Exploring contemporary archaeologies of plastic pollution: Perspectives from Galapagos, the East Pacific Coast, and Europe

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Abstract

In collaboration with the Galapagos Conservation Trust, this journal-style thesis explores the potential of contemporary archaeologies to address plastic pollution from a theoretical standpoint and through the presentation of several case studies in Europe, and the Pacific region including Galapagos. By considering plastic pollution a topic of interest and concern for archaeologists, this work contributes to establishing a theoretical framework for contemporary archaeologies of plastic pollution. Archaeologists can regard plastics as artefacts, as components of archaeological layers, as part of waste landscapes, or focus on plastic pollution threatening archaeological sites. These perspectives were explored across all chapters, combining three methodological approaches: the use of object itineraries, the implementation of story-writing workshops, and the potential of social media analysis.

The thesis shows the diversity of archaeological approaches to plastic pollution. The focus on sinking plastics entering the riverbed of the Sambre river in Belgium sheds light on less visible plastic pollution and advocates for the potential of studying plastics as part of more traditional archaeological projects. Observing plastics as artefacts and reconstructing their itineraries was central to the design of engaging story-writing activities in the Pacific including Galapagos. Stories and surveys offered a window into local perceptions of the issue, reflecting a good understanding of sources and impacts while emphasizing that more focus should be on solutions. The focus on plastics as material culture was explored in an analysis of social media reactions to policies limiting the use of plastic items during the COVID-19 Pandemic.

Archaeology holds the potential to address plastic pollution within multi-disciplinary projects and contribute to different fields including environmental education and policymaking. The discipline contributes to understanding plastic pollution providing a focus on plastics as artefacts, approaching behaviours and perceptions through engaging activities, and providing a framework to evaluate and contribute to policymaking.

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Declaration

I declare that this thesis is a presentation of original work and I am the sole author. In the case of co-authored papers, my own contribution is described and evaluated in a co-authorship statement signed by all co-authors and located at the end of each paper. This work has not previously been presented for a degree or other qualification at this University or elsewhere. This work was supported by the Arts & Humanities Research Council (grant number **AH/R012733/1**) through the White Rose College of the Arts & Humanities. All sources are acknowledged as references. With exception of the introduction and conclusion, all chapters of this thesis have been published or are under review:

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Chapter 1 - Introduction

Plastic pollution is a global challenge threatening most landscapes, whether urban or rural, cultural or natural, terrestrial or underwater. It is a topic that worries the general public and is concerning for researchers from different disciplines. While marine biology often focuses on plastic litter density and potential impacts on wildlife, oceanography is notably concerned with the role of currents in plastic transport. Environmental engineers contribute to determining plastic types and degradation rates while environmental psychology often focuses on understanding the behavioural drivers of littering and the perception of plastic litter and pollution. But what if archaeology could help bring all those disciplines together to reconvey the complexity of plastic pollution? Building on the potential of interdisciplinary and intersectoral approaches to investigate the topic of plastic pollution and eventually "reconfigure how modern societies engage with plastics" (Napper, Pahl, and Thompson, 2021: 34), this thesis argues for the use of contemporary archaeologies to address the issue of plastic pollution.

This introduction will first present a short history of plastics, detail the development of contemporary archaeology as the discipline focused on addressing plastics as artefacts of the Anthropocene (or the Plastic Age), and lay out the regional focus of the PhD in the Pacific. It will then successively introduce the aims of the research, the methods used, and the structure of this journal-style thesis.

Plastics are fantastic?

The word plastics refers to polymers (e. g. macromolecules containing carbon), which can be natural (e. g. rubber), semi-synthetic (e. g. cellulose derivatives), or fully synthetic (e.g. Bakelite). Generally, the term plastic encompasses several types of polymers all sharing a material property that constitutes the core of the material's success. The etymology of the word, from the Ancient Greek word "plasticos" (πλαστικοσ) meaning suitable for modeling (Gontard, 2020), is embedded in their plasticity, a property that has contributed to plastics' success story quickly becoming an indispensable material across contemporary societies.

Throughout time, humans have always looked for materials that can be easily modeled. Natural polymers have been exploited worldwide, from rubber balls used during ball games in Mesoamerica (Hosler et al., 1999) to bitumen contributing to mummification processes in Egypt (Shashoua, 2008). The elasticity and eased modification of natural polymers shaped the demand for synthetic plastics and drove creative processes culminating with the invention of semi-synthetic and synthetic polymers. The first synthetic polymer, Bakelite, was created in 1907 and paved the way for the creation of 15 polymers in the first half of the twentieth century (Andrady and Neal, 2009). Rapidly, mass manufacturing took advantage of plastics' flexibility and moldability to create any shape at a low cost and replace natural materials with cheaper alternatives. As of today, there are hundreds of plastics but the focus of this thesis is on a selection of synthetic polymers that represent 90% of the demand, including low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET) (Andrady and Neal, 2009). In addition to these plastic types, other chemicals added either intentionally (e.g. additive) or unintentionally (e.g. reaction byproducts), can be found on plastic objects (Wang and Praetorius, 2022). There are over 10,000 potential chemical substances that can be added to create plastic products (Wiesinger, Wang and Hellweg, 2021) rendering their chemical composition complex and turning their waste processing into a challenging operation (Wang and Praetorius, 2022). In this research, the term plastic will refer to fully synthetic plastics, without discussing natural and semi-synthetic plastics. Specific references to polymer types are only included when identified and when relevant to the case studies presented.

During the twentieth century, the emergence of synthetic plastics was met with enthusiasm and joy to develop an infinity of products at a low cost and large scale. Designers felt inspired by plastics, recognising their potential to create new shapes and forms. Ironically, plastics were first seen as a more sustainable option to ivory and tortoiseshell, unaware that their resistance to degradation and omnipresence would threaten the same animals they aimed to save in the first place. Despite this excitement, some scholars, such as Norman Mailer and John Gloag, feared the future that plastics would bring (Meikle, 1992). Plastics facilitated the creation of new social habits (Bensaude-Vincent, 2013; Hawkins, 2018), those marked by consumerism of post-war societies leading to mass production and consumption of plastic objects (Meikle, 1992; Strasser, 2000). In that perspective, experimentation in the production of plastics quickly entered the realm of magic and chemistry (see Graves-Brown, in press). Already in the 1950s, Barthes (1957: 159) noted that:

> More than a substance, plastic is the very idea of its infinite transformation, it is, as its vulgar name suggests, ubiquity made visible; and in this way, it is a miraculous material: the miracle is always a sudden conversion of nature. Plastic remains imbued with this astonishment: it is less an object than a trace of a movement.[1]

In this quote, Barthes identified two key elements that will be explored in this dissertation through an archaeological lens: plastic as “ubiquity made visible” and as the “trace of a movement”. Plastics’ ubiquity turns them into artefacts that (contemporary) archaeologists can difficultly ignore as they have the potential to permeate most archaeological contexts and records. As artefacts, they can also become a powerful tool to engage people on the topic of plastic pollution and encourage discussions about human behaviours and people’s relationships with these objects. Their ubiquity is made visible because plastic products invade our daily lives, and they pollute landscapes, plastic being ubiquitously “out of place” (after Douglas, 2002: 44 discussing dirt being “out of place”). Nonetheless, the visible plastic pollution is only a part of the issue with considerable amounts of plastics that have sunk, polluting the seafloor and the riverbed, or degraded, becoming micro- (between 1 to 10000 μm) and nano-plastics (smaller than 1000 nm) permeating our bodies (Jenner et al., 2022a), the atmosphere (Jenner et al., 2022b), and even space (Gorman, in press). In addition to their transformation and disappearance from the most visible landscapes, plastics travel extensively, from their liquid flows characterising their production to their journey as waste. Considering how plastics represent global flows of material in a supermodern society (see González-Ruibal, 2018 for a discussion on supermodernity), the idea that plastic artefacts illustrate this movement and can be perceived as traces fits very well with an archaeological consideration of plastics proposed in this thesis.

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[1] Translated from French: “Ainsi, plus qu’une substance, le plastique est l’idée même de sa transformation infinie, il est, comme son nom vulgaire l’indique, l’ubiquité rendue visible; et c’est d’ailleurs en cela qu’il est une matière miraculeuse: le miracle est toujours une conversion brusque de la nature. Le plastique reste tout imprégné de cet étonnement: il est moins objet que trace d’un mouvement.” (Barthes 1957: 159)

It is both the scale, and the undesired and overwhelming presence in our environment, that led to the consideration of plastic pollution as a visual, chemical, and physical issue threatening most places around the globe. A summary of plastic pollution sources and impacts, as well as potential solutions is presented in the following section, before considering how archaeology can address this issue.

Plastic pollution

Plastic pollution is one of the most pressing issues that contemporary societies are facing. Plastic production keeps increasing with over 400 million tons (Mt) of plastics produced in 2022, of which 90% is still made of fossil fuel (Plastics Europe, 2023). Not only do societies need to manage persistent plastic waste that has accumulated throughout the Plastic Age (starting in 1950; see below for a discussion of the period), but they also need to envision how increasing plastic production will lead to severe pressure on waste management systems. Waste management systems in the Global North are unable to manage their waste and therefore export it (Barnes, 2019) notably to the Global South, reinforcing the inequalities existing between waste management systems of both regions (Kalina, 2020). Despite all the efforts to counter plastic pollution, the (projected) amount of plastic waste still exceeds how much plastic can be adequately managed (Borrelle et al., 2020). It is estimated that as of 2015, almost 80% of plastic waste accumulated in landfills and in the environment with 20% of plastic waste either recycled or incinerated (Geyer, Jambeck, and Law 2017). Plastic waste makes no distinction and reaches all environments, from the deep sea (Pham et al., 2014), remote inhabited islands (Lavers and Bond, 2017), the highest peaks (Napper et al., 2020), and even space (Gorman in press). Their fragmentation into micro- and nano-plastics means that plastic particles are present in the atmosphere of our living spaces (Jenner et al., 2022b) and even our bodies (Ragusa et al., 2021; Jenner et al., 2022a; Leslie et al., 2022).

Defining plastic waste

Exactly as there are different potential typologies of plastic as products (see above), plastic that has been disposed of and is no longer used for its *proper* function (after Preston 2000;

see Chapter 3 for a discussion of functions) can be referred to as waste, litter, or debris (for a definition of each term, see the Lexicon p81). The definition of waste is embedded in its uselessness and a loss of value, which has been criticised for considering value only from an anthropocentric perspective (see Chapter 6). While the term litter emphasises the fragmentary state of the remains, the definition of debris notes the destruction or breakage that provoked their becoming. While waste is a concept that has raised a lot of discussions in archaeology (e.g. Rathje and Murphy, 2001; Reno, 2014; Sosna and Brunclíková, 2017; Reno, 2018) and anthropology (e.g. Harvey, 2013; Dey and Michael, 2021), environmental or marine biology studies seem to refer to litter, waste or debris indifferently, notably in the following definition: "Marine litter (also called marine debris) is solid waste that has been discharged into the marine environment resulting from activities on land or at sea" (Napper, Pahl, and Thompson, 2021: 25). Scholars working on the marine environment seem to use both marine litter (e.g. Pham et al., 2014; Hidalgo-Ruz and Thiel, 2015; Rodríguez, Ressurreição, and Pham, 2020; Int-Veen et al., 2021) or marine debris (Wilson and Verlis, 2017; Krelling, Williams, and Turra, 2017; Napper and Thompson, 2020; Gaibor et al., 2020). This interchangeable use of litter and debris reflects the focus on waste as *marine* and its *anthropogenic* nature. Plastic waste is another term commonly used across disciplines, mostly to quantify the issue of plastic pollution (e.g. Borrelle et al., 2020; Jambeck et al., 2015; Lebreton and Andrady, 2019) and to reflect on waste (mis)management and export practices (e.g. Brooks, Wang, and Jambeck, 2018; Brooks, Jambeck, and Mozo-Reyes, 2020; Winterstetter et al., 2023). While all terms refer to plastic fragments and/or objects found in the environment once they acquire the status of waste, more consistency in the language adopted would benefit scholars from different disciplines. As an archaeologist interested in naming and categorising objects, here plastics, a clarification of the terms used is presented next.

In this thesis, I prefer the term marine plastic litter (MPL) (see Chapters 4-5). Litter particularly suits plastics as their fragmentation is at the core of the issue, leading to the accumulation of microplastics in our environment and the difficulty of removing them. I also discuss plastic waste, emphasising the loss of both value and proper function and allowing me to explore how plastics become components of broader waste landscapes (see Chapter 6 for a discussion about the value associated with the term waste). In addition to the different names plastic litter can be given, several ways to classify plastic litter exist based on its shape, colour, composition, and origin among others. This lack of consistency in plastic classification was raised by Hartmann et al. (2019; see Table 1 for a classification of plastics based on non-exclusive properties). In this thesis, different aspects of plastics as artefacts will be considered, with size being one of the most recurrent. As there have been many debates regarding the size limitations used to differentiate macro-, micro-, and nano-plastics, I here follow Hartmann et al. (2019) considering that macroplastics are bigger than 1 cm, mesoplastics measure between 1 mm and 1 cm, microplastics span sizes from 1 to 10000 μm, and nanoplastics are smaller than 1000 nm. Microplastics are further differentiated as a) primary microplastics manufactured at a reduced size such as microbeads or resin pellets, or b) secondary microplastics being the result of degradation of larger items through abiotic factors (Van Cauwenberghe et al., 2015; Welden, 2019).

Table 1: Proposed classification of plastic debris (Hartmann et al., 2019: 1045)

Criterion	Recommendation	Examples
I: Chemical composition		
Ia: Polymers	All synthetic polymers:	
✓ Include	▪ Thermoplastics	All commodity plastics
	▪ Thermosets	Polyurethanes, melamine
	▪ Elastomers	Synthetic rubber
	▪ Inorganic/hybrid	Silicone
✓ Include	Heavily modified natural polymers (semi-synthetic)	Vulcanized natural rubber, regenerated cellulose
× Exclude	Slightly modified natural polymers	Dyed natural fibers
Ib: Additives		
✓ Include	All polymers included in Ia disregarding their additive content	Plasticized PVC with >50 % additives
Ic: Copolymers		
✓ Include	All copolymers	ABS, EVA, SBR
Id: Composites		
✓ Include	All composites containing synthetic polymer as essential ingredient	Reinforced polyester and epoxy
✓ Include	All surface coatings containing polymers as essential ingredient	Paints containing polyester, PUR, alkyd, acrylic, epoxy resin
✓ Include	Tire wear (and road) particles	-
? Open question	Is it necessary to define a minimum polymer content?	
II: Solid state		
✓ Include	All polymers with a T_m or T_g >20 °C	See examples in Ia
× Exclude	Polymer gels	PVA, PEG
? Open question	Should wax-like polymers (T_g <20 °C) be included?	
III: Solubility ✓ Include	All polymers with a solubility <1 mg L^{-1} at 20 °C	See examples in Ia
IV: Size	▪ Nanoplastics: 1 to <1000 nm ▪ Microplastics: 1 to <1000 µm ▪ Mesoplastics: 1 to <10 mm ▪ Macroplastics: 1 cm and larger The largest dimension of the object determines the category. Comprehensive reporting of multiple dimensions is preferred (e.g., for fibers).	
V: Shape and structure	Spheres: Every surface point has the same distance from the center Spheroid: Imperfect but approximate sphere Cylindrical pellet: Rod-shaped, cylindrical object Fragment: Particle with irregular shape Film: Planar, considerably smaller in one than in the other dimensions Fiber: Significantly longer in one than wide in two dimensions Additional information on the structure (e.g., porosity) can be included.	
VI: Color	Not crucial but useful in some biological contexts. Use a standardized color palette.	
VII: Origin (optional)	Primary: Intentionally produced in a certain size Secondary: Formed by fragmentation in the environment or during use Origin should only be used if the primary origin can be established.	

Scale of the issue

Attempts have been made to quantify the amount of plastic waste in the environment. The first method of calculation is based on plastic products' lifetime, recycling, and incineration rates at a global level (Geyer, Jambeck and Law, 2017). As of 2015, it was estimated that 6300 million metric tons (Mmt) of plastic waste were present in landfills and/or the environment and that by 2050, its levels could reach 12,000 Mmt if production and waste management follow the same trend (Geyer, Jambeck and Law, 2017). A study estimated that in 2016, aquatic systems received 11% of the global plastic waste generated, accounting for 19 to 23 Mmt (Borrelle et al., 2020). Once in the marine environment, plastic waste can either sink or float, sometimes accumulating in oceanic gyres forming garbage patches (Lebreton et al., 2018). A recent study by Eriksen et al. (2023) estimated that 170 trillions of plastic particles are floating in the ocean, weighing between 1.1 and 4.9 million tonnes (Mt). This does not account for sinking waste that previous studies identified on the seafloor (Int-Veen et al., 2021), and also on the riverbed (Praet and Delaere, in press). While it is challenging to obtain global estimates, numerous studies adopted a national or regional scale to determine plastic abundance, density, distribution, and/or composition on beaches (Gaibor et al., 2020; De Veer et al., 2023), in marine sediments (e.g. Brandon, Jones, and Ohman, 2019; Amrutha et al., 2023), deep basins (e.g. Pham et al., 2014) and on the seafloor (Int-Veen et al., 2021), among others. The potential of using citizen science for the monitoring of plastic litter has been explored in several studies for micro- and macro-plastics (Hidalgo-Ruiz and Thiel, 2013; 2015; Jones et al., 2022). From that perspective, regional datasets expand the panorama and help us understand the specificity in terms of litter composition, distribution, and density, refining the regional sources and impacts on the region studied. Determining the exact amount of plastic pollution in the environment is challenging as studies often do not consider clean-up actions and may have impacted the record that (citizen) scientists are faced with. Some studies also included a diachronic perspective to understand the evolution of plastic quantities through time (e.g. Brandon, Jones, and Ohman, 2019; Ostle et al., 2019), rendering the issue of plastic pollution even more archaeological. With gigantic amounts of plastic waste being mismanaged and eventually polluting our rivers, oceans and lands, solutions need to consider the sources of plastic pollution, as well as their impacts.

Sources

Plastic becomes waste at two main stages: during production (pre-consumer) or after its use as a product (post-consumer) (Yang et al., 2018). While pre-consumer plastic waste is generally directly recycled, or at least managed within the industries, the management of post-consumer plastic waste is more challenging as it occurs across industrial, agricultural, commercial, and residential sectors (Yang et al., 2018). Residential waste accounts for the majority of post-consumer plastic waste (see Yang et al., 2018). Some plastic types are greater contributors to the issue of marine pollution, notably polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS) (Andrady, 2011).

When studying plastic pollution, the global nature of the issue should be considered with a disparity in contributors. As of 2015, the leading generator of mismanaged plastic waste was Asia (82 Mmt) followed by Europe (31 Mmt) and Northern America (29 Mmt) (Lebreton and Andrady, 2019). Despite the lower proportion of mismanaged plastic waste in western countries found by Lebreton and Andrady (2019), their contribution to plastic pollution was found significant by Law et al. (2020). Once considering illegal domestic dumping and international exports, the US was found to be the major contributor to plastic pollution in 2016 with 42 Mmt (Law et al., 2020). In general, high-income countries in Europe and America share a high rate of waste generation per capita coupled with large coastal populations, which leads them to be responsible for most coastal plastic waste worldwide (Law et al., 2020). Despite generating more waste, western countries have low recycling rates, insufficient to process the waste produced nationally. For example, in France, only 1% of PET bottles can be recycled in national recycling centres, leaving out 99% of national PET consumption (Gontard, 2020). This unrealistic plastic consumption of western countries has led to the development of a large waste export market, facilitated by disparities in environmental standards between the South and the North. Where environmental regulations are less rigid, imports of waste levels are higher (Kellenberg, 2012), contributing to toxic colonialism or toxic imperialism (Gregson and Crang, 2015). Global South countries are often importing this waste despite the lack of robust and reliable waste management facilities (Borrelle et al., 2017). For decades, China imported half of the world's plastic waste until the 2018 ban (Brooks, Wang, and Jambeck, 2018), leading western countries to manage the waste in the country of origin (landfill) or re-route their plastic waste to other destinations, mostly South-East Asian countries at first (INTERPOL, 2020), and then Kenya for US waste (Tabuchi and Corkery, 2021) and Turkey for waste coming from the UK (Gündoğdu and Walker, 2021).

In addition to the disparity between countries producing and suffering from plastic waste, some industries are higher contributors to the issue. Packaging is the leading sector in plastic production (Geyer, Jambeck and Law, 2017; Tsakona and Rucevska, 2020;

Plastics Europe, 2023), also associated with the highest rate of production for the shortest use (Geyer, Jambeck and Law, 2017). The sector also benefited from the COVID-19 Pandemic boosting the consumption of single-use items (Silva et al., 2021). Several studies of MPL identified packaging as one of the most recurrent categories of plastic litter found on the coast (Garcés-Ordóñez et al., 2020a; Okuku et al., 2020). While packaging items are associated with land local sources, notably constituting the main category of mismanaged plastic waste (at least in Europe, see Winterstetter et al., 2023) and from tourism on beaches (Williams et al., 2016; Wilson and Verlis, 2017), marine activities are also important contributors to MPL (Muñoz-Pérez et al., 2023; Sánchez-García and Sanz-Lázaro, 2023). Fishing-related litter may not necessarily reach the shores and can accumulate in the gyres, as illustrated in the Great Pacific Garbage Patch (GPGP) where almost 50% of the waste is made of fishing nets (Lebreton et al., 2018). Marine activities not only produce waste in the form of fishing gear, but such activities also require a life at sea including the consumption of packaged goods. A recent study showed that most plastic bottles found at Pitcairn islands in the Pacific originate from illegal dumping from ships (Ryan, 2023).

While the pathway of plastic litter to the environment can be diverse, an important pool of literature contributes to our understanding of sources. For example, marine plastic litter mostly comes from land sources carried by rivers into the marine environment (Harris et al., 2021; Lebreton et al., 2017; Li, Tse, and Fok, 2016). However, there are important regional variations in the distribution of sources. For the Pacific region, it seems that the role of rivers may not be as central as the one played by Asian rivers (De Veer et al., 2023). For the Pacific coast, sources of marine litter include land activities notably tourism (Garcés-Ordóñez et al., 2020b), as beach access is correlated to higher densities of marine litter (De Veer et al., 2023). Exceptions to that may be islands and archipelagos where external sources represent the majority of plastic sources, with plastics carried by oceanic currents coming from the mainland or marine activities including fishing (van Sebille et al., 2019; Jones et al., 2021; Muñoz-Pérez et al., 2023). Independently from the sources they originate from, plastics have a wide range of impacts on the surrounding environment detailed in the next section.

Impacts

Despite plastics having a wide range of societal benefits and applications (Andrady and Neal, 2009), their omnipresence as waste, and as a matter “out of place” (after Douglas, 2002: 44) have a series of impacts on our environment and societies. Impacts can be either bio-ecological, transforming the equilibrium and health of our environment, or socio-economical, affecting our societies and their economies.

Bio-ecological impacts include consequences for wildlife and us. Plastic waste can be particularly dangerous, even lethal, for wildlife that suffers from entanglement with plastics and ingestion of plastic items or fragments (Wright, Thompson and Galloway, 2013; Kühn, Bravo Rebolledo and van Franeker, 2015; Thiel et al., 2018; Blettler and Mitchell, 2021). Plastics can also absorb, transport, and/or release harmful chemicals, some of which are concerning for the health of wildlife (Rochman et al., 2013) and humans (Campanale et al., 2020). The matrix of plastics can also serve as a vector for invasive or non-native species posing a threat to the equilibrium of environments (Rech, Borrell and García-Vazquez, 2016; Krelling, Williams and Turra, 2017).

When it comes to plastic pollution’s socio-economic consequences, these can range from an economic impact on activities (Rodríguez, Ressurreição and Pham, 2020) including tourism (Williams et al., 2016). Plastic litter can also have negative impacts on well-being (Beaumont et al., 2019), contributing to rising levels of eco-anxiety (Smith and Brisman 2021) - i.e. distress and anxiety caused by climate change, and the uncertainties this can cause for the future (see Coffey et al. 2021 for a review of the term eco-anxiety). The range of impacts that plastic waste pose emphasises the need for solutions to address the issue of plastic pollution.

Solutions

Plastic pollution as both a crisis and a “wicked problem” (Vince and Stoett, 2018) requires solutions that are thought of at every step of a plastic’s journey, from object design to disposal. Some technologies (Falk-Andersson, Haarr and Havas, 2020; Schmaltz et al., 2020) or collective actions such as beach clean-ups with known co-benefits (Wyles et al.,

2017) may be able to diminish plastic waste already in the environment. Policies may limit the use of single-use plastics (Ortiz et al., 2020), along with the development of alternatives to fossil fuel plastics (Goel et al., 2021). These are examples of solutions that all address a different aspect of the issue. A mix of preventive - or upstream - (i.e. preventing plastic waste from entering the environment - the “tap”) and reactive - or downstream - (i.e. addressing plastic waste already in the environment - the “sink”) solutions are needed to address the issue in its complexity and change our habits towards more sustainable practices. Preventive solutions could be a reduction of plastic use, reuse of plastic objects, improvement of waste management, and offering alternatives such as bio-based biodegradable plastics. Reactive solutions include recycling or transformation of plastic waste into fuel or construction materials, as well as technological solutions to collect legacy plastics (i.e. non-recyclable or reusable plastics already in the environment or about to enter the economy; see Lexicon p81). This review does not intend to evaluate all potential solutions nor participate in building a discourse on circular economy. What it does is highlight the need for actions at different stages of plastic production, use and disposal, and levels of capacity.

The design of solutions needs to include changes in the industry (e.g. disposal considered from the design phase), government (e.g. more consistency in policies and regulations between countries), public awareness and education (e.g. education and changes in behaviour along the supply chain), waste management (e.g. connection to reliable waste management systems) and avoid a future over-reliance on plastics (e.g. carefully consider the viability and impacts of alternatives such as biodegradable (bio)plastics) (Napper and Thompson, 2020). The scale of the issue of plastic production, use, and pollution, calls for international actions and agreements (already identified by Borrelle et al., 2017). In that perspective, the Global Plastics Treaty (planned for 2024) offers hope for the establishment of standardised decisions and policies, understanding the complexity of the issues and the socio-economic factors at stake. As plastic industries employ 1.5 million people across more than 50,000 companies and together have a 400 billion euros turnover (Plastics Europe, 2023), the importance of the sector in the contemporary world needs to be considered for a transition that has controlled impacts on people and the planet.

