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MICROPLASTICS IN THE OCEANS: THE SOLUTIONS LIE ON LAND

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The Tara under sail power
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Tara Expeditions Foundation is a recognized public interest non-profit organization that has been working for 15 years to improve understanding of the oceans and promote their protection.

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KEYWORDS

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- MEDITERRANEAN

There are 5,250 billion¹ plastic particles floating on the surface on the world's seas and oceans, equivalent to 268,940 metric tons of waste. These fragments move with the currents before washing up on beaches, islands, coral atolls or one of the five great ocean gyres. As early as 2010, Tara Expeditions Foundation was one of the first bodies to undertake a scientific examination of microplastic pollution in the oceans, an issue previously subject to very limited scientific study. Tara wanted to use its ocean study programs to understand the impact of this pollution on marine life. In 2014, Tara conducted a seven-month expedition in the Mediterranean Sea to improve understanding of the consequences in a semi-enclosed sea. The expedition highlighted the fact that microplastics are heavily colonized by bacteria. Research into sea-borne plastic has since become an integral part of Tara's work. Excessive consumption of plastics, and the waste this generates, has a massive impact on the natural world and the marine environment in particular. In this knowledge, Tara conducts scientific studies to improve our understanding of the risks to humans and marine ecosystems. Faced with the gravity of the situation Tara is convinced that, if we are to avoid plastics ending up in the oceans, the solutions lie on land. This involves a collective re-engineering of how we produce and consume, for example banning single-use plastic bags.

INTRODUCTION

MICROPLASTICS: WHAT ARE WE TALKING ABOUT HERE?

The vast majority of plastic fragments in the seas are microplastics. These are pieces of debris smaller than 5 mm in size and very varied in dimensions, color, shape, density and chemical composition. Although some fragments do wash up on beaches and coastlines, the vast majority of microplastics stay far out at sea before eventually breaking up, a process that can take anywhere from 100 to 1,000 years.

We distinguish between primary microplastics, which are directly introduced into the environment in the form of small plastic particles (microbeads in cosmetics, textile fragments, fragments from vehicle tires, etc.), and secondary microplastics that result mainly from the break-up of large pieces of plastic waste into smaller plastic fragments once exposed to the marine environment. Single-use plastic bags are among the largest sources as they break up very easily under the action of sun and seawater.

¹ Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. Plastic waste inputs from land into the ocean. *Science* 347, 768–771. doi:10.1126/science.1260352

Recent research¹ estimates that there are 5,250 billion plastic particles floating on the surface on the world's seas and oceans, equivalent to 268,940 metric tons of waste. These fragments move with the currents before washing up on beaches, islands and coral atolls. Other fragments end up in one of the five giant ocean gyres, the largest and best-known being the North Pacific Gyre. And if the impact of this ever-growing pollution remains little understood in terms of biodiversity and human health, the economic costs are considerable. Recent studies suggest that the financial damage caused by plastics in marine ecosystems amounts to around \$13 billion annually. The negative impacts are felt by fishing industries and boaters as well as the islands and coastal towns that rely on tourist income.

I - MICROPLASTICS IN THE OCEANS: AN UNDER-STUDIED FIELD

Plastics are materials with immense potential. Plastics are cheap to make and have ideal properties: lightweight, strong, resistant, flexible or rigid, opaque or transparent, they adapt to every imaginable type of product. They were quickly taken up by industries worldwide. Since modern plastics were first invented in the early 20th century, production and use of plastics has grown exponentially in all fields, from construction to vehicles and electronics, to the current position where annual production amounts to around 300 million metric tons. Designed to last, most plastics are nonetheless produced for applications with short lifespans: almost half will end up as packaging to be thrown away immediately after purchase. Their uses might be ephemeral but their presence in the environment is anything but transitory: once used, if they are not collected and recycled, plastics systematically end their lives abandoned in nature, particularly the sea.

