RESEARCH ON MARINE PLASTICS 101 IN THE EAST ASIAN SEAS

Marine Plastic Research Inventory in the East Asian Seas

Analysis prepared by the Regional Project Team coordinated by the Centre for International Law (CIL) of the National University of Singapore (NUS)
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This factsheet provides an introduction to marine plastic research and the data captured in the Regional Research Inventory (RRI) 2.0 for the purpose of policymakers. It seeks to highlight key characteristics of regional research on marine plastics and the features of the display of data and findings captured in the research inventory, where over 700 publications are collected and analysed. A good understanding of the research context is necessary to inform appropriate use of the data.

Marine plastic debris surveys and monitoring, sizes and types

Surveys and Monitoring

In the ASEAN+3 region, the survey and monitoring of marine plastics has often started with clean-up initiatives involving citizens, with some of the debris collected being taken to the lab subsequently for analysis. At this stage, the inventory does not capture systematic monitoring programmes for baseline assessment and changes, although some long-term monitoring is known to occur locally. Results from published research that were captured were generally conducted on an ad-hoc basis, for the purpose of a specific research or in the context of citizens' beach clean-up.

Research into plastic loads in the marine environment often consists of collection of plastic debris in specific locations, and/or collection of either water, sediment or organisms. In the case of the latter, samples are brought back to the laboratory where plastic particles will be extracted, after numerous (and often long) intermediary steps. Plastic sizes are then measured for further analysis.

Categories of Sizes

There are several concurrent categorisations of plastic particle sizes and no global consensus. The 2019 GESAMP Guidelines (Fig. 1) propose a classification which the body found to be often embraced and scientifically sound. However, adoption of the GESAMP size categories is not universal. In many research articles, plastic particle sizes are referred to as micro or macro, as defined within each study, with 5mm commonly used as the boundary. The size of marine debris studied is captured in RRI 2.0 in four columns (See the inventory methodology: https://mapla-riv.web.app/data/methodology-and-ontology).

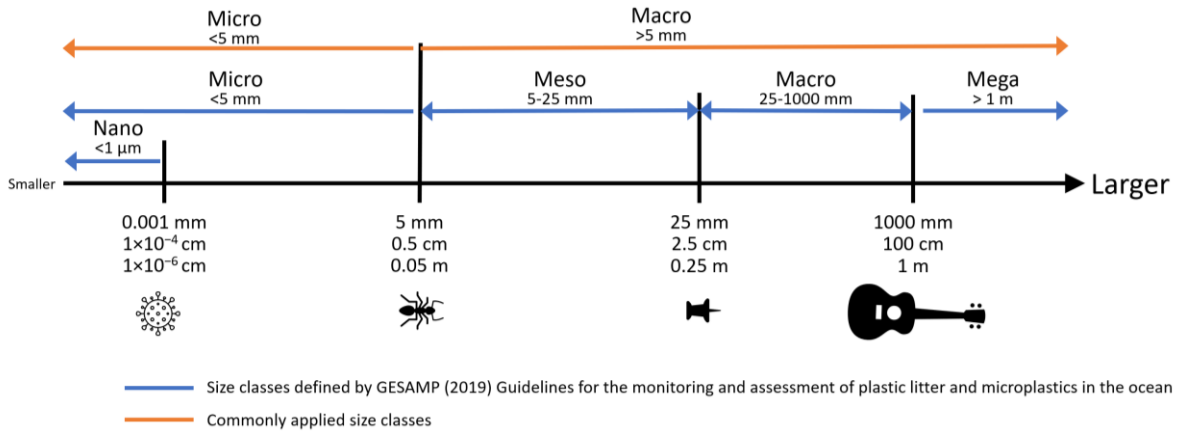

Figure 1. Visual representation of plastic particles class sizes as defined by GESAMP, compared to plastic size classes commonly used in research articles in ASEAN+3.

Categories of Types

Plastic debris, such as plastic bags and cups, are recorded during field sampling and monitoring events. Fig. 2 shows the plastic types commonly found and reported in the research articles included in RRI 2.0.

