13. RO KOREA

Summary of research topics: *RO Korea has acknowledged issues linked to pollution from marine plastic and surveyed marine debris since the 1990s. However, scientific research papers on the topic were only published after 2000 and mostly since 2014. Early publications focused specifically on pollution from EPS (styrofoam) buoys used in mariculture. Studies from RO Korea covered the most number of research foci among the ASEAN+3 countries, and had the most balanced representation of different research foci. A majority of the papers examined (n=67) focused on surveys and monitoring to understand pollution status, followed by plastics as a transport vector, and other contaminants associated with marine plastics (especially HBCD and PCB). However, there is a lack of research and consistent methodology to survey macroplastics found in the water column, on or in the seabed and coastal environments other than sandy beaches (e.g. mudflats).*

Summary of understanding at national level: *Plastic pollution research is concentrated mostly on sandy beaches and near-coastal sea surface, with a particular focus on the region of Geoje Island and the Nakdong River. Several surveys advance beyond inventorying and compare plastic abundances and composition within their environ, leading to a more specific understanding of the distribution and accumulation of plastic debris. ALDFGs are the subject of a number of papers which suggest that they represent a very substantial contribution of marine plastic debris. Another finding is that concentration in HBCD would be greater in sediments close to industrialised areas and EPS buoys (such as those used in aquaculture farms). Several articles highlighted a strong interest to and proposal for improving methodologies for sampling and research on marine plastics. Several papers stand out as they focused on marine plastic clean-up operations on the seabed and in the water column. However, they focus primarily on the cost-effectiveness of existing methods without an analysis of net ecological benefit or relative benefits of different removal methods.*

Keywords/research fields: *National approach; solid waste; trade of plastic waste; research foci; marine environs; public outreach; beach clean-up; waste management; surveys and monitoring; methodology for the monitoring and assessment of marine litter; source differentiation; fibreglass-reinforced plastic vessels; contribution from fisheries; ALDFG; contribution from rivers; accumulation zones; hotspots; fragmentation and degradation; ecological and environmental impact; socio-economic impact; methodology for marine plastic clean-up; movement of plastics; social perceptions; adsorption-desorption of contaminants; organic contaminants; inorganic contaminants; plastics as transport vector; plastic additives; heavy metals; main players*

13.1 Context

13.1.1 National approach to plastic waste and its management

RO Korea has acknowledged issues linked to pollution from marine plastic for a number of years. The government has been surveying marine debris and developing strategies to combat them since the late 1990s, first under the Ministry of Maritime Affairs and Fisheries (MOMF), and now under the Ministry of Oceans and Fisheries (MOF). Multiple nationwide surveys to determine the extent of marine debris pollution have been conducted in 2002 (Cho, 2005), 2008-2009 (Hong et al., 2014), and 2015 (findings not found). Subsequent monitoring appears to have also been carried out, though the details were not found (MOF, 2018: available https://wedocs.unep.org/bitstream/handle/20.500.11822/26499/ML_Korea.pdf?sequence=1&isAllowed=y).

The Ministry of Environment has established a long-term master plan called the National Waste Comprehensive Management Plan (First: 1993–2001, Second: 2002–2011, Third: 2012–2021) (Cho, 2005), which requires land-based waste management systems. To tackle marine-based issues, MOF adopted the National Marine Litter Management Plan (First: 2009–2013, Second: 2014–2018, Third: 2019–2023). As part of the 2nd National Marine Litter Management Plan, KRW 331.9 billion (USD 280.2 million) have been spent on marine debris collection projects, the management of marine litter sources, and public awareness programmes. EPS buoy debris was among the key issues tackled in this programme (Lee et al., 2015). RO Korea is currently engaged in its 3rd National Marine Litter Management Plan (2019–2023) (MOF, 2019: available in Korean http://www.mof.go.kr/synap/view.do?fn=MOF_ARTICLE_26953_2019080516c607d33cb790&fd=202002). The aims of the Plan include: to analyse and forecast global and domestic trends in marine litter policies, to estimate the volume of domestic marine litter, to establish directions for mid- to long-term management policies under the review of expert advisory groups, and to improve the implementation of legislation and management actions (MOF, 2018: available https://wedocs.unep.org/bitstream/handle/20.500.11822/26499/ML_Korea.pdf?sequence=1&isAllowed=y).