WHY IS IT SO IMPORTANT TO STUDY THIS? TARA FOUNDATION AND ITS PROGRAM ON PLASTICS IN THE SEAS

Tara Foundation is France's only recognized public interest non-profit organization focused specifically on the oceans.

Using a variety of advanced technologies, genetics, genomics, the latest advances in sequencing and Big Data, Tara is helping to foster the emergence of innovative and groundbreaking science that helps improve understanding of the oceans and the impact of climate change and environmental degradation on this ecosystem of vital importance for humanity's future. As a fully operational floating laboratory, Tara's schooner has already completed 11 major expeditions to all the world's oceans, collaborating with many top-flight international research institutions including CNRS, CEA, ENS, EMBL, MIT and NASA.



Microplastics sample taken from the Great Pacific Garbage Patch at 34°42'210 N - 142°21'004 W.
© Samuel Bollendorff - Tara Expeditions Foundation

The foundation is also fully committed to open science and citizen science, sharing all its data and scientific protocols. Tara is convinced that sharing knowledge and transcending traditional frontiers is the best way to protect and manage the oceans. It makes all data acquired during its expeditions – currently the world's largest multi-disciplinary ocean database – available to scientists worldwide.

All its missions fully support Agenda 2030's Sustainable Development Goal 14, "Conserve and sustainably use the oceans, seas and marine resources", something that the foundation is deeply engaged with at international and national levels. With observer status at the UN since 2015, it plays an active part in various U.N. commissions and conferences, providing its scientific expertise to multilateral negotiations on the high seas, climate change and reducing pollution from plastics. It is also a member, and currently chair, of Océan et Climat, a French umbrella body whose 80 or so members include research institutions and actors from civil society and business.

Tara's program on plastics in the sea concentrates on research into microplastics, with a split focus between the Mediterranean and the world's great oceans via our program of expeditions. The Tara Méditerranée expedition was designed to grow knowledge about the impacts of plastics on the Mediterranean ecosystem. The mission quantified numbers of plastic fragments, their size and mass. It also identified the types of plastics found in the sea. As yet unexplored microscopic ecosystems of bacteria, viruses, micro-algae and micro-predators form on the surface of these plastic fragments, which raises the question of their probable entry into the food chain, an issue previously almost completely ignored in the Mediterranean.

Beyond the scientific aspects, the issue of marine plastics is also a key vector driving awareness of the oceans. Press and social media are awash with pictures of floating plastic bags, bottles and other debris, triggering worldwide indignation and concern. Extensive media interest is

¹ Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. Plastic waste inputs from land into the ocean. *Science* 347, 768–771. doi:10.1126/science.1260352



Justine Jacquin sorts samples, Jonathan Lancelot and Nils Haentjens haul in the Manta net.
© Samuel Bollendorff - Tara Expeditions Foundation

certainly beneficial but it is too often overly hasty, peddling unverified information and figures. Tara's preference is to work from robust scientific data, respecting the science and not scaremongering about the potential dangers of marine plastics.

The oceans are under pressure, but unsettling images and alarmist statements often do nothing to further the search for actionable solutions with the various stakeholders. We sincerely believe that solutions are possible, no matter how bad things may seem, but these solutions are to be found on land, in a circular economy with recycling, reuse of resources and transition to environmentally friendly and non-polluting packaging.

II - THE MEDITERRANEAN: ONE EXAMPLE OF THE IMPACT OF MARINE MICROPLASTICS

The Mediterranean Sea is one of the world's regions most impacted by marine pollution. Some 700 tonnes of waste pour into it daily. Being semi-enclosed, the Mediterranean is even more vulnerable to plastic pollution than the ocean; its water has a 90-year renewal period and plastics persist

for periods in excess of 100 years. There are currently 1,000 to 3,000 tonnes of plastics floating on its surface: fragments from bottles, bags, packaging, fishing lines and so on, mostly accumulating from large coastal towns and cities, regions with significant tourist activities, and open-air waste dumps.

The majority of pollution in the Mediterranean is not visible floating waste (macroplastics) but the 250 billion fragments of microplastics it contains.