Plastic pollution is a global issue, one that benefits from interdisciplinary approaches to understanding the issue, and to implementing solutions. Building on the history of plastics throughout the Plastic Age and the “wicked problem” (after Rittel and Webber, 1973; see Vince and Stoet, 2018; Schofield, 2024) that plastics represent nowadays, the following section will offer a vision of plastics (and plastic pollution) through the lens of contemporary archaeology. Plastic pollution can be considered as a “wicked problem”, a unique problem with multiple solutions that cannot be classified as good or bad nor be tested immediately and include consequences with every attempt to solve the issue (Rittel and Webber, 1973). Wicked problems have no definite end and are the symptom of other issues (Rittel and Webber, 1973), for example, plastic pollution illustrates an issue in mass-consumption and waste mismanagement. Archaeology can then contribute to understanding plastic pollution as a wicked problem, by shifting the focus to plastics as material culture of the twentieth and twenty-first centuries. While processual archaeology had already started to give relevance to modern material culture, it is the development of contemporary archaeology that allows plastics to be considered as artefacts of interest for archaeologists. The theoretical development of the discipline is presented first before the consideration of plastics as artefacts of the Anthropocene and the Plastic Age. Finally, the framework of the object itinerary is presented as a basis to re-construct plastics’ complex and global journeys, reinforcing the view that plastics are more traces than objects.

Plastics through the lens of contemporary archaeologies

Understanding plastics as artefacts of the Anthropocene and as an object of study for archaeologists is enabled through the formulation of contemporary archaeology as a discipline in the last twenty years thanks to developments and questionings arising since the 1960s. Before the 1960s, archaeology had always been “the science of the past” but theoretical debates started to define archaeology as a set of methods rather than a discipline focusing on a specific - and often geographically and chronologically remote- epoch (e.g. Graves-Brown, 2000; Buchli and Lucas, 2001). This chapter will be subdivided into two parts to understand the study of plastics through an archaeological lens. First, the formal establishment of the archaeology of the contemporary world in the 2000s will be put in context, describing the influences and theoretical debates that have paved the way for the discipline’s development since the 1960s (see Harrison and Schofield, 2010). Second, as my approach considers plastics as artefacts, I will present how plastics are increasingly considered archaeological artefacts, particularly to reflect on the Anthropocene and Plastic Age. Finally, as plastics are artefacts taking a global journey, I outline the emergence and relevance of the concept of object itineraries to work *on* and *with* plastics.

The emergence of contemporary archaeology

Far from reconstructing a history of archaeological thought (for this see Trigger, 2006), this section aims at presenting the increasing interest in (modern) material culture, and eventually for contemporary societies, developed through the different currents of archaeological thought and practice. This will help situate plastics as artefacts of interest for contemporary archaeologies.

Material culture was central to the development of archaeology as a discipline since its early days, sometimes arguably questionable particularly for Antiquarianism preferring artefacts over contextual information. While archaeologists have always worked with artefacts, other disciplines realised the potential of material culture for their studies. In the 1970s, the Material-Culture turn opened the potential of material culture for social scientists (Schiffer, 2017: Chapter 29). The role and importance of material culture within archaeology have shifted through time, from being ways to identify cultural groups (for Culture Historians) to becoming a source of information about people’s behaviours, even including contemporary material culture (for Processualists).

Processualists were the first to consider contemporary material culture as of interest to answer archaeological questions. Following and contrasting the approach of Culture Historians associating shifts in artefact typology and style with cultural changes (e.g. the Neolithic revolution proposed by Childe, 1935), processual archaeology developed an interest in cultural processes through the extensive use of models and systems thinking (e.g. Binford, 1962; 1965). First interested in the use of new scientific techniques such as radiocarbon dating (e.g. Renfrew, 1972) starting a radiocarbon revolution (Renfrew, 2011: Chapter 3), processual archaeology also explored contemporary ethnographic examples as a way to infer past practices and behaviours (one of the most famous examples given by

Binford 1980 in his study of hunter-gatherer settlements; the use of ethnography is also evoked by Renfrew, 2011: Chapter 12). This interest in ethno-archaeology was fully explored in the study of Millie's camp as an archaeological site, inferring behaviours and practices from the material record of this abandoned camp in Canada, and then tested and contrasted with information shared by Millie, a former camp occupant (Bonnichsen, 1973). Building on processual archaeology, behavioural archaeology focused on the relationship between material culture and human behaviour (Schiffer, 2002; 2010), including modes of inferring about past/present practices through past/present material culture (Reid, Schiffer and Rathje, 1975). Using modern material culture to infer modern or past behaviours were two strategies of behavioural archaeology (see Reid, Schiffer, and Rathje 1975 for the four strategies of behavioural archaeology). Behavioural archaeology mostly explored (modern or past) material culture as a source of information, including behaviour, about people (see Hicks, 2010 for a summary of the development of material culture and the material-cultural turn). Reconstructing a holistic perspective on human behaviour was possible by combining ethnography and sociology with the analysis of material culture (Rathje and Murphy, 2001). Exploring the potential of behavioural archaeology, several projects were developed in the 1970s and combined those methods.

The most emblematic project illustrating those new approaches to modern material culture was the Garbage Project developed by William Rathje. This project regarded modern garbage as a source of interest for archaeologists and a way to acquire information about consumption patterns of contemporary society. Rathje contributed to the development of Garbology, first theorised and put into practice by the journalist Weberman (1980) analysing garbage first from his idol Bob Dylan and then from various individuals, politicians, musicians, actors, and even first lady Jackie Kennedy. Rathje's Garbage Project promoted the application of archaeological methods, such as surveys and typologies, to study contemporary waste (Rathje and Murphy, 2001). In the US, between 1973 and 2005, the Garbage Project analysed 192.2 tons of garbage from 20,416 households in seven areas and 45.3 tons of refuse from 19 landfills and four open dumps in 15 cities (Rathje, 2011). This enabled the project to find answers to concerns about consumption levels, food waste, and reactions to shortages (Reno, 2013). Considering that "garbage, then, represents physical fact, not mythology" (Rathje and Murphy, 2001: 11), the project illustrated the difference between reported and actual levels of alcohol consumption (Rathje, 1992). The

Garbage Project emerged in an era concerned with social and environmental issues (Reno, 2013), which makes it still relevant nowadays. The legacy of the project is still visible today with several approaches using waste as a method to understand social practices (Högberg, 2017), re-construct narratives of illegal migrations (De León, 2015) and of object journeys (Schofield et al., 2020), and as an engagement tool in marketing research (Damron-Martinez and Jackson, 2017).

In the mid-80s, post-processualists rejected the science-driven and systemic approach through model testing praised by processualists (for a review on the development of post-processualism see Preucel, 1995). Influenced by Marxist socio-anthropology and postmodernism, post-processualism brought the focus on the meaning and symbolism of material culture and how this shaped human social practices (Trigger, 2006: Chapter 8), in an active way recognising the agency of objects (Jones and Boivin, 2010). Post-processualists mobilised theory as a practice going beyond the theory/practice divide advocated by processualists (Shanks and Tilley, 1989) mostly interested in using theory to test its applications in the archaeological record. Post-processualism particularly focused on theories of power and ideology and on understanding the social role of artefacts (summarised in Harrison and Schofield, 2010: 27-30). This interest replaced the focus on technology praised by processualists, and collided with the "material-cultural turn" in the 80s (see Hicks, 2010 for a review on the topic), a revival of interest from archaeologists and anthropologists for the study of material culture *per se* and not as means to infer behavioural trends. While material culture was an object of interest to understand meaning, symbolism, and social interactions, some approaches, notably feminist archaeology, advocated focusing on people to re-populate the past instead of reconstructing faceless societies (Tringham, 1991). Besides, feminist archaeology, along with indigenous archaeologies, questioned the positionality of researchers undertaking material culture studies (Hicks, 2010). Contrasting with the ethnoarchaeological analogies used by processual archaeologists to understand the archaeological record, post-processualists in the UK started to use contemporary material culture to reflect on social meaning and values. Research on the design of beer cans in Sweden versus Britain (Shanks and Tilley, 1992) and of bow ties in a pet food factory (Hodder, 1987) participated in the understanding of modern material culture within social practices (summarised in Harrison and Schofield, 2009: 187-188). This approach slowly expanded the potential meaning and relevance of material culture, which would then be central in the development of several approaches including New Materialisms.

The complexity of material culture, and the different approaches to its study from a wide range of disciplines, required to extend the perspective beyond western considerations. The use of material culture as a prism into culture, behaviour, or society, reached its limits, often reproducing an object-subject dualism, the object informing about different aspects of the subject's life. Expanding the post-processual approach, the 2000s saw the development of posthumanism in archaeology (see Fernández-Götz et al., 2021 for a review), calling for a consideration of different ontologies. Several frameworks were proposed to study material culture, developing object-centred approaches (e.g. the ontology of things in Olsen, 2010: 21; inspired by Harman's Object Oriented Ontology, the concept is explored archaeologically as Artefact Oriented Ontology A-O-O by Edgeworth, 2014: 227), exploring object's agency (e.g. Gosden, 2005), and recognising how objects contribute and are entangled in relationships with different actors through Actor Network Theory (ANT) (see Latour, 1996; 2005 for the framework of ANT; see Vadala and Duffy, 2021 for an example of its application in archaeology through the study of Maya caches in Belize). In addition to de-centering the human, scholars also questioned the nature/culture divide deriving from a modern western dualist consideration of nature separated from culture and of subject/object relationships (Haila, 2000). Building on archaeological reflections on posthumanism (de-centering of the human, see Fernández-Götz et al., 2021) and New Materialisms (a recognition that materials are central for archaeologists but considering them in a non-reductionist manner, see Witmore, 2014: 205) addressing the discomfort with former material culture studies (Hicks, 2010), archaeologists considered ways to apply these to the archaeological record (e.g. Fowler and Harris, 2015 in their New Materialist approach to the Neolithic funerary chamber of West Kennet) including of the contemporary era (e.g. see Yaneva, 2013 for an application of ANT to archaeology and architecture of the contemporary world, offering a reflection on things' multiple materiality and agency).

Inspired by Latour's symmetrical consideration of humans and non-humans (Latour, 1994), a symmetrical archaeology was proposed as a more egalitarian regime considering things and people without opposing them (Olsen, 2003; Witmore, 2007; Sørensen, 2013).

Those expanding perspectives were facilitated by the consideration for modern and contemporary material culture, particularly in anthropology and sociology (e.g. Hawkins, Potter, and Race, 2015 for an analysis of bottled water), but also in archaeology (e.g. Erny and Caraher, 2020; Letelier Cosmelli and Goldschmidt Levinsky, 2021). Among those studies, some focused on new synthetic materials, such as plastics, and offered avenues to explore different concepts, such as that of natureculture to go beyond the nature/culture dualism, and recognised the actions of human and nonhuman actors. The entanglement of plastics with humans and non-humans alike, and its contribution to new geological forms (see below for a detailed review) make this distinction even less relevant for contemporary assemblages. The focus on modern material culture therefore inscribes itself in those approaches, opening interpretations beyond an anthropocentric and western lens. After focusing on modern material culture, it is modern societies in their integrity that naturally became a topic of interest for archaeologists, leading to the development of contemporary archaeology.

Parallel to the development of de-centered approaches to material culture at the start of the twenty-first century, archaeologists started to formally consider the “contemporary past” as an object of study. In the first instance, “*Archaeologies of the contemporary past*” (Buchli and Lucas, 2001a) summarised the contribution of archaeology to the current world through participating in building memory, resilience, and ethics. This approach was mostly focused on the social significance of archaeology, exploring “new ethical and socially creative aspects” of the discipline in its diversity (Buchli and Lucas, 2001b: 174). Holtorf and Piccini (2009) also acknowledged the diversity of archaeology by adopting the term “contemporary archaeologies”. For them (2009:16), contemporary archaeologies are a way to “marry archaeology in the modern world and archaeology of the modern world”. In a sense, those projects were building on the awareness that archaeology is situated and political (González-Ruibal, 2008), and advocated for its relevance in our contemporary context. In *After Modernity* (2010), Harrison and Schofield defined an archaeology of the contemporary past corresponding to the Late Modern period that distinguishes itself by increased communicative technologies and electronic media, a globalised technology impacting production and consumption, mass migration, new modes of capitalism and more leisure time. Reflecting on the challenges of an archaeology *of* and *in* the present, and the need for multidisciplinary perspectives, Graves-Brown et al. (2013) preferred to use "archaeology of the contemporary world", recognising its relevance for the world's future. A recurrent theme in archaeologies of the contemporary past is their relevance for everyone. Never had any field of archaeology tried so hard to broaden the discipline by including more specialists, reiterating that "we are all archaeologists now" because we all have something to say about our material culture (Harrison and Schofield, 2010; Holtorf, 2015: 217). Several academic traditions have contributed to providing a different perspective on contemporary archaeologies. While contemporary archaeology is seen as an extension of historical archaeology in North America and Australia, the Latin American perspective has emphasised the discipline's importance for recovery after disaster, trauma, and conflict (González-Ruibal, 2018). The British/Nordic tradition has focused on the concepts of landscapes and aesthetics, using surveys more than excavations while objects and history were key to the mainland European perspective (González-Ruibal, 2018).

In brief, the last two decades have contributed to refining this new field of study and distinguishing it from ethnoarchaeology, archaeological ethnography, and historical archaeology despite the thematic and methodological overlaps between those disciplines (see Harrison and Breithoff, 2017 for a thorough discussion). Yet, the discipline has faced severe critiques, sometimes describing it as not being proper archaeology. Its detractors worry about the limited or absent time-depth of the research focus, an argument often used to criticise historical archaeology compared to the valued archaeological research of a remote and exotic past (Gilardenghi, 2021). These critiques emerge from a consideration of the discipline of archaeology as excavation uncovering a buried and hidden past (Harrison, 2011). In this work, I use contemporary archaeolog**ies** as a framework building both on the creativity and diversity of their applications, their ability to foster interdisciplinary approaches and their relevance for current and future challenges. There are many ways of undertaking contemporary archaeologies of plastics and plastic pollution (see Chapter 2 for more detail), and several projects, reviewed below, have paved the way for the archaeology of plastics and plastic pollution explored in this thesis.

A review of archaeological approaches to plastics and plastic pollution

Since the Garbage Project was the first archaeological approach to modern waste including plastics, archaeologists have been keen on exploring plastics from different angles, sometimes as part of interdisciplinary projects. Whether it is by considering plastics as artefacts, heritage, or legacy, and focusing on mega, macro, or microplastics, archaeologists have studied plastics' presence in a wide range of contexts.

With the interest of archaeologists in waste (see Chapter 6), plastic litter and pollution have become the focus of several studies. The accumulation of plastics was identified on the heritage site of Castell Henllys where two reconstructed houses were excavated by Mytum and Meek (2020). Plastics were considered as artefacts informing on the site's occupation and visitors' behaviours (Mytum and Meek, 2020). Building on the potential of material culture to inform behaviours, an archaeological framework was used to correlate the accumulation of plastics in rivers with littering behaviours, differentiating culture from natural contributors (Carpenter and Wolverton, 2017). Taking a landscape approach, surveys of drift matter including plastics yielded insight into the relationship to this material culture of the Anthropocene and how it is perceived locally (Pétursdóttir, 2017; 2020). Using plastic waste collected on beaches of the Galapagos, Schofield et al. (2018) organised a narrative workshop to re-construct in groups the journeys that those plastic artefacts had taken before reaching the archipelago's shores. Sampling of plastic bags in the town of Santa Cruz, Galapagos was also undertaken to approach disposal practices through time (Schofield et al., 2021a). These two related studies provided the groundwork and the opportunity for my own collaborative PhD with the Galapagos Conservation Trust. The potential of studying marine debris as an archaeological object of study was already identified by Arnshav (2014). The author encouraged marine archaeologists to consider waste found on the seafloor as a source of information on our contemporary societies through the development of maritime garbology. Plastic waste is not limited to terrestrial and marine environments. It can also be found in space (Gorman in press). An archaeological approach to the material culture of the International Space Station, much of which is plastic, revealed the values assigned to this waste and how it is handled, registered, and discarded (Walsh, Gorman and Castaño, 2022). Sometimes, access to physical artefacts is challenging as was the case during the COVID-19 lockdowns. From that perspective, social media also offers an archive of plastic use and disposal. Using evidence from social media, Schofield et al. (2021b) studied Personal Protective Equipment (PPE) such as face masks and gloves from an archaeological perspective to develop policy recommendations.

The archaeological approaches are not limited to plastic waste and can include perspectives on plastic production sites (e.g. Caraher, in press; Nevell, in press; Stewart, in press) and the use of plastics as products (e.g. in art, e.g. Bryning, in press; in games, e.g. Merrill, in press; in ritual settings, e.g. Moretti and Toso, in press) sometimes re-used as building material to maintain heritage building traditions (e.g. in the case of the Flipflopi, a dhow made of former plastic flip flops Müller et al., in press). Plastic production sites can become part of a toxic heritage, one facilitated by industrialisation and waste disposal, and that has shaped our current landscapes (e.g. artistic responses to landscapes holding toxic nuclear waste, see Joyce, 2023; landscapes shaped by anthracite waste in Pennsylvania, see Shackel, 2023). The extraction of natural plastics can also contribute to the development of toxic landscapes, for example with the addition of chemicals to process rubber in the Amazonia (Alves Muniz, 2023). In addition, archaeological theory can approach plastic from different angles, questioning the role of the discipline in addressing this current environmental crisis. A recent reflection by Wooten (2023) offered to focus on plastics archaeologically as a basis for activism and public outreach, leading to reflections on behaviour and the current climate crisis. This refreshing approach used archaeology as a situated practice without entering in the details of how archaeological methods could be applied to the study of plastics. To fill this theoretical gap, Chapter 2 looks at plastic pollution as an object of study and object of concern for archaeologists, respectively exploring the potential of its materiality suggesting different techniques, and acknowledging its impacts on heritage and archaeological sites.

While there are many ways to consider an archaeology of plastics or plastic pollution, as a subfield of contemporary archaeologies, transdisciplinary approaches are particularly welcome to study and approach this “wicked problem” (see Bernstein, 2015). Archaeologists can be part of teams spreading across disciplines or an archaeological lens can be adopted by non-archaeologists without presenting it as such. For example, some scholars have become interested in the accumulation of plastics over time in sedimentary records (Brandon, Jones and Ohman, 2019; Li et al., 2020; Simon-Sánchez et al., 2022) while others have explored the information available on plastic objects (Falk-Andersson et al., 2021), notably on PET bottles (Ryan, 2020; Ryan et al., 2021). Other studies have focused on plastic litter weathering and degradation, notably with the Lego Lost at Sea project (Turner, Arnold and Williams, 2020). While a thorough discussion of ways to look at plastics archaeologically is provided in Chapter 2, the forthcoming Routledge Handbook of Archaeology and Plastics (Godin et al., in press) will be the first work exploring the diversity of archaeological approaches to plastics and plastic pollution. For the scope of this thesis, I focus on using contemporary archaeologies to understand and work with plastic artefacts as an overwhelming material culture of the Anthropocene or the Plastic Age. Plastic artefacts are explored as a basis to re-create itineraries and as a way to move from re-constructing behaviours to understanding perceptions.

Plastics as artefacts of the Anthropocene or the Plastic Age

The history of synthetic plastics highlights how they have acquired socio-economic values and importance. In that sense, they have become what archaeologists consider artefacts, shaping new social practices (Hawkins, 2018) and holding cultural meaning (Ingold, 2000). Emblematic of our contemporary world, plastics were both praised and hated alternatively. In the first instance, plastics were seen as cheap substitutes for other materials (Bensaude-Vincent, 2013), offering a way to protect natural resources while paving the way for democratisation of several products. Followed a tangible excitement to explore the potential of plastics' materiality in art and design, preceding an ecological consciousness of plastics' impacts and persistence (Bryning, 2024). In that perspective, plastics offered emancipation "from the constraints of matter" (Bensaude-Vincent, 2013: 10) and their flexible material properties became a source of inspiration for artists and designers. Plastics also became of interest for scholars interested in modern material culture including archaeologists (as detailed above), notably as a symbol embodying consumer culture, supermodernity, and destruction (in the sense defined by González-Ruibal, 2018). For example, the plasticity of plastics, and their mutable qualities, created new socio-economic dynamics and markets (Hawkins, Potter and Race, 2015; Dey, 2021), but also reinforced and reproduced some immutabilities including social hierarchies and exposure to waste (Dey, 2021).

Like other (pre)historic artefacts, plastics are abundant, ubiquitous, and pervasive. Plastics have become so emblematic that several scholars (e.g. Thompson et al., 2009; Mytum and Meek, 2020; Porta, 2021) have adopted the use of a new period, the Plastic Age, mirroring a trend naming periods after important material resources (Stone Age, Bronze Age). Yet, it is the persistence and the impact of their presence, despite often being more the "trace of a movement" than an object (Barthes, 1957: 159), that separates plastics from other materials. Their ubiquity and the way they affect people unequally (e.g. plastic waste exports to the Global South) emphasises the colonial dynamics in which plastics are entangled, from production to disposal (Liboiron, 2021; Davis, 2022). By being global, colonial, political, and persistent, they embody anthropic impacts on the environment, a key characteristic of the Anthropocene. Plastics are emblematic of both the Anthropocene (see Chapter 2 for a discussion on plastic and the Anthropocene) and the Plastic Age (see Godin et al. in press for a discussion on the Plastic Age). In this work, I use both terms, considering them non-exclusive concepts emphasising different aspects of our societies since the 1950s.

Plastics were essential in shaping the definition of the Anthropocene. Along with other anthropogenic impacts such as - in order of importance - radionuclides, carbon isotopes, and industrial fly ash, plastics are considered markers of the Anthropocene, an epoch starting in the mid-twentieth century (Zalasiewicz et al., 2017). The integration of plastics, and other proxies of anthropic impacts, in the stratigraphical and sedimentary record was noted in several studies (e.g. Thompson et al., 2009; Corcoran, Moore, and Jazvac, 2014; Rangel-Buitrago, Neal, and Williams, 2022; Simon-Sánchez et al., 2022), and recognised as a global or near-global phenomena (Zalasiewicz et al., 2017). Many debates followed the term being coined by Crutzen and Stoermer (2000) to determine if the geological and stratigraphic signal was different enough to establish the Anthropocene as a different epoch or unit of geological time following the Holocene (Zalasiewicz et al., 2017). While its acceptance as a geological epoch raised questions and provoked debates, the term was adopted widely and quickly by different disciplines, including - but not limited to - archaeology (e.g. Erlandson and Braje, 2013; Graves-Brown, 2014; Harris, 2014; Pétursdóttir, 2017; Mytum and Meek, 2020). The start date of the Anthropocene as an epoch, and hence the transition from the Holocene, was also a topic of debate with scholars associating its beginning with a) the start of the Holocene to consider how domestication shaped human-environment interactions (e.g. Smith and Zeder, 2013 make the Holocene and Anthropocene coeval), b) the industrial revolution in the western world around A.D. 1800 (Crutzen and Stoermer, 2000; Steffen et al., 2011) or synchronous markers such as c) the Orbis spike, a dip in CO_2, in 1610 resulting from the decrease of farming after the colonisation of the Americas, or d) the ^{14}C peak in 1964 (Lewis and Maslin, 2015) (see Zalasiewicz et al., 2017 for a discussion on the debates regarding the starting date of the Anthropocene). The identification of changes in several markers mid-twentieth century was associated with the Great Acceleration, an unprecedented increase in production and consumption of post-war societies (Steffen et al., 2011; 2015). In that perspective, 1950 marked the start of the Great Acceleration and was identified by the Anthropocene Working Group (AWG) as marking the start of the Anthropocene (Zalasiewicz et al., 2017). While members of the AWG recognise that plastics have entered the record, they are only perceived as one marker of the Anthropocene, the plutonium fallout being the best primary marker for the epoch (Zalasiewicz et al., 2017). While using the Anthropocene contextualises plastics as one of several anthropic impacts, the use of the Plastic Age may be more adapted to scholars interested in material culture, recognising how this “magical” material (see Graves-Brown, in press) has shaped our societies, economies, and relationships with waste.

The Plastic Age, first mentioned in an American novel of the 1920s, has become a term adopted by different scholars (e.g. Thompson et al., 2009; Porta, 2021; Kramm and Völker, 2023), to mirror the periodisation of prehistoric periods such as the Stone Age, the Bronze Age, and the Iron Age. Similarly to the Anthropocene, debates have arisen regarding the starting point of the Plastic Age. The invention of synthetic plastics in the early twentieth century, and their increasing importance, served to suggest a starting date for the Plastic Age after the First World War (e.g. Sklar, 1970). Yet, the consumption of plastics increased drastically after the Second World War to meet the demands of post-war societies rushing into mass consumerism (Meikle, 1992; Strasser, 2000). This period also coincides with the diversification of plastics’ chemical signatures (Geyer, 2020), hence making 1950 a most commonly accepted starting date for the Plastic Age. A few variants were also proposed including the Plasticene (Ross 2018; Haram et al., 2020) starting in 1907 with an intensification since 1950 (Rangel-Buitrago, Neal, and Williams, 2022) and the Plastics Age (Sparke, 1993 in Hawkins, 2018). Following the use of the singular for other periods, we here refer to the Plastic Age (as in Godin et al., in press). The Plastic Age emphasises the key role of plastics as material culture shaping practices of our contemporary societies, mirroring archaeological periods centred on the material properties and technology of artefacts (Graves-Brown, 2014). While plastic is not the unique marker of the Anthropocene, it is the most visible and pervasive which explains its use for periodisation. Aside from being a material culture most of us interact with daily, plastics are becoming historical, entering museum collections and forming (toxic) heritage. Plastics can then be considered artefacts of the Anthropocene or the Plastic Age, but it is not the only way they can be envisioned archaeologically.

Plastic artefacts enter the archaeological record and can even become part of the geology, acting as a signature of the Anthropocene. This is where geology meets history, considering the tension between global and local (Palacio Castañeda et al., 2019). In 2014, Corcoran, Moore, and Jazvac were the first to identify a hybrid artefact (in the sense given by Liebmann 2015) in Hawaii which they called plastiglomerate. Since then, different ways in which plastic can be the locus of nature/culture hybridisation have been identified. In Colombia, Rangel-Buitrago, Neal and Williams (2022) have identified altered plastic types (pyroplastics and plasticrusts), soil types (plasticlasts and anthrosols), rock types (plastiglomerates and quartz plastisandstones) and artefacts (fossils) all including plastics. The “Plastic Geological Cycle” is a term proposed by Rangel-Buitrago, Neal and Williams (2022) to explain the processes and pathways by which plastics, especially micro- and nano-particles, are incorporated into the Earth's geosphere and potentially impact the natural rock cycle. The existence of anthrosols (i.e. a mix of litter with organic and/or mineral matter) and plastisols (i.e. plastic mixed with organic and/or mineral matter) (Rangel-Buitrago, Neal and Williams, 2022) highlight how plastics can enter the archaeological record and indicate another layer of occupation.

When considered as artefacts, questions arise regarding an archaeological study of plastics and plastic pollution. Different ways of undertaking plastic classification, typology, and analysis will be considered in this thesis (see the aims of the research for more detail). Considering plastics as artefacts of the Anthropocene and the Plastic Age also questions their traceability and understanding of what behaviours and actions led to their arrival in the archaeological, or geological, record. Itineraries of plastic objects can be particularly helpful to understand plastics as artefacts and the global flows characterising plastic pollution. In that perspective, the framework of object itineraries is explored and adopted to understand plastic litter from different contexts and through a diversity of case studies.

