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Scientific input to the Intergovernmental Negotiating Committee (INC) on Plastic Pollution

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The North Atlantic Microplastic Centre NAMC is a multi-disciplinary, multi-actor and international project focused on understanding the fundamental aspects of microplastic pollution in the North Atlantic with relevance to the wider ocean. NAMC is coordinated by the Norwegian Research Centre NORCE and is composed of leading experts in plastic pollution from 17 institutes located in six countries (Norway, Denmark, Germany, Italy, England, United States of America) and thus provides an international voice. The purpose of the project is to support international cooperation on generating knowledge on the complexities of microplastic pollution. The aim of this document is to provide knowledge-based input on the multifaceted aspects of plastic pollution to support the negotiations towards a Global Agreement on Plastic pollution.

Key messages:

1. Although the social, economic and financial benefits of the agreement will outweigh any immediate costs, an approach that balances regulations with new and alternative solutions is vital for efficient transitions towards reduced use of plastic materials within society and industry.
2. A working definition of microplastics that encompasses the varying characters of microplastics size and form, polymer chemistry and composition – and thereby also provides a necessary tool for environmental risk assessment and regulations is: '***microplastics are particles of synthetic or semi-synthetic organic polymer or rubber between 1 µm and 5 mm in size along their largest dimension***.'
3. The agreement would benefit from rooting in the existing international frameworks, especially to reflect the specificity of different regions and challenges therein. It will require strong and efficient implementation and compliance mechanisms, involving the private and industry stakeholders.
4. Researching past experiences of global pollutants can better frame our approaches for managing plastic pollution, but it is necessary to adapt current understanding of environmental pollutants to the multifaceted characters and harms of plastic pollution.
5. Account should be taken of the variable distribution of the financial gains and losses across the identified countries.
6. Connect to the Science-Policy Panel to Support Action on Chemicals, Waste and Pollution.

1. The social, economic and financial benefits of taking action

There are significant social, economic, and financial benefits associated with reducing plastic pollution. Coastal waters are particularly vulnerable to plastic pollution owing to their proximity to land-based sources of pollution, the high biological productivity of coastal and estuarine habitats[1], the prevalence of tourism, aquaculture, and in-shore fisheries that are of value to the economy and society[2]. Global damages related to plastic pollution have been estimated at USD $13 billion[3] with a **potential to gain an annual $500–$2500 billion** in the value of benefits derived from marine ecosystem services[4] if the pressure of marine plastic is reduced.

2. The definition and characterisation of plastic

Clear definitions of plastics and plastic waste are necessary for understanding the distribution and fate of plastics in the ocean, the environmental and human health effects, and effective designation of policy. **This definition and characterization of plastics is complex and a current challenge for interpretation**. As an example, the quantification of micro-and nano-plastics contains many unsolved issues which must be resolved as a prerequisite to monitoring; for microplastics (MP) there is a focus on the 5mm upper size limit. The lower size limit of MP has been set either to 1000 or 100 nm. In term of physical and chemical properties 5mm particle is very different to a 100 µm particle which again is very different from 1 µm. There are several initiatives working on definitions, harmonisation and standardisation within the scientific and international standards community[5]. Projects linking such initiatives are tightly bound within NAMC.

NAMC has, through dedicated working groups, over the recent years researched options to support a clearer understanding of the complexities of marine litter and plastic pollution to generate common and workable solutions (see schematic 'Addressing the complexities of marine litter and plastic pollution').

The NAMC project propose the following working definition for microplastics; ***'microplastics are particles of synthetic or semi-synthetic organic polymers or rubber between 1 µm and 5 mm in size along their largest dimension.***

Microplastics comprise particles of a wide range of chemical and physical properties in term of polymer structure, added compounds (additives), part of the composite material, size, shape and surface properties. These diverse characteristics means that different microplastics may "behave" differently in the environment and in organisms, and therefore have very different effects on ecosystems, organisms and human health.
Listed below are parameters which can further characterize microplastics:

Intrinsic characteristics:

- Molecular structure (polymer type)
- Primary particle size
- Primary morphology
- Source
- Chemical additives (product source information needed)

Environmental characteristics:

- Secondary particle size
- Secondary morphology
- Weathering status
- Adsorbed pollutants

3. Current governance and connecting a global agreement to regional efforts

While there is an extensive international governance framework to address different types of pollution ranging from local to global level that addresses the plastic problem [6,7] it is inadequate to respond to the challenges facing the global community. Several studies in the recent years reviewed and provided a comprehensive analysis of the existing instruments, including their shortcomings and gaps in the broader plastic pollution governance system (e.g. [7,8,9,10]). These can be summarised in three categories:

1. Coordination (lack of a coordinating institution)
2. Management (lack of globally binding standards)
3. Assessment (lack of global standards for national monitoring and reporting)[7,9]. A new possible global instrument on the plastic pollution must address these issues.