Several schemes have been employed to collect marine debris, such as a buyback programme for fishermen to bring marine debris caught in their nets back to port for processing (in operation since 2003), clean-up of port regions using ships (since 1995), beach clean-up programmes (both municipal and community-based), and floating reception barges for trapping riverine waste (since 2009) (Morishige, 2010; Hong et al., 2015). Through these various programmes, about 42,917 tonnes of marine debris was collected from the environment in 2018, or 52.3% of the total estimated annual national output of marine litter (Marine Environment Information System, 2019: available in Korean https://www.meis.go.kr/portal/main.do).

As with other countries in the region, China's 2018 ban of plastic imports was a catalyst for the Korean government to pursue stronger measures. Following the 2018 China ban, the Ministry of Environment indicated that it would halve plastic waste generation and raise the domestic recycling rate from 34% to 70% by 2030. The aim of plastic use reduction is handled through a series of measures and regulations. These include bans and levies to manage excessive and/or harmful packaging and change consumer behaviour with respect to single-use plastic items. Disposable plastic bags were banned in supermarkets from 1 April 2019, followed by paper boxes and packaging tapes in November 2019

(Yonhap News Agency, 2019: available
https://en.yna.co.kr/view/AEN20190902003600315?section=search).

Under a revised Extended Producer Responsibility (EPR) legislation put in place on 25 December 2019, importers and producers of various packaging materials are required to pay higher financial contributions, depending on the recycling rate of the product. This resulted in manufacturers designing more recyclable packaging, e.g. by changing from coloured to clear plastics (Yonhap News Agency, 2019: available https://en.yna.co.kr/view/AEN20191227004000320?section=search).

13.1.2 Plastics as a proportion of solid waste

In 2016, the MSW for the RO Korea was estimated at 18.6 million tonnes, and with a projection of reaching 22.4 million tonnes in 2030 and 24.6 million tonnes in 2050 (Kaza et al., 2018). Government statistics for 2017 estimated daily household and industrial waste production at about 53,490 tonnes (i.e. 19.5 million tonnes for the year), including 5,850 tonnes of plastic, 2,168 tonnes of recycled synthetic resins, and 143 tonnes of recycled foamed plastics. Of the total daily MSW, 61.5% are recycled, 13.5% are put into landfills, and 25% are incinerated. Overall plastic waste (categorised in the study as general plastic waste, foamed plastics and resins) are 15.3% of solid waste, with 57.5% of this being recycled. Of the category of general plastics, 2,382 tonnes (40%) are recycled daily, not including the synthetic resins and foamed plastics collected through specialised recycling channels; for these, 100% of segregated waste is recycled.

In the 2016 National Waste Statistics Survey, about 21.6% of household waste (total: 306.5 g/day/capita) consists of plastics (PET: 21.7 g/day/capita, HDPE, LDPE, PP, PS, PVC, EPS: 29.9 g/day/capita, film packaging: 6.63 g/day/capita, disposable plastic products: 1.14 g/day/capita, other plastic: 6.93 g/day/capita) (Statistics Korea, 2020: available http://kosis.kr/index/index.do). The RO Korea is estimated to generate approximately 25.7 billion plastic cups and 21.1 billion plastic bags as waste each year (Yonhap News Agency, 2019: available https://en.yna.co.kr/view /AEN20190902003600315?section=search).

In 2018, an estimated 117,000 tonnes of marine debris were generated in the RO Korea, with 67% from land-based sources and 33% from sea-based sources (Marine Environment Information System, 2019: available in Korean https://www.meis.go.kr/mli/intro/learn.do).

13.1.3 Illegal trade of plastic waste

The RO Korea is both an importer and exporter of illegal plastic waste. In 2018, 170,000 tonnes of waste plastics were reported to have been imported into the RO Korea (Yonhap News Agency, 2019: available https://en.yna.co.kr/view/AEN20190816004000315?section=search).

Following the 2018 Chinese ban on illegal plastic waste imports, the RO KOREA's plastic waste exports were diverted to Southeast Asian countries (Greenpeace, 2019). However, a number of these shipments have since been returned by importing countries, such as in a prominent dispute with the Philippines over 6,300 tonnes of plastic waste which included hazardous materials (Yonhap News Agency, 2019: available https://en.yna.co.kr/view/AEN20190104004200315?section=search).

