UN environment programme

FORESIGHT Brief

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018

Early Warning, Emerging Issues and Futures

Unveiling plastic pollution in oceans

Background

The Foresight Briefs are published by the United Nations Environment Programme to highlight a hotspot of environmental change, feature an emerging science topic, or discuss a contemporary environmental issue. The public is provided with the opportunity to find out what is happening to their changing environment and the consequences of everyday choices, and to think about future directions for policy. The 18th edition of UNEP's Foresight Brief highlights the global concern on marine plastic litter pollution and calls for monitoring and assessment.

Abstract

Marine plastic litter pollution is a global concern that threatens seas and the ocean, biodiversity, human health and economic activities such as tourism, fisheries and marine navigation/transportation. Plastics represent approximately 80% of marine litter and result from both land and sea-based human activities. Combating marine litter requires knowledge of sources, pathways, sinks and impacts, which calls for worldwide harmonized monitoring and assessment programmes to guide measures and assess their effectiveness.

Introduction

Marine litter is a common threat in our oceans. Plastics often form the major component of marine litter. Approximately 5.25 trillion plastic particles float on the ocean surface[1], weighing about 269,000 tons, with

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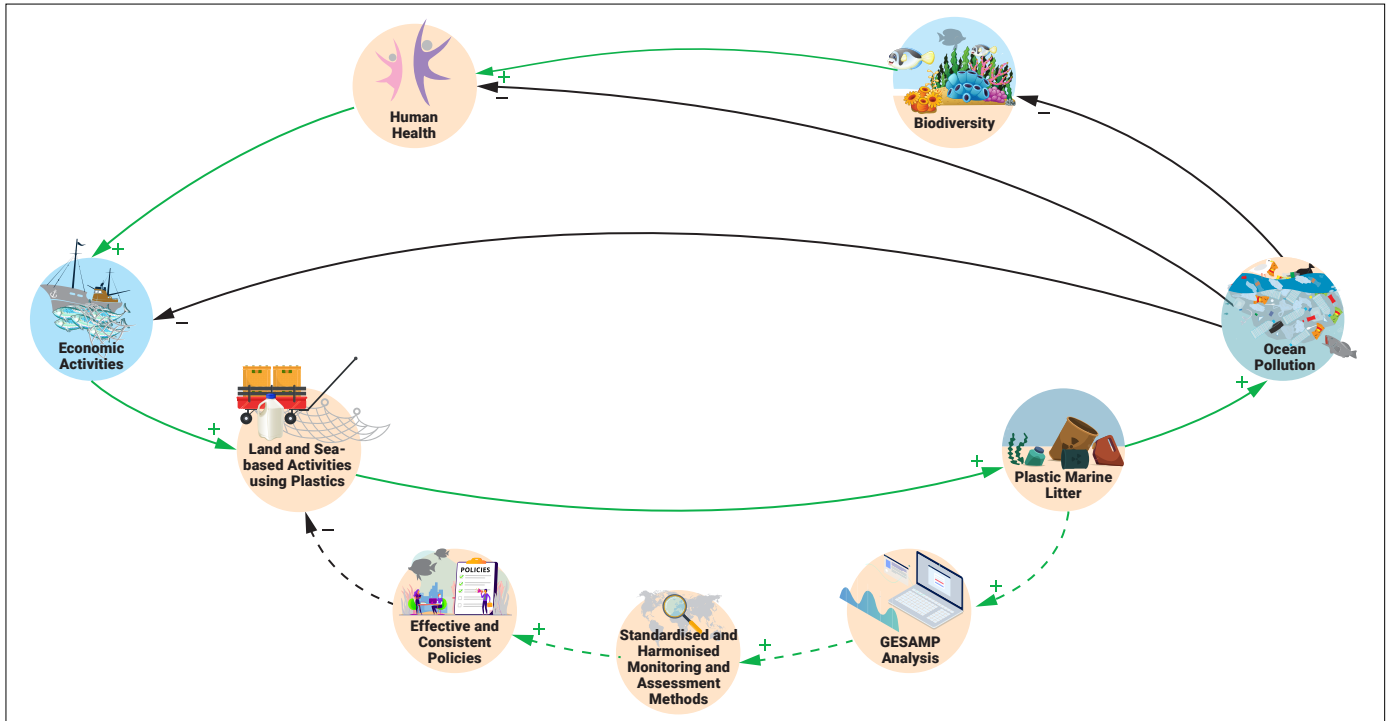
concentrations of up to 64 millions particle per square kilometre in the Mediterranean Sea.[2]