Plastic itineraries: a window into plastic pollution

By being the "trace of a movement" (Barthes, 1957: 159), plastic highlights the global mechanics at the core of its production, use, and discard. Re-constructing its temporal and spatial journey is a complex task, one that requires specific frameworks. In this thesis, the framework of object itineraries is preferred over that of chaîne opératoire, life history, or object biography (see Chapters 3 to 6 for case studies exploring this approach). After a brief overview of the concept's development, this section will briefly present how object itineraries allow us to move beyond temporal, human, and spatial scales necessary to understand plastics' journeys and networks.

Object itineraries

The interest in artefacts, and their complex histories, led to the development of the chaîne opératoire, a concept developed thanks to the theories of the anthropologist Mauss (1936 discussing techniques of the body that are culturally influenced) and framed by the prehistorian Leroi-Gourhan (1964) to account for the sequence of actions necessary for an artefact's production (see Lewis and Arntz, 2020 for a review of the term's genesis, present uses and potential developments). This concept offered a very systematic way of re-constructing the different steps included in the making of an object. It offered possibilities to inform on the technology of societies (Martinón-Torres, 2002), and was first predominantly used by French academics for lithics studies (Sellet, 1993). The chaîne opératoire mostly focused on the objects by reconstructing production steps, starting with the procurement of raw material and ending with the discard of the artefact (Sellet, 1993). The framework and its focus on technology were deemed too rigid to understand other aspects of artefact production (Bar-Yosef and Van Peer, 2009), which were central to the development of alternatives inferring behaviours from the material record. For example, Schiffer (1975) developed the behavioural chain analysis, considered in some ways very similar to the chaîne opératoire (Sellet, 1993; Martinón-Torres, 2002; Lewis and Arntz, 2020), aiming at reconstructing a sequence of activities and testing how these correspond to the archaeological record. In his development of behavioural archaeology, Schiffer (2002; 2010) was interested in the relationships between people and objects. The behavioural approach considered cultural and non-cultural processes, including taphonomic factors, to reconstruct materials' life histories and understand the record the archaeologists are faced with (Schiffer, 1975). Both the chaîne opératoire and the behavioural chain analysis have since informed studies using the chaîne opératoire to reconstruct with more precision the steps of artefact production, use and discard for a wide range of materials (see Driscoll, 2009 for a study of quartz in Prehistoric Ireland; Drieu, Lepère, and Regert, 2020 for a study of ceramic post-firing practices). Since then, the concept has evolved to be more inclusive of social practices and its reconstruction has built upon multidisciplinary works, facilitated by the rise in material science studies (Lewis and Arntz, 2020). While the social and cultural aspects of material culture are therefore considered in more recent applications of the chaîne opératoire (Lewis and Arntz, 2020), it was their absence that led archaeologists, particularly post-processualists, to look for approaches focusing on the social life of objects such as object biography and life histories.

The consideration for the sociality of material culture naturally led archaeologists to focus on how the social nature of objects was expressed through interactions with humans, and how their lives paralleled our own. Two concepts were developed building on an analogy with human life: object biographies and life histories. First coined by the anthropologist Kopytoff (1986), object biographies were seen as a way to ask the same questions about objects (or as he called them *things*) and people including their origin, cultural meaning, and changes throughout their lives. A *thing* could have multiple biographies whether social, economic, or technical but all would be culturally constituted (Kopytoff, 1986). The potential of the framework was then explored for archaeological artefacts in Gosden and Marshall's (1999) iconic publication. The authors considered object biographies as an accumulation of histories and relationships with people crystallising in the present significance of the objects. Biographies facilitated the consideration of shifting and changing meanings and perceptions during the life of an artefact (Hahn and Weiss, 2013). Life histories, already considered as a part of behavioural archaeology (Schiffer, 1975), aimed at understanding and reconstructing the trajectory that artefacts had taken, adopting a social (e.g. Holtorf, 1998; Crown, 2007) or material science perspective (e.g. Sáenz-Samper and Martinón-Torres, 2017; Plaza Calonge, Figueroa Larre, and Martinón-Torres, 2022). While the focus on morphological and/or functional changes had been central to use-life approaches developed by processualists (Tringham, 1995), life histories also considered the social interactions in which objects and monuments were and still are entangled (e.g. Holtorf, 1998), and the meaning they hold (Gosden and Marshall, 1999). The concept allowed for an object's life to be told independently from its maker(s) or owner(s), a vision particularly helpful when multiple hands contribute to the existence of clay pots (Crown, 2007) and to consider the role of past monuments for subsequent societies (Holtorf, 1998).

Limitations of both concepts were quickly identified, and scholars attempted to clarify both frameworks to make them more nuanced. Despite the success of object biographies for almost 25 years in archaeology (e.g. Mytum, 2003/2004.; Pearson and Connah, 2013; Jones, Díaz-Guardamino, and Crellin, 2016; Guzzo Falci et al., 2020), concerns regarding its limitations were also raised. For example, limitations of object biographies include the ontology (dualism subject/object), the linearity of the reconstructed biography, and the start and end point of an object's life (see Hahn and Weiss, 2013; Bauer, 2019). The risks posed by the linear nature of object biographies was already identified by Joy (2009) who advocated for a relational biography focusing on the set of relationships an object was entangled in. Scholars using life histories identified similar issues, particularly the determination of start (birth) and end (death) points (see Holtorf, 1998 for the death of megaliths). To acknowledge this, Holtorf (2002) distinguished between short and long life histories, the former including an object's life until it is buried whereas the latter extends to include interactions that led the object to reach the present time. The development of the long life histories framework enabled Holtorf (2002) to situate material culture in the present while recognising its extension into the past and the future, and evaluate the evolution of its meaning through time. Despite those attempts, the development of a new framework, object itineraries, allowed us to move away from the problematic analogy with human life at the core of object biographies and life histories.

The concept of object itineraries was first proposed by Hahn and Weiss (2013) mostly to account for the mobility of objects. In their book *Mobility, Meaning and Transformation of Things*, the editors encourage the use of itineraries to "highlight the non-linear character of an object's mobility and the subsequent changes in its contexts and roles" (Hahn and Weiss, 2013: 8). In addition to de-focusing on the individuality of objects necessarily depending on the values given by human actors, itineraries can also account for the periods of stasis that objects undergo (Hahn and Weiss, 2013). Central to the volume edited by Joyce and Gillespie (2015a), the potential of object itineraries as an alternative to object biographies was explored for archaeological artefacts. Itineraries are defined as *"*routes by which things circulate in and out of places where they come to rest or are active*"* (Joyce, 2015: 29), fully considering the modalities of circulation of the objects (Joyce and Gillespie, 2015a). Going beyond the tension between relational and narrative biographies, itineraries connect objects to their representations (Joyce and Gillespie, 2015b) and the engagement they have with researchers and with the public (Joyce, 2015). Since then, the concept has gained interest in archaeology (e.g. Joyce, 2017 for itineraries of Ulua pottery in Honduras) including examples from museum studies (McGill and St. Germain, 2021 for a discussion on controversial artefacts belonging to museum collections) and heritage (Bauer, 2021 for a discussion on itineraries of contested heritage), creative writing (e.g. Nisbet, 2021 exploring the link between objects and memory) and even marketing studies (e.g. Santana and Botelho, 2019 evaluating the relationship between sacred objects and consumers during a pilgrimage in Brazil). The framework has been seen as having several advantages (see Bauer, 2019 for an evaluation of its potential), for example mapping out how the stops and journeys of an object can be interconnected (Nisbet, 2021) and working on different scales, from human life span to geology (Joyce, 2015). Object itineraries also allow us to consider the ethical and political implications of material culture (Bauer, 2019). In that perspective, the potential of object itineraries is key to moving beyond the limitations that life histories and biographies could not overcome. Itineraries offer space to consider a network of processes and relationships that go beyond the temporal, human, and geographical scales usually considered. For plastics, this is particularly important because of their plasticity, ubiquity, "globalised unlocality", untraceability, (im)mutability, and persistence evidenced by several scholars (Dey, 2021; Davis, 2022: 5). This framework suits plastics particularly well, breaking away from the technical focus of chaîne opératoire, the linearity of biographies and the analogy with human life.

While plastic encapsulates deadly processes from its extractive production to the deathly entanglements occasioned by its disposal, several scholars have used the term "life" to understand both the manufacture, use, and disposal of plastic objects and their role through a social lens. Reconstructing the “life cycle” of plastics was proposed to understand the different steps and processes contributing to plastic pollution, including extraction and conversion, transport, production, distribution, use, and disposal (Rangel-Buitrago, Neal, and Williams, 2022; Williams and Rangel-Buitrago, 2022). More systematic studies of products are undertaken under the concept of Life Cycle Assessment (LCA), mapping the environmental impacts throughout the life of an object. While LCA approaches are particularly popular for plastic products (e.g. Humbert et al., 2009; Walker and Rothman, 2020), they focus less on the social aspect of plastic interactions, a key topic of this thesis. The social life of plastics was notably recognised by scholars in anthropology and sociology. In that perspective, the concept of “social life” (key to the development of object biographies and life histories, see above) was used by Dey (2021) to map the social possibilities plastics created and the social inequalities they re-enacted. While biographies emphasise the analogy with human lives, the focus of the life cycle remains on the lack of cyclical nature of plastic objects and on the sociality in which they are embedded throughout their life as products and then waste. Social life and the life cycle of plastics are complementary tools to the use of object itineraries to analyse plastic. For this thesis, object itineraries will be preferred and used to reconstruct an object’s journey based on the evidence found in (marine) plastic litter. With plastics considered artefacts representative both of the Anthropocene and the Plastic Age, the concept is particularly suited to the unusual temporal, geographical, and (non)human scales that plastic objects cross (see Edgeworth, 2013; Pétursdóttir, 2017 for a discussion on the scale in contemporary archaeology).

Beyond the temporal scale

No material encompasses better the constant alternance between short-term and long-term processes than plastics. The lengthy process that has contributed to the formation of petroleum contrasts with the ephemerality of plastic’s use, particularly for single-use plastic packaging. The relatively quick production also counters the varying timelines of plastic degradation, depending both on the material composition and on the conditions it is exposed to. Plastics alternate between those short processes, mostly associated with their use, and the long-term process of its management and persistence as waste likely to enter our environment. In addition to their short-use and long-lasting legacy, plastic objects are made from past matter (for fossil fuel plastics), anchored in the present while shaping the future of our surrounding environment and health.

Plastics embody both the obsession for the present over all times and the acceleration through its ephemerality, obsolescence, and globalised mobility (see González-Ruibal 2018 for an understanding of the relationship with time in supermodern societies). While this may seem at odds with the focus of our supermodern era on presentism, and associated materiality being present-oriented (González-Ruibal 2018), plastics' production and persistence respectively question the relationship of the material with the past and the future. As Davis (2022: 33) indicates: "Plastic fits within a blind drive toward the future, where the present is consistently being discarded and the past has ceased to exist". This tension between past, present, and future is characteristic of plastics, a material that confronts "the idea of duration" (Bensaude Vincent, 2013: 11). Plastics destroy the past, facilitate our present, and will constitute our future: "While the manufacture of plastics destroys the archives of life on the earth, its waste will constitute the archives of the twentieth century and beyond" (Bensaude Vincent, 2013: 11). Those long-lasting archives of anthropic impacts on the environment are the result of a sustained fossil fuel extraction, the ephemerality of plastic use and the uncertainties about its future degradation.

The framework of object itineraries allows us to overcome those temporal tensions between past, present, and future. By considering the "objects' present entanglement as central to their story" (Bauer, 2019: 336), the framework blurs the line between past and present, recognising that material culture is not only a window into the past separated from the present (Bauer, 2019). This also echoes New Materialisms' perspectives that contribute to thinking archaeology "without the Past" and establishing it as the discipline of things (Witmore, 2014: 204). Those temporal scales of plastic production, use, and discard also go beyond the human scale at the core of object biographies and life history approaches. In that perspective, object itineraries need and allow us to think beyond the human, which is particularly relevant for plastic objects in constant interaction with a network of humans and non-humans.

Beyond the human scale

The use of object itineraries in this thesis reflects the impossibility of creating object biographies for plastic artefacts. The analogy with human life is difficult to sustain for plastic objects constantly in tension with the temporal and geographical scales. This is even more difficult as plastics question the nature/culture divide through their interactions with non-humans (see Chapter 6 for examples of human/non-human interactions).

The creation of plastics was quickly identified as stepping outside the realm of nature. The chemical processes at the core of synthetic plastic creation set plastics aside from other materials that eventually go back to the natural carbon cycle, and that are most commonly studied by archaeologists. These anti-natural, almost magical, properties of plastics were quickly grasped and explored by artists, as they offered limitless possibilities (Bryning, in press). Despite their distinct composition, plastics are not separate from the natural world, entering the geological record (as plasticrusts, plastiglomerates, anthrosols among others see Rangel-Buitrago, Neal, and Williams, 2022), non-human and human organisms (Rochman et al., 2013; Thiel et al., 2018; Ragusa et al., 2021; Leslie et al., 2022), and our environment even in the most remote of places (Lavers and Bond, 2017; Napper et al., 2020). Plastic/environment interactions illustrate the blurry lines drawn between natural and cultural actors in plastic/environment interactions. This makes the dualistic opposition nature/culture that had characterised much of western science establishment and development irrelevant to the understanding of plastic in our modern societies. Posthumanism literature has questioned this opposition, which is particularly artificial for archaeologists who are crossing the nature/culture fine divide all the time, notably through excavation trying to distinguish between natural and cultural features (Edgeworth, 2014). The archaeological nature of this thesis, and the focus on plastics, therefore, call for a consideration of natureculture as a continuous set of relationships.

Along with considering natureculture as a continuum, the broadening of material culture studies to different ontologies has allowed the development of several frameworks considering non-human actors. This consideration for non-humans is relatively recent in archaeology. Building on the development of actor-network theory (Latour, 2005; Yaneva, 2013), several scholars proposed a symmetrical archaeology (e.g. Olsen, 2003; Witmore, 2007), which inspired consideration of humans and non-humans as part of a network of relationships where they can both interact with material culture (Bauer, 2019: 340). Adopting this approach is particularly relevant for the study of plastics through archaeology, as plastics' materiality represents the application of industrialised processes to organic matter that has accumulated for millions of years. Their manufacture breaks away from the carbon cycle, but their disposal is often associated with a return to "natural" environments, for example melting and/or fragmenting into the earth's geology. While the posthuman and symmetrical approach to plastics as material culture is particularly helpful, the focus on a network of agents may lead to disregarding human's responsibility for their actions (Bauer, 2019). To avoid this shortfall, this thesis uses plastics as a way to think beyond the human scale while recognising how human practices and behaviours can contribute to plastic becoming waste, and often undertaking global journeys.

Beyond the local spatial scale

Plastics' journey through production, use and waste is a global one, marked by their importance as commodity goods either as raw material, products, or waste. In her study of flip flops, Knowles (2015) traces the journey of this iconic plastic shoe, spanning several countries, from Kuwait to China and finally to Ethiopia. Those global flows reflect the spatial excess of supermodern societies (González-Ruibal, 2018). Plastics act as a trace of this global movement (to paraphrase Barthes 1957: 159), facilitated by the expansion of capitalism leaving traces everywhere (González-Ruibal, 2018). This excessive and rapidly moving spatial scale of plastic objects contrasts with the scale at which archaeologists are used to working, particularly for prehistoric societies. Archaeologists *in* and *of* the Anthropocene need to learn how to work across those scales (Pétursdóttir, 2017). In that sense, considering the global spatial scale is a necessary task for the reconstruction of plastics' itineraries.

Itineraries of plastic objects go beyond the local scale, from where they may be produced, used, and discarded. Those movements do not necessarily follow a logical and linear way limiting the distance covered. Movements are subject to flows of matter and economic requests. In that perspective, the framework of object itineraries offers space to consider the mobilities of material culture in a non-linear way, recognising that itineraries are “open-ended and multidirectional” (Bauer, 2019: 343). Where a plastic object is manufactured may be the encounter of matter originating from different places including fossil fuel, chemical additives, and labels. Those components can also have their itinerary with (in)visible detachments from the main object (for example in the form of additives leaking into the marine environment). This approach particularly fits the liquid, solid, and fragmented flows of plastic production. The nodes (or stops) of plastic’s itinerary can be associated with different states and activities, for example, liquid/production, solid/use, and fragmented/waste. Reconstructing those nodes and flows shapes the itineraries, connecting the local with the global. Bridging the tension between global and local is explored in this thesis across several case studies, most of which focus on the Pacific region.

A regional focus on the Pacific

This dissertation is the result of a collaborative doctoral award between the University of York and the Galapagos Conservation Trust (GCT) as part of the Plastic Free Galapagos Programme (PFGP). Through this collaboration, several chapters focus on the archipelago of Galapagos and the broader Pacific region. Despite its remoteness, the Galapagos islands have always participated in and suffered from global dynamics, including the presence of pirates, whalers, and colonists, throughout its human history (see Stahl et al., 2020 for an overview). This interconnectedness is characteristic of islands that despite seeming remote and isolated are an integral part of global markets. Focusing on plastics in Galapagos therefore requires putting the issue in perspective with data from the East Pacific coast, as it is a common source of the islands’ MPL. The plastic pollution crisis in Galapagos cannot be considered in isolation from the regional context since sources of (marine) plastic pollution include: a) marine activities such as fishing and transport, in and around the Galapagos Marine Reserve (GMR); b) oceanic currents, notably Humboldt, carrying litter mostly originating from mainland South America; and c) plastic used and disposed of locally. Therefore, the work presented in this dissertation also considers the regional perspective (presented in Chapter 4) which was facilitated by the Pacific Plastics: Science to Solutions (PPSS) network.

The focus on Galapagos can be understood by a specific concern for the unique biodiversity and environment of this archipelago located in the Pacific, about 1000 km from coastal South America. This UNESCO World Heritage Site (WHS) embodies the complexity of plastic pollution as a global and ubiquitous issue. Being exposed to consequent plastic pollution reaching its shores, the islands are questioning the responsibility and financial liability of removing and processing plastic waste coming from external sources. It is also strategic to consider the issue at a local scale and envision solutions easy to implement to limit plastic waste from local land sources. For example, controlling the import of plastic products would be easier in the case of Galapagos due to its physical remoteness and the generally good control over imported goods. Besides, the archipelago plays a strategic role in the fight against plastic pollution, with several programmes hoping to transform Galapagos into a plastic-free environment.

Building on the existence of the PPSS network and the PFGP from GCT, this research addresses the gap of knowledge of local views, perceptions, and insights on the problem. Local views have not often been considered in the Galapagos archipelago, an “Eden" that has often been the scene of colonial approaches in the management of its biodiversity (e.g. goat eradication in Isabela as described by Hennessy, 2019). Plastic pollution is a direct threat to this biodiversity, a key aspect of tourism and the economy of the islands. While international interest has also characterised the study of plastic pollution in Galapagos, several approaches have relied on local Citizen Scientists to contribute to understanding the issue on the islands (e.g. Muñoz et al., 2023).

To complement this consideration of local knowledge and familiarity with the issue, the dissertation will focus on utilising an archaeological approach to plastic pollution particularly in the Pacific. The presence of three chapters that are not discussing examples of the Pacific can be understood by the necessity of a theoretical framework to develop an archaeology of plastic pollution (Chapter 2), the need to envision rivers as a pathway for plastics to reach the marine environment and an archive of invisible plastic pollution trapped in riverbed sediments (Chapter 3), and the potential of evaluating and informing policymaking by analysing social media reactions to new policies shaping human behaviour towards material culture, here plastics (Chapter 7).

Challenges of undertaking fieldwork abroad in the context of a PhD pre-date the Pandemic. Yet, it should be noted that the timeline of the PhD and the fieldwork in Galapagos were severely impacted by restrictions of the Pandemic (see Covid impact statement for a full understanding of the impact of the Pandemic on the scope and structure of the PhD). As the project was designed before the COVID-19 Pandemic, the impacts of lockdowns and restrictions on the scope of the work need to be acknowledged, with the first field trip taking place in Summer 2022, almost two years after the start of the PhD. This has impacted the organisation of activities in Galapagos, as well as the timeline of research permits presented by GCT to the Galapagos National Park Directorate (GNPD). With those limitations in mind, the structure of the PhD includes a theoretical framework and two case studies not located in the Pacific. Including those case studies is relevant due to the global nature of the issue of plastic pollution, and the need for archaeological research on plastic pollution to inform the Pacific case studies forming the core of the thesis.

Aims of the research

Building on the problem that plastic pollution poses and the potential for contemporary archaeologies to address the issue, the research presented in this thesis cover three aims: 1) to develop the theoretical framework for contemporary archaeologies of plastic pollution; 2) to explore methods inspired by archaeological thinking to study plastic pollution; and 3) to contribute to the understanding of plastic pollution in the Pacific, including Galapagos.

Aim 1 - To develop the theoretical framework for contemporary archaeologies of plastic pollution

Despite the interest of archaeologists in plastic since the 1970s (e.g. The Garbage Project; Rathje and Murphy, 2001), no theoretical framework offers an overview of archaeological approaches to plastic pollution. While plastics have been the topic of several studies by archaeologists (e.g. Mytum and Meek, 2020; Schofield et al., 2021a) or taking an archaeological approach (e.g. Ryan, 2020; Falk-Andersson et al., 2021), a review of the theoretical framework and the methods to undertake an archaeological study of plastic pollution was missing so far.

In that perspective, the second chapter regards plastic pollution as a climate emergency of the Anthropocene, an issue that should be both an object of study and an object of concern for archaeologists. The chapter summarises how archaeologists can approach and study plastic pollution, and what are the specificities of their contribution. This framework is necessary before exploring some archaeological approaches to the study of plastic pollution (Aim 2) and contributing to understanding plastic pollution at the regional scale (Aim 3).

Aim 2 - To explore methods inspired by archaeological thinking to study plastic pollution

After establishing the theoretical framework for an archaeology of plastic pollution (Chapter 2), the second aim of the thesis was to offer several case studies exploring archaeological approaches to the issue of plastic pollution. The archaeological study of plastic is often seen as anecdotal, and the aim here was to present how archaeology could be used both as an analytical and engagement tool. Building on a set of different methods (outlined in the following section), the thesis aims at using one archaeological framework, in particular that of object itineraries, to understand the issue and reveal how it is perceived locally.

As detailed above, the framework of object itineraries allows us to overcome the issue of spatial, temporal, and human scale. The framework is not only used as an archaeological tool (Chapter 3) but explores how itineraries can act as a “narrative device to present temporalized stories” (Joyce, 2015: 23). Object itineraries offer both a method and a way to have a better representation of an object’s journey (Joyce, 2015: 23), here of plastics. The framework serves to inspire story-writing and becomes part of engaging activities on the topic of plastic pollution (Chapters 4 to 6). The potential of this approach is explored in case studies from Belgium (Chapter 3), the East Pacific Coast (Chapter 4), and Galapagos (Chapters 5 and 6). Object itineraries allow us to consider waste in a different light, moving away from a reconstruction of behaviours (praised by processual approaches) to reveal perceptions of the issue (for the theoretical framework of MPL perceptions, see Chapter 3).

With the issue of plastic pollution being global and complex, a wide range of case studies adopting an archaeological approach are presented to get an overview of the problem. With most marine plastic litter originating from land sources and carried by rivers (Lebreton et al., 2017), the first case study offers a view on plastic found in the river Sambre in Belgium. MPL washing up on beaches only represents a small percentage of the plastic pollution in the environment, with plastics accumulating in gyres and/or sinking before reaching the marine environment. Plastics recovered from sediments in the Sambre are considered here. Marine plastic litter then represents the focus of three chapters (Chapters 4, 5, 6) and serves as a basis for designing environmental education activities either online along the East Pacific coast (Chapter 4) or in-person in Galapagos (Chapters 5, 6). The story-writing activities were used as a window into perceptions of plastic pollution, as well as activities engaging on the topic of plastic pollution. The surveys monitored self-reported knowledge of the issue and pro-environmental behaviours (PEBs) before and after the activity. As plastic pollution is not limited to marine environments, a perspective of reactions to plastic policies and perceptions of plastic products during the COVID-19 Pandemic is also presented (Chapter 7). This exploratory social media analysis was based on the role that plastic artefacts play in our daily lives, particularly in times of crisis. It offers a conclusive vision of how archaeological approaches can be useful to policymaking, and how archaeology can be a situated practice.

The core of the thesis explores the use of archaeological frameworks, particularly that of object itineraries, to understand plastic pollution. While acknowledging the global nature of the issue, the majority of the thesis adopts a regional (Pacific), and local lens on Galapagos to explore those new methods.

Aim 3 - To contribute to the understanding of plastic pollution in the Pacific, notably Galapagos

Along with presenting the diversity of archaeological approaches to study plastic pollution (Aim 1 - Chapter 2) and offering case studies of its application (Aim 2 - Chapters 3-7), the objective of the thesis was to contribute to the understanding of plastic pollution at the regional level (Pacific), with a particular focus on Galapagos (through the CDA with the

Galapagos Conservation Trust). Several studies have contributed to a regional understanding of plastic pollution sources, impacts, and solutions (e.g. Hidalgo-Ruiz and Thiel, 2013; Thiel et al., 2018; Ortiz et al., 2020; De Veer et al., 2023). Despite the problem being increasingly understood, local perceptions of the issue were missing, particularly in Galapagos. Local perceptions of MPL are key to the design and implementation of solutions (see Chapter 4 for an explanation of the focus on perceptions). It also contributes to giving local voices a chance to express their concern and be represented in the literature, breaking away from colonial approaches to conservation in Galapagos. The story-writing activities were designed not as an educational tool, but as an engaging activity, one that aims at sharing knowledge about the issue, and taking an archaeological framework to study plastics as modern material culture and artefacts of the Anthropocene and Plastic Age.

By exploring archaeological methods to design environmental education activities (Aim 2), the data collected - including surveys and stories for Chapters 4 to 6 - offered a window into local perceptions of the issue, and a potential comparison between mainland South and Central America, and the archipelago of Galapagos. This comparison is essential as the Galapagos archipelago is entangled in global and regional dynamics, with most of its marine litter coming from mainland South America carried by oceanic currents and from marine activities. As sources of MPL differ drastically between the Galapagos islands and the East Pacific coast, the latter receiving MPL mostly from local land activities including tourism, it was important to compare if perceptions reflected this locally. In addition to the activity being evaluated as an efficient engagement tool, the content of the stories and surveys was analysed to identify recurrent themes and concerns on the topic of plastic pollution. Discrepancies between data from surveys and stories highlighted the potential of the narrative process and steered a reflection on expected answers.

Aims 1, 2, and 3 complement and respond to each other, calling for a set of distinct methods to be applied across the chapters. In addition to the chapters' respective detailed methods section, the following section will give an overview of the methods used.