Difficulties encountered in the export of plastic waste resulted in waste piles being more visible in Korean cities such as Uiseong (CNN, 2019: available https://edition.cnn.com/2019/03/02/asia/south-korea-trash-ships-intl/index.html). According to the Ministry of Environment, there were 1.2 million tonnes of illegal trash in South Korea in 2019, which is planned to be removed by 2022 (Yonhap News Agency, 2019: available https://en.yna.co.kr/view/AEN20190221006400315).

13.2 Research review of pollution from marine plastic

13.2.1 Research overview

There is a significant body of research on marine plastics in the RO Korea, which spans across a large breadth of topic and shows a strong government interest in this body of research. Much of the work on marine plastic litter has been conducted by the Korea Institute of Ocean Science and Technology (KIOST - formerly known as the Korean Ocean Research and Development Institute, KORDI), the Korea University of Science and Technology, as well as Our Sea of East Asia Network (OSEAN), which is a non-profit research organisation dedicated to studying marine debris.

The research inventory built for this study includes 67 studies for assessing the current state of knowledge of pollution from marine plastics in the RO Korea. Most of these studies were conducted after 2012 and published after 2014, though there are some studies from as early as 2005. Early studies had been interested in general marine debris and pointed to ALDFG, especially EPS buoys, as major contributors to the marine debris issue. The increase in marine litter research coincided with more interest in plastic-specific studies. Studies from the RO Korea covered the greatest number of research foci among the countries analysed in this report, and had the most balanced representation of different research foci. A majority of the papers examined focused on surveys and monitoring to understand pollution status, followed by plastics as a transport vector, and other contaminants associated with marine plastics.

Six out of 23 of the papers that involved monitoring the status of marine plastic debris covered sites that are distributed around the entire coast of South Korea. Most of the rest of the papers focused on areas near the Nakdong River mouth and around Geoje Island, along the south coast of the RO Korea. KIOST is located on Geoje Island, and the area is known for oyster mariculture, which has been identified as a major source of EPS debris in the area.

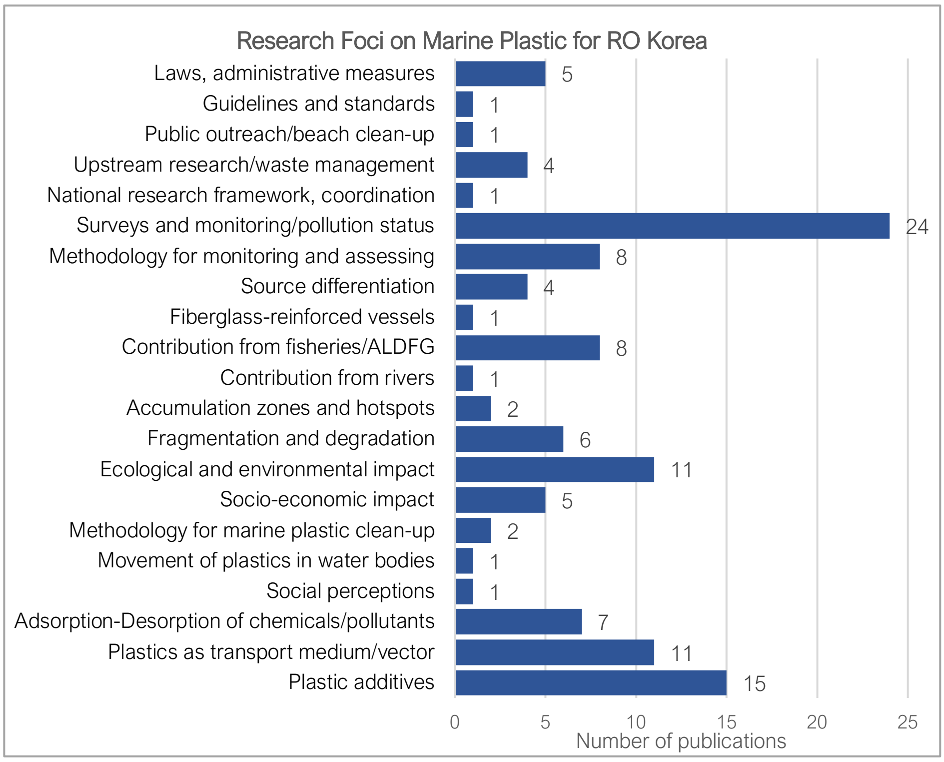

Figure 1.2.13.1. Research foci of marine plastic research conducted in RO Korea.