A global agreement on plastic pollution should take as a point of departure different regional arrangements (such as the UNEP's Regional Seas Convention and Programmes, as summarised by e.g. [6,11] to reflect the variety of challenges and solutions adopted in specific regions. **Adopting a hybrid binding-voluntary framework convention may be a favourable way forward that will ensure that all states, regardless of their development status, will be able to commit and engage in the joint global effort.** The first phases of the framework convention (to be expanded with specific region- and sector-based protocols, annexes or other instruments) should strive for increased interplay with the existing instruments that over time can be incorporated into the global framework. The global instrument (for instance, through its secretariat) could also serve as a platform for sharing experiences and good practises and, in the longer term, harmonising and unifying the global efforts.

NAMC encourages the inclusion of strong implementation and compliance mechanisms, in line with and based on solutions from other multilateral environmental agreements, such as an implementation and compliance committee (eg. Minamata Convention) or nationally determined contributions (eg. Paris Agreement) in estimated levels of reduction of plastic discharges in relevant sub-categories (type, size, source, secondary and primary microplastics, intentional and unintentional). There is a need for precise and unquestioned definitions and delineating the scope of the agreement in reference to these aspects of plastic pollution. **NAMC is undertaking interdisciplinary research to link the definitional, assessment and policy questions. A robust monitoring and assessment component (eg. modelled on the AMAP working group of the Arctic Council) that would ensure state-of-the-art scientific knowledge and a continuous science-policy interaction to assist the implementation is highly recommended.**

Furthermore, in our view, it is essential to include elements promoting sustainable consumption and production across the life cycle of plastics [9] to provide for incentives and benefits from a global plastic circular economy. This in our view, requires close cooperation with the private sector such as plastic producers, large plastic users and waste management industry to include the views of the relevant stakeholders, especially in reference to implementation and compliance. **NAMC endorses the approach that such an agreement should include elements that will ensure a stable and**

sustained framework, embracing all stages of plastic life cycle and the value chain (upstream, midstream, and downstream) and will incorporate the circular economy path.

4. What can be learnt from other global pollutants?

Today, several governmental establishments across the globe are in collaboration for regulating several hazardous substances, and many research and governance organizations provide valuable data regarding the regulations of these substances, scientific classifications, and human exposure. Current research in NAMC is taking a **structured approach to comparing marine pollution to other recognized global contaminants that have been encompassed by international regulations,** including – but not limited to SO_2, CFCs, asbestos, persistent organic pollutants (such as "the dirty dozen" from the Stockholm Convention), mercury and lead, and to see if there are lessons which could learned from previous global regulation. NAMC is currently building a database containing various pollutants coded according to, for example: their substance groupings (e.g., POPs, PAHs, PBDEs); hazard classifications; degree of regulation; economic impact of regulation; availability and benefits offered by substitutes; technological solutions available and the price of these; whether the regulation succeeded. In the second phase of the analysis NAMC will utilize the database to conduct a meta-regression for determining the recommended level of regulations for marine pollution based on the existing information and regulations on other pollutants.

5. The Importance of global modelling to develop an effective and efficient Global Agreement

Understanding plastic pollution requires research into the drivers bringing plastics to the environment and spreading it from local to international waters. In this way, **plastic emissions from a given country may be incurred by one or more other countries.** Translating this into costs will play an important role in developing an effective global agreement, leading researchers on this topic are incorporated within NAMC. A combination of observations and modelling can assist in identifying where the greatest damage costs will be incurred, and where the plastic likely came from[12].

Efforts to develop a coordinated, international agreement must account for the movement of plastic through rivers, estuaries, shelf seas and the open ocean, which can result in **damage costs (e.g., to wildlife and citizens) associated with plastic emissions from a given country being incurred by one or more other countries**. Damage costs to each country will likely depend on (i) the total volume and type of plastic waste in the sea, (ii) ocean circulation patterns, (iii) exposure (e.g., length of coastline; vulnerability of coastal ecosystems; relative importance of coastal economy), (iv) localised use of coastal resources and attendant effects of marine plastic pollution on welfare, and (v) values lost by residents of a country as a result of marine plastic effects on other countries.