Estimates of plastic that wind up in the ocean by way of rivers vary from 0.41 and 4.00[3] in one study, and between 1.15 and 2.41[4] million metric tons in another study, as part of the 8 to 15 million tons entering the ocean every year[5]. On the sea floor, densities reached 1.3 million items per square kilometre[6]. In remote islands, between 80% and 90% of all chicks of Flesh-footed Shearwaters studied have at least one piece of plastic in their stomachs[7], evidencing the impact of marine litter on biodiversity. The economic impact of marine litter in the 21 countries in the Asia-Pacific Economic Cooperation region increased ten times in the last decade and is estimated at U$ 11 billion per year.[8] The growing concern about the environmental, social, economic and human health impacts of plastic litter in the ocean, requires appropriate information to assess and combat this problem.

Pollution of the marine environment by plastic litter is a complex and challenging issue (**Figure 1**). Plastic litter includes a wide variety of synthetic polymers with diverse compositions and properties that influence their distribution and fate, as well as effects on the environment. *Marine litter can range in size from ocean-going boat hulls many meters in length to micro and nanoplastics, particles smaller than 5 mm* (GESAMP, 2019), and can be globally widespread and distributed in different marine environments.

The existing knowledge of the quantities of marine litter in the ocean is based on variable sampling methods and indicators, as well as differing environments, and is limited to only some regions of the world. This hinders comparability of data and limits the full understanding of the global impacts and effectiveness of both the policy response to marine litter and the existing marine litter policies, thus emphasizing the need for harmonized methods and approaches for the monitoring and assessment of marine litter.

Monitoring the marine environment for the presence of plastic litter is a necessary part of determining the sources, fates, extent, trends and possible impacts of marine litter GESAMP (2019)[9]. It also provides information that informs possible mitigation measures (aimed at reducing inputs) and that can be used to evaluate their effectiveness.



Economic activities drives land and sea based activities that also use plastics. Plastics of many different sizes end up in the ocean resulting in increased marine litter and ocean pollution. Increases in ocean pollution causes reduced biodiversity, human health and in turn reduced economic activities. Standardised monitoring of ocean plastics will result in more consistent and effective policies that will reduce plastics polluting the ocean and in this system will improve biodiversity, human health and economic activities.(+) Influence is in the Same direction, (-) influence is in the Opposite direction.

Figure 1: A Systems Thinking Perspective

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As described in GESAMP (2019)[9], the *UN Environment Programme, supported by the Intergovernmental Oceanographic Commission of UNESCO and other UN agencies (IMO, FAO, UNIDO, WMO, IAEA, UN, UNDP), is coordinating the effort to promote a more harmonized, coherent and standardized approach when designing sampling programmes for monitoring and assessment of marine litter, including the selection of appropriate indicators (i.e. sampling methods, protocols, assessment units). UNEP and IOC/UNESCO organizations have been given the task of supporting countries to implement methods and procedures to report against target 14.1: 'By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine litter and nutrient pollution' under Sustainable Development Goal 14 (Life below water) of the United Nations 2030 Agenda for Sustainable Development.*

To address the lack of an internationally agreed methodology for reporting the distribution and abundance of marine plastic litter and microplastics in marine environments, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP[10]) published, in 2019, the report "Guidelines for the monitoring and assessment of plastic litter and microplastics in the ocean".[11]

The GESAMP report is intended to complement and harmonize established monitoring and assessment programmes, such as those developed in the framework of the Regional Seas, the European Union and by several individual countries. These existing initiatives, together with the UNEP and Intergovernmental Oceanographic Commission of UNESCO guidelines, published in 2009, provided a key input to the development of these updated guidelines (GESAMP 2019).

The guidelines include a step-by-step approach to assist national authorities and regional bodies in setting up programmes to assess the marine plastic contamination, including sampling design, indicator selection and method harmonization (Table 1)[12].