Methods

This thesis is a journal-style dissertation composed of six papers framed by an introduction (Chapter 1) and a conclusion (Chapter 8) (see the section Structure for more details). The papers use qualitative and/or quantitative methods and explore archaeological approaches to plastic pollution including object itineraries. While each paper presents a methods statement, this section offers a brief overview of the frameworks used and the mixed methods adopted across all chapters. The exception to this is Chapter 2, which acts as a literature review setting the theoretical foundations to approach plastic pollution through contemporary archaeologies. This paper establishes plastic pollution as an object of study and concern for archaeologists and informs the methods used in the case studies presented in this thesis, from Chapters 3 to 7. The papers presenting case studies explore complementary qualitative and quantitative approaches, relying on a series of four different datasets. The nature of the journal-style thesis with case studies in Europe, the East Pacific Coast and Galapagos, and the exploration of methods required several datasets and data types analysed. For more clarity, a presentation of the datasets and data types analysed across the case studies (Chapters 3 to 7) are presented in the following section. The raw data is available for Chapters 3 to 6 on a Google drive (accessed through the links provided in Table 2). Yet, it is important to note that data limitations and publisher requirements may impact data accessibility in open access (Table 2). The different datasets, and how these were obtained, are presented in the following section before offering a perspective on the quantitative and qualitative methods adopted and the exploration of the archaeological framework of object itineraries throughout the thesis.

Table 2: Datasets used in the thesis

Datasets	**Data type**	**Chapter**	**Available at:**
Plastic world in the Sambre	Artefact typologies and categorisation	Chapter 3	Artefact distribution
East Pacific dataset	Surveys Stories	Chapter 4	Survey results Stories
Galapagos dataset	Surveys Stories	Chapters 5 and 6	Survey results Stories
Plastic agenda	Tweets	Chapter 7	Due to privacy policies on Twitter at the time of analysis, the content of tweets cannot be shared. This would represent a breach of users' privacy.

Datasets

Plastics as artefacts constitute the golden thread of the thesis, from shaping the theoretical approach (Chapter 2) to their analysis (Chapter 3), and use as a basis for activities and as a window to approach perceptions (Chapters 4 to 7). The second chapter is a literature review establishing the theoretical basis for the development of the case studies composing the thesis and therefore does not present original data. The third chapter focuses on plastic artefacts collected and recorded during the 2017 underwater excavation of the river La Sambre, undertaken by C. Delaere, co-author of the chapter. Artefacts were analysed in Belgium, and a selection was used to reflect on the concept of object itineraries. The potential of plastics as artefacts are explored theoretically (Chapter 2) and archaeologically (Chapter 3), and then as a focusing point for data collection through story-writing activities (Chapters 4 to 6) and social media analysis (Chapter 7).

Building on the potential of educational activities using artefacts and/or narrative writing (Aerila, Rönkkö and Grönman, 2016; Foster, 2017), plastics were presented as archaeological artefacts to design story-writing activities. While many educational activities discuss and integrate facts about plastic pollution, the focus on evidence of events in the "life" of marine plastic litter *as* artefacts was first trialed by Schofield et al. (2020). The story-writing activities developed in this thesis was inspired by the method applied by Schofield et al. (2020) asking several adult groups to reconstruct narratives of plastic objects recovered from the Galapagos shores. In 2018, Schofield et al. (2020) designed the activity following the World Café model and used a set of guiding questions to help reconstruct the journeys that the plastic objects had undertaken before reaching the shores of the Galapagos islands. The method used by Schofield et al. (2020) proved that the approach was engaging and successful and this thesis contributes to this work, by providing a more systematic analysis of the content of stories telling the objects' itineraries, and an evaluation of the impact that the activity had on the participants. The choice of children as a good audience for story-writing and environmental activities is detailed in Chapter 4. Two versions of the activity were designed: 1) online activities with a network of Citizen Scientists along the East Pacific coast, and 2) in-person workshops as archaeological interventions in the Galapagos archipelago.

The first story-writing activity was designed by a multidisciplinary team, including all co-authors from Chapter 4. Participants were selected from a network of Citizen Scientists from Latin American Countries along the East Pacific Coast (facilitated by the Red de Científicos de la Basura - ReCiBa - literally translated as Litter Scientists Network). Choosing among domestic marine plastic litter items collected on the Pacific coast during a previous activity, participants were invited to write a story and answer a pre- and post-survey. Due to the limitations of the COVID-19 lockdowns, the activity took place online with survey answers and stories uploaded via an application. The story content and the survey scores were used to monitor perceptions of marine plastic litter, self-reported knowledge, and pro-environmental behaviours, and how these changed after the activity.

Based on the results of the first story-writing activity undertaken online in 2020, an in-person story-writing activity was designed by Estelle Praet and Anne Guézou. The activity took place in Galapagos in the Summer of 2022, contributing to the gap in knowledge regarding local perceptions of plastic pollution in Galapagos. The aim was to compare a regional study (Chapter 4) with a local focus on Galapagos (Chapters 5 and 6). The selection of marine plastic litter items was different from items from Chapter 4, reflecting the difference in litter composition in Galapagos. In light of the importance of fisheries for local livelihoods and the considerable contribution of marine activities to plastic pollution, the selection of 11 objects collected also included fishing-related items. Stories and surveys obtained from the two sets of activities were analysed through qualitative and quantitative analysis, using the framework of object itineraries during the design, organisation of the activities, and interpretation of the data.

Qualitative analysis

In this study, qualitative analysis in the form of thematic coding of stories was used to help understand perceptions of plastic pollution. Views obtained from codes present in the stories were contrasted with quantitative data. Quantitative analysis was used to monitor changes in survey answers on a Likert scale before and after the activity, and to evaluate agreement with different statements regarding plastic pollution sources, impacts and solutions. Qualitative analysis was undertaken for plastic artefacts from archaeological contexts (Chapter 3), stories based on MPL (Chapters 4 to 6), and tweets (Chapter 7) about plastic objects banned or used during the COVID-19 Pandemic. The respective approaches are fully detailed in the chapters.

In Chapter 3, the presence of plastic artefacts in the three test pits from the Sambre project was explored qualitatively. Building on the importance of labels and information on the plastic objects themselves to determine their age and origin (e.g. Falk-Andersson et al., 2021; Ryan et al., 2021), the information was used to explore itineraries while recognising the multitude of potential pathways into the riverine environment. In Chapter 3, a visual analysis of the artefacts allowed for the partial reconstruction of their itineraries, accounting for their chronology, importance locally, and potential geographical origin (see Chapter 2 for a discussion on the potential of visual analysis and for reflections on the use of complementary techniques from archaeological science).

While artefacts themselves can be scrutinised for qualitative information, plastic products and waste served as a basis to obtain the data, either stories or tweets, analysed qualitatively. Stories written by the participants in the online activity (Chapter 4) and the in-person workshops (Chapters 5 and 6) were analysed thematically. Thematic coding is the preferred method for the analysis of narratives (Savin-Baden and Howell-Major, 2013). The first study, Chapter 4, adopted an inductive and deductive thematic analysis, first establishing codes from the data itself (inductive) followed by a group discussion about themes that could be relevant to the study (deductive) (see Appendix 3 of Chapter 4 for a description of the coding strategy). Several meetings were held to discuss and agree on the codebook, before undertaking the inter-coder reliability (ICR) calculations for Chapter 4 (see Appendices 5 and 6 of Chapter 4 for a detailed review of all disagreements between coders). The results of the ICR analysis included a measure of agreement and a Kappa Coefficient that were robust. After an evaluation of the disagreements, the method of the Kappa Coefficient proved to overestimate the disagreements, reinforcing debates about the usefulness of ICR calculations (O'Connor and Joffe, 2020). Once the codebook had included the modifications suggested after the ICR evaluation, its applicability was proven and therefore an ICR analysis was not deemed necessary for the comparative study in Galapagos.

Stories written by participants in Galapagos were the object of two different coding strategies. To ensure a rigorous comparison with the Pacific case study, the same codebook was applied to the data for the deductive coding strategy. The author retained some flexibility and adapted some codes, mostly descriptive codes such as object categories and wildlife (see Appendix 3 of Chapter 5 for full detail on the coding strategy). The second coding strategy consisted of inductive coding to explore the concept of object itineraries in Chapter 6 (see Appendix 1 of Chapter 6 for a detailed overview of the codebook). Independently of the coding strategy adopted, all chapters reported the occurrence of codes, and their importance was discussed quantitatively, based on the absence/presence of a code per file instead of the number of times these codes were counted (references), with several references of one code within the same file.

Social media content can also be screened qualitatively to evaluate reactions and perceptions of some issues. Mirroring the importance social media have reached in people's daily lives, there has been a growing interest in social media research including in heritage and archaeology (e.g. Bonacchi, Altaweel, and Krzyzanska, 2018; Schofield et al., 2021b). While we recognise the limits that social media analysis poses (see Chapter 7 for a full discussion), the content posted also offers a unique view on direct reactions to socio-political changes. Social media data can be gigantic, and often analysing big data is perceived as undertaking quality research. But big data poses several issues including a tendency to focus on the quantity of the data instead of quality, reflecting a "big dick data" trend (as explained thoroughly by D'Ignazio and Klein (2020) in their book *Data Feminism*, Chapter 6). Chapter 7 explored different methods of social media analysis as a window into perceptions of changing policies during the COVID-19 Pandemic. First, discourse analysis was undertaken by identifying the most recurrent words used by industry and government in the US. Thematic coding of tweets, manually screened (to avoid big data trends and ensure their relevance), identified recurrent themes in tweets for the Mexican and Australian case studies, evaluating the emotions and concerns associated with changes in plastic policies during the COVID-19 pandemic. Furthermore, sentiment analysis was also undertaken for the Australian case study comparing the emotions associated with keep-cups over time with the changing policies. It should be noted that the research presented in Chapter 7 was undertaken before Twitter became X, and it is clear that the same study would not have been considered with data from X, due to the unethical decisions that have shaped the platform development in the last months, even leading some universities to stop using the platform for their communication strategies.

Quantitative analysis

The use of quantitative methods is considered in this thesis as a complementary tool to understand and quantify the proportion of artefact types from archaeological contexts, the importance of themes in stories, the changes in PEBs, knowledge, and perceptions before/after the story-writing activity, and the changes in sentiment and perception in times of crisis.

As with any other artefacts, quantitative methods can be applied to the study of archaeological contexts. In that perspective, plastic artefacts recovered during the 2017 underwater excavation of La Sambre were recorded, counted, and classified into chronological and functional typologies (for a detailed review of the typologies, see Chapter 3). The use of typologies assigns, often qualitative, criteria to material culture and quantifies their occurrence per type. This approach applies traditional archaeological methods (typologies, distribution through time, and abundance) to plastic artefacts, and questions how methods could be refined for a better consideration of plastics as archaeological artefacts offering information on a site's occupation.

The interest in perceptions of plastic pollution sources, impacts, and solutions led us to use mixed methods to better understand how people make sense of plastic pollution and how they act towards it. The importance of codes was quantified and their occurrence across all stories was reported in the papers to evaluate the most common themes and pathways of MPL. The quantitative aspect of code recurrence is emphasised in Chapters 4 and 5, contrasting with the most qualitative analysis of stories content explored in Chapter 6. Recognising the mechanisms at the core of story-writing (see Chapter 4 for a discussion on this), the use of surveys acts as another line of evidence to approach perceptions. The surveys designed as part of Chapters 4 to 6 aimed at evaluating self-reported knowledge of plastic pollution, levels of agreement on statements regarding MPL sources, impacts, solutions, and presence, and their PEBs. Questions for Chapter 4 were agreed upon by the multidisciplinary group designing the activity, notably building on questions from previous surveys (e.g. Hartley, Thompson, and Pahl, 2015; Wyles et al., 2017) (see Chapter 4 for a detail of the methods). Pre- and post-survey questions were adapted to the local context in Galapagos by E. P. and A. G. (Chapters 5 and 6). In Chapters 5 and 6, the consideration of fishing-related items extended the questionnaire beyond domestic litter for reasons outlined previously. With Likert-scale answers considered as not following a normal distribution, the use of nonparametric statistical tests is usually preferred (Miller and Salkind, 2002; Harpe, 2015). In Chapters 4 to 6, Wilcoxon signed rank tests are applied to evaluate if the answers changed significantly after the students participated in the activity. Exploring perceptions of plastic products during the Pandemic, Chapter 7 also quantified the results obtained for thematic analysis of the Mexican and the US case studies. The distribution and importance of sentiments associated with tweets for the Australian case study were also quantified and their evolution through different key points of the COVID-19 Pandemic was analysed.

Quantitative and qualitative methods were used in a complementary way for all case studies presented in this thesis. In addition to common methodological approaches, the case studies all explore the framework of object itineraries.

Object itineraries as a framework

The framework of object itineraries, presented earlier, is particularly useful to understand plastics as material culture and artefacts of the Anthropocene and the Plastic Age. This framework is present across all chapters and is explored in different ways. Chapter 3 explores how visual analysis can contribute to obtaining information that can be of use to reconstruct the object itinerary and understand the site when archaeologists are confronted with plastics in their most recent strata. It is a direct application of the suggestion presented in the theoretical framework in Chapter 2. Chapters 4 to 6 used the concept as part of the story-writing activity. The online activity presented a series of questions, helping students re-constructing their chosen object's itinerary (Chapter 4). In Galapagos, the in-person story writing was facilitated by the author, an archaeologist, who emphasised the potential of observing a plastic object to reconstruct its journey (Chapters 5 and 6). The framework was facilitated by the presentation and the handling of objects by participants. Chapter 6 highlighted themes commonly discussed by students that confirmed the suitability of the framework to understand plastic as material culture and artefacts. While not making any explicit reference to the theoretical framework and not constituting a direct application of it, Chapter 7 evaluates changes in the usual itineraries of plastic items, and their reconfiguration in moments of crisis, such as the COVID-19 Pandemic. It questions how perceptions of plastics and behaviours changed when certain items are presented as unsafe and/or banned. All chapters contribute differently to understanding plastic pollution through an archaeological lens, and their succession and configuration as a whole thesis is detailed below.

Thesis structure

This thesis is divided into six main chapters that are also papers either under review, accepted, and/or published (Table 3 for an outline of the papers and their progress) and these are framed by an introduction (Chapter 1) and a conclusion (Chapter 8). Because of the nature of a journal-style thesis, the papers are presented successively as separate entities, each with their spelling, structure and bibliography formatted according to the publisher's requirements, and with their supplementary materials. In that perspective, the figures' numbers and the style of the bibliography are retained to respect the published version of the papers. The introduction and conclusion include their respective bibliography following the Harvard referencing style.

Table 3: Status of the papers included in the thesis

Chapter number	**Title**	**Author(s)**	**Journal**	**Research aims**	**Status**
2	Plastic pollution: Archaeological perspective on an Anthropocene climate emergency	Praet, E.	World Archaeology	1	Under review
3	An underwater archaeology of plastic in inland waterways	Praet, E. and C. Delaere	Routledge Handbook of Archaeology and Plastics	1 - 2	Accepted
4	Bottle with a message: the role of story writing as an engagement tool to explore children's perceptions of marine plastic litter	Praet, Estelle, J. Baeza-Álvarez, D. De Veer, G. Holtmann-Ahumada, J. S. Jones, S. Langford, J. Michel Dearte, J. Schofield, M. Thiel, and K. J. Wyles.	Marine Pollution Bulletin	2 - 3	Published
5	Story-writing workshops as archaeological interventions: local perceptions of Galapagos marine plastic litter	Praet, E. and A. Guézou	Cambridge Archaeological Journal	2 - 3	Under review
6	Waste Journeys: Using Object Itineraries to Investigate Marine Plastic in Galapagos	Praet, E., Guézou, A., Schofield, J. and R. M. Tamoria	Journal of Contemporary Archaeology	2 - 3	Published
7	'Windows of opportunity': exploring the relationship between social media and plastic policies during the COVID-19 Pandemic	Vince, J., Praet, E., Schofield, J. and K. Townsend	Policy Science	2	Published

Together with the introduction and conclusion, the six papers form a coherent work. The articulation of the thesis reflects the complexity of the global flows and itineraries that plastic artefacts take once they become waste. The lack of reflections on the use of archaeological methods to approach plastics as artefacts required the establishment of a strong theoretical foundation for its study. This framework is then explored in different case studies including examples from Belgium, the Pacific, and Galapagos. The way all chapters relate to each other regarding methods, datasets and research aims is detailed in Figure 1, and the focus of the chapters is presented next.

This introduction (Chapter 1) presented the development of synthetic plastics in the twentieth century and how mass production, consumption and waste mismanagement contributed to the issue of plastic pollution. After presenting the scale of the issue, its sources, impacts and potential solutions, the chapter explored the consideration of plastics through contemporary archaeologies. Building on the development of contemporary and previous archaeological approaches to plastic pollution, the framework of object itineraries was considered a window into plastic pollution.

The first paper (Chapter 2), titled *Plastic pollution: Archaeological perspective on an Anthropocene climate emergency,* aims to lay out the necessary foundations to approach plastic pollution from an archaeological perspective. This chapter presents the consideration of plastic pollution both as an object of study and an object of concern for archeologists. In that perspective, plastics are explored as artefacts, stratigraphy markers, and components of waste landscapes. It opens the possibility to different archaeological approaches to address and study plastic pollution, recognising the global nature of this issue characteristic and representative of the Anthropocene.

The second paper, *An Underwater Archaeology of Plastic in Inland Waterways*, attempts to address plastic pollution from its sources as inland waterways, notably rivers, are responsible for the arrival of much of the land-based waste into the marine environment. Using plastic artefacts from underwater archaeological contexts in La Sambre (Belgium), this chapter contextualises river sediments as archives of anthropic impacts through time. The chapter explores ways to analyse plastic objects found at different levels of the riverbed, notably questioning the typology and classification of plastics when considered as artefacts. This research also questions how plastics inscribe themselves as another layer of anthropogenic impacts and modifications on rivers. Finally, it offers suggestions if archaeologists want to consider plastics as artefacts to document the chronology and nature of a site's occupation.

The third paper presents research designed and undertaken in collaboration with ReCiBa. The research explores the use of an archaeological framework, particularly that of story-writing based on a plastic artefact, to engage students on the topic of marine plastic litter and address human behaviours contributing to plastic becoming waste. The activity with schoolchildren along the East Pacific Coast was designed during the COVID-19 Pandemic lockdowns of 2020 to offer an online activity for an audience particularly affected by the restrictions. In that perspective, the online story-writing activity was designed both as an engagement tool and a window into perceptions of MPL, as reflected in the title: *Bottle with a message: the role of story writing as an engagement tool to explore children's perceptions of marine plastic litter*.

The fourth paper, *Story-writing workshops as archaeological interventions: local perceptions of Galapagos marine plastic litter,* replicated the previous study, at the local level in Galapagos with story-writing workshops carried out in person, particularly important as access to the internet is unreliable in the archipelago. This activity was developed in collaboration with Anne Guézou from the Galapagos Conservation Trust and forms part of the PPSS programme. Despite a relatively good understanding of marine plastic litter sources, impacts, and potential solutions for the Galapagos islands, research into what people think and perceive locally was missing. Organising story-writing workshops appeared as an opportunity to consider local views and test the success of in-person workshops as archaeological interventions. With the potential of comparing the results with our research undertaken along the Pacific Coast focusing on domestic MPL, this study explores perceptions of MPL, along with self-reported knowledge and PEBs, through stories and surveys. Comparison of the results also yields insights about the specificities of Galapagos regarding the pathway that MPL undertakes to reach the island, and how the perception of impacts and solutions may differ, reflecting the socio-economic reality of the archipelago.

The fifth paper, *Waste Journeys: Using Object Itineraries to Investigate Marine Plastic in Galapagos*, used data from the story-writing activities in Galapagos to reflect on the framework of object itineraries. Through thematic coding of stories' content, the paper explores how object itineraries are used by students, sometimes recognising how plastics participate in shaping waste landscapes. The scale of plastic pollution makes it impossible to consider plastics only as isolated artefacts, and their accumulation transforms natural landscapes, particularly emblematic in the case of Galapagos, into waste landscapes. Finally, this paper examines the complexity of MPL itineraries and how these are grasped and perceived by students in Galapagos.

Building on the interest of archaeology for human behaviour and perceptions of material culture with a focus on plastics, the sixth paper represents an application of archaeological thought to approach reactions to policy changes. Taking a transdisciplinary approach (particularly important to address "wicked problems", see Bernstein 2015), the paper develops a method using social media as a way to gather information about people's relationship with plastic artefacts amid a global health crisis, the COVID-19 Pandemic. Using evidence from social media, the research explores people's reactions to changing policies that limit or modify their behavioural habits. The paper takes three case studies: a) the USA and industry pressure; b) Australia's non-decision making regarding consumer behaviour; and c) politics in Mexico regarding the plastics agenda, to assess how social media may have impacted and reflected those new policies. This last paper sets the basis for a reflection on the use of archaeological perspectives and frameworks to evaluate policy changes, and eventually inform policymaking.

The conclusion focuses on five themes that played a key role in the theoretical framework and the case studies presented in this thesis. The use of contemporary archaeologies is reviewed through the consideration of plastics as artefacts and the use of object itineraries. The global flows of plastic pollution are recognised, notably through the pathway that plastic waste follows, and are illustrated with the regional and local scale being the focus of this work. A reflection on plastic pollution on islands relying on tourism is provided emphasising the tensions between plastics as toxic heritage and the values of some islands as natural heritage sites. The contribution of archaeology to the study of plastic pollution is envisioned by exploring the opportunities for environmental education and policymaking already presented in the thesis. Finally, a reflection on my positionality and on the project legacy conclude the chapter.

In brief, the research at the core of this project aims to provide a theoretical framework defining an archaeology of plastics (Chapter 2) and case studies illustrating the application of archaeological methods to address plastic pollution in rivers (Chapter 3) and in the marine environment with a specific focus on the Pacific (Chapter 4), including Galapagos (Chapters 5 and 6). The diversity of methods used to explore the complexity of MPL global itineraries culminates with possibilities for archaeology to evaluate and inform policymaking through social media analysis (Chapter 7). In addition to identifying key themes, the conclusion wraps up the thesis by offering a reflection on my positionality and the project's legacy.

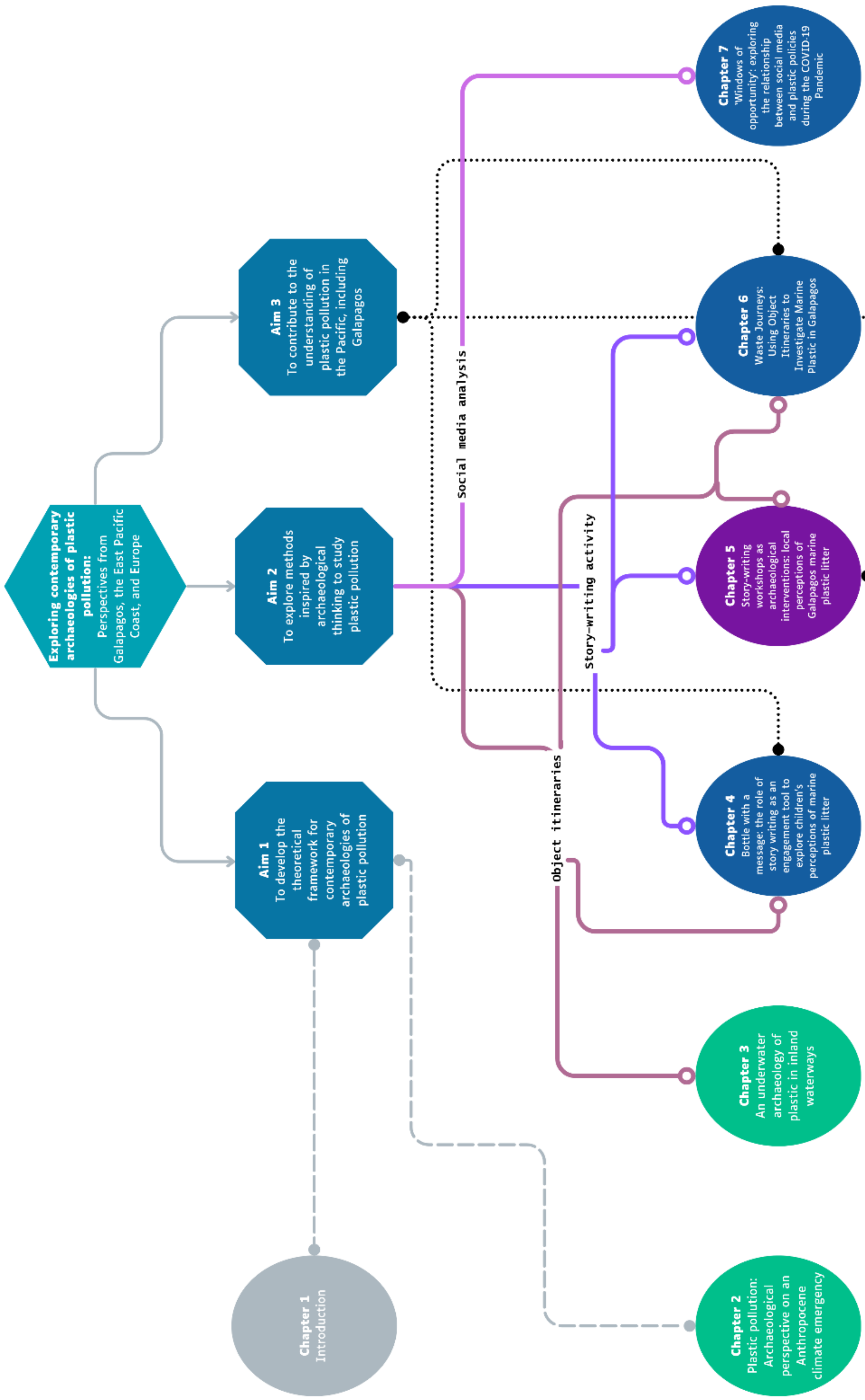

Figure 1: This diagram illustrates how the aims, methods, frameworks, and chapters are articulated throughout the thesis. The chapters are coloured in blue when published, in purple when they are submitted, and in green when they are accepted.

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Lexicon

The lexicon presents the preferred definition of several terms used in this thesis.