13.2.2 Types of research conducted

Types of plastics research foci

Microplastics and macroplastics appear to be of equal concern, with a comparable number of studies focusing on only microplastics (n=29) or only macroplastics (n=27), and nearly a fifth (n=18) examining both. Papers examining microplastics are predominantly about surveying quantities and distributions in the marine environment (e.g. Song et al., 2018; Eo et al., 2018), and laboratory studies regarding the physio-chemical impacts of ingested microplastics (e.g. Jeong et al., 2016; Chae et al., 2020). Papers examining macroplastics are largely also about surveying their quantities in the environment (e.g. Hong et al., 2014a), as well as their role as vector of additives and persistent organic pollutants (e.g. Rani et al., 2014). Studies regarding laws, policies and other domestic measures on pollution from marine plastic debris are focused on macroplastics.

A majority of the plastics research singled out styrofoam as a major component of plastic debris found in their areas of study. The nine papers which surveyed microplastics in Korean environments identified PS, PP, PE, and alkyd paint particles as major polymers. Papers which surveyed macroplastic tended to mention EPS as a major component of marine debris, likely originating from buoys used in mariculture, though vinyl was also mentioned in some papers. When it is not the primary focus of papers, EPS is frequently included in the research scope of many papers which examine plastics as vectors of harmful chemicals or investigate impacts of plastic consumption on marine organisms in laboratory settings.

Six papers investigated plastic fragmentation, through surveying styrene oligomers which are the molecules comprising EPS (Hong et al., 2016; Kwon et al., 2015; Saido et al., 2014) and its fragmentation process, through field observations (Rani et al., 2017) and laboratory experiments using abiotic simulations (Song et al., 2017) and ingestion by polychaetes (Jang et al., 2018).

15 of the studies examined contaminants associated with marine plastics, primarily HBCDs, PCBs, and other organic chlorinated compounds. Six of them measured levels of these associated plastic contaminants in the marine environment, either directly on debris or in mussels, while five of them measured desorption rates into either seawater or simulated fish intestinal fluid. Chae et al. (2020) examined the effect of polystyrene leachate on photosynthetic activity of marine algae, and measured levels of common plastic associated contaminants in the leachate.

Notably, in three papers examined for this study, the Korean authors attempted to estimate country-wide output of plastics into the marine environment, one of which was published prior to the seminal work of Jambeck et al. (2015). Jang et al. (2014a) attempted to estimate macroplastic debris output, extrapolating from both local surveys and data from other regions; they included estimates of land-based and sea-based plastic debris as well as river outputs. However, this study was not considered by Jambeck et al. which only focused on land-based sources. Interestingly, Jang et al.'s assessment is consistent with recent estimates published by the government. Kim et al. (2015a) estimated the output of HDPE and LDPE using economic and waste data from 1995–2012. Lee and Kim (2017) estimated the output of microplastics into the marine environment.

<u>*Coverage of marine environs*</u>

Most of the studies have been conducted either on the shoreline or on the water surface/water column. 23 papers include the water column in their research environments. Nearly all of the studies have been conducted on surface waters. A notable exception is the paper by Song et al. (2018), which focused on samplings in the water column at multiple depths. 22 papers included shorelines in their research scope; those indicated that their study had been conducted on sandy beaches, or did not specify the type of coastal environment being studied.