The report is intended to maximize the utility of the data gathered, recognizing that, in many cases, resource constraints will limit the scale of any individual monitoring programme. In this context, *deciding on what constitutes the target or preferred state of marine litter is beyond the scope of the GESAMP report, being part of the local/regional governance process.*[13]

The guidelines cover all size ranges of plastic litter and present definitions of common terminology used in existing marine litter monitoring, which is key to creating a harmonized approach and increasing the potential for sharing data and information.[14] *They also describe some basic principles of monitoring and assessment, including the possible involvement of citizen scientists.*[15]

Table 1: Summary of the recommended sampling approaches for different compartment and plastic sizes, regarding their feasibility (1 more feasible, 7 less feasible; based on resource sampling and processing requirements) and common policy concerns addressed, with reference to the specific chapters in the report. This policy relevance index is the sum of the policy concerns addressed by the sampling approach. ***Compartments*** *- SL: shoreline; SF: seafloor; B: biota; SS: sea surface.* ***Sub-compartments*** *- BE: beach; FISH: fish; INV: invertebrate; SEAB: seabed; MEG: mega-fauna.* ***Plastic sizes*** *- MA: macro-plastic; ME: meso-plastic; MI: micro-plastic.*

	Compartments and plastic size			Resource sampling nd processing equipments (costs increse from left to right)							Examples of policy concerns									
													Impacts on							
Feasability	Compartment	Sub-Compartmnt	Plastic size	People	Basic field equipmen	Sleeves	Nets	Dissecting microscope	Ships	Chapter	Cistribution and Abundance	Source lentification	Tourism	Seafood safety	Human health and injuris	Navigational	Fisheries and aqualculture	Animal welfare	Biodiversity	Policy relevance index
1	SL	BE	MA	R	R					4	R	R	R		R				R	5
2	SL	BE	ME	R	R	R				4	R		R						R	3
3	SF		MA	R			R		R[a]	6	R	R				R	R		R	5
3	SF		MA	R[b]	R					6	R	R	R			R	R	R	R	7
4	8	FISH	ME MI	R		R		R		7	R			R			R	R	R	5
4	8	INV	ME MI	R				R		7	R			R			R	R	R	5
5	8	SEA B[c]	ME MI	R		R		R		7	R	R						R	R	4
5	8	MEG[c]	MA ME MI	R				R		7	R							R	R	3
6	SS		ME MI	R		R	R	R	R[d]	5	R						R		R	3
7	SS		MA	R	R				R[e]	5	R					R	R	R	R	5

[a] *Opportunistic sampling using fishing vessel* | [b] *Opportunitstic observations using recreational divers* | [c] *Stranded organisms* | [d] *Research vessel* | [e] *Visual observation from ship of opportunity*

There is a description of the environmental settings, selection of monitoring strategies and special considerations for each environmental compartment: shoreline, sea-surface and water column, seafloor and biota (**Figure 2**)[16]. *Many of the techniques described can be used to quantify, identify and report on specific items or items from specific sources, e.g. Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG), to evaluate the efficiency or effectiveness of reduction measures. The guidelines may also be used for monitoring, with appropriate modification, other environments such as rivers and lakes.*[17]

The report also includes a selection of sample preparation procedures in the laboratory, as well as a range of more sophisticated techniques for recording the biological, chemical or physical characteristics of plastic samples. It provides links to protocols and data recording sheets for monitoring marine plastic litter. Links are also provided to sources of information, including existing monitoring programmes, more detailed descriptions of methods and case studies.

Development of indicators within SDG 14.1.1

A key intention of the GESAMP guidelines is to support the further development of the marine litter monitoring framework under SDG 14.1.1 and to improve the associated indicators.[19] *This includes the selection of indicators on the sources, environmental concentrations and impacts of marine litter.*[20] *Using harmonized methods will encourage the development and implementation of regional or global monitoring programmes, and facilitate the exchange of monitoring results, as already being done by the Regional Seas Programmes.*[21] *A key role of the guidelines is to ensure the interoperability of different databases, data exchange and integrated regional and global monitoring.*[22]

The UN Decade of Ocean Science for Sustainable Development (2021-2030) presents an opportunity to the wider ocean science community to develop a more effective, reliable and cost-effective global monitoring framework, as the inter-calibrated remote and *in situ* observations in the context of a consolidated Integrated Marine Litter Observing System (IMDOS)[23].