- Anthropocene = an epoch starting mid-twentieth century and marked by the scale and consequences of anthropic impacts, including (but not limited) plastics, on the stratigraphical and geographical record.
- Legacy plastics = "plastics that cannot be reused or recycled, including plastics that are already in the environment as existing pollution, or are stocked or will enter in the economy e.g. in short-lived or durable products designed without considering their circularity or long-term use in the economy" (United Nations Environment Programme, 2023: v)
- Debris = "The remains of anything broken down or destroyed; ruins, wreck" https://www.oed.com/dictionary/debris_n?tab=meaning_and_use#7298896
- Litter = **"**Odds and ends, fragments and leavings lying about, rubbish" https://www.oed.com/dictionary/litter_n?tab=meaning_and_use#38981074
- Waste = "Refuse matter; unserviceable material remaining over from any process of manufacture; the useless by-products of any industrial process; material or manufactured articles so damaged as to be useless or unsaleable." https://www.oed.com/dictionary/waste_n?tab=meaning_and_use#15000618
- Marine plastic litter = Adapting it from Napper, Pahl and Thompson (2021:25), marine plastic litter is plastic "waste that has been discharged into the marine environment resulting from activities on land or at sea".
- Plastic Age = period based on plastic as material culture, starting in the 1950s marked by the mass production and use of plastics.
- Plasticrusts = "plastic debris encursting the rocky surface" (Gestoso et al., 2019: 413)
- Plastiglomerates = "an indurated, multi-composite material made hard by agglutination of rock and molten plastic" (Corcoran, Moore and Jazvac, 2014: 5)

Chapter 2 - Plastic pollution: Archaeological perspective on an Anthropocene climate emergency

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Abstract

Plastic pollution is a global phenomenon offering a vivid illustration of the scale of anthropic impacts on the environment, a key characteristic in defining the Anthropocene. Plastic pollution not only contributes to the current climate crisis but is also accentuated by extreme events caused by climate change. The scale and omnipresence of the issue of plastic pollution makes it a relevant object of study for archaeologists, as well as an object of concern for heritage and archaeological sites marked by plastic pollution.

In this paper, I advocate for an archaeological consideration of plastic pollution, by exploring plastics as artefacts (through visual analysis and archaeological science), as chronological markers in the stratigraphy and eventually as components of waste landscapes. While the issue of plastic pollution can be studied archaeologically, I argue that it must be considered by archaeologists, especially as natural and cultural heritage sites are threatened by the presence of plastic pollution.

Keywords

Anthropocene, plastic pollution, archaeology of plastic, plastic, climate change

Introduction

Despite having traditionally focused on the past, archaeology is also now anchored in problems of the present and future, notably the climate crisis. The discipline is facing the consequences of climate change (e.g. Hollesen 2022). The climate crisis affects archaeological sites and contexts through erosion (e.g. Reimann et al. 2018), change in groundwater levels (e.g. Woodward and Cooke 2022, 75 for the case study of Chan Chan, Peru), floods (Daly et al. 2022 for the case study of Ayutthaya, Thailand), increased temperatures (Matthiesen et al. 2022 for potential impacts on wetland archaeology), ocean acidification (notably for underwater heritage see Gregory et al. 2022), and an increase in extreme weather events (Rivera-Collazo 2020). While archaeological contexts are increasingly exposed to climate events, archaeology can also act as a window into societies' resilience, by studying how past civilizations have coped with climate crises (e.g. Sandweiss and Maasch 2022). But the current climate crisis is different: it is driven by human actions that have been prevalent since the Industrial Revolution. And what is more anthropic than synthetic objects? Developed in the twentieth century, synthetic plastics illustrate an increasing interest in human experimentation with flexible and moldable materials. New habits of post-war societies rushing into consumerism stimulated plastic mass manufacturing since the 1950s (Strasser 2000) turning it into an indispensable material for most households and overwhelming substance spreading across natural environments.

While plastics are praised because they are clean, cheap, available, and disposable, they actively contribute to climate change (Ford et al. 2022). Their production, mostly from fossil fuels (around 90% as of 2021, Plastics Europe 2022), and (mis)management as waste contribute to the climate crisis by releasing Greenhouse Gases (GHG) (Ford et al. 2022; Lavers, Bond, and Rolsky 2022). The scale and omnipresence of plastic waste resulted in a global issue affecting most if not all, environments: plastic pollution. Despite those evident impacts, plastic (pollution) is not often considered as an aspect of climate emergency in discussions about heritage and climate change (except e.g. Pétursdóttir 2017). This paper approaches plastic pollution as a global issue of the Anthropocene and then describes how plastic pollution represents both an object of study for archaeologists and a threat to heritage sites. While this paper addresses the global scale of the issue and plastic's degradation, the main focus is on macroplastics (more than 1 cm, after Hartmann et al. 2019) that represent a visible and tangible aspect, both contributor and consequence, of the current climate crisis. I recognise the limitations of focusing on macroplastics only, as meso-, micro-, and nano-plastics enter the archaeological record and would benefit from more archaeological studies. Due to the scope of this paper and the scarce quantity of archaeological studies of microplastic pollution, this paper will determine how plastic pollution can be studied archaeologically, focusing on evidence from macroplastic artefacts.

Plastic pollution: a global issue of the Anthropocene

Plastic pollution is a global and visible challenge of the Anthropocene with severe impacts on the environment. Impacts encompass threats posed by the materiality of plastics, such as ingestion and entanglement (e.g. Gall and Thompson 2015), and others created by their chemical properties (Takada and Karapanagioti 2018), such as biological tissues absorbing chemicals from ingested plastics (Takada et al. 2021). The marine environment can be severely affected by plastic pollution, as plastics can be vectors for biotic colonisation (Carlton et al. 2017), transport non-native species (Rech et al. 2016), and modify natural environments such as coral reefs (Lamb et al. 2018). Additionally to ecological impacts (Rochman et al. 2016) and the risk for human health and wellbeing (Beaumont et al. 2019), marine plastic pollution can have socioeconomic impacts, notably on tourism (Krelling et al. 2017). In addition to marine environments, agricultural areas are also exposed to microplastics (Nizzetto et al. 2016) permeating through fertiliser, plastic films, atmospheric deposition, and wastewater irrigation (Zhu et al. 2019). While plastic's potential impacts on soil are documented in rural areas (Steinmetz et al. 2016), urban plastic pollution also constitutes an environmental and socio-economic issue, from tap water containing microplastics (Pratesi et al. 2021) to plastic litter polluting cities (Seco Pon and Becherucci 2012). When plastics eventually break down, they start permeating our homes (Jenner et al. 2022) and eventually our bodies (Leslie et al. 2022).

The scale and consequences of anthropic impacts on the environment (of which plastic pollution is representative) led Crutzen and Stoermer (2000) to propose the term

Anthropocene to differentiate this epoch from the Holocene (the last 11,000 years). At the time of writing, the Anthropocene has still not been accepted as an official geological epoch by the International Union of Geological Sciences (IUGS) despite the repeated events and discussions of the Anthropocene Working Group (AWG) exploring how the term could overcome the nature-culture divide shaping society (Rosol et al. 2023). To recognise the Anthropocene as an epoch, the geological signal needs to be evident and present in most parts of the world. In 2023, researchers proposed several potential sites presenting sections that could illustrate the presence of the Anthropocene chrono-stratigraphically (see the Special issue on Global boundary Stratotype Section and Point - GSSP- for the Anthropocene series edited by Waters et al. 2023). Far from being only a geological question, the concept caught the attention of archaeologists who debated the discipline's role in defining and studying the Anthropocene (see The forum *Archaeology of the Anthropocene* in 2014). The relevance of the concept for archaeology was defended on the basis that geologists use the archaeological record through stratigraphy to define this new period (Edgeworth 2014). The role of archaeology is also evident in the proposal of the anthropogenic urban sediments of Karlsplatz, Vienna, as a reference section for the Anthropocene (Wagreich et al. 2023). While archaeology plays a key role in defining and illustrating the Anthropocene, the term, and its consideration as an epoch, also has limitations.

While some consider archaeological and geological strata as complementary systems characterising the Anthropocene (Harris 2014), others see the problem the term poses both as a period only relevant for the western world and as an over-simplistic category erasing local differences (Graves-Brown 2014). I here consider the Anthropocene as a political term that considers the impacts humans are having on their environment evident in the scale of the climate crisis. While the term has been considered too deterministic (Clarke 2014), I advocate that the Anthropocene serves as a platform for all disciplines to emphasise the severity of climate change, facilitated by extractivism and mass production, while stressing the urgent changes needed. I also recognize that the term is western-centred but globalisation has led to an ultra-connected world where this speed and scale of production have consequences, although unequal, on all humans. While the term "human" takes away responsibility from the white western man at the core of the destruction (González-Ruibal 2018) characterising the ongoing climate crisis, the contribution of patriarchy, along with capitalism, was not fully recognised in debates on the Anthropocene. My use of "Anthropocene" here draws inspiration from eco-feminist scholars (e.g. d'Eaubonne 1974; Mies and Shiva 2014) to consider the submission mechanisms at the core of nature's destruction and women's oppression (see Burgart Goutal 2020).

The consideration of plastic production, use, and pollution through a gender lens (for a review see Lynn, Rech, and Samwel-Mantingh 2017) offers insights into how this material has shaped new dynamics (Hawkins, Potter, and Race 2015). While the invention of disposable alternatives (e.g. diapers, plastic bags) facilitated the domestic lives of western women from the mid-twentieth century and liberated time for them to focus on other things, it contributed to the unprecedented production of plastic waste representing a threat to human and environmental health. Women of the Global South are particularly exposed to the consequences of its presence and (mis)management as waste. Yet, they sometimes rely on their reuse for their economies, particularly for waste pickers (Wittmer 2021). This contributes to the reality of plastic waste reproducing colonial dynamics, particularly affecting marginalised groups, through waste export practices (Barnes 2019). From that perspective, an archaeological lens can prove useful by highlighting patterns of use of plastic artefacts and distribution of plastics in the landscape, and how these can be considered through a gender and intersectional lens. Gender dynamics influence plastic use and exposure to its impacts but also act as a determining factor linked to environmental responsibility (e.g. Hanson 2017) and higher levels of pro-environmental behaviours adopted by women consumers (e.g. Muralidharan and Sheehan 2018). Gender archaeology as a discipline (see Conkey and Spector 1984; Sørensen 2000) can therefore contribute to the study of plastics as modern and contemporary material culture and reveal the gender dynamics they were entangled in, for example during their use.

Plastics are central in the argument that human impacts on the environment are leaving long-lasting and undesirable traces representing a different epoch, one shaped by the climate crisis as a result of anthropic activities. They illustrate how synthetic materials became entangled with the natural environment in the shape of plastiglomerates (a multi-composite material made of plastic and rock first identified by Corcoran, Moore and Jazvac 2014) and plasticrusts (plastic waste entangled in the geology of intertidal shores, see Haram et al. 2020). In addition to their presence in geology and archaeology, plastics' ubiquity (Barthes 1957) theorised by Davis (2022, 5) under the concept of *globalised unlocality* (separation from a specific location) has contributed to their emblematic nature. Plastics as artefacts created in the West for the West rapidly reached all corners of the world. The disposable nature of this material culture facilitated western post-war domestic life but has far-reaching and long-lasting impacts on the environment once plastic waste enters global networks and dissociates from the local scale of its production and use. Plastic pollution is then a global issue, facilitated by the spread of mismanaged plastic waste, notably from rivers to the marine environment (Lebreton et al. 2017; Meijer et al. 2021). Plastic abundance and specific flexibility were used to define the Plastic Age (Thompson et al. 2009) or Plasticene (see Haram et al. 2020 for the development of the term) referring to a period starting in the 1950s and centred around plastics as material culture. This period is parallel to the Anthropocene as an epoch marked by a series of anthropic impacts and signals, including plastics, on the chrono-stratigraphic record. In that perspective, plastic makes both an artefact indicative of the Anthropocene (Davis 2022) and a techno-fossil representative of the Plastic Age due to the extractivist strategies at the core of their deadly production from trapped organic matter (Araújo 2019), their impact on the environment (Gall and Thompson 2015), and the western lifestyles associated with their disposability (Strasser 2000).

Archaeology of plastic pollution

Current understanding of plastic pollution benefits from contributions from several disciplines including (but not limited to) marine biology, oceanography, chemistry, and environmental psychology. Plastics are already shaping an archaeologist's work, for example through the use of hi-vis and Wellington boots to excavate during rainy days to plastic bags used for soil samples and storing artefacts. Plastic tarpaulin was also used to delimit areas already excavated when filling up excavation pits and trenches. Those uses of plastics in archaeological practices are also shaping the future of the discipline and the archaeological record, from the bags containing samples for decades to the degradation of tarpaulin if contexts are re-opened and excavated. Despite plastic permeating the living and working environment of archaeologists, the discipline has been slow in considering plastic pollution an object of study. In this paper, I advocate for the use of archaeology to study plastic pollution, from individual artefacts to components of stratigraphic layers and emblems of wider waste landscapes.

Plastics as artefacts

Despite archaeology's interest in human experimentation at the core of artefact design (e.g. Ingold 2000), archaeology has been relatively slow to consider plastics of interest for the discipline. Since the focus on contemporary waste including plastics during the Garbage Project in the 1970s (Rathje and Murphy 2001), only a handful of studies (e.g. Mytum and Meek 2020; Schofield et al. 2021) and projects (e.g. the Plastic Archaeology project developed by A. Agbe-Davies, E. Deetz, and R. Frohardt) are considering plastics as archaeological artefacts potentially yielding relevant information for contemporary societies. If the global presence of plastic is insufficient to prove the existence of an anthropocenic strata, plastics serve as artefacts informing a site's occupation. Plastics are mostly fossil fuel based materials (i.e. "matter considered in respect of its occurrence in processes of flow and transformation", Ingold 2012, 439) that can become artefacts (i.e. "objects thought to be made rather than grown", Ingold 2012, 439) at any point. While archaeologists can study plastics as *materials*, focusing on plastic production sites as contributors to climate change, they can also study them as *artefacts*, focusing on their omnipresence and degradation as waste constituting an additional aspect of the climate crisis. It may be challenging to identify "the limits of where a plastic artifact begins and ends" (McMullan 2019), just as identifying a plastic's birth and death when reconstructing its biography (see Praet et al. 2023 for an evaluation of object biographies and itineraries applied to plastics). The focus of this paper will be on studying macroplastics as artefacts, stratigraphy markers, and components of waste landscapes. While this limit is arbitrary and I recognise that microplastics entering our bodies could also be considered artefacts, macroplastics offer a tangible and visible illustration of the many aspects of the climate crisis.

Visual analysis

Despite the design of plastic objects as universal and untraceable (Davis 2022), using an archaeological framework yields information to reconstitute an object's journey. In that perspective, the use of production and expiry dates on labels, and object design of litter found in Svalbard allowed for an increased sourcing (by 19%) and dating (by 22%) (Falk-Andersson et al. 2021). This set of information is commonly used by archaeologists for relative dating: the production date can be understood as a terminus *post quem* with the object entering the environment after this date. While these elements were often considered anecdotal in environmental studies, bottle manufacturing marks were used to infer production date and country of origin, contributing to identifying plastic pollution sources (e.g. Ryan 2020). If dates of production and/or consumption are not visible on the plastic artefacts, assigning them a date becomes a challenge. The composition of artefacts may give an insight into their chronology, for example, Bakelite preceding PVC. But as plastics remain in the environment and their chemical composition becomes more complex through time and the use of additives, assemblages of plastics in stratigraphy may be complicated to locate chronologically as the plastic signal becomes more integrated into the stratigraphic layer. The design of plastic objects can also be a source of information on the object' chronology through the use of typologies and their chronological situation. Dating a plastic artefact through design, labels, and composition is not necessarily a straightforward task, particularly for fragmented plastics, a common finding in archaeological contexts and the broader environment.

Suppose a date cannot be assigned to the objects from visual analysis only. In that case, plastics may still hold information regarding the object's use and/or taphonomic processes the object has gone through. The potential to use sediments as natural archives to approach taphonomy for plastics remains largely unexplored (see Bancone et al. 2020 for a review of the gap of knowledge regarding taphonomic processes for microplastics). And this is maybe where archaeology can be most helpful. The discipline can provide historic samples and include taphonomic processes within artefact analysis (whether buried or exposed) to explore the factors that contributed to plastic degradation (e.g. yellowing, breaking, loss of colour, …). Despite their mass manufacturing, plastics remain cultural objects (Ingold 2000) as they are revealing of "western cultural values and assumptions, economies and epistemologies" (Davis 2022, 38). There are more cultural decisions in plastic production than meets the eye, and their design can change reflecting cultural decisions. Similarly to ceramic, some plastic objects can become diagnostic (e.g. plastic *papel picado*, originally made from paper) but others will appear across different cultures (e.g. a global PVC tube).

For example, the red bucket bottom in Figure 1 contains several elements of information. The HDPE stamp indicates the plastic category it belongs to, namely high-density polyethylenes. It has a partial inscription "…Ecuatorianos Guayaquil Ecuador", indicating its potential fabrication in Ecuador, and a clock with years indicating 98, potentially corresponding to the bucket production date. Found on Galapagos shores during a beach clean-up, the bucket fragment has smooth edges indicating a long time spent in water, whether at sea or partially submerged in the coastal environment. It is weathered and slightly whitened and has remains of a mollusk shell. The bucket is most likely to have been used in marine activities, potentially on fishing vessels. It may have reached the ocean after breaking, and not be able to fulfil its assigned function. This exercise based on a simple plastic fragment shows the interest in asking archaeological questions to re-construct plastic itineraries (after Joyce 2015). But while visual exploration presents limitations for the study of artefacts, archaeological science can complement the study of origin (e.g. Cabadas-Báez et al. 2017), making (e.g. Ménager et al. 2021) and use (e.g. Plaza Calonge et al. 2022), and their potential for plastic is explored next.

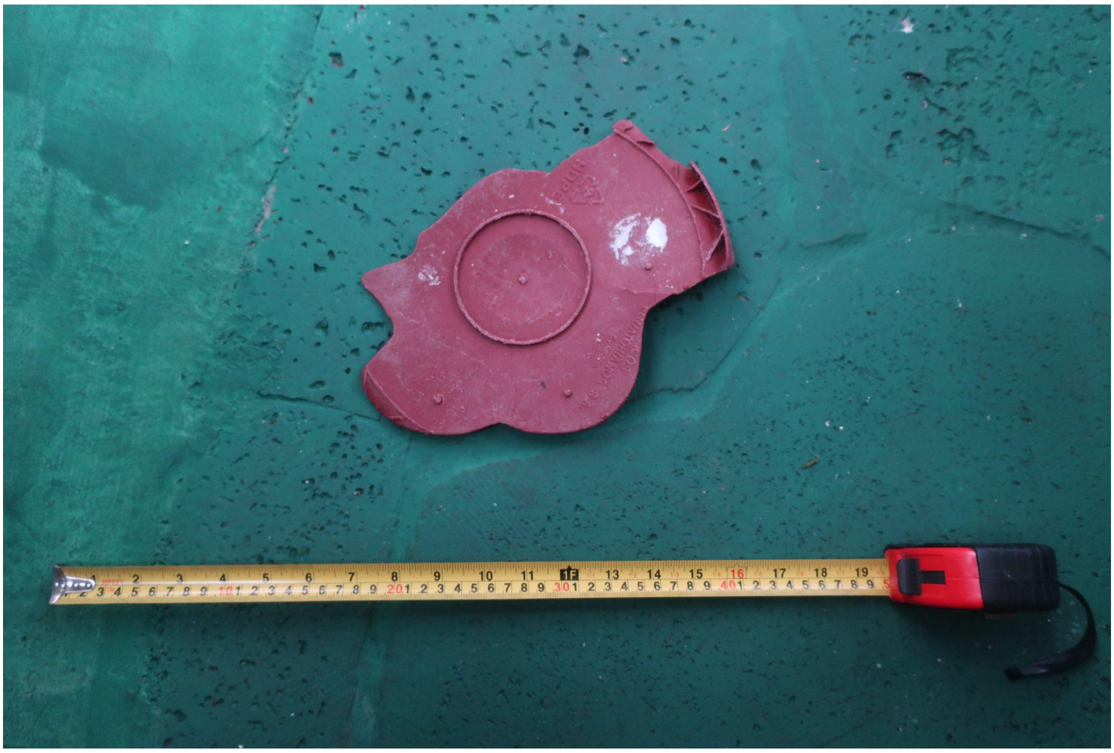

Figure 1: Bucket bottom found in Galapagos with a stamp for plastic type 2 - high density polyethylene (HDPE). Picture by the author.

Archaeological science

Archaeological science can be used to approach plastic's composition, use, and degradation notably to infer elements of chronology and making. The composition of plastics has changed drastically, notably through the use of additives and plasticizers diversifying the chemical signatures of synthetic plastics (Geyer 2020). The chemical composition of plastics became highly complex over time, with more than 10,000 chemical substances that can potentially be added to create plastic objects (Wiesinger, Wang and Hellweg, 2021). Here, the use of categories becomes helpful to analyse plastics as artefacts. Despite the diversity of plastics' chemical signatures, a common categorisation is the use of seven plastic types (PET, HDPE, PVC, LDPE, PP, PS, other), used to sort and recycle materials (Jung et al. 2018) and helpful to approach marine plastic litter PE, PP, PET, and PS are greater contributors to the issue (Andrady, 2011). But this limited classification is not the only way to divide plastics into categories, as their degradation pathway (biodegradable or not), material properties (thermosets that do not remelt once hardened or thermoplastics), and their source (either fossil or biogenic) also define plastic categories (Geyer 2020) (Figure 2).

Determining the composition of fragmented plastic waste is a challenge if no information is available on the object. Yet, several methods, based on microscopy, spectroscopy, and thermal approaches (Lakshmi Kayva et al. 2021), exist to identify plastics and determine the polymer types, notably attenuated total-reflectance Fourier transform infrared spectroscopy (ATR FT-IR) (e.g. Jung et al. 2018), portable x-ray fluorescence spectrometers (pXRF) (e.g. Turner and Solman 2016), pyrolysis gas-chromatography mass-spectrometry (Py-GC/MS) (e.g. Hermabessiere et al. 2018). Some of these methods are also used in archaeological contexts, for example, pXRF as a non-intrusive method (Forster et al. 2011) shedding light on a material's composition (e.g. Plaza Calonge et al. 2022). The method of pXRF applied to plastics can identify their elemental composition (Turner 2017), and the presence of pollutants including heavy metals (Turner and Solman 2016). Using methods to determine plastic types then becomes a way to identify the presence of additives and pollutants in plastic waste, which can eventually contribute to understanding the object chronology and use.

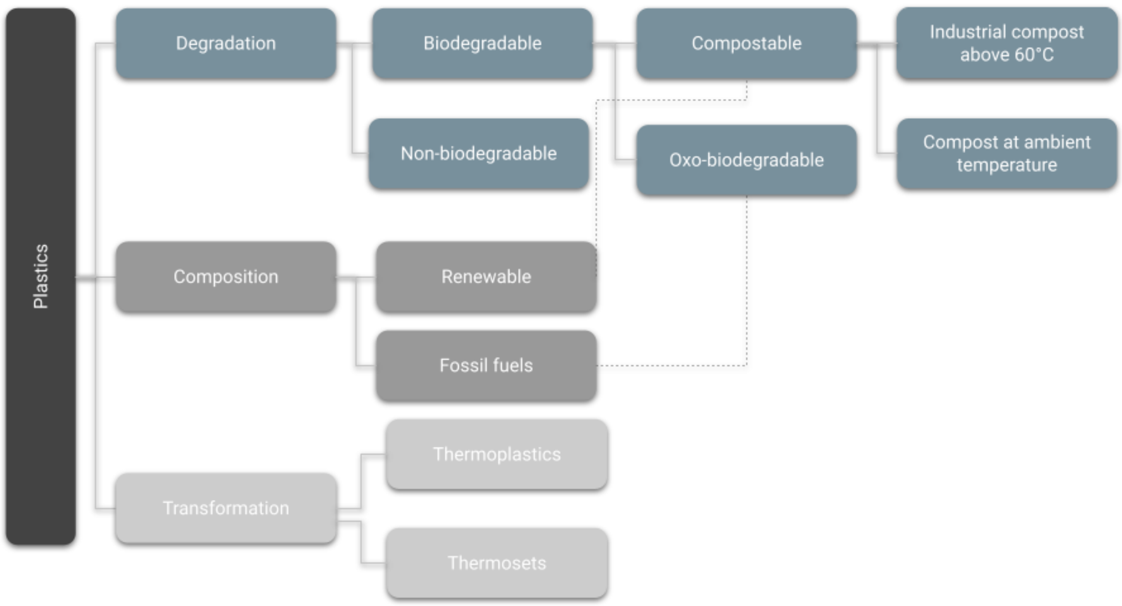

Figure 2: Categories of plastic according to carbon source, biodegradability and material properties (after the categorization from Geyer 2020).

Plastic poses the challenge of an ever-resisting material that slowly degrades and infinitely breaks down to the despair of material engineers and policymakers, becoming harder to retrieve and manage the smaller it gets. Archaeologists are exposed to the degradation of material culture, and accustomed to recovering fragmented artefacts through excavation. But plastics' degradation is difficult to grasp and even more difficult to avoid, particularly for museum curators, conservators, and restorers caring for collections including culturally important plastic artefacts (Kean 2021). Archaeology can build on this knowledge of plastic conservation when encountering culturally important plastics. While plastic conservation is not necessarily a priority for archaeologists, the discipline can provide more data through the excavation of modern material culture, and shed light on plastic degradation processes. This helps understanding how degradation occurs and what factors contribute to it. Once the presence of plastic types is determined in the archaeological record thanks to the methods outlined above, the focus can shift to identifying degradation processes of plastics (Zhang et al. 2020) facilitated by their exposure to a series of biotic (e.g. bacteria, funghi, insects) and abiotic (e.g. light, air, temperature) factors. To study artefact degradation, archaeologists use a wide range of microscopic and spectroscopic methods such as scanning-electron microscopy (SEM) and FT-IR (e.g. Łucejko et al. 2015). For plastics, degradation can be identified by a loss of molecular weight and mechanical strength, colour, texture and spectral signature changes (Turner et al. 2020). On the one hand, degradation is physically visible through modification of the polymer's surface (Chamas et al. 2020). Changes in morphology and porosity can be evidenced by SEM and atomic force microscopy (AFM) (e.g. Araujo et al. 2009). While the use of SEM for plastics is rare (Corcoran et al. 2009), it has been used extensively by archaeologists to understand processes of manufacturing (e.g. Ménager et al. 2021), use-wear (Cuenca-Solana et al. 2013), and composition (Sáenz-Samper and Martinón-Torres 2017). On the other hand, plastic's degradation can also be understood chemically by comparing ATR FT-IR spectra of virgin with degraded polymers found in the marine environment (e.g. Ioakeimidis et al. 2016). A few studies combined insights into physical and chemical degradation such as Turner et al. (2020) who used ATR FT-IR and SEM to better understand the weathering of Lego blocks. But often studies focusing on degraded plastic waste use weathering and degradation interchangeably. Weathering, at least in the archaeological sense, refers most often to subaerial weathering, the exposure of the material to open air conditions (e.g. Madgwick and Mulville 2012). Considering subaerial weathering as a specific degradation pathway would be particularly relevant for plastics, notably as exposure of plastic waste to solar UV, the main driver of plastic fragmentation (Bancone et al. 2020), and their oxidation produce secondary microplastics (Andrady 2022).