Eleven papers examined plastic debris in marine biota. Hong et al. (2013) described a participatory survey of volunteers and experts in recording entanglement and ingestion in wild organisms, which included 18 species of birds, two species of mammals, and one species of crab. Cho et al. (2019) measured microplastics found in bivalves obtained from seafood markets, namely oyster (*Crassostrea gigas*), blue mussel (*Mytilus edulis*), Manila clam (*Tapes philippinarum*), and scallop (*Patinopecten yessoensis*). Other papers examined plastic ingestion in wild mussels (Jang et al., 2016), marine polychaetes (Jang et al., 2018), and zooplankton (Kang et al., 2015a). Laboratory-based studies tended to use plankton as model organisms, such as marine algae (Chae et al., 2019, 2020), rotifers (Jeong et al., 2016, 2018), and copepods (Lee et al, 2013a; Jeong et al., 2017).

Comparatively few papers considered plastic debris on and in the seabed. Two papers provided measures of plastic in seafloor sediments, namely styrene oligomers in a lagoon (Hong et al., 2016) and macroplastics in the deep sea (Lee et al., 2006). Other papers reviewed methods and policies regarding plastic debris clean-up operations from the seafloor (Cho et al., 2009; Jung et al., 2010; Hong et al., 2015), or were more general literature reviews.

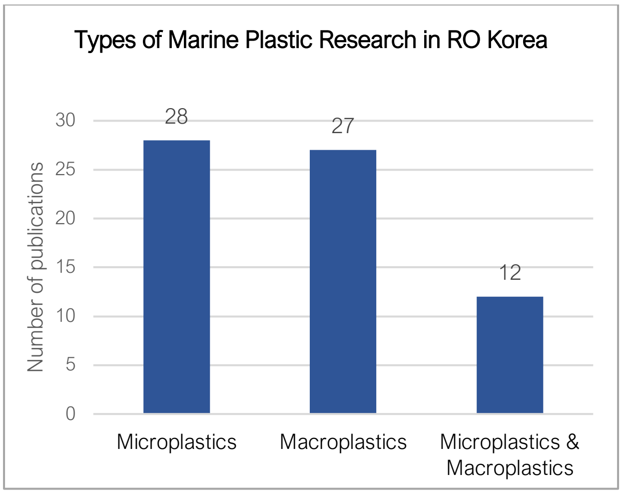

Figure 1.2.13.2. Micro- and macro-plastic research in RO Korea.

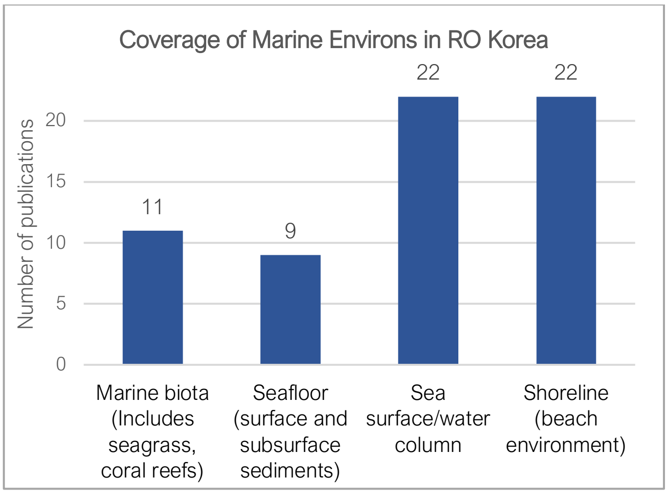

Figure 1.2.13.3. Marine environs studied in marine plastic research in RO Korea.

12.2.3 Survey and monitoring

There is substantial interest in monitoring marine plastic pollution in the marine environment, with 24 relevant papers from Korean authors. 21 of these papers refer to studies that conducted original field research on marine debris pollution in various environs within the RO KOREA, with a slightly greater interest in microplastics compared to macroplastics. Notably, several of these papers reported data dating back to the early 2000s or even the 1990s (Lee et al., 2006). Kwon et al. (2015) reported results from a long-term survey of styrene oligomers, with a dataset spanning 2003–2013.

Some papers discussed research scoping and aims which went beyond inventorying, such as predicting factors to determine the abundance or distributions of plastics (Song et al., 2018; Eo et al., 2018; Kim et al., 2015b), correlating abundances across size classes (Eo et al., 2018; Lee et al., 2015; Lee et al., 2013b), or highlighting potential ingestion risks to zooplankton (Kang et al., 2015a).