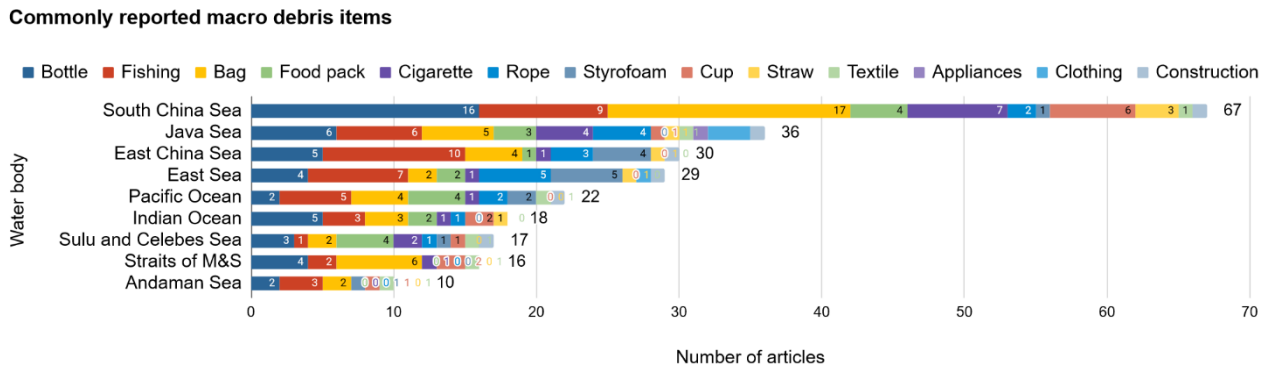

Figure 2. Commonly reported macro plastic items in ASEAN+3 research articles (Source: https://mapla-riv.web.app/data/scientific-research, SR1.B)

Research topics

Marine plastics pollution is a broad topic, within which eight general categories of topics were identified upon examination of the research articles captured in ASEAN+3: (1) Survey and monitoring/pollution status, (2) Sources and pathways, (3) Ecological and environmental impacts, (4) Contaminants associated with marine plastics, (5) Socio-economic impacts, damage and opportunity, (6) Research methodology/approach, (7) Policy response measures, and (8) Education, outreach and capacity building.

Across all the countries/territories in ASEAN+3, survey and monitoring/pollution status, sources and pathways, and ecological and environmental impact related topics were most frequently studied (Fig. 1). Topics least studied include education, outreach and capacity building, and socio-economic impacts, damage and opportunity (Fig. 1).

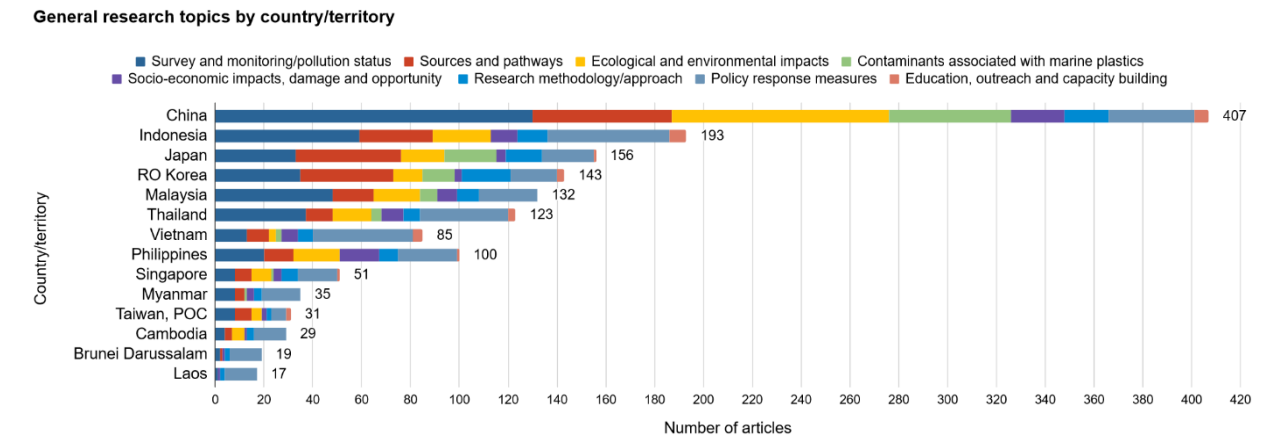

Figure 3. General research topics covered across countries/territories in ASEAN+3 (Source: https://mapla-riv.web.app/data/research-landscape, RL1.B)