Plastics as an archaeological layer

The widespread presence of plastics in the environment means that they enter, as micro- or macro-plastics, archaeological contexts, and stratigraphies. The focus of this paper is on macroplastics entering archaeological layers illustrative of the Anthropocene. This paper argues for considering the presence of plastics in stratigraphy as a source of information. From that perspective, macroplastics can become chronological markers for the strata, often offering more precise dating than pre-industrial materials, especially if found with labels. Several studies have aimed at considering plastics as a source of information on the site use and chronology, notably in landfills (Rathje and Murphy 2001), on heritage sites (Mytum and Meek 2020), in underwater excavations (Praet and Delaere in press) and urban sedimentary record (Wagreich et al. 2023). More systematic archaeological studies of macroplastics in stratigraphies, with plastics sampled, quantified, and classified, could contribute to understanding plastic pollution through time. Here again, macroplastics found in stratigraphy are visible and often colourful items that make the presence of modern humans and their impact on the environment undeniable. In addition to providing good archaeological indicators of the Anthropocene, plastic artefacts can also act as a way to engage on the topic of plastic pollution and anthropic impacts on the environment.

It is the presence of microplastics in sea sediments, and the fossilisation of plastic in landfills that led Zalasiewicz et al. (2016) to advocate for the use of plastic as a stratigraphic indicator of the Anthropocene while cautioning more studies to understand this new stratigraphy. Microplastics also hold the potential to serve as stratigraphy markers notably of the Anthropocene, facilitated by their exclusive anthropogenic nature and the comparison of their widespread presence at a global level (Bancone et al. 2020). While microplastics are not the focus of this paper, their presence in archaeological contexts holds the potential to provide diachronic perspectives of microplastic presence in soils. While not explicitly adopting an archaeological lens, several environmental studies have become interested in identifying temporal trends of microplastic pollution, mostly focusing on coastal sediments (e.g. Matsuguma et al. 2017; Brandon, Jones, and Ohman 2019; Long et al. 2022). But more research is needed to understand microplastics' distribution, and the taphonomic processes they undergo (Bancone et al. 2020). Despite the potential of archaeology to consider the stratigraphy of archaeological sites as an archive of plastic pollution through time, there is a striking lack of archaeological studies considering macro- and micro-plastics in the stratigraphy (except Rotchell et al. 2024). This paper highlights this gap of knowledge of plastics in stratigraphical contexts from archaeological sites. Contributing to this literature would help understand and measure how anthropic impacts on soils and sediments have changed through time, and what that means for future soil use.

In addition to plastic becoming a topic of interest for archaeologists through stratigraphy, areas receiving plastic pollution can benefit from an archaeological perspective. Environmental and marine biology studies of plastic pollution on beaches and shorelines are often limited to sampling of surface-level sediment. Yet, studies have highlighted that microplastic pollution is more abundant below the surface (e.g. Tavares et al. 2020). Despite their importance for contemporary archaeology (see Harrison and Schofield 2010 for an introduction to contemporary archaeology), surface assemblages (e.g. Harrison 2011) and surface sampling can only give us a partial understanding of plastic pollution, especially given the breaking down of plastics into microplastics. Adopting a stratigraphical perspective, for example, through augering polluted beaches, can reveal buried plastics and contribute to developing an understanding of these supermodern landscapes.

Plastics as part of waste landscapes

As plastics enter marine and terrestrial environments, they can be studied not only as artefacts and components of archaeological layers but also as a material that permeates a multitude of landscapes. The global ubiquity (after Davis 2022) of plastics questions the scale at which archaeologists are usually working. For plastics, the scale may be planetary, contrasting with traditional archaeological approaches working at the household, town, or one river valley level (Agbe-Davies in McMullan 2019). This scale disruption is characteristic of contemporary archaeology (see Edgeworth 2010, 2013). It is also the scale of plastics' presence and impacts that transforms some environments into waste landscapes. Ubiquitous and diverse, waste landscapes share a characteristic omnipresence of waste materials that have lost socio-economic and symbolic value (compared to their value as products) and are no longer entangled in terms of ownership (see Reno 2013 for losses of ownership and value as central to the definition of waste). The concept of waste landscape is here used to approach landscapes marked by plastic pollution (see Praet et al. 2023 for a consideration of plastics as components of waste landscape). As the scale of plastic pollution, its visibility and impacts on landscapes may greatly vary. As a result, a diversity of waste landscapes shaped by plastic pollution emerge, from the ones marked by invisible micro- and nano-plastic leaking resulting from agriculture processes to the melting and incorporation of plastics into the geological record (see Rangel-Buitrago, Neal, and Williams 2022) and the highly visible accumulation of mega- and macro-plastic in Garbage patches (see Tamoria and Schofield in press). Those newly formed landscapes both contribute to climate change, for example through the presence of synthetic objects of all sizes having a series of impacts on their environment, and are impacted by climate change's consequences, when severe weather further spreads plastic pollution.

Archaeologists became interested in those landscapes and adapted archaeological techniques, notably surveys and excavations, to study them (see Pétursdóttir 2017 for a study of drift matter). While these studies do not solely focus on plastics, they represent a considerable part of the landscape. Recognising the geographical amplitude of plastic pollution allows for its consideration as a global issue. These newly configured landscapes offer another argument for an archaeological study of plastic pollution. Building on the potential of archaeology to approach and reconstitute past landscapes, a series of techniques can contribute to understanding these recent waste landscapes. Coupled with artificial intelligence (e.g. Politikos et al. 2023) or Citizen Science (Merlino et al. 2021), drone surveys can identify the proportion of plastic types in a defined area (e.g. Andriolo et al. 2021) providing an aerial perspective on the issue when the landscape is visibly marked by plastic pollution. An archaeological approach to the issue could combine this aerial perspective with surface sampling in transects, and stratigraphical views of plastic pollution through augering. The presence of plastic at depth was shown to sometimes reach higher levels than those of surface sampling (e.g. Tavares et al. 2020). While plastic distribution depends on the landscape dynamics, archaeology brings a stratigraphic approach to the landscape. Archaeology contributes to the study of these landscapes by questioning the formation of these landscapes and adopting a multi-level approach, combining aerial, surface, and in-depth inquiries into plastic presence within one landscape. Studying how these spatial and temporal levels relate to each other would offer an archaeological perspective on this specific landscape. It may confirm if areas that appear as most polluted on drone images are also characterised by specific plastic types in surface sampling alongside increasing microplastic pollution below the surface. This could contribute to improving monitoring practices and offer policy recommendations for clean-ups.

Archaeology covered in plastic pollution

Plastic pollution is a visible issue, one that can hardly be hidden. Despite being linked to climate change (Ford et al. 2022; Lavers et al. 2022), plastic pollution has not often been recognised as an issue in the heritage literature discussing climate change impacts. Pollution is recognised as a threat to the Outstanding Universal Value of World Heritage Sites (UNESCO), for example, but is most discussed for natural heritage sites (see Woodward and Cooke 2022). With the global interconnectedness of marine currents, waste dropping, marine activities, and rivers as sources of plastic, plastic pollution characterises most landscapes including important natural and cultural sites. Plastic pollution can occur as a result of increasing tourism but also due to the site's geography being exposed to marine and/or land sources of plastic pollution.

The impacts of tourism on archaeological sites have long been documented for world renowned sites (e.g. Green and Vaschetto 2022). While tourism can have a multitude of impacts (see Wilson 2008), this paper has focused on environmental impacts notably resulting in plastic pollution and how this directly relates to the climate crisis. Construction and operation of tourism facilities can negatively impact the environment by respectively provoking vegetation, soil, and habitat loss, and producing byproducts such as solid waste (Leung 2001). From that perspective, an increased number of visitors puts pressure on the site and nearby facilities including waste management. Tourists' behaviour (e.g. littering) can also become a threat to heritage sites (Leung 2001) and contribute to plastics entering the site and its surroundings, with known consequences for wildlife (Ayala et al. 2023) and soils (Zhu et al. 2019). The potential impacts of plastics, entering the stratigraphy of archaeological and heritage sites, are unknown and would benefit from more research. These could include impacts on the soil properties and eventually on the preservation of other materials. Before they degrade and enter the stratigraphy, the visible accumulation of plastics in and near the sites poses a threat to local livelihoods, and potentially transforms the tourist experience negatively (as in Umm-Qais in Jordan, see AlMasri and Abadneh 2021), as plastics affect negatively landscape aesthetics (e.g. Gascón 2021). World Heritage Ssites (WHS) such as Angkor Wat and Machu Picchu saw the unprecedented development of cities next to the sites, respectively Siem Reap and Aguas Calientes, to accommodate tourists but lacked adequate waste management systems. While the issue of plastic pollution is acknowledged in the literature, more research is needed to identify strategies adopted by archaeological and heritage sites to limit and address plastic pollution.

The entry of this recent material culture in heritage sites was documented at Castell Henllys, Wales. Excavations of two reconstructed Iron Age roundhouses shed light on tourist behaviour (Mytum and Meek 2020). A careful analysis enabled the differentiation of material culture between the Cookhouse, usually quickly inspected by the visitors, and the Earthwatch where benches invited people to sit and pupils to eat their packed lunches. Even though both spaces were regularly cleaned to provide the illusion of authentic Iron Age houses, plastic items have made their way into the soil facilitated by rodent and human factors. While the authors' analysis is limited to the interpretation of the spaces and reflections on the "Plastic Age", those same findings could be used to make recommendations for policymakers and heritage site managers to limit the entry of plastic pollution. This shows the potential contribution of (contemporary) archaeology to policymaking and its relevance nowadays (e.g. Holtorf 2009; Sabloff 2009; Kaufman, Kelly, and Vachula 2018; Vince et al. 2022), hopefully contributing to the design of solutions to address plastic pollution along with other disciplines.

In addition to the number of visitors constituting an environmental issue (Leung 2001) and leading to plastic waste entering the archaeological record, the location of certain sites makes them particularly prone to receiving plastic pollution. Coastal heritage sites, as well as islands, are exposed to the global flows and dynamics of plastic pollution coming from a variety of sources including marine activities and land pollution. The WHS of Galapagos receives pollution from oceanic currents, marine sources, and local pollution although the latter is scarce (Jones et al. 2021). Aside from coastal sites, natural heritage located close to river basins can also suffer the consequences of microplastics' presence and toxicity (Amrutha et al. 2023), especially as rivers play an important role as sources of marine litter (Lebreton et al. 2017). With plastic pollution entering and accumulating on the seafloor (acting as a sink for marine plastic litter, see Cau et al. 2022) and riverbed (van Emmerik et al. 2016), the impact of plastic pollution on submerged heritage, for example, shipwrecks, may be extensive but remains largely unexplored. Urban sites can also receive plastic pollution in their sequence (see Wagreich et al. 2023), as illustrated in this road cut, containing deposits from 200 years ago to the present where plastic represents another layer of the urban history (Figure 3; Morgan 2024, pers. com.). There, plastics are present in the road cut stratigraphy, as eroding from the top surface, and accumulating at the base (Morgan 2024, pers. com.). While plastics seem to be imported from worldwide sources, their weathering and the lack of comparative typologies make the identification of their origin challenging (Morgan 2024, pers. com.). In brief, heritage can be exposed to a series of factors, from anthropogenic actions to natural elements allowing the entry of plastic into these iconic and protected areas and sites. Those sites suffer from the socio-economic impacts of plastic pollution, notably impacting tourism and people's wellbeing, as well as requiring a budget to remove the litter and manage the waste. Bio-ecological impacts of plastic pollution are also threatening these sites, notably as plastic poses a threat to local, and sometimes endemic, wildlife, and constitutes a danger to human health through certain additives.

Figure 3: Dr Colleen Morgan recording a road cut with plastic in the stratigraphy as part of the Origins of Doha/Qatar project in 2012. Picture by Daniel Eddisford. Licence CC-BY.

Conclusion

In this paper, I argue that plastic pollution represents an object of study for archeologists amid a climate crisis. There are several ways in which archaeologists can decide to approach the issue. First, plastic objects can be studied as cultural artefacts, considering the amount of information they hold to reconstruct sections of their journey, from production to waste. In addition to visual examination, notably of labels, archaeological scientific techniques can contribute to a better understanding of plastic's physical and chemical degradation. The occurrence of plastics of all sizes in stratigraphy can also be revealing of occupational trends and yield chronological information useful for relative dating. As the scale of plastic pollution is characteristic of the Anthropocene, archaeologists might want to explore how plastics affect a diversity of landscapes and create new geographies.

Archaeologists need to account for plastic pollution, especially in times of climate crisis. While plastic pollution actively contributes to climate change (Ford et al. 2022; Lavers, Bond, and Rolsky 2022), it is likely to be exacerbated by consequences of the climate crisis turning it into a threat to archaeological sites. Sites face climate change consequences such as erosion (Reimann et al. 2018), floods (Daly et al. 2022), increased temperatures (Matthiesen et al. 2022), and extreme weather events (Rivera-Collazo 2020). Those critical events, notably floods and extreme weather events, can contribute to the increased spread of plastic pollution (Ford et al. 2022), whose accumulation can become a threat to these sites and their environment. In the Anthropocene, there are infinite ways to develop an archaeology *of* plastic pollution, and to actively engage with archaeological and heritage sites affected *by* and covered *in* plastic pollution.

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Chapter 3 - An Underwater Archaeology of Plastic in Inland Waterways

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Abstract

Rivers have played a crucial role in transportation for past societies and within them they contain some of the evidence for this past use. They now carry with them large amounts of plastic pollution into the oceans, and this evidence is also accumulating, for example in river sediments and on the riverbed. Modern inland waterways are shaped by anthropogenic impacts that increased through the development of international transport. This required intense modifications, including dredging and canalisation, so invasive that they removed part of the ancient heritage of the riverbed. These modifications physically marked the stratigraphy and act as chronological markers for the new fluvial sedimentary deposits associated with contemporary material culture informing us about the recent history of rivers.

Based on the results of underwater excavations conducted in 2017 in the Sambre River (Province of Namur, Belgium) at its confluence with the Meuse River, this chapter highlights the contribution of studying plastic artefacts and their context in an environment marked by anthropogenic impacts. We propose to explore the nature and origin of contemporary archaeological contexts evident in superficial sedimentary levels of the riverbed. Contemporary archaeology, combined with inland water archaeology, can shed light on modes of production and address the anthropic impact on the riverine environment through time.

Keywords

inland waterways, international transport, dredging and canalisation of rivers, plastic heritage

Introduction

Rivers are strategic features of the landscape that have been used by humans for resources, transport and defence throughout human history. Their socio-economic importance has also, however, resulted in recent activities leading to the transport of contaminants (e.g. Feng et al., 2002) and the movement of plastics towards the sea, contributing heavily to marine pollution (Lebreton et al., 2017). We here argue for a consideration of plastic pollution in inland waterways (IW) through an archaeological lens. Combining a theoretical framework derived from contemporary archaeology with underwater archaeological surveys, we illustrate the potential of considering plastic artefacts (understood here as synthetic plastics) as evidence of anthropogenic impacts on river systems. Rivers are hybrid forms (following Edgeworth and Benjamin, 2017) shaped by human impacts, in particular that of plastic pollution. They are both means of transport for plastic pollution and victims of plastics' physical and chemical impacts on riverine ecosystems. If studied through an archaeological lens, river sediments act as archives of human impact through time. Bringing this to light this paper provides an archaeological study of plastic assemblages in La Sambre, a river in Belgium.

Towards a contemporary archaeology of inland waterways

The modification of inland waterways, encompassing natural or artificial water bodies (e.g. rivers, canals, lakes) suitable for navigation (International Transport Forum et al., 2019: 59), is by no means a modern feature. Such waterways were built, modified and exploited across time (Crompton, 2004) by a wide range of societies from Asia (e.g. see Sanderson et al., 2003 for dating of canals from Angkor Borei), Europe (e.g. see Lisé-Pronovost et al., 2019 for an example of canalisations and dredging in Ancient Rome) and Latin America (e.g. see Scarborough and Gallopin, 1991 for a discussion on water management and the creation of canals and reservoirs at Tikal) among others. Their modification allowed for greater control and transport of goods, contributing to the development of trade and commerce. Rivers are so heavily modified by humans that they can be considered as hybrid forms combining artificial with natural forces (Edgeworth and Benjamin, 2017: 162).

Inland waterway transport (IWT) defined as "any movement of goods and/or passengers using IWT vessels which is undertaken wholly or partly on navigable inland waterways" (International Transport Forum et al., 2019: 68) has often been associated with industrialisation. The eighteenth and nineteenth centuries saw an unprecedented rise in IWT in Europe, perceived as a better alternative to poorly developed road transport (Crompton 2004, 2). IWT contributed to the development of coastal and international commerce in the US, the UK and Europe (Crompton 2004, 10). The Industrial Revolution was the golden age for the building of artificial canals that presented the advantage of being controlled more easily than natural rivers (Crompton 2004, 3). Despite numerous human, technological and financial investments to adapt the rivers in the nineteenth century (e.g. construction of locks, increase of draught, etc.), railways have been a serious economic challenger to the development and use of waterways (see Kelso, 1941: 537-544). More recently, we have observed a will to favour a return to the use of inland waterways as alternatives to contemporary traditional transport (road, air and sea freight) through policies of environmental transition (e.g. Sys et al., 2020).

With rivers being used as navigation routes, they would also endure modifications of different types, such as dredging and canalisations. The dredging of rivers consisted of levelling the riverbed by removing the sediments to prevent the clogging of waterways used as navigation routes. Dredging has been used from at least the fourth century B.C. with archaeological evidence from France, Italy and Phoenicia (Morhange and Marriner, 2010). The canalisation of rivers consisted of their permanent transformation into canals (often involving straightening) offering easier passage partly through increased control of river flow. This anthropogenic modification of rivers was already noticed in the Roman period (e.g. canalisation of the Thames see Milne, 2015) but was exponentially adopted during the industrial period. This option has sometimes been preferred over dredging as in the case of the Moselle (France, Luxembourg and Germany) where it allowed for the production of hydroelectricity and to maintain navigation depth all year round (McIntyre, 1957: 257). It is important to note that many waterways are dredged without being canalised, whereas canalised waterways are then almost systematically dredged on a regular basis. Indeed, dredging makes it possible to maintain a high draught and to prevent silting, as we will see with the example of the Sambre in Belgium. Those modifications are particularly important to archaeologists who can use historical documentation of dredging and canalisation to date and interpret archaeological evidence on the riverbed.

Most research undertaken on modern inland waterways is in the field of economics (e.g. Cenci et al., 2014), history (e.g. Crompton, 2004; Honnoré, 2016) or even engineering to understand their modifications (e.g. Gob et al., 2005). Little attention has been paid to their understanding from a contemporary archaeological perspective. Following one of the few studies on contemporary inland waterway heritage (Firth 2015, 230), in this chapter we advocate for the consideration of inland waterways as archaeological features that have been impacted by human activity through structural modifications thus generating a distinct data set relating to global pollution.

Rivers of the Anthropocene (see below for a discussion of the term) are particularly vulnerable to a series of anthropogenic threats including pollution (Best, 2019). Plastic pollution is one aspect of this, but often also the most visible of anthropogenic impacts, more so than other (e.g. liquid) pollutants and the modifications of the river course through dredging and canalisations, which are often only visible on the riverbed. In addition to being directly affected by plastic pollution, rivers also transport land-based plastic to the oceans (van Emmerick and Schwarz, 2019), estimated between 1.15 and 2.41 million tonnes every year (Lebreton et al., 2017: 3). Not only is this true for floating plastic, but submerged plastic is also moving downstream and finally ending up in the marine environment (see Morritt et al., 2014 for a study of submerged plastics in the Thames). While floating plastic makes the issue more visible, river sediment acts as a relatively hidden archive that offers insights into the less visible submerged plastic pollution.

Building on archaeological studies identifying early human modifications of rivers through dredging (e.g. Morhange and Marriner, 2010) and canalisations (e.g. of the river mouth in Sanchez and Jézégou, 2014), and on marine biology studies focused on contemporary plastics in river systems, our study aims at exploring the river Sambre as an archive of anthropogenic impacts (e.g. dredging), and particularly plastic pollution. This will provide a better understanding of the modifications and uses of the Sambre between 1859 and 2017 with a focus on its later history and use as evidenced by plastic artefacts. Studying inland waterways' plastics from an archaeological perspective has theoretical and practical implications which are explored in the following section.

An underwater archaeology of plastic in the Sambre

This chapter, and this whole section, reflects the omnipresence of plastic, from urban litter (see Papoli-Yazdi, this volume) to plastics in archaeological sites (see Moretti and Toso, this volume). Our study focuses on the contribution of underwater archaeology to approaching plastic pollution in rivers, and to an archaeology of plastic as a subfield of contemporary archaeology.

The archaeology of plastic, and plastic pollution, is a relatively new field, a component of contemporary archaeology which has its roots in New Archaeology in the 1970s (e.g. Schiffer, 1972; Reid et al., 1975) and became firmly established since the early 2000s (e.g. Buchli and Lucas, 2001; Harrison and Schofield, 2010). The inherent industrial nature of plastics automatically places their archaeological study within contemporary archaeology. Building on reflections from processual and post-processual archaeologies, a discipline embracing the modern world and the very recent past has emerged. While its name has changed (*archaeology of the contemporary past* by Buchli and Lucas in 2001; *archaeology in and of the present* by Harrison in 2011; *archaeology of the contemporary world* by Graves-Brown et al., 2013; *archaeology of the contemporary era* by Gonzalez-Ruibal in 2018 to *archaeology of Plastic Age* by Schofield in press), the discipline shares a focus on global issues in the present and future through a multidisciplinary approach (Harrison and Schofield, 2010; Graves Brown et al., 2013), along with its political nature (González-Ruibal, 2018). In that sense, plastics embody a series of issues across gender (Sylla Traore and Braun, 2015), human-environment relationships (e.g. plastiglomerate identified by Corcoran et al., 2014), globalisation and colonisation (Liboiron, 2021; Davis, 2022) that are all of interest for contemporary archaeologies.

The establishment of an archaeology of plastics requires their consideration as artefacts. Archaeology has historically always placed emphasis on artefacts, from

Antiquarianism using them to build the nation state (Fowler, 2008) to Culture History creating typologies to classify artefacts and associate them with specific cultures (Webster, 2008). This focus on artefacts was then criticised, leading processual archaeology to adopt the concept of material culture, developed by British social anthropology to study people instead of only the objects that represented them (Hicks, 2010: 38-39). Material culture was then used to inform past behaviours (Hicks, 2010: 38-39) leading to the subfield of behavioural archaeology (e.g. Schiffer, 2002). This systematic use of artefacts to infer behaviours (from things to people) was then critiqued by post-processualists, and more particularly by feminist archaeology wanting to bring back the focus on people (Webmoor, 2008) by engendering prehistory and moving away from perceptions of faceless societies (Tringham, 1991). Besides, the material-cultural turn shaped post-processual archaeology and emphasised the contextual nature of material production (Hicks, 2010) overlooked by the generalising and systemic approach of artefacts of processual archaeology.

The omnipresence of plastics in both the archaeological and geological record (for example in the shape of plastiglomerates identified by Corcoran et al., 2014) and their global predominance since circa 1945 have led some scholars to adopt the terms Plastic Age (Thompson et al., 2009) or Plasticene (Ross, 2018), referring to other archaeological periods centred on the material and technology of artefacts such as the Iron and Stone Ages. Graves-Brown (2014) even considered plastics as the diagnostic artefact of the period (if considered archaeologically) along with aluminium. The term Plasticene, commencing in the 1950s and characterised by a stratigraphic layer of plastic, first appeared in 2011 (Stager 2011 in Haram et al., 2020) to refer to a sub-period of the Anthropocene. The latter was first introduced by Crutzen and Stoermer (2000) to refer to an epoch that follows the Holocene and that is marked by the influence of humans on the stratigraphical and geological record. From that perspective, plastic appears as another impact of human presence on the environment, a tendency that has characterised several landscapes of the Anthropocene. This influence of humans on the environment since the Industrial Revolution has led to modifications of rivers (Kelly, 2017) and coastal areas of the Anthropocene to accommodate human activities (Byrne, 2020). Without entering into the debates regarding the adoption of the term Anthropocene across geology and archaeology (see the Forum on Archaeology of the Anthropocene published in 2014 by the *Journal of Contemporary Archaeology*), this study will consider Anthropocene and Plasticene as non-exclusive terms that allow us to refine the chronology of our recent past where the impact of humans (Anthropocene), notably through Plastic (Plasticene), is visible geologically and archaeologically. That aside, the focus of this study on plastics in inland water contexts sheds light on their presence as archaeological markers of anthropogenic change.

Despite considerable literature on the relevance of plastics as material culture (e.g. Hawkins, 2018; Dey, 2021; Davis, 2022) and the interest for contemporary material culture by a wide range of disciplines (e.g. Graves-Brown, 2000), little work has been done with plastics recovered as artefacts from conventional archaeological contexts. Garbology is the earliest attempt to include plastic as archaeological material. In Rathje's (1992) Garbage project, a series of US landfills were excavated to better understand consumer behaviour. The project recorded volume and weight ratios of different materials including plastic (Rathje, 1992). While these ratios were used to compare material types and proportions, the amount of information available on plastic containers and labels was only fully exploited in household garbage analysis (Rathje, 1984). More recent projects exploring the potential of plastic as artefacts include excavations at Castell Henllys by Mytum and Meek (2020). Here, the authors excavated the sites of two reconstructions of Iron Age roundhouses, which shedded light on tourist behaviour on this popular heritage site in Wales. The authors identified both rodent and human factors contributing to the entry of plastic items into the soil and observed no evidence of plastic decay for the burial period of 30 years. Another study by Arnshav (2014) highlighted the potential of maritime garbology to understand behaviours associated with litter found on the seafloor. This study examined results from underwater surveys of the seafloor along the coast of Sweden which yielded many artefacts associated with boat activities and indicative of waste disposal practices at sea. These projects show that insights from plastics as artefacts can help understand associated behaviours, and eventually find solutions.

Despite developments in post-processual archaeology to address new types of material culture through archaeological methods (e.g. the thorough analysis of Swedish and British beer cans by Shanks and Tilley, 1992), there is an absence of literature regarding the classification of plastic artefacts. While we recognise that typologies present limitations (and so does their ordering into seriation developed by Culture Historians), their use helps to address and further understand patterns of occupation, as well as reflect use and technology. We here decide to explore different typologies for the analysis of plastic artefacts, before offering a selection of object itineraries recovered from the Sambre.

Reflections on plastic typologies

The establishment of plastic typologies requires a consideration of plastic's material properties. Traditionally, archaeology approaches the study of material culture through two lenses: a) materials and shapes, and b) function (Preston, 2000). The materials and shapes of objects are ways to categorise them (Hurcombe, 2007) that usually give information about the procurement of materials and the process of production of the object. It can also be revealing of a particular region or period (Hurcombe, 2007). Functions of objects, on the other hand, have been a topic of debate in archaeology as they can be numerous and diverse. There seems to be a consensus that function cannot be understood as a unique element and scholars have proposed different sorts of functions. For example, Schiffer (1992: 10-11) identified three types of functions for any artefact: techno-function (i.e. utilitarian function), socio-function (i.e. function as sign and/or symbol within a society), and ideo-function (i.e. function responding to the ideas, knowledge, values that the object embodies) whereas Preston (2000: 23-29) builds on philosophical approaches to differentiate between proper (i.e. the function for which the object was designed) and system functions (i.e. as the capacity of an object to fulfil a function within a specific system). Beyond their "proper" or techno-function, objects also present what Gibson (1986: 39-42) has conceptualised as affordances, and which can also be understood as systemic functions following Preston (2000). The material properties of an object will 'afford' other uses. While the word affordance implies that those are inherent to objects and inscribe themselves in an object-agent relationship, Costall and Richards (2013) suggest using the verb "afford" instead to reflect the diversity of potential functions depending on the network of relationships an object is entangled in.