Microplastics

Most of the 15 surveys that included microplastics were conducted on either near-coastal surface waters or on sandy beaches, with one in marine biota (Cho et al., 2019) and one including deeper parts of the water column (Song et al., 2018).

The size definition used is these papers is considerably varied, especially before 2016. The three papers published after 2016, however, all used the more typical definition of less than 5 mm. Among the studies published prior to 2016, two studies used definitions smaller than the 5 mm threshold. Two papers only surveyed ‘large microplastics’ (1-5 mm).

All the papers identified at least a selection of the polymers found in their sample, whether through purely visual means, using FTIR spectroscopy to identify more specific polymer compositions, or by focusing on one specific polymer (styrene oligomers in Kwon et al., 2015 and Saido et al., 2014). Authors who used visual means primarily singled styrofoam out of other types of plastic debris. Authors who investigated specific polymers found mostly similar types across different environs, though their relative proportions differed. Cho et al. (2019) found the most common polymers in market-bought bivalves to be PE, PP, PS, and PET. Kim et al. (2015b) found predominantly EPS, PP, PE, and PU foam on sandy beaches. Three papers surveying sea surface environments all found EPS, alkyd paint particles, PP, PE, and polyacrylate/styrene to be among the most common polymers. Song et al. (2018) surveyed deeper parts of the water column in addition to the surface, and listed PP, PE, and PEVA as the predominant polymers.

Most papers further described the shapes of microplastics found, primarily as pellets/spherules, hard plastic fragments, fibres, film/sheets and foam. One paper (Kang et al., 2019) additionally visually distinguished paint resin particles. Whether or not papers include a description of morphologies did not depend on the level of technology used, however – two of the papers which did not include a description of shapes reported on results from spectroscopy. Some of the earliest papers (Lee et al., 2013b; Heo et al., 2013; Hong et al., 2014b) mentioned the status of degradation on the samples by distinguishing between fragmented pieces and intact items, but later papers did not make this distinction.

Units used to report results are fairly consistent. Due to their focus on the molecular scale, Kwon et al. (2015) and Saido et al. (2014) reported their results on styrene oligomers in terms of μg/kg wet weight of sand and μg/L seawater. All other papers included units in terms of item counts:

- In the marine biota study (Cho et al., 2019), the units used were item/g of tissue (wet weight) and item/individual for bivalves.
- On the sea surface (n=6), all papers used items per volume of seawater, though some additionally reported items per area of sea surface. None reported the weight of the plastics surveyed.
- On the shoreline (n=6), papers primarily reported in terms of item count per area. Three papers additionally included weight per area (Heo et al., 2013; Hong et al., 2014b; Lee et al., 2015).

The methodologies employed by the authors depended on the environs studied. Sea surface surveys consistently referred to Song et al. (2014). Shoreline surveys were more varied, using sampling methods that referred to or modified Hidalgo-Ruz et al. (2012) or Browne et al. (2010), or made no reference. Processing methods were generally not referenced, and differed in whether FTIR spectroscopy and density separation methods were used. In the marine biota study, Cho et al. (2019) referred to Karami et al. (2017).

Macroplastics

The 11 studies which investigated macroplastics mostly surveyed sandy beaches, with a minority investigating sea surface waters (Kim et al., 2005, Jo et al., 2005) and the seabed (Lee et al., 2006).

There were no harmonized detailed categories used to describe macroplastic items found. The main mode of description was done by visually distinguishing between EPS and other plastic polymers. Early papers used the additional categories of nylon rope (Kim et al., 2005) and vinyl (Kim et al., 2005, Jo et al., 2005, Lee et al., 2006). Five papers described the types of macroplastic items found: Hong et al. (2014b) focused on EPS buoys, others anecdotally described fishing gear including EPS buoys, nets, fishing lines, ropes, and octopus pots (Jang et al., 2014b; Heo et al., 2013; Lee et al., 2006), and Hong et al. (2014a) are the only authors who provided systematic sorting of macroplastics based on ICC categories.