Evolution of the research focus

The recent decade has witnessed the quick development of research on marine plastics in the ASEAN+3 region, demonstrating a fast formation of regional research capacities and skills, as well as expansion in research foci. As can be shown in Figure 4, (1) Survey and monitoring/pollution status, (2) Sources and pathways, (3) Ecological and environmental impacts and (4) Policy response measures have seen the fastest development in research outputs. Overall, compared with the number of publications in these research foci when research on marine plastics first emerged in the region (around the 2010s), there has been a drastic increase in the numbers of publications as well as the number of research topics covered.

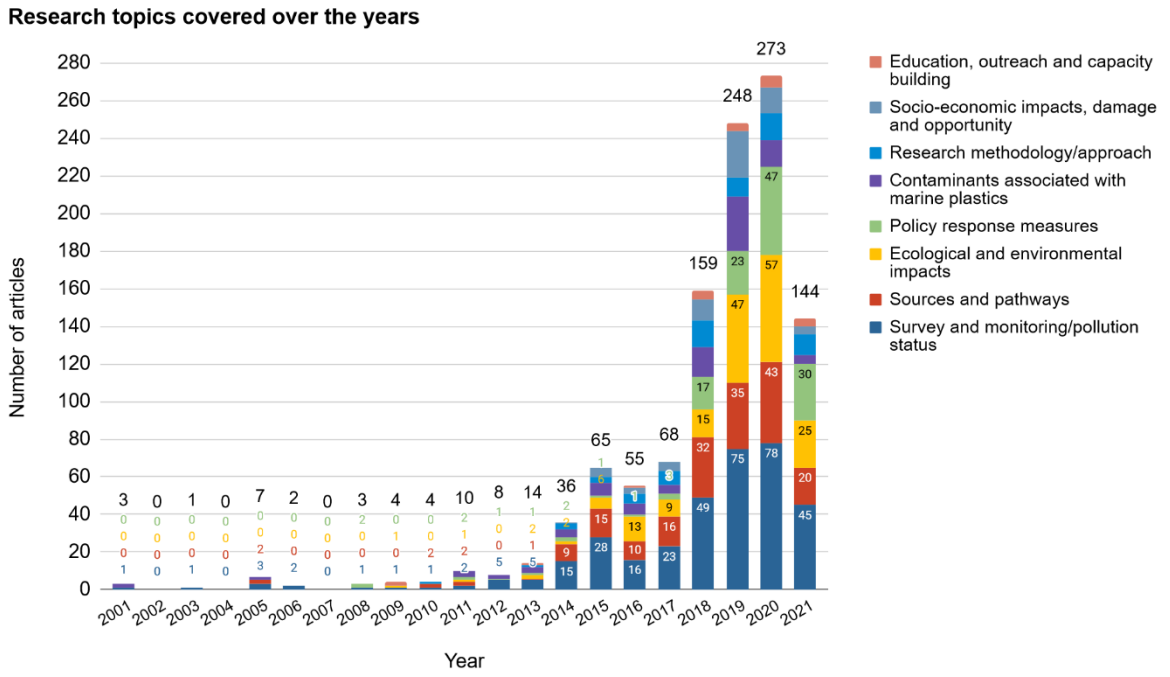

Figure 4. General research topics on marine plastics covered over the years, in ASEAN+3 region. (Source: https://mapla-riv.web.app/data/research-landscape, RL1.G)

Understanding sources and pathways

Policy documents frequently refer to the identification of sources and pathways of plastic debris in the marine environment as key concerns. The RRI 2.0 has attempted to extract information from research publications to inform these concerns in the region.