Data management and sharing

The harmonization of sampling protocols and reporting methods will help to reduce barriers to data sharing and support the development of effective global data management, linked to existing regional and global platforms where possible.[24] For example, at a regional scale the European Commission has developed the European Marine Observation and Data Network (EMODnet), a system designed to collect, harmonize and share a wide range of marine environmental data in cooperation with Regional Seas covering the North Eastern Atlantic (OSPAR), Baltic (HELCOM), Mediterranean (UN Environment MAP) and the Black Sea (Black Sea Commission). Recently, EMODnet has been extended to include data on marine litter, specifically from the shoreline, seafloor and sea surface.

A series of recommendations, including selection criteria dependent on both resource/capacity limitations and policy questions being addressed, are provided at the end of the report[18].

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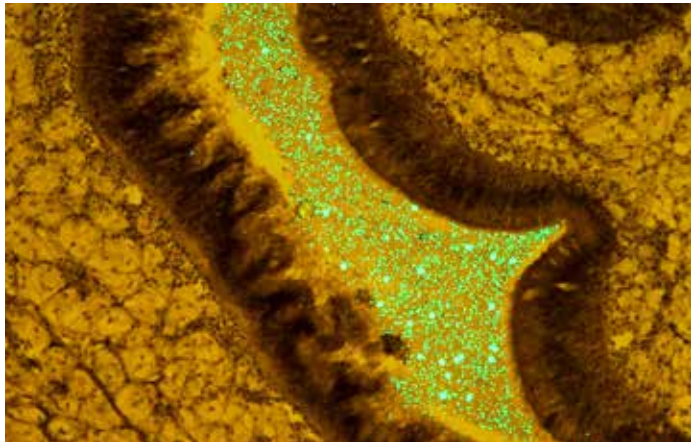
Credit:NOAA



Credit: I. Paul Pont

Figure 2: Methods employed to sample marine litter in the different compartments in the ocean (shorelines, sea surface, seafloor and biota). Diving in shallow waters (Pacific Coast, US, <30m), sampling microplastics, evaluating ingested micro-particles by molluscs and beach sampling

How much plastic is estimated to be in the oceans and where it may be

Total plastic estimated to have ended up in the sea[1]

86 million tonnes

Annual input from maritime activities*
50 000 tonnes/year
* Latest estimates available are from the 1970s

Coastal ocean waters
23 million tonnes[2]

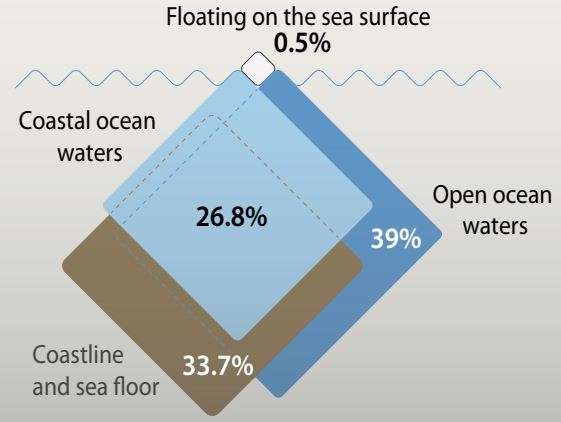
Floating on the open ocean surface
210 000 - 439 000[4] tonnes

Plastic mass
■ = 100 000 tonnes

Coastline and sea floor
29 million tonnes[3]

Open ocean waters
34 million tonnes

Floating plastic, just the tip of the iceberg



Notes:
[1] Calculated as 1.4% of all the plastics produced since the 1950s. From Jang et al., 2015
[2] Lebreton et al., 2012
[3] Assuming 66% of the plastic is buoyant. From Jambeck et al., 2015
[4] From Cózar et al., 2014; Eriksen et al., 2014; van Sebille, 2015

Sources: GRID-Arendal own calculations, each source is indicated in the notes

Towards more effective monitoring programmes

The guidelines have been based on generally accepted sampling and analytical techniques developed for investigating natural features of the environment. However, there still are methodological challenges to overcome, since many techniques under-sample smaller sized items and are affected by *the inherent heterogeneity of marine litter distributions, resulting in variations of abundance that may exceed a factor of 10 at any one 'site'.*[25] *This needs to be addressed as part of the overall design of the sampling strategy.*[26] *In the future, increasing automation of sampling and sample analysis may allow a greater throughput of material and reduce some of the uncertainty in the measurements.*[27]