The units used to report results of the surveys were very consistent across the seven papers focused on sandy beaches, but inconsistent across the three surveys carried out in sea surface waters, as follows:

- On sandy beaches, most papers reported findings in terms of both items/m^2 and g/m^2, with only one paper omitting weight (Lee et al., 2013b) and one paper using weight and volume per 100m of transect (Hong et al., 2014a);
- On the sea surface, Kim et al. (2005) used items/km^2, Jo et al. (2005) used items/site, and Kang et al. (2015b) used items/m^3. The relative earliness of the two first papers in marine plastic research may explain this choice of unit;
- On the seabed, Lee et al. (2006) used kg/km^2.

Meta-analysis and methodology for the monitoring and assessment of marine litter

In a meta-analysis paper, Khim et al. (2018) conducted a literature review of papers regarding various measures of ecosystem health of the Yellow Sea, including surveys of marine plastic pollution from both the RO KOREA and China. These authors concluded that the region generally has a higher density of plastic debris as compared to other Regional Seas.

Eight papers on different aspects of monitoring methodologies pointed to a strong interest in improving methodologies used in this field. These articles focused in particular on improving areas of sampling in beach surveys (Heo et al., 2013), use of remote surveillance and citizen science for rapid surveys of macrodebris (Jang et al., 2015; Lee et al., 2019), and methods to quantify styrene oligomers in beach sediments and sea surface waters (Saido et al., 2014), separate low-density PE films by size (Kim and An., 2019), and identify microplastics (Song et al., 2015; Shim et al., 2016) and associated contaminants (Hong et al., 2017a).

13.2.4 Source differentiation and pathways

Many of the papers point to fisheries as a likely source of plastic debris, particularly EPS buoys. Four papers attempted to explicitly identify sources. Authors of two of these papers, Hong et al. (2014a) and Jang et al. (2014b), used similar probabilistic scoring methods to suggest possible sources for plastic debris on beaches and estimate proportionate contributions of land- and sea-based sources to marine plastic pollution. They also suggested that sea-based activities, particularly commercial fisheries and aquaculture, would be the main source of macroplastic debris. However, proximity to a river mouth has also been found to be a significant factor in abundance of microplastics in a study of 20 sites throughout coasts in South Korea (Eo et al., 2018).

With respect to other associated contaminants, Al-Odaini et al. (2015) measured HBCDs in Jinhae Bay and Masan Bay and found three main areas with HBCDs in high concentrations – the outfall of a WWTP, in sediments close to industrialised areas, and in waters and EPS (styrofoam) buoys near aquaculture farms.

13.2.5 Movement of plastics, accumulation and hotspots

Jang et al. (2014c) modelled the behaviour of floating debris within the Nakdong River basin through tracking buoys. Through this method, they were able to identify hotspots of debris accumulation within the downstream portions of the river, as well as estimate flow rates of debris being discharged into the ocean, which were estimated as >4500 m^3/s.

As mentioned previously, Al-Odaini et al. (2015) identified hotspots of HBCD concentrations within Jinhae bay and Masan bay in the outfall of a WWTP and of aquaculture farms.

13.2.6 Ecological and environmental impacts

There are comparatively few field studies on plastic ingestion in marine organisms in the RO KOREA relative to its total body of work (n=5). Only one of these involved macroplastics (Hong et al., 2013), where 45 records of entanglement and ingestion of marine debris in wild organisms were collected through a participatory survey of volunteers and experts who recalled incidents spanning between 2003–2012. Of the 21 species recorded to have been impacted by marine debris, five were threatened, and fishing gear was recorded as the most frequent debris type.

Two papers were specifically focused on marine organisms found living on EPS buoys: polychaetes buried in buoys (Jang et al., 2018), mussels adhered to buoys (Jang et al., 2016), ratio of microplastic to zooplankton (Kang et al., 2015a), and bivalves from seafood markets (Cho et al., 2019).

There is relatively high interest in laboratory-based studies compared to field studies, to understand specific physio-chemical impacts of plastic exposure to marine organisms. The RO KOREA is one of only two countries in the region to have more than one such published paper on this. Again, there is a strong interest in the effect of polystyrene (as PS beads and EPS leachates).

Chae et al. (2019, 2020) found that the photosynthetic activity of marine algae was increased upon exposure to EPS leachates and PE beads. Three papers examined the effect of PS microbead ingestion on the survival, development, and fecundity of zooplankton such as rotifers (Jeong et al., 2016), and copepods (Lee et al., 2013a; Jeong et al., 2017). Jeong et al. (2018) specifically investigated the impact of PS bead exposure to the activity of molecules associated with multi-xenobiotic resistance in rotifers. In all four papers, the toxic effects of PS microbead ingestion increased as the size of the microbeads decreased.

