

Liro, M., Emmerik, T. V., Wyżga, B., Liro, J., & Mikuś, P. (2020). Macroplastic storage and Remobilization in rivers. *Water, 12*(7), 2055. doi:10.3390/w12072055

Ministry of Health of the People's Republic of China. (2011). *National Food Safety Standard Standard for nutrition labelling of prepackaged foods.* Retrieved from https://extranet.who.int/nutrition/gina/sites/default/files/CHN%202011%20Standard%20for%20Nutrition%20Labelling%20of%20Prepackaged%20Foods%20-%20Unofficial%20Translation.pdf

Mott MacDonald Hong Kong Limited. (2015). *Investigation on the sources and fates of marine refuse in Hong Kong: study report*. Retrived from https://www.epd.gov.hk/epd/clean_shorelines/files/common2015/MarineRefuseStudyReport_ENG_Final.pdf

Mouat, J., Lopez Lozano, R., Bateson, H. (2010). *Economic impacts of marine litter.* Kommunenes Internasjonale Miljøorganisasjon (KIMO): Grantfield. 105 pp. Retrieved from http://www.kimointernational.org/wp/wp-content/uploads/2017/09/KIMO_Economic-Impacts-of-Marine-Litter.pdf

Ng, T. P. T., Cheng, M. C. F., Ho, K. K. Y., Lui, G. C. S., Leung, K. M. Y., & Williams, G. A. (2016). Hong Kong's rich marine biodiversity: the unseen wealth of South China's megalopolis. *Biodiversity and Conservation, 26*(1), 23–36. doi: 10.1007/s10531-016-1224-5

Nihei, Y., Yoshida, T., Kataoka, T., & Ogata, R. (2020). High-Resolution mapping of JAPANESE MICROPLASTIC AND macroplastic emissions from the land into the sea. *Water, 12*(4), 951. doi:10.3390/w12040951

OceansAsia. (2020). *COVID-19 Facemasks & Marine Plastic Pollution.* Retrieved from https://oceansasia.org/covid-19-facemasks/

Ocean Conservancy. (2021). *2020 International Coastal Cleanup Report.* Retrieved from https://oceanconservancy.org/wp-content/uploads/2020/10/FINAL_2020ICC_Report.pdf

Ocean Conservancy. (2019). *International Coastal Cleanup (ICC) Volunteer Ocean Trash Data Form.* Retrieved from https://www.mass.gov/files/documents/2019/05/31/icc-data-card.pdf

Pearl River Water Resources Commission of the Ministry of Water Resources China. (2019). *River system.* Retrieved from http://www.pearlwater.gov.cn/swh/zjzj/201807/t20180720_84920.html

Peart, M. R., & Walling, D. E. (1986). Fingerprinting sediment source: the example of a drainage basin in Devon, UK. In *Drainage basin sediment delivery: proceedings of a symposium held in Albuquerque, NM., 4-8 August 1986.*

PlasticsEurope. (2020). *Plastics - the Facts 2020: An Analysis of European Plastics Production, Demand and Waste Data.* Plastics Europe Market Research Group, Brussels, Belgium. Retrieved from https://issuu.com/plasticseuropeebook/docs/plastics_the_facts-web-dec2020

Romeo, Teresa; Pietro, Battaglia; Pedà, Cristina; Consoli, Pierpaolo; Andaloro, Franco; Fossi, Maria Cristina (2015). First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea. *Marine Pollution Bulletin, 95*(1), 358–361. doi:10.1016/j.marpolbul.2015.04.048

Sheavly, S. B., & Register, K. M. (2007). Marine debris & Plastics: Environmental Concerns, Sources, impacts and solutions. *Journal of Polymers and the Environment, 15*(4), 301-305. doi:10.1007/s10924-007-0074-3

STAP (2011). *Marine Debris as a Global Environmental Problem: Introducing a solutions based framework focused on plastic.* A STAP Information Document. Global Environment Facility, Washington, DC. Retrieved from http://www.stapgef.org/sites/default/files/stap/wp-content/uploads/2013/05/Marine-Debris.pdf

UNEP (2009). *Marine Litter: A Global Challenge.* Nairobi. UNEP.232 pp. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/7787/-Marine%20Litter_%20A%20Global%20Challenge%20%282009%29-2009845.pdf?sequence=3&isAllowed=y

UNEP (2005). *Marine Litter. An analytical overview*. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/8348/-Marine%20Litter%2c%20an%20analytical%20overview-20053634.pdf?sequence=3&isAllowed=y

Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., . . . Munster, V. J. (2020). Aerosol and surface stability Of HCoV-19 (sars-cov-2) compared to SARS-CoV-1. doi:10.1101/2020.03.09.20033217

Van Emmerik, T., Tramoy, R., Van Calcar, C., Alligant, S., Treilles, R., Tassin, B., & Gasperi, J. (2019). Seine plastic Debris Transport Tenfolded during INCREASED River Discharge. *Frontiers in Marine Science, 6*. doi:10.3389/fmars.2019.00642

Wang, J., Kiho, K., Ofiara, D., Zhao, Y., Bera, A., Lohmann, R., & Baker, M. C. (2016). Marine Debris. *The First Global Integrated Marine Assessment*, 389–408. doi: 10.1017/9781108186148.028

Winton, D. J., Anderson, L. G., Rocliffe, S., & Loiselle, S. (2020). Macroplastic pollution in freshwater environments: Focusing public and policy action. *Science of The Total Environment*, *704*, 135242. doi:10.1016/j.scitotenv.2019.135242

Yeung, P., Lam, A., Kwok, M., Leung, S., & Lee, S. (2016). *Coastal Watch Turning The Tide Against Marine Litter* (pp. 1–46). Hong Kong: World Wide Fund For Nature Hong Kong. Retrieved from https://plasticschange.hk/download/cowmarinelitterreport-eng/