This is a problem exacerbated by other factors: densely populated coastlines, highly developed tourism, the passage of 30% of the world's maritime traffic, and additional waste inflows from rivers and highly built-up zones. Some 95% of marine waste in the Mediterranean is plastic, leading some experts to label it the world's sixth major marine waste accumulation zone, after the five ocean gyres.

Invisible pollution has numerous impacts and consequences are little understood:

- Microplastics attract and accumulate contaminants already present in the water, such as chemicals and fertilizers.
- Their small size means there is a real risk that filtering animals, such as fishes and whales, will confuse microplastics with plankton.

- The role waste plastic may play in the emergence of human health problems remains uncertain because of a lack of understanding of:
 - levels of exposure to contaminants caused by waste plastic;
 - mechanisms by which chemicals absorbed by plastics are then transferred to humans and marine species.

TARA MEDITERRANEAN EXPEDITION

In 2014, with support from the Veolia Foundation, Tara led a unique seven-month expedition around the Mediterranean basin specifically to study microplastics. The expedition took 2,000 samples from 350 different areas near to coasts, cities, river mouths and in ports. The data gathered, representing 75,000 plastic particles, is the largest collection of microplastics ever gathered from the Mediterranean.

These data are currently being analyzed by a number of laboratories, including Villefranche-sur-Mer, Banyuls and Université Bretagne Sud. Since 2015 these labs have also been monitoring the most polluted part of the Ligurian Sea.

After the Tara Mediterranean Expedition returned to shore, Tara teamed up with other partners involved with the Mediterranean as part of Beyond Plastic Med, a body seeking to find actionable solutions for reducing plastic pollution in the Mediterranean rather than just recording the facts. Members of this initiative are Tara Foundation, the Prince Albert II of Monaco Foundation, the Veolia Foundation, Surfrider Foundation, the International Union for Conservation of Nature, and the Mava Foundation. Since its establishment it has run a number of initiatives including workshops with the private sector, awareness-raising films and funding for grassroots civil society projects around the Mediterranean.

At the same time, scientific institutions involved in the Tara Mediterranean Expedition continued their research into microplastics and are in the process of consolidating their initial results, with publication expected within the coming two years. News of a first discovery, published in February 2018, concerned bacterial colonization of microplastic fragments. Tara's schooner continued to make marine studies and analyze samples collected from the Arctic region, and it is currently applying new protocols for collecting samples from the Pacific.

Today, faced with the enormity of the challenge, it is vital to support research designed to produce actionable results capable of driving changes in public policy and transition to more environmentally friendly practices.

To this end, Tara has designed its marine plastics program so that it conducts scientific studies to improve understanding of both the origins and routes to the sea

followed by microplastics, of how it disperses, its toxicity and impacts on marine biodiversity and the food chain. We thereby hope to further our understanding of the risks to humans and the marine ecosystem.

FOCUS: MICROPLASTICS IN THE MEDITERRANEAN, PATHWAYS FOR INVASIVE SPECIES

In 2014, after traveling the Mediterranean for a seven-month expedition aboard the Tara's schooner, the conclusion was stark: whether near to the coast or out at sea, plastics were everywhere; 100% of the Mediterranean is polluted with plastics. More alarming still, the concentration of microplastics (< 5 mm) in some locations is greater than in the Great Pacific Garbage Patch, the so-called seventh continent of plastic, and in numbers of a similar order to plankton, which forms the base of the food chain.

In March 2018, the Banyuls Oceanic Observatory team led by Jean-François Ghiglione published an article in *Environmental Pollution* demonstrating that microplastics are heavily colonized by bacteria. "Bacteria love living on plastics. We find them in very large concentrations, with great biodiversity, greater still than in an equivalent volume of seawater", says the CNRS researcher.