13.2.7 ALDFG

Eight papers focused on plastic pollution from ALDFG and aquaculture equipment, especially EPS (styrofoam) buoys, including pollution surveys (Hong et al., 2014b; Al-Odaini et al., 2015), and ingestion in marine organisms (Jang et al., 2016, 2018), and marine debris management (Cho, 2005; Hong et al., 2015). All the experimental fieldwork was conducted on or near Geoje Island. Hong et al. (2017b) examined navy records of ship propeller entanglement in derelict fishing gear, and found an average of 397.7 cases of propeller entanglement every year over a period of six years.

13.2.8 Social perceptions and socio-economic impacts

Three of the five papers published on economic impacts of marine plastic pollution sought to measure economic costs: loss in beach tourism (Jang et al., 2014d), cost of naval ship propeller entanglement (Hong et al., 2017b), and the cost of potential programmes for derelict fishing gear removal (Hong et al., 2015). Choi & Lee (2018) also estimated the value of social willingness-to-pay for removing microplastics from the ocean, implying that the social perception of risks from microplastics are high. One study (Choi et al., 2019) can be considered to also provide information on the potential economic impact of marine plastic pollution through the presence of microplastics in seafood.

13.3 Main players in marine plastic research

All of the research reviewed for the RO KOREA have been led by local researchers, with one paper with a second corresponding author from a Japanese institution, and much of it conducted by the Korea Institute of Ocean Science and Technology (KIOST), particularly the Oil and POPs Research Group, as well as the Korea University of Science and Technology and Our Sea of East Asia Network (OSEAN).

Won Joon Shim and Sang Hee Hong of KIOST and of the Korea University of Science and Technology, as well as Jongmyong Lee and Sunwook Hong from OSEAN, stand out as lead researchers who frequently collaborate to survey plastic pollution and other associated contaminants, particularly HBCDs. Jung Hwan Kwon from Korea University focuses on desorption modelling of chemicals from plastic materials. Other institutions with researchers working on marine plastic debris include Pukyong University, Korea Maritime Institute, Konkuk University, Incheon University as well as the Korea Marine Environment Management Corporation (KOEM).

13.4 Summary of understanding

Research on marine plastic pollution in the RO KOREA is at an advanced stage, with a strong interest on the impact of marine debris since the early 2000s. There is a diverse spread of research topics presenting evidence of impacts of marine plastic debris on the marine environment, marine organisms, and human society. This body of research also demonstrates particular interest in understanding less commonly studied topics, such as the distribution of plastic additives and other plastic-associated contaminants; fragmentation of plastic in the marine environment; economic and monetary impacts of plastic pollution; and laws and policies on marine debris. Some papers also use comparatively long-term datasets to study plastic abundances, calculate outputs of marine debris, and estimate economic impacts.

Understanding of the status of marine plastic pollution in the RO KOREA includes multiple nation-wide surveys of pollution status. Environs and regions where plastic pollution research is conducted are concentrated mostly on sandy beaches and near-coastal sea surface, with a particular focus on the region of Geoje Island and the Nakdong River. There is a need for a greater understanding of marine plastic pollution on and in the seabed, in the water column, and coastal environments other than sandy beaches (e.g. mudflats). Several surveys advance beyond inventorying and compare plastic abundances and composition within their environ, leading to a more specific understanding of the distribution and accumulation of plastic debris. This could be used for further studies using hydrological modelling to predict the movements of plastic debris on a larger scale coupled with a risk assessment approach to aid more targeted intervention strategies.

Uniquely, research in the RO KOREA initially focused on a single polymer and industry, namely expanded polystyrene (EPS and often known as styrofoam) used in mariculture. This has allowed in-depth research into the potential ecological and environmental impacts of this material, and its role as a vector of hazardous chemicals. While EPS understandably is of particular interest due to its prevalence, other polymers such as alkyd paints, PP, and PE are also abundant in the environment, and there is comparatively less research on them. It may be beneficial for researchers to extend their expertise to other commonly found polymers.