The materials and shapes of plastics are particularly challenging for archaeology due to the diversity of components and the infinity of shapes that this flexible synthetic polymer can adopt. We here use "plastic" to refer to synthetic plastics comprising thermoplastics and thermosets that respectively can and cannot be reshaped following the application of heat, melting and hardening after cooling. It is the flexible and elastic properties that contributed to the birth of synthetic plastics with humans succeeding to synthetically reproduce the elastic material properties of natural polymers (e.g. rubber). This relationship between humans and nature, characteristic of artefact creation (Ingold, 2000; 2012), was at the core of plastic experimentation.

While the flexibility of plastic, embedded in the etymology of the word (from the Greek πλαστικος = that can be moulded), was key to their success, this shared property overlooks the diversity of materials existing. While plastic has only recently become of interest for archaeologists, biologists and chemists follow typologies based on their chemical components, for example differentiating Polyethylene terephthalate (PET) from Polyvinyl chloride (PVC) and Polypropylene (PP). Material conditions determining plastic production have contributed to encourage a single-use culture through the tension between disposability and durability crystallising in plastics. By being so accessible, materials become more ephemeral (Schiffer, 2002). The material properties of plastics led to them taking a diversity of shapes that no other material ever could. Those limitless properties might give the impression that plasticity slowly kills culture by erasing all material limitations. Yet, the shape that plastic takes is still revealing and its extraordinary nature does not make it any less culturally relevant (Ingold, 2000). The wide range of shapes that plastic takes is both a result of cultural decisions and of their functions responding to endless needs of our capitalist and consumerist culture.

The material properties of plastic then allowed for an infinite diversity of shapes, as well as functions. Material properties here do not limit functions but serve them, with plastic being the material that has the widest range. Plastics are present in health sectors, food packaging, transport, building materials, agriculture, amongst other sectors. Their relatively short use life to complete their "proper" function, and ensued disposal, contrasts with the numerous afforded uses facilitated by their material properties. By being entangled in a large network of relationships from production to disposal, plastic has developed new affordances even as waste: bottle caps are used as shelters by crabs (Grijseels, 2020) and plastic bags used as the object of games involving young sea lions in Galapagos (Lucas, 2018). While these affordances illustrate both the omnipresence of plastics and the environment's adaptability to plastic artefacts, it needs to be emphasised that plastic pollution represents a serious threat to wildlife due to their toxicity, especially in marine environments (e.g.

Takada & Karapanagioti, 2018), and the risk of ingestion and entanglement that they pose (e.g. Gall & Thompson, 2015; Thiel et al., 2018).

The diversity of characteristics to be considered in the establishment of plastic typologies makes the attempt challenging and prevents the categorisation of all plastic artefacts into a single typology. Building on these reflections, this chapter will explore categories and typologies of plastic assemblages from a specific context, an inland waterway in Belgium, the Sambre, and consider them as another aspect of human modification of the riverine system.

The Sambre case study

Our case study focuses on the inland waterway of the Sambre, a tributary to the Meuse (Belgium), and explores the results of underwater excavations undertaken in 2017 by Christophe Delaere from the Université libre de Bruxelles (ULB) as part of Le Grognon Project led by the Agence Wallonne du Patrimoine (AWap). Three underwater test pits were excavated in the Sambre next to the neighbourhood Le Grognon located strategically at the confluence of both rivers (Figure 1 and 2). Underwater excavations methods followed published methodologies including the record of artefacts underwater and the use of an Air-Lift that aspires sediment which is then sieved on land with a mesh size of 1 cm^2 (Delaere, 2017; Delaere and Warmenbol, 2018; 2019; Pieters and Delaere, 2020; Delaere and Guédron, 2022). While the sieving ensures that smaller artefacts are considered, the small mesh size would not have recorded microplastics measuring less than 5mm.

The neighbourhood of Le Grognon has evidence for a series of human activities since the Mesolithic (Vanmechelen et al., 2018). This evidence also includes bronze metallurgy (Vanmechelen et al., 2007: 231) and a Roman confluence sanctuary (Vanmechelen et al., 2018). The area was “modernised” destroying densely populated neighbourhoods for automotive industries in 1968-1973 (Jacquet & Jacquet-Ladrier, 1997 in Vanmechelen et al., 2007: 231). A series of construction projects led to numerous excavations (1994-2000; 2016-2018) contributing to our current understanding of the neighbourhood.

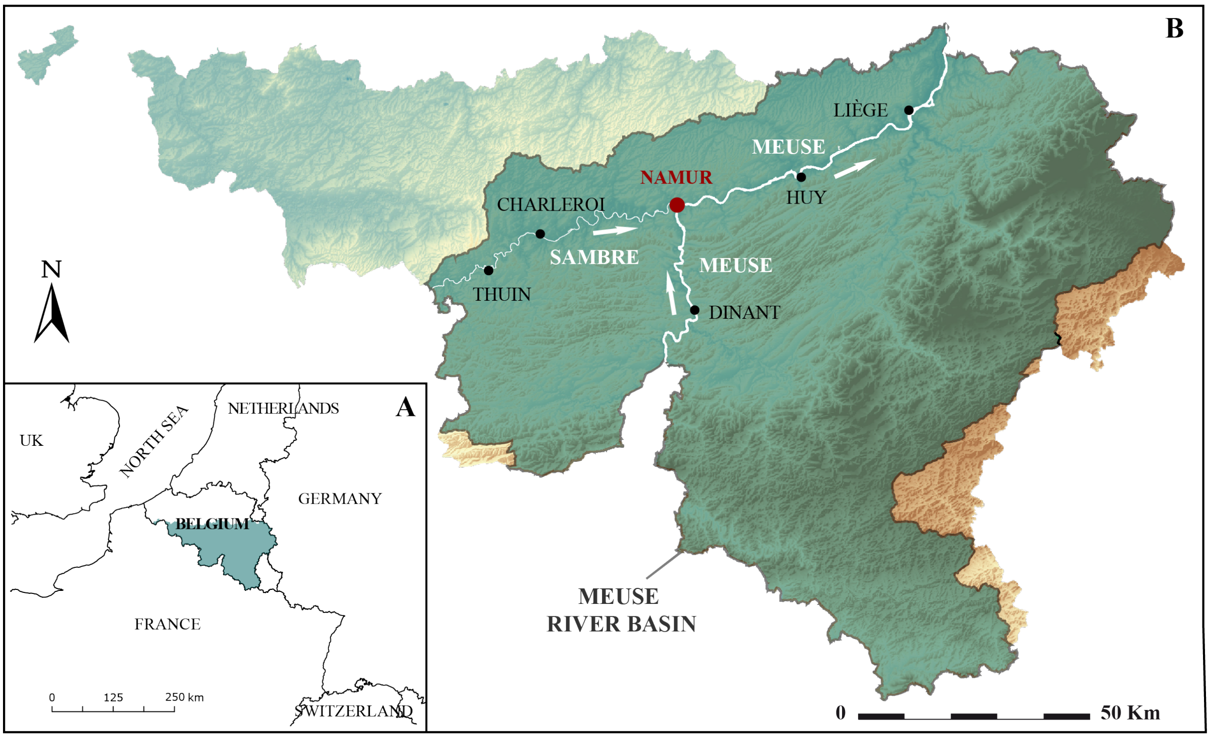

Figure 1: a) Location of Wallonia (Southern part of Belgium) and b) the Meuse River basin in Wallonia. The confluence point between the Sambre (tributary) and the Meuse is located in Namur in the neighbourhood Le Grognon.

Both rivers, the Sambre and the Meuse, have undergone human modifications, with the introduction of wooden structures on the riverbank of the Meuse at least from the fifth century AD (Vanmechelen et al., 2007: 232). Excavations yielded evidence of slipways dating from the sixth and seventh centuries AD allowing the launching of boats into the river (Vanmechelen et al., 2007: 234-237). The Sambre river bank also underwent modifications from the second century AD with a masonry wall potentially interpreted as a structure used for the terracing of the riverbank (Vanmechelen et al., 2017: 110-111).

We here focus on the modifications of the tributary to the Meuse, the Sambre. With modifications to the natural gradient of the river through deposits on the riverbanks evident since Roman occupation (Vanmechelen et al., 2017: 114), the Sambre took an essential role as a navigation route during the mediaeval period (Tilly, 2016). The morphology of the river, along with the numerous natural resources available, have led to a transformation of the Sambre basin since the proto-industrial era with new economic centres along its course (Cenci et al., 2014: 88).

This potential as a navigation route for transnational commerce was further exploited in the industrial period, especially with the coal industry (Cenci et al., 2014; Tilly, 2016). The river underwent modifications of two types: successive dredging events and canalisations, the first one occurring in 1825-1830; the second in 1950-1953. The first industrial dredging in the Sambre, carried out from a boat using mechanical shovels to dig and level the riverbed, is attested in 1859 (Lallemand, 1989). Dredging of the Sambre (1859, 1930, 1940, ≥ 1950), as for other rivers, was aimed at improving the river flow (Burton et al., 2010). canalisations allowed for bigger and heavier boats to transport materials, with a shift from 48T in 1825 to 1350T in 1836 (Cenci et al., 2014: 89). Those modifications led to a more intense and sustained transport of products towards Paris (Cenci et al., 2014: 89).

All the modifications that occurred after 1830 were under the control of the newly born Belgian state claiming responsibility over all waterways that were previously privatised (Honnoré, 2016: 1016). However, the first canalisation of the Sambre was undertaken under the Dutch provincial government between 1814 and 1830 (Honnoré, 2016: 1025). The key role of the Sambre in industrial transport slowly faded in the twentieth century (with an increase of only 331 km of navigable IW between 1830 and 1913), a situation understood through increasing infrastructure for railway transport (Tilly, 2016) and the global post-war development of road networks (Crompton, 2004: 12). The Sambre also lost its importance due to the broadening of another river facilitating transports between Belgium and France, L'Escaut (Cenci et al., 2014: 89).

These modifications, allowing transnational transport between Belgium and France, have impacted the morphology of the riverbed that had probably been untouched until the nineteenth century. It allowed for sediments to settle between those modifications, clearly visible in the stratigraphy, providing time capsules comprising artefact assemblages including plastics. We hope that by focusing on plastics as a material culture, we will be able to better understand the broader context of the site through a close examination of types and explore assemblages of buried plastics in riverine contexts through archaeology.

The Sambre is now almost entirely canalised along its 87 km of Belgian territory. The river is punctuated by numerous hydraulic structures, including 17 locks, allowing the navigation of barges with a draught not exceeding 2.2 metres. At Namur, the Sambre has a current width of ± 35 metres, a depth of between 3.8 and 4.2 metres, and a moderate flow rate not exceeding 87.5 m^3 per second during the months of October and November (the period of the archaeological excavations).

Archaeological finds in the Sambre riverbed

The archaeological significance of the Sambre was revealed in the first half of the 19th century when thousands of Roman coins were found in the bed of the river during low water periods at Namur (Lallemand, 1989). The majority of the studies carried out on the artefacts discovered in the bed of the Sambre between the beginning of the nineteenth century and 1953 were almost exclusively devoted to the study of Roman coins and the Roman ford of Namur.

Some of the artefacts from the dredging operations could still be preserved in the dredging soil and, as such, could warrant archaeological investigations in the future, particularly in the dredging soil that was used as fill and foundations for the riverbank built between 1950 and 1953. In addition, archaeological layers reached during canalisation of the right bank were divided into a section sent to other Belgian cities with another part kept for urban development (see Hoc et al., 1960: 312). Dredging operations also led to displacement of archaeological layers (see Hoc et al., 1960: 312). While those levels and their associated heritage were not actively nor entirely destroyed, they were displaced, becoming archaeological layers “out of place” (after Douglas, 2002).

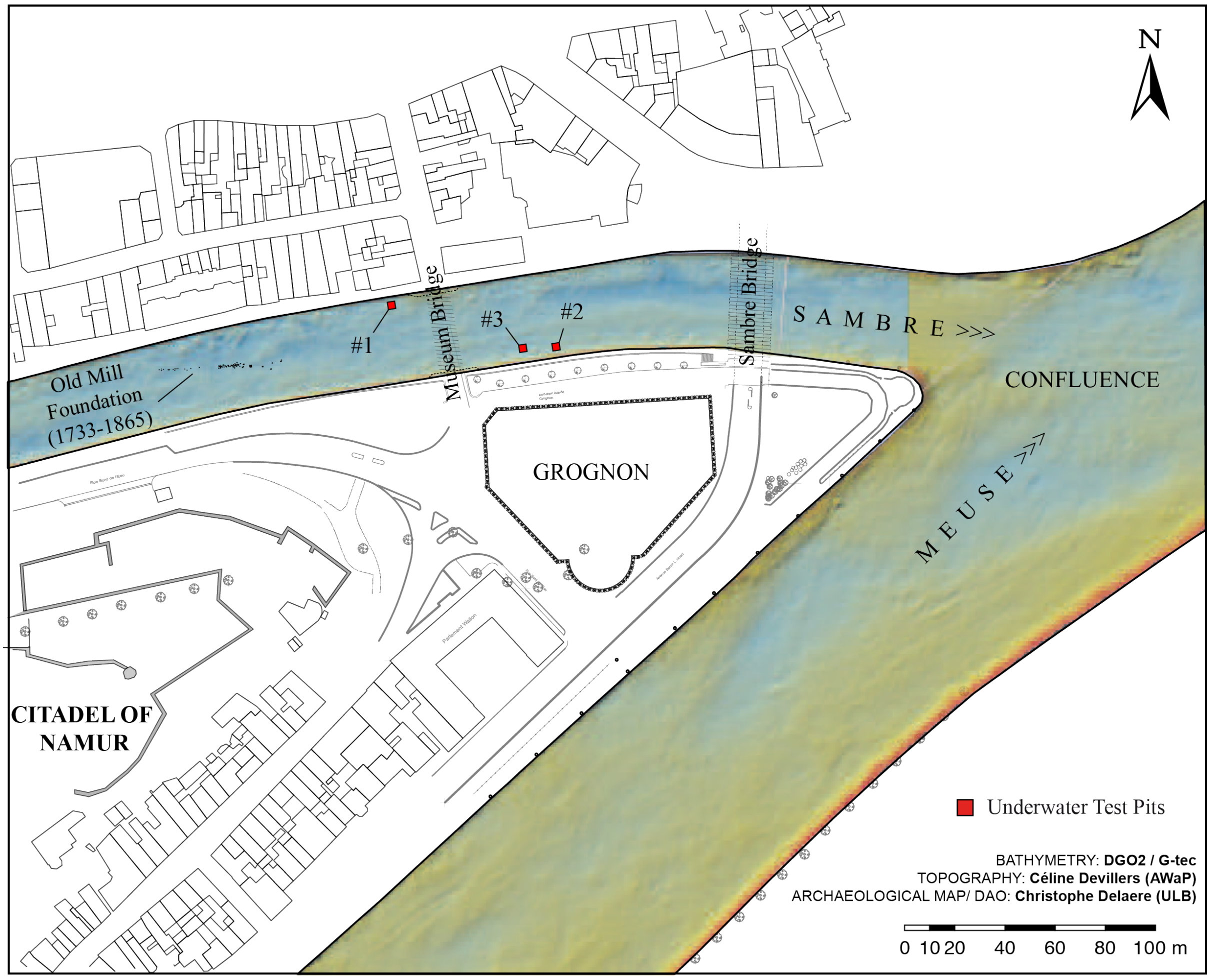

Figure 2: Bathymetric map of the Sambre and the Meuse (maximum depth: 5 m / DGO2, G-tec) at the confluence point of the two rivers in Namur on the Grognon site (Namur Province, Belgium) with the location of underwater archaeological test pits (#) excavated for 12 days in 2017 in the river Sambre, representing a total of 62 immersions and 79 hours of cumulative diving for a total excavation area of 12 m^2.

Therefore, by the beginning of the twenty-first century, the majority of the underwater river heritage at Namur had probably been displaced or destroyed by two centuries of canalisation, dredging and recovery of the remains by the city's inhabitants. The displacement of the dredging waste nuances this approach, because it is probable that a part of the sediments and the heritage are still preserved today, but elsewhere. The essential point here, however, is that this successive removal of sediments (and artefacts) over the last two centuries has left a void at the bottom of the river, which has gradually restarted a process of sedimentation and deposition of testimonies of daily life since the second half of the nineteenth century, regularly disturbed by new dredging operations. The supermodern society (in the sense developed by González-Ruibal 2018) has eventually displaced or even destroyed this heritage from the riverbed but, in return, has left its own heritage, one that includes plastics. Beyond acting as chronological markers for the different layers containing plastic, dredging events of the river show how human activities have physically shaped the riverbed. These modifications in the nineteenth and twentieth century have removed earlier archaeological evidence of the river's usage, with its layers of the riverbed and sediments now providing archives only for the most recent assemblages.

Plastic assemblages in riverine contexts

We here focus on plastic items found in the upper layers of the excavation undertaken in 2017 in la Sambre, a river flowing through the city of Namur, Belgium. All three sectors excavated yielded plastic items with Test Pit 1 (TP1) providing more than 60% of the plastic found. Just over 100 plastic artefacts were found across the three areas. TP1 was located on the left riverbank west of the Museum Bridge while TP2 and TP3 were placed east of it on the right riverbank of the Sambre (Figure 2).

Test Pit 1 (TP1)

TP1 saw the accumulation of sediments of 190 cm thickness separated in five major stratigraphic units after the dredging of the river in 1859 of which traces of the mechanical shovel are still visible on the riverbed rock (Figure 3). Units 4 and 6 contain less material culture and only six plastic artefacts, potentially dating before the 1940s-1950s when a second and third dredging occurred (Units 3 and 5). Units 1 and 2 are associated with the accumulation of sediments in the riverbed after the second canalisation of the Sambre from 1950-1953 and show an increase in the quantity of material culture reflected in the numbers of plastic artefacts recovered. Only Unit 3 did not yield material culture and constitutes a level associated with a dredging event (with evidence of shale fragments as waste from the dredging) (Table 1).

Table 1: Number of artefacts and plastic artefacts for each test pit. Most of the plastic artefacts are from Units 1 and 2 (After AD 1950-1953), but a few rare artefacts – or simple polymers - were found in Units 4 and 6 of TP1 and TP2 and probably date from the 1930-1940s.

	TP1		**TP2**		**TP3**		**Interpretation**	
Units	Artefacts	Plastic	Artefacts	Plastic	Artefacts	Plastic	Lithology	Chronology
1	1102	38	801	5	430	20	Alluvial deposit	1953-2017
2	840	25	255	1	173	0	**Colluvium**	**1950-1953**
3	0	0	0	0	0	0	Dredging discharge	1950-1953
4	194	**4**	172	**1**	/	/	**Colluvium**	**1940-1950**
5	/	/	0	0	/	/	Dredging discharge	1930-1940
6	214	**2**	438	**6**	/	/	River-filling event	1859-1930
7	/	/	3	0	/	/	Riverbed	> AD 1859
	Bedrock		Bedrock					
Total	**2350**	**69**	**1669**	**13**	**603**	**20**		

Test Pit 2 (TP2)

TP2 includes an accumulation of sediments of 205 cm thickness divided into seven phases with the Units 6-7 interfacing at 155 cm depth in the Test Pit marking the 1859 dredging of the river followed by successive anthropic accumulations (Units 1, 2, 4, 6) (Figure 3). Several levels yielded no material culture and respectively correspond to modifications of the river in the form of dredging in ca. 1930-1940 (Unit 5) and in 1950-1953 (Unit 3) (Table 1). Plastic artefacts appear from Unit 6, estimated to date between 1859 and 1930, and their presence increases in Units 1 and 2 (Figure 3). Unit 7 corresponds to the original riverbed sediment and was probably never affected by dredging operations. The bedrock of the river was reached between 10 and 50 cm below the Units 6-7 interface, and the slope of the bedrock below the present dock (Figure 3) would indicate that older artefacts could still potentially be preserved in the lower levels of some parts of the river. Furthermore, the discovery of wooden piles west of the Museum Bridge belonging to a mill that was destroyed by fire in 1865 (Figure 2) also informs us that the first dredging of 1859 was the most destructive (the deepest), as older remains were recorded on the riverbed. The mill was indeed still present at the time of the 1859 dredging, and the building preserved some of the sediment and archaeological heritage that had been lost in other parts of the river.

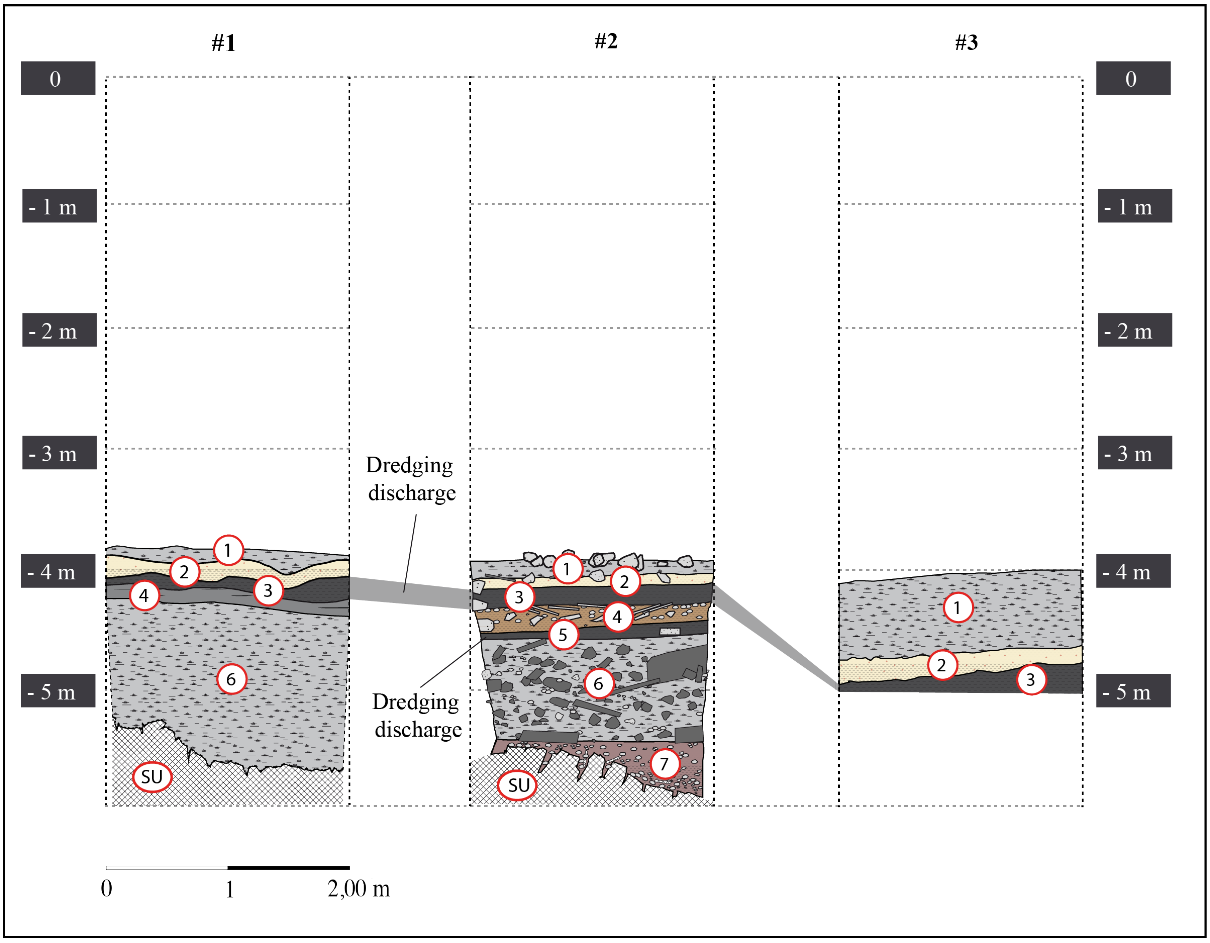

Figure 3: Composite archaeological transect of underwater archaeological test pits (#) excavated at the river Sambre site with their respective depth values below the river level. In lithostratigraphic profiles, the stratigraphic units 1 and 7 refers to alluvial deposits (slow and constant natural sedimentary deposits), the stratigraphic unit 2 refer to the second canalisation of the river between 1950 and 1953, the stratigraphic units 3 and 5 refers to dredging discharge (slabs of dark grey schist), and the stratigraphic unit 6 refer to a river-filling event that followed a major transformation of the riverbed, probably after the first canalisation of the river in the mid-19th century. The primitive riverbed sediment (which has not undergone any anthropogenic modification) was reached in Unit 7 of TP2, which brings the depth to 4,5 m of the first dredging during channelization of the river in the mid-nineteenthth century. The bedrock was exposed in TP1 and TP2 (Substratum = SU). Most of the plastic artefacts are from Units 1 and 2 (After AD 1950-1953), but a few rare artefacts – or paleo-polymers - were found in Units 4 and 6 of TP1 and TP2 and probably date from the 1930-1940s.

Test Pit 3 (TP3)

TP3 was only partially excavated to a depth of 105 cm revealing the presence of three levels. Plastic artefacts were only found in Unit 1, dated approximately between 1953 and 2017 after the river canalisation (1950-1953) noticeable in Unit 2.

Having reviewed the archaeological evidence from the excavations in the riverbed, and positioned these relative to the river's historical context, we will now examine the assemblage as a whole, with a view to revealing additional information about their use and thus demonstrate the archaeological potential of plastics to reveal new information both about the history of the river and its pollution. We will first explore the use of typologies to classify plastics and then adopt the object itinerary framework to gather more information about these artefacts.

A functional typology

Plastic artefacts recovered from the Sambre were first classified according to their proper function (described by Preston (2000: 23-29) as the function for which the object was designed). Function was determined based on the sector of activity where such plastic types were most commonly used. One of the challenges of determining plastic artefacts' function from an archaeological perspective is the omnipresence of this material in our daily lives and their high fragmentation. Highly fragmented materials that are not identifiable constitute the biggest category of our sample, under non-determined function (nf) (Figure 4). Clothing and drinking/eating are the main categories for all test pits. Without considering the nf category, TP1 is dominated by clothing and eating/drinking elements whereas TP2 is mostly associated with artefacts related to construction and transport and TP3 dominated by clothing items. This emphasis on daily life artefacts in TP1 is probably linked to it being on the left riverbank which is oriented towards the downtown area and whose survey is located in front of the backhouse of the old haberdashery and hosiery *Depommier* located at 5 rue des Brasseurs, whereas TP2 located on the right riverbank reflects more events related to the destruction of the historic neighbourhood Le Grognon destroyed between 1968 and 1972; TP3 is located near the base of the bridge on the left bank almost opposite TP1.