Citizen Science

Members of the public are an important sustainable resource for *finding out more about the environment in their role as citizen scientists, enhancing ownership*[28]. *There is a long tradition of citizen science volunteers in marine litter research and monitoring* (**Figure 3**), which can be scaled up to support regional and ultimately global monitoring and assessment initiatives coupled with awareness raising and citizen participation. Most citizen science efforts have been conducted on beach stewardship schemes and may be applied in other marine compartments (e.g. shallow water – scuba divers).

In addition to citizen science generating relevant scientific information and contributing to marine litter monitoring, the involvement of the wider general public in research can generate additional outcomes, promoting attitudinal and behavior change which is linked to increasing social consciousness, custodianship of local environments and pressures on policy and decision makers to take action.

Figure 3: Participation of citizen scientists in marine litter research

Policy Concerns

A comprehensive monitoring programme should ensure that sampling strategies, protocols and indicators are tailored to the specific questions to be answered. These questions are often driven by policy considerations *and may include risks to human health, compliance with national or international environmental regulations, impacts on biodiversity*[29] and the influence on tourism and maritime safety. Monitoring may also assess the efficiency of remediation/mitigation efforts, or simply, how effective a ban is on certain items.[30]

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Several aspects were highlighted in the guidelines to improve the indicators for monitoring and assessment programmes, such as the selection of measurement units, *the recording of ancillary data to describe the monitoring activity (i.e. metadata)*[31], the consideration of a data management policy (i.e. storage of data in data banks), and the selection of sampling strategy. Each of these has implications on how the data collected may be utilized. The flexibility of the guidelines also matches the varying capacity of government agencies or other organizations, especially at the national and sub-national levels, to develop and maintain monitoring programmes.

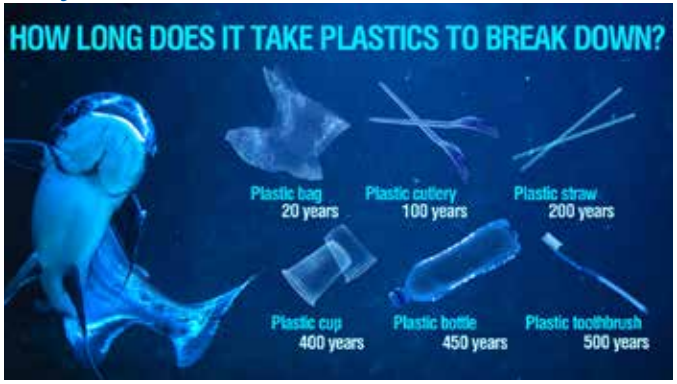
Strengthened and harmonized monitoring and assessment efforts will help meet global commitments under the UN Sustainable Development Goals targets and to support global initiatives such as the United Nations Environmental Assembly and related Open-ended Ad hoc Expert Group on Marine Litter, and Marine Litter Action Plans developed under the Regional Seas Conventions, G7 and G20, that are already working together *to target and gauge the effectiveness of marine litter reduction measures.*[32]

Conclusions

It is not possible to manage without information. The absence of reliable monitoring and assessment of marine litter prevents informed decision-making, including on SDG 14.1. An urgent call is needed for both local and global action to foster a comprehensive long-term monitoring and assessment programme. As the subject is complicated and costly, member-states and other relevant stakeholders should commit to reaching the best trade-off among simpicity of indicators, cost, and comprehensiveness to support decision-making at both local and global levels.

Such an endeavour involves capacity building efforts and links with regional marine litter working groups. To support more effective monitoring, those interested are encouraged to join the Global Partnership on Marine Litter (GPML)[33], a multi-stakeholder partnership which provides a unique mechanism to bring together all the actors working on marine litter to share knowledge and experience and to advance solutions to this pressing global issue. The GPML also facilitates capacity building, providing access to training and collaboration among partners, including a Massive Open Online Course (MOOC) on Marine Litter in partnership with Open Universiteit, using the guidelines as training material.[34]

Do you know?



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Link to the report: http://hdl.handle.net/20.500.11822/30009

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