Like other international pollution control problems where the environmental damages and required emissions reduction actions are asymmetrically distributed across countries (e.g., as was the case with sulphur dioxide emissions and acid rain in Europe in the 1980s), a multilateral environmental agreement (MEA) would allow countries to explore opportunities for a cooperative solution to reduce plastic pollution. The net payoff to any one country from costly abatement actions, which reduce their own emissions of plastic into the oceans, depend on the actions of other countries in reducing their plastic emissions as well. The unequal distribution of emissions reduction that this cooperative solution requires implies, however, that some countries are likely to lose out from this cooperative solution, even though the total net benefits from international cooperation across all countries are positive. **Losing out at the individual country level from a specific control programme makes it unlikely that some countries would willingly participate, unless a mechanism can be found to offset these country-level net costs**. An effective MEA takes account of the distribution of the financial gains and losses across the identified countries. **A benefit-oriented cost sharing approach built into an MEA can be used to identify ways to address equity considerations in the context of international marine plastic pollution abatement.**

6. Connection to the draft resolution to establish a Science-Policy Panel to Support Action on Chemicals, Waste and Pollution

The recent quantification of the chemical pollution (aka "novel entities") planetary boundary confirms that the increasing rates of production and releases of larger volumes and higher numbers of chemicals is an important factor in pushing the Earth System outside of it's safe operating space [13]. Plastic pollution is one of the largest component groups of pollutants, not only in terms of global production, which continues to rise, but also in the inseparability of plastics and chemicals. Plastics are manufactured with a multitude of chemicals (additives) that provide properties of, for instance, thermal resistance, malleability, hardness, colour and many others. Many of the these 'additives' are known to be toxic in their own right. In addition, plastics of their breakdown products (micro- and nano- plastics) enter an environment that already contains a high number of chemicals (organics, pharmaceuticals and metals). These chemicals are known to associate ('sorb') to the plastic polymer surface of find space within the internal (crystalline) structure of the plastic. In this way, plastics can be carriers for both the additives and sorb chemicals and change their interaction with wildlife when the plastic particle is ingested [14].

Thus, the environmental presence of plastics and chemicals are intrinsically linked meaning that the Global Plastics Agreement and the Draft resolution for a Science-Policy Panel are also fundamentally connected. NAMC welcomes Norway's co-sponsorship of the Draft resolution for a Science-Policy Panel to support action on chemicals, waste and pollution and can provide scientific and technical expertise to the government in the Panel implementation phase.

Taking into consideration the **multifaceted hazards of microplastic pollution**, its risk assessment and regulation should include the following criteria: 1. the size and quantity of microplastics, 2. the inherent toxicity of microplastics, 3. the added toxicity or harm developed during exposure to environmental factors, 4. the potential for transport and translocation in the environment and food chain, including final sinks, 5. the physicochemical effects that may interfere with organisms or ecosystems functioning.

Recent research indicates that MP concentration is correlated to population levels and that humans are likely to be more exposed in urban areas. Urban areas are likely to be hot spots of microplastics contamination from litter and car tyre wear for example and may be an efficient point of interception to prevent further environmental contamination. Understanding the processes and sources leading to urban plastic pollution and the distribution from sources may help identify measures to reduce global plastic and microplastics emissions.

Health effects – routes of exposure and what can be learned from exposure and effect studies in animals.

In the perspective of human exposure, health effects and risk of microplastics is an integrated part of the microplastic challenge, yet, knowledge of these aspects is scarce and in need of detailed studies.

Recent work demonstrates the uptake of microplastic across the intestines, and the translocation into tissues that are food for humans. Exposure to microplastics is from ingestion (food, beverages and water) and inhalation. The multiple exposure routes for humans imply a need for identifying dominant exposure routes as well as at-risk groups for exposure. The identification of exposure routes also leads to the understanding that there may be several target organs where detrimental effects can be expected.

In all biological systems, microplastic exposure may cause particle toxicity, with oxidative stress, inflammatory lesions and increased uptake or translocation, however mechanisms of effects are not well understood and still need to be addressed. Furthermore, microplastics may release their constituents, adsorbed contaminants and pathogenic organisms. Nonetheless, knowledge on microplastic toxicity is still limited and largely influenced by exposure concentration, particle properties, adsorbed contaminants, tissues involved and individual susceptibility, requiring further research.