The researchers found colonies of unexpected types of bacteria, including certain cyanobacteria typically found in sediment layers that were found to be extremely abundant on plastics floating on the surface. "Dispersion of invasive species is one of the big problems with plastic pollution, as these attach themselves to what are effectively artificial rafts and can thus travel great distances. Such species are capable of effecting lasting change to ecosystems they colonize", he warns.

We sincerely believe that solutions are possible, no matter how bad things may seem, but these solutions are to be found on land, in a circular economy with recycling, reuse of resources and transition to environmentally friendly and non-polluting packaging.



Tara Méditerranée plastics - ©N.Sardet/TaraExpeditions

The team joined the Tara Pacific expedition in June 2018 to take samples from the plastic gyre and continue their investigation into the lives of microorganisms that colonize the new plastic ecosystems known as the plastisphere. Research into interactions between microplastics and the marine microbiota are important if we are to gain an understanding of how and under what conditions certain bacteria are able to degrade, or even digest, plastics, as recent laboratory studies have shown.

III – THE SOLUTIONS LIE ON LAND!

OUR FUTURE: AN OCEAN OF PLASTIC?

“Plastics comprise the vast majority of the 10 to 20 million tonnes of waste influx of all types into the ocean every year. Almost all objects floating on the surface are plastics. Although some debris does come from marine activities, on average 70% to 80% of waste in the sea comes from land, most of it carried by rivers”.² Excessive consumption of plastics and the waste that this generates has a massive impact on the natural world, and the marine environment in particular. Environmental damage caused by waste plastic to marine ecosystems in terms of species mortality, habitat destruction, chemical contamination, propagation of invasive species and financial losses to fisheries and tourism may represent over \$13 billion per year.³ “Plastics undoubtedly play a crucial role in modern life, but the environmental impacts of the way we use them cannot be ignored”, says Achim Steiner, former Executive Director of the United Nations Environment Program. It is urgent to act now for the Mediterranean, which is subject to enormous strains caused by human activities.

We need to re-examine our lifestyles if plastics are to stop taking over the oceans.

WASTE PLASTIC MUST NO LONGER END ITS LIFE IN THE SEA: THE SOLUTIONS LIE ON LAND

Faced with this alarming situation, many people’s first reaction is to turn to technology in the hope of finding a solution that will clear floating plastics from the planet’s seas and oceans. But the oceans are vast and the amount of debris is growing all the time, and the emergence of microplastics makes it harder and harder to collect. Although clean-ups remain indispensable, focusing on them is to attack the consequences of the problem but ignore the causes. We have to act upstream. Only by preventing waste from entering the sea can we hope to protect and restore the oceans for the long term. Despite the seeming simplicity of this solution and the strategy it implies – reducing the amount of plastic produced and persuading people not to litter – it is by no means easy to put in place, being predicated on fundamental changes in behavior by plastics manufacturers as well

as consumers. We need to re-examine our lifestyles if plastics are to stop taking over the oceans.

CHANGE CONSUMER BEHAVIOR: REDUCE, REUSE, RECYCLE

Not many people have any idea of the amount of waste that they produce simply as a result of their day-to-day activities. Awareness-raising and a conscious effort to change habits are needed if the impact of plastics is to be minimized: we need to move toward less waste and more reuse and recycling. Consumers clearly play a vital role. Buying responsibly is one way to prevent the production of waste plastic: opting for products with little or no packaging, choosing products that are long-lasting and reusable rather than highly waste-generating disposable products such as plastic plates and glasses, disposable razors, etc., and refusing plastic bags from shops. Reusing items instead of throwing them away can give objects a new life. Maintain and repair, sell or give away items that are no longer used, reuse packaging, containers and spare parts, return bottles for a deposit where possible – these are all simple ways for people to reduce their waste footprint.

Lastly, consumers must also take responsibility for sorting their waste and making sure that end-of-life products are sent for appropriate recycling, where this is available. Awareness-raising and the presence of appropriate infrastructure are both critical if changes in behavior of this type are to occur. And this is about more than just plastics – the way that we think of the sea must change too. Considerable education is needed to stop people thinking of the seas as a vast reservoir where waste can be dumped without any consequences.