Sources

The RRI 2.0 captures information of the most likely plastic sources, verbatim from the article and in generalised categories (refer to the inventory methodology for more information: https://mapla-riv.web.app/data/methodology-and-ontology). Although 301 articles (out of 702 articles captured in RRI 2.0) reported plastic source information, some reported plastic sources are implied, or inferred. The most commonly reported sources of marine plastics are aquaculture (such as buoys and particles from disintegration of nets), fisheries (fishing gear such as fishing rods or nets) and non-industrial human coastal activities (such as single-use plastics from human activities along coasts).

Research articles that focus on the methods and techniques of plastic source differentiation are captured under the 'Differentiation between plastic sources' research topic in the RRI 2.0.

Sources of plastic debris found in the marine environment are often difficult to establish or are not documented, especially in the case of smaller macroplastic debris and microplastics. A large proportion of the marine plastic debris surveyed in the region are degraded as a result of the combined impact of weather and climate conditions (such as temperature, UV radiation), extreme natural events (Rajakumar, 2009, Andrady, 2019), and degradation by organisms. Physical, chemical, and biological processes can also fragment larger plastic debris into smaller microplastics, and microplastic into nanoplastics (Andrady, 2019).

Pathways

There are three research topics within RRI 2.0 that focus on plastic movement and pathways: (i) Movement of plastics in water bodies, (ii) Marine plastics as pathways for the introduction of alien/non-native/invasive species, and (iii) Plastics as transport vector/medium.

Research articles on plastic movement commonly study the characteristics of plastic fragments, such as the impact of shape and size on the buoyancy of plastic, and design and test models (such as particle-tracking and hydrodynamic models) to apply the plastic characteristics to different water bodies. There has been such research conducted in the Sea of Japan, Java Seas, and equatorial Singapore (articles #00599, #00456, #00382 and #00527 in RRI 2.0).

Plastics can potentially act as transport medium for alien/invasive species, bacterial communities, and toxic chemicals. Rich diversity of microbial communities was found on microplastic surfaces retrieved from Singapore coasts (#00586). Polypropylene resin pellets collected from Japanese coasts had high accumulation potential of toxic elements, suggesting potential medium of transport of toxic chemicals across distances (#00573). Plastic fishery floats have been found, experimentally, to leach toxic additives during long-distance drift at sea (#00675).

Understanding impacts

Information on ecological, economic and social impacts of marine plastics are captured in RRI 2.0, under the topics (research focus) of research articles, and under research aim and key findings.

Ecological impacts

Ecological impacts of marine plastics are wide-ranging. Marine plastics can impact marine organisms through entanglement, such as in RO Korea, where a study recorded 42 reported cases of seabirds caught on recreational and commercial fishing hooks, lines and/or ropes (#00413).

Plastics can impact marine organisms when ingested and/or through branchial uptake. Some polychaete species, or sea worms, sampled in RO Korea waters were found to exhibit high levels of expanded polystyrene (EPS) when inhabiting EPS buoys (#00392). Also in RO Korea, mussels adhering to styrofoam debris had higher levels of toxic additives than mussels adhering to other surfaces (#00648). Internalised plastics particles may go through trophic transfer and accumulate in organisms further along the food chain. In a Malaysian study, abundant levels of microplastics were found in wild and cage-cultured Asian sea bass, potentially due to prey fish and fish feed from the regional waters (#00425). Seabirds (fulmars and albatrosses) along the coasts of Japan were found with plastic additive chemicals in their stomach tissues, at much higher levels than those in marine organisms (#00380).

Plastics accumulated in marine organisms may result in risks of toxicity and/or physicochemical impacts, usually at high exposure levels to the hazardous additives and chemicals. For example, plastic leachates have been found to impair the larvae development in some clam species in China (#00362), barnacle species sampled in Chinese waters (#00362), mussels in Brazil (Gandara e Silva et al., 2016), and sea urchins in the United Kingdom (Rendell-Bhatti et al., 2021).