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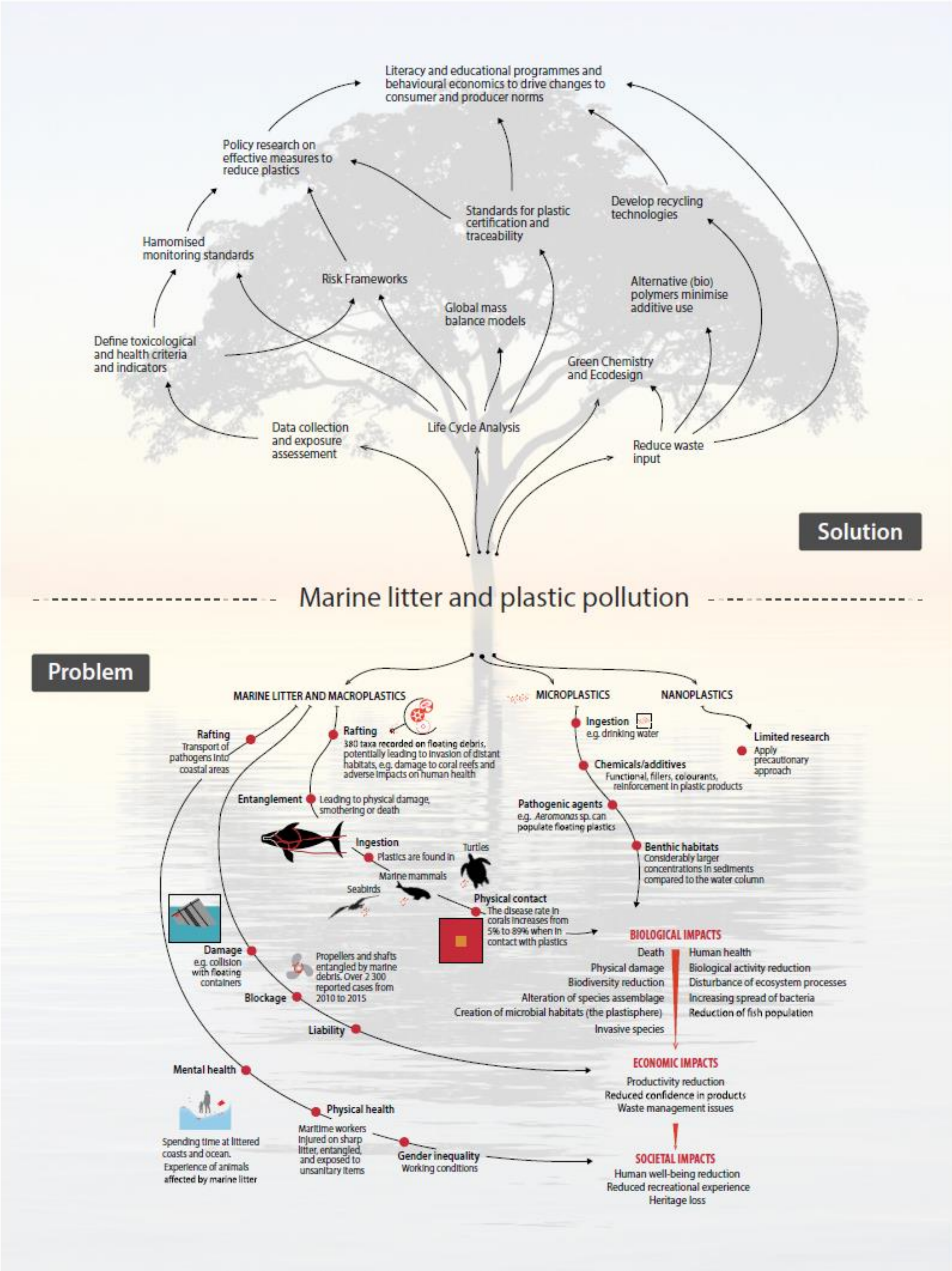
A problem/solution tree schematic addressing the complexities of marine litter and plastic pollution



Problem figure source: UNEP (2021). From Pollution to Solution: A global assessment of marine litter and plastic pollution. Nairobi.

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