SINGLE-USE PLASTICS: ENCOURAGING PROGRESS

Plastic bags were for a long time features of our daily lives without us knowing anything of the consequences. But scientists are increasingly highlighting the alarming impact they have on the seas. Tara is now lobbying governments and multilateral bodies to take concrete steps, given the scale of plastic pollution observed during its expeditions and in the light of France’s decision to ban lightweight plastic bags as of 2016. A worldwide ban on single-use plastics, which cause such harm to our environment, is vital for the health of humanity and the seas.

Mediterranean basin countries including Morocco and Monaco have announced bans on single-use bags but more progress is needed among the region’s big polluters, such as Egypt and Lebanon, where waste management remains inadequate. Faced with this scourge, it is important to remember that solutions always inevitably involve creating suitable, which means costly, infrastructure such as wastewater treatment plants and recycling facilities. These investments are needed more than ever in countries of the South, all the more so as the oceans know no frontiers and marine currents quickly circulate plastic particles across the entire Mediterranean basin.

² UNEP, Achim Steiner, 2014

³ <http://www.unep.org/newscentre/Default.aspx?DocumentID=2791&ArticleID=10903&l=en>



©Jonathan Lancelot - Tara Expeditions Foundation

Billions of thin plastic bags continue to be handed out every year in France at tills or when buying fruit and vegetables, and most of them are discarded after a single use. It takes 100 to 500 years for bags like this to degrade in the environment. Being extremely thin, they are of no use to monetized recycling systems, unlike bottles and rigid containers that can be sold by weight. They are easily carried by the wind and whether or not carefully deposited in a waste bin, waste plant or deliberately thrown on the ground, the majority of them will end their journeys in the sea. Once in the sea, their impact is devastating. Carried over great distances, they damage the seabed and endanger animals that ingest them, become entangled in them or contaminated by the toxic substances they give off. Under the action of sea currents the bags are fragmented into microparticles that disperse throughout the environment. Absorbed by marine organisms the microparticles move up the food chain, ultimately ending up on our plates. Single-use plastic bags are a potential threat to human health and represent a not inconsiderable cost to society as a whole. Every activity in some way related to the sea or coast – fisheries, fish farming, leisure activities and tourism – is harmed by their presence.

CONCLUSION

There is no golden bullet – genuine solutions will arise from concerted action by civil society, policymakers and business.

Faced with the sheer scale of the task of tackling ocean pollution, some people suggest miracle solutions for a clean-up of the seas, others propose developing enzymes that will eat the plastic, while others still attempt to build boats that

will clean the oceans. Although it would of course be wrong to exclude explorations of possible technological solutions for the future, we believe that achievable solutions exist already, and that most of them are to be found on land, focused on prevention and proper processing of waste and water.

To transform habits so that every household produces less waste, and people no longer automatically throw things away, will require an enormous effort to educate people, be they inhabitants of coastal countries or one of the many millions of tourists who flock each year to the Mediterranean or the isles of the Pacific. Of course, citizens are not the only ones at fault here. Prevention of plastic waste also has to happen upstream, among manufacturers and retailers, long before products reach consumers. Attempts to persuade plastics manufacturers to stop producing the material are doomed to fail. More responsible forms of manufacturing are the key to reducing the amount of waste generated. Business can alter the paradigm by reducing the amount of packaging and designing long-lasting products that are easy to maintain and repair, able to be reused or recycled.

According to Achim Steiner, “Reducing, recycling and redesigning products that use plastics can bring multiple green economy benefits – from reducing economic damage to marine ecosystems and the tourism and fisheries industries, vital for many developing countries, to bringing savings and opportunities for innovation to companies while reducing reputational risks”. At the same time, replacement with alternative materials and better management of plastics to encourage recycling and reuse would deliver significant savings to manufacturers of retail goods. Annual savings are currently estimated at some \$4 billion and this amount can only increase.