Economic impacts

They are identified in publications are mostly linked to the cost of removing marine plastic debris or the loss of earnings resulting from the presence of such debris. A research project focused on ships associated with propeller entanglement by derelict fishing gear (DFG) evaluated the frequency of entangled ships, the amount of DFG disentangled, the loss of fishery production (ghost fishing), and the cost of driver's labour needed for disentanglement (#00298).

Another research project conducted by Chinese scholars proves that small plastics are often overlooked by beach clean-up activities at selected tourism beaches around the South China Sea. A large amount of small plastic debris, therefore, remains on beaches despite daily beach clean-ups, which deteriorates the ecosystem service of beaches as a public space (#00212). Economic study on the economic cost and control of marine debris damage in the Asia-Pacific region recommends the development of a marine debris cycle model to discuss the costs and benefits of prevention, clean-up and the benefits of using biodegradable materials. Further, the cost can be reduced through policy implementation to economically optimal levels, including adopting regulations, technical intervention and MBIs (#00102).

Social impacts

Social impacts usually refer primarily to the non-monetary costs of marine debris and interactions with social behaviour and choices. However, economic and social impacts are sometimes studied together. An economic evaluation of reducing submerged marine debris was conducted in RO Korea and concluded that a reduction of submerged marine debris is socially beneficial and, the investment in the reduction can be "economically justified" (#00042).

Responses and interventions

Data captured under sources, pathways and impacts can inform responses and interventions, whether at regional, national or local levels. In addition, RRI 2.0 has designed metadata to collect data that are relevant to responses and interventions adopted at different levels and include legal, economic, social and policy perspectives. RRI 2.0 also identifies the following

research topics which can relate to government responses and interventions:

- legal and regulatory analysis, action plans and compliance and implementation (which are subtopics of the research topic on laws, administrative measures);
- re-use, recycle and other mitigation measures, other market-based measures, social perceptions/ social behavioural studies, and policy (which are subtopics of the research topic on economic measures);
- citizen science, communication and coverage of marine plastic and language and cultural barrier (which are subtopics of the research topic on education, outreach and capacity building).

RRI 2.0 contains separate data entries on legal, policy, economic and social responses. The data captured shows a diversity of responses in the different countries including top-down and bottom-up approaches. For example, local communities are involved in awareness-raising campaigns to understand the negative impacts of marine plastics on the environment; stakeholder communities including fisher associations or consumers are included for broader outreach engagement and more comprehensive research outcomes. Under Fishing for Litter projects, fishers are paid to collect, and retrieve discarded and lost fishing gear. At the regional level, COBSEA and NOWPAP have also adopted and updated regional action plans (COBSEA, 2019; NOWPAP, 2008). Publications also report that several states have adopted national action plans for marine debris, including Indonesia, Malaysia, the Philippines and Vietnam.

Limitations and opportunities for policymaking

In the use of research publications to establish baselines

With regards to regional-level monitoring, the inventory provides very useful insights into the status of regional marine plastics, but this inventory cannot replace a national monitoring program. The context and methodology of research findings are critical to determine how the findings may be used as each publication's findings are influenced by the specific methodology used, which is in turn determined by the purpose of the study. As a result, these research findings have their limitations in being applied to different conditions and contexts and are inevitably constrained by initial research questions and funding sources. These restrictions and differences result in the (in)comparability of results directly obtained from different samplings realised for different purposes. For results to be comparable, when measuring microplastics in the environment, for example, the methodologies used for counting would have to build in steps that will improve the potential comparability of the count.

In shaping research projects to inform policy concerns

RRI 2.0 reveals that whilst most of the research publications are, to some extent, policy-relevant, they are often not sufficient to provide the information needed by policymakers. However, it highlights an opportunity for further work to be done at the interface of the policymaking and the research communities, where the needs of policymakers may be translated into realistic research objectives, and the constraints faced by the research community be taken into account in the formulation of these objectives. Such an approach could include addressing policy-making needs formulated at the national level as well as at the regional level, in the context of intergovernmental bodies.

References:

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