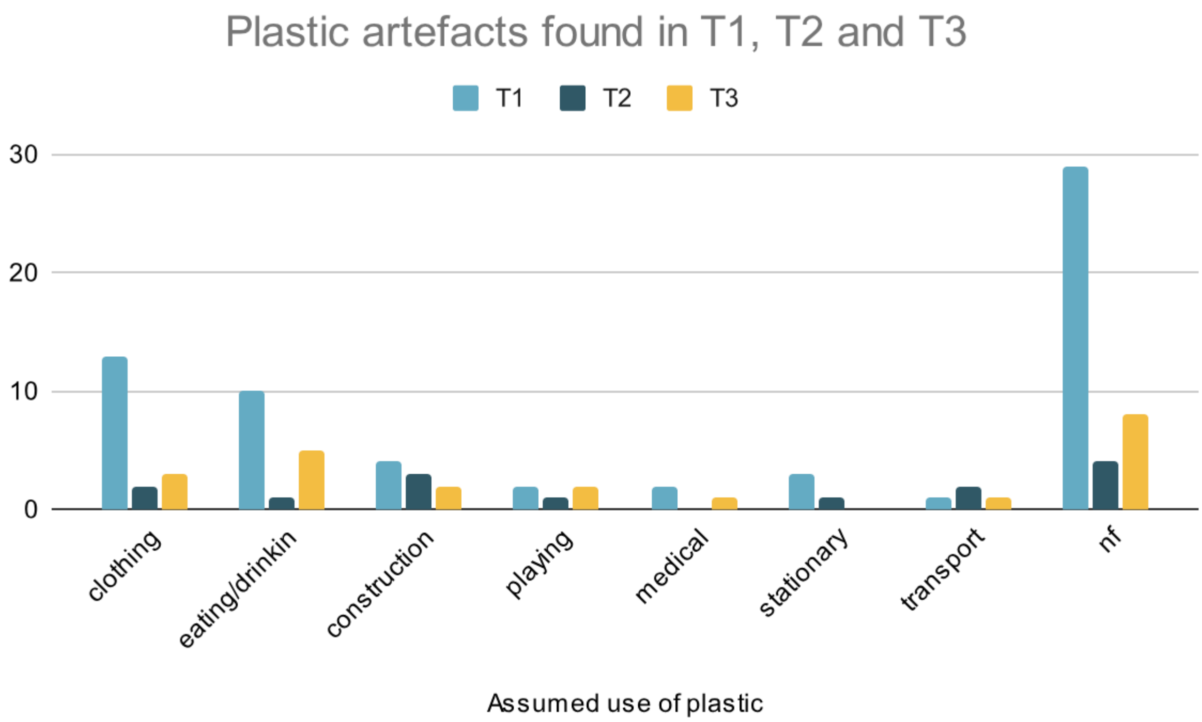

Figure 4: Assumed function of plastic artefacts found in TP1, TP2 and TP3 during the 2017 campaign in the Sambre.

A *chronological* typology

The use of plastic as a chronological indicator might also yield more refined chronologies for a context experiencing a rapid modification of the environment through sedimentation of the riverbed. Quick sedimentation processes have been identified in archaeological studies, for example of the dredging events of Portus (Rome) in Antiquity (Lisé-Pronovost et al., 2019). Lisé-Pronovost et al. (2019) used a set of different methods (magnetic, physical and mineralogical) applied to core samples to refine the chronological understanding of human-environment interactions in the harbour.

Plastic artefacts here give a better perspective on the chronology of the test pits, as well as contributing to the understanding of activities happening along the river banks explored in the previous typology. Even if short, the history of plastics provides information that can act as potential chronological markers. After the invention of the first synthetic man-made plastic, more commonly known as Bakelite in 1907, a series of synthetic polymers were developed and their diversity increased through the use of additives (e.g. the use of phthalate as a plasticizer allowed PVC to be more flexible and softer, see Geyer, 2020: 32; see Stewart, this volume). The potential of plastic as a chronological marker has mostly been considered in a quantitative way, with studies noting the higher abundance of microplastics found in the more recent upper levels of sediment cores compared to the deeper (more ancient) levels (e.g. Matsugama et al., 2017; Li et al., 2020). While this difference has been interpreted as a reflection of the boom of plastic production and use, little has been done qualitatively to understand the shift in plastic types and the different uses they might reflect.

Our samples reflect a similar trend across all trenches: plastic artefacts become more abundant through time. They are mostly associated with two periods: 1950-2017 (Units 1, 2) and 1859-1940 (Units 4, 6). Due to few plastic artefacts being found for the second period, we raise the question of intrusive materials and argue that further chemical analysis of plastics and additives can yield a more precise chronology. For example, plastics produced before the 1950s could only correspond to a handful of plastic chemical types such as Bakelite and PVC, a production (Units 4 and 6; first half of the twentieth century) that we can classify at this point as simple polymers, in opposition to later plastic artefacts with a more complicated chemical signature due to additives (Units 1, 2; second half of the twentieth century).

Itineraries of plastic artefacts from the Sambre

With developments of post-processual and feminist archaeology (e.g. Webmoor, 2008; Tringham, 1991), a different perspective on material culture was explored in archaeology contesting subject/object dualism during the material-cultural turn (Hicks, 2010). The assumed similarity between the life stages of animate and inanimate beings, including birth, life and death, served as a basis to broaden our understanding of material culture through the concept of object biographies. The concept was first developed in anthropology by Kopytoff (1986) and rapidly adopted in archaeology (Gosden and Marshall, 1999; Joy, 2009). Despite its popularity (e.g. Mytum, 2003-2004; Pearson and Connah, 2013; Meirion Jones et al., 2016), the concept was quickly at the centre of critiques. Joyce (2015: 21-22), amongst others, noted that it was not escaping the subject/object dualism by being very anthropocentric and did not recognise the multiple lives of objects. To address those limitations, Joyce (2015) proposed the term of object itineraries allowing for a recognition of the temporal and spatial aspects of objects' journeys. Object itineraries transcend the personification inherent to the biographical stages (existing because of human action) to consider the entanglement between objects and people without establishing the birth and death of the object as starting and end points (Joyce, 2015: 26-29).

The concept of object itinerary will here be applied to a selection of four artefacts (Figure 5), reflecting on the amount of information they hold and serve as a basis to offer a reflection on the spatial and temporal aspect of their journey.

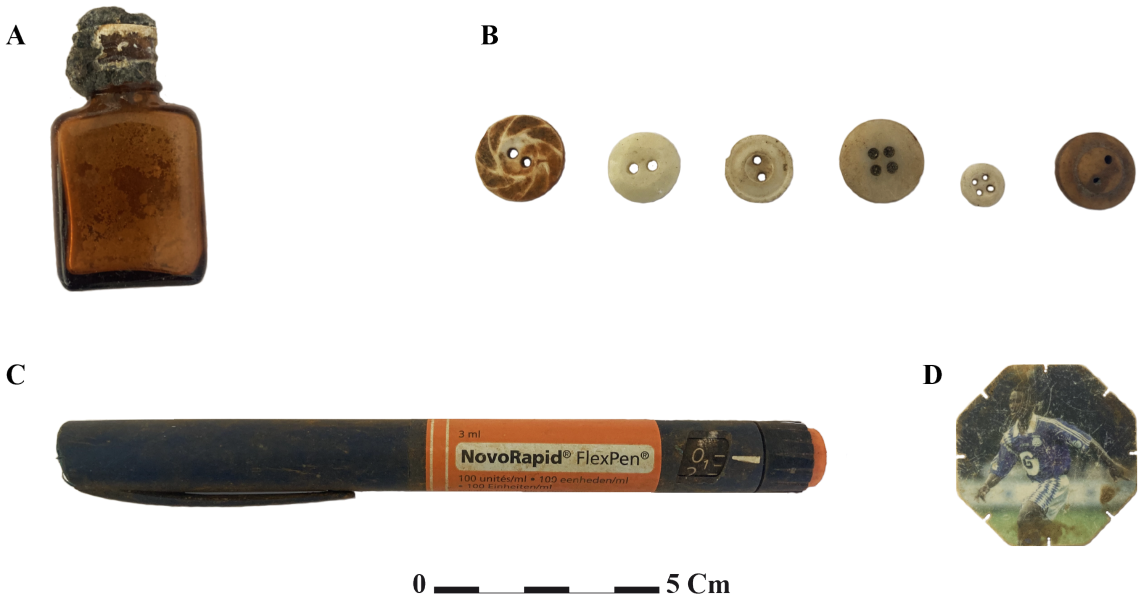

Figure 5: Selection of artefacts from 2017 excavations in the Sambre a) apothecary phial, b) buttons, c) flexpen, d) flippo.

An apothecary phial with a degraded tap was found in TP1 Unit 6 (dated between 1920-1940). It contains an inscription of "Roche 108" and the content seems to be a white powder. The phial is from the Roche company founded in 1896 that had expanded in Europe and beyond by 1914 (https://www.roche.com/about/history). The archival team of the Roche company advised us that this phial most likely contained the barbiturate sleeping agent Allonal first introduced in the early 1920s until shortly after the Second World War (Bieri 2022, pers. com.). The filling of the phial was made locally and the composition of the lid might have been metal or bakelite, the former being in use until the late 1920s when it was replaced by the latter (Bieri 2022, pers. com.). This artefact illustrates how plastics rapidly replaced other materials in daily objects.

A novorapid flexpen of 3 ml was also found in TP1 level 1. This unused object contains various items of information, such as the expiry date (10/2018) and a lot number (GP52115). Produced by the Danish company Novo Nordisk, this flexpen contains insulin aspart and is used by diabetic patients. While pharmaceutical traceability, especially in hospitals, has become a major component of modern medicine (Rozenbaum, 2013), the only information available was for the sale of the product between May and June 2017 in Belgium (Roelandt 2022, pers. com.).

A flippo topshot sponsored by the Banque Générale (now ING in Belgium) with football player Celestine Babayaro playing for Anderlecht was found in TP1 (Units 2-3). Received with Croky crisps or Sultanas biscuits, these topshots were collected and exchanged, often by children. As Celestine Babayaro was a player of the Anderlecht team between 1994 and 1997, we know that this flippo must have been produced within this timeframe and discarded not earlier than 1994.

Buttons were found in different levels and units: TP1 and TP2 (Units 1 and 2), TP3 (Unit 1). The history of buttons, first considered as an element of jewellery carefully chosen, changed after the Second World War when ready-to-wear clothing became dominant in the market leaving little space for originality and uniqueness (Meredith and Meredith, 2004: 16). Buttons can be made of a diversity of materials (including glass, bone, ceramic, metal). The shift in material production through the use of synthetic plastics did not spare buttons that were quickly made of bakelite, and then of other plastic types that are often difficult to identify without further analysis (Meredith & Meredith, 2004: 76, 107). The robustness of the material, contrasting with other materials (e.g. ceramics), led to their dominance of the button industry by the 1950s-1960s (Sprague, 2002: 115). The diversity and handcrafted nature of buttons until the twentieth century constitutes an advantage for their use to create typologies and infer chronologies when found in archaeological contexts (e.g. Venovcevs, 2013). Differences in button manufacture go beyond their material components. They have different sizes, shapes, decor and often different numbers of holes. Our sample consists of six buttons (Table 2) found in the upper layers of the three trenches all more likely to be later in date than 1950. This corresponds to the industrial manufacture of buttons, mostly made of plastic. More recent buttons present little originality compared with older non plastic buttons that were conceived as an ornament to the garment instead of a simple functional addition.

Table 2: Categories of buttons

Button	Size	Holes	Colour
N°1	Big	2	white/brown
N°2	Medium	2	white
N°3	Medium	2	white
N°4	Big	4	white
N°5	Small	4	white
N°6	Big	2	brown

While the first two objects were made of a series of different materials including plastic, the flippo and buttons are entirely made of plastic. The concept of object itinerary allows us to consider the different steps that contributed to the production of these objects and also their arrival in the archaeological record. When it comes to the production of plastic, as a material issued from the decay of organic matter trapped in the soil for millions of years, the process can be transnational and illustrates globalisation, as in the study of a flip flop's journey from Kuwait to China, Korea and then Ethiopia by Knowles (2015). In this case, the local nature of the flippo and the flexpen commercialised in Belgium contrasts with the difficulty to trace back the origin of the buttons and the phial. The latter could also have been sold in Belgium depending on the exact production date as Roche was a company that had quickly expanded by 1914. At some point, the objects entered the river, either accidentally or voluntarily. There are different potential sources, from activities on the river banks to others on the water. While none of these objects has a use directly related to waterway transport, that does not exclude them to be items lost by boat staff while travelling on the Sambre. The captain of a barge might have been diabetic and accidentally lost his flexpen while a child playing with the flippo might have thrown it a bit too hard, leading it to land in the river. It is everyday actions like these that create the archaeological record. Additionally, with contemporary archaeology, most objects reflect daily local life, which could be used to raise awareness of the impact of our own behaviour on the environment. A similar initiative has been created by @Raf-sur-Seine on Instagram who retrieved metallic objects from the Seine in Paris through the use of a magnet and exposed them in a pop-up museum along the river's course. These itineraries help people to visualise human impacts on waterways, even those of sinking plastics.

Plastic pollution as an indicator of anthropogenic change

A series of anthropogenic changes have marked river systems across the globe. Their exploitation as a source of minerals led to chemical contamination, documented historically through waste-water discharge entwined with colonial dynamics in the case of gold-digging practices in the province of Victoria, Australia (Lawrence et al., 2016). Beyond their use as a resource, the energy of rivers has also been redirected to improve consistency and volume of transport and trade, especially since the industrial period. Those goals have led to a series of anthropogenic modifications, which are visible in the archaeological record. Dredging has an effect on the environment, sometimes leading to irreversible consequences with a riverbed unable to return to its original morphology (Gob et al., 2005), but also impacts the heritage of the river. In this case, the Roman occupation of the site, and its associated material culture, were disturbed, perhaps even destroyed. This destruction is an inherent part of the supermodern world as defined by González-Ruibal (2008). In that sense, plastics are the supermodern material by definition crystallising production, consumption and the destruction of previous heritage. Plastic pollution is here considered an archaeological signature of anthropogenic change on rivers in a similar way to the consideration of mining colonial practices and their impacts on rivers (Lawrence et al., 2016).

This study documents the global pollution of inland waterways through time, beyond the visible macroplastics washing on the shorelines. Inland waterways play an important role as one of the major entryways of plastic pollution into the marine environment (Lebreton et al., 2017). Through aggregation processes, plastics can sink and settle in the sediment or float and be carried downstream towards the sea (Yan et al., 2021: 701). Several studies that analysed microplastic pollution in sediments have found it to be higher than in surface water (e.g. Matsugama et al., 2017; Zhang et al., 2018 in rural areas). While our study solely accounts for macroplastics (the smallest mesh size for sieving as 1 cm, letting microplastics <5 mm escape), the project as a whole emphasises the importance of archaeological methods to document the impact of human activities on inland waterways through time, with plastics constituting one of the most recent additions.

The focus on several specific and relatable artefacts holds the potential to understand and render visible to everyone the plastic pollution of the riverbed (in much the same way as Raf-sur-Seine's pop-up museum in Paris). Studies have shown that submerged items in rivers are unseen yet actively contribute to plastic pollution at sea (Morrit et al., 2014). The identification of plastics also provides a clear example of the impact of our behaviours on the environment and their continuation (if not always their accumulation) over time. The Sambre has yielded archaeological layers with evidence of occupation since the Mesolithic. But since the industrial period, the lost or discarded objects have had a higher impact on the environment through their increased abundance and toxic nature (of plastics and their additives, see Stewart this volume). From that perspective, the presence of plastics in the environment poses a physical and chemical threat through their respective breaking down into microplastics and release of chemical additives. The focus on plastics offers a way to address a diversity of practices contributing to the pollution of the river. Whether this pollution is the result of accidental or intentional actions, the result is the same, an increasing omnipresence of sinking macroplastics that will gradually break down into equally (if not more harmful) micro- and nano plastics. While we recognise the small sample size, this chapter offers a new interpretative framework, one in which archaeology makes the issue of plastic pollution visible by retrieving these objects that sank and re-creating their itineraries that are intertwined with our daily behaviours.

Conclusion

Consumer waste in the form of throwaway plastics is now characteristic of the natural and cultural landscape. In the western world, the discarded waste is today often sorted and recovered by urban authorities for recycling or exported to other parts of the world. But one context in particular escapes this process: the aquatic environment and inland waters in general. Water bodies and rivers hide a secret universe, except for the divers, to whom a whole plastic world is revealed, not only floating within the water column, but also in the underlying levels of the sedimentary substrates. Faced with this observation and using the techniques and methods of inland water archaeology, we explored this contemporary material culture to identify plastic pollution as another anthropic impact on the Sambre dated thanks to the record of several invasive modifications of the riverbed for international transport. We also proposed a general reflection within the discipline of contemporary archaeology by developing new concepts and exploring analytical trajectories. This information, hidden in the stratigraphy, presents a unique archive for archaeologists to understand the less visible anthropic pressures on rivers through time. We hope that future studies will build on the indicative framework of this study to explore the plastic world that enters archaeological contexts both on land and underwater.

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By signing this Statement of Authorship, each co-author agrees that:
(i) the candidate has accurately represented their contribution to the work;
(ii) if required, permission is granted for the candidate to include the work in their thesis (note that this is separate from copyright considerations).

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**The description of the candidate and co-authors contribution to the work may be framed in a manner appropriate to the area of research but should always include reference to key elements (e.g. for laboratory-based research this might include formulation of ideas, design of methodology, experimental work, data analysis and presentation, writing). Candidates and co-authors may find it helpful to consider the CRediT (Contributor Roles Taxonomy) approach to recognising individual author contributions.

Chapter 4 - Bottle with a message: The role of story writing as an engagement tool to explore children's perceptions of marine plastic litter

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Abstract

As human behaviors play a crucial role in addressing the global threat of plastic pollution, it is vital to understand perceptions about marine plastic litter (MPL) and to develop interventions encouraging pro-environmental behaviors (PEBs). This study evaluates story writing as a window to explore perceptions and as an engagement activity to boost PEBs. During the COVID-19 lockdowns, schoolchildren from the East Pacific coast participated in this activity, each creating a story and answering a pre-post survey. Qualitative and quantitative analysis of 81 stories and 79 surveys show awareness of sources and impacts. Participants identified land and local pollution as significant contributors to MPL and emphasized bio-ecological impacts, reflecting concern for landscape and wildlife. While the stories presented a diversity of solutions, recycling dominated the surveys. As participants reported an increase in self-assessed knowledge and improved PEBs after this activity, it can be seen as an engagement tool to encourage behavior change.

Keywords

marine plastic litter, engagement, object itineraries, story writing, surveys, pro-environmental behaviors, recycling

Introduction

Marine plastic litter (MPL) presents a global challenge that is deeply linked to human behaviors. Whether land- or ocean-based, all litter share a common interaction with humans (Sheavly and Register, 2007). At individual, industrial or governmental level, decisions are made by humans who (in)directly and (in)voluntarily contribute to the issue of MPL. This complex issue poses a global threat to our societies and to the environment (MacLeod et al., 2021). To better address this issue, it is important to understand the sources and impacts of MPL in order to help design solutions. While marine biology, environmental and policy studies can help evaluate different aspects of MPL, behavioral sciences have long emphasized the importance of how people perceive and consequently act towards plastic litter (Pahl and Wyles, 2017).

Despite its importance, the theoretical framework behind the term "perception" is almost never described in MPL studies where it is often used to refer to public (e.g. Hartley et al., 2018) or to risk perceptions (e. g. Oturai et al., 2022). We here follow Brewer (2011) in considering perceptions as conscious acquaintances of physical objects that vary according to the perceiver's circumstances and their point of view. Perceptions of MPL by the public are then defined by a series of interactions with the environment, local context and societal beliefs among other things (see Tuan, 1974 for the impact of culture and environment on perceptions; see Wolf and Moser, 2011 for an example of these influences in perceptions of climate change). In this paper, perceptions are differentiated from knowledge (understanding of the facts) and awareness of the issue (consciousness of its existence). While someone might be *aware* that plastic pollution is an issue, they do not necessarily *know* where MPL comes from but still have *perceptions* of the sources by looking at an object or the surrounding environment, even if those perceptions can be misconceptions (see La Fuente et al., 2022 for misconceptions of plastic types). We acknowledge that perceptions can contribute to epistemological processes (see Cassam, 2008 for a discussion on perception as a source of knowledge) but acquisition of knowledge relies on other elements (see Brewer, 2011, Chapter 6). Along with their importance to tackle plastic pollution, the variation in perceptions of MPL has probably contributed to a recent interest in studying them through surveys (e.g. Forleo and Romagnoli, 2021; Soares et al., 2021), questionnaires and interviews (e.g. Rayon-Viña et al., 2018; Van Rensburg et al.,

2020) or as part of wider engagement activities (e.g. Rayon-Viña et al., 2019; Oturai et al., 2022).

Several activities have been designed to evaluate perceptions along with knowledge of MPL while also acting as engagement tools on the topic. For example, some environmental education projects aim at improving the understanding of the local context (Hartley et al., 2015; Owens, 2018; Locritani et al., 2019; Salazar et al., 2022). Citizen Science (CS) projects (i.e. collaborations with non-professional scientists such as children engaging in science) have been shown to improve perceptions of sources and impacts of plastic pollution, often leading to increased concern for the issue (e.g. Locritani et al., 2019) in addition to contributing to data collection (e.g. Hidalgo-Ruz and Thiel, 2015). As a more hands-on experience, beach clean-ups have allowed participants to become familiar with the bio-ecological impacts of MPL. Such activities appear as good tools to improve local perceptions of MPL while encouraging people to take action (Rayon-Viña et al., 2019).

The frequency of participation might also influence perceptions with recurrent participants showing higher levels of concern for the issue of plastic pollution (e.g. Oturai et al., 2022). Independently of factors leading individuals to participate in beach clean-ups (e.g. socio-cultural context in Rapa Nui in Kiessling et al., 2017; previous participation and feeling of collective responsibility in Lucrezi and Digun-Aweto, 2020; socio-demographic and travel characteristics in Adam, 2021), participation seems to boost marine awareness, environmentally responsible intentions (Wyles et al., 2017) and behaviors (Owens, 2018). While activities can contribute to approach and improve perceptions of MPL's sources and impacts, they can also present solutions to the issue and encourage participants to take action. Other activities share a focus for driving change in human behaviors, as a solution to MPL. For example, communication, educational and information campaigns try to raise awareness (Belontz et al., 2018) and eventually influence human behaviors to reduce, reuse and recycle (3R's campaigns), and to not litter (e.g. Rayon-Viña et al., 2019).

While the issue is complex, all aspects of MPL including sources, impacts and solutions can be better understood through the itineraries of littered objects. A focus on macroplastics makes the issue more tangible, and contributes to engaging the public on this topic, about which they feel less informed than microplastics (Frias and Nash, 2020).

Investigating the larger objects through an archaeological lens, as artifacts (e.g. Schofield et al., 2020), can help understand the behaviors leading to their disposal and dispersal, for example by looking closely at details of each object (e.g. labels and weathering) and acknowledging the impacts it might have if it remains within the environment. The objects also serve as a basis to think about potential alternatives and solutions in design and materials. Everybody can relate to these often familiar plastic objects yet people's perceptions of them will vary. While these perceptions can be multi-sensorial (see Tuan, 1974), we focus here on visual perceptions that emerge on seeing either the object or a picture of it. By considering MPL as material culture (as artifacts) representing behaviors from the recent and contemporary past (e.g. Harrison and Schofield, 2010), stories can be created from the objects' characteristics that compose their unique itineraries. The concept of object itinerary was proposed by Joyce and Gillespie (2015) to consider the journey that archaeological artifacts take over time and the set of relationships they weave with humans and non-humans along the way. The geographical component of MPL journeys as well as their temporality outliving humans (especially as waste) makes the framework of object itineraries (Joyce, 2015) particularly relevant to address MPL.

Considering plastics as artifacts, each with its individual itinerary, allows for the visual identification of elements informing the different processes that each artifact has been subjected to, from production to use and disposal. Some elements of the object itinerary will remain unknown, yet those gray areas can still become an active part of the object itinerary through speculative or creative fiction. Creating fictional stories based on elements that belong within the object itineraries can help their authors to reflect on the plastic pollution problem. Inspired from behavioral sciences, story-telling and writing have been adopted as a method to engage people more efficiently (Moitra, 2014), connect them to their environment (Fanini and Fahd, 2009), and help them to reflect on their behaviors (Schofield et al., 2020). Several studies have confirmed the potential of creating stories based on artifacts (e.g. Aerila et al., 2016), including plastic waste (e.g. Schofield et al., 2020; McKay et al., 2021).

The use of stories to reconstruct an object itinerary of MPL has been proposed and later trialed by Schofield et al. (2020) in Galapagos in 2018. In that earlier study, adults were asked six questions in order to develop a story for a number of pre-selected MPL items (e.g.

a child's shoe, a bottle with a toothbrush in it, the torso of a doll) regarding the origin, use, and journey of the object, as well as human behaviors that either provoked this outcome or could have prevented it from happening. By developing hypothetical stories built around evidence derived from examining each object (e.g. lettering and date stamps as well as the physical appearance of stranded plastic litter, such as fragmentation, evidence of biofouling, exposure to the sun), participants did come to recognise that human behaviors are at the root of plastic pollution (Schofield et al., 2020). Thus, these stories can help to identify and understand those human behaviors and thereby contribute to mitigating or reducing pollution.

In addition to providing an engaging activity for participants to reflect on MPL, stories can be analyzed for what their content reveals about the beliefs of their authors (Savin-Baden and Howell-Major, 2013, Chapter 19). While knowledge and perceptions of MPL were traditionally evaluated through surveys (e.g. Forleo and Romagnoli, 2021; Krelling et al., 2017), other methods such as story writing can generate a richness of data (see open-ended questions in Pearson et al., 2014) that can complement these traditional surveys. Stories can therefore be an innovative way to portray perceptions, and whilst they were not designed to provide a comprehensive record of the participants' perceptions of MPL, they can provide insight into some of their views about this global socio-environmental issue. Beyond what the content of the stories tells us about meaning and beliefs, the potential of activities with plastic waste was noted by McKay et al. (2021, p241) who organized a workshop of art-making and story-telling with plastic waste, considered by participants to be “enabling”. While story-telling has therefore proved useful for participants to reflect on plastic waste, the potential of individually writing stories about MPL objects has not yet been explored.

An audience particularly keen on creating stories are children (Aerila and Rönkkö, 2015). Several studies have shown the potential of writing for children to share their experiences in an open manner through narratives (Foster, 2017) and to process information in a different way by creating stories (Aerila et al., 2016). Aside from being a powerful tool in education and various forms of therapy, the content of stories can also serve as a basis for analysis to better understand how children express their experiences (e.g. trauma in Foster, 2017) and their perceptions of the world around them (e.g. through artifacts and historic sites in Aerila et al., 2016). On the topic of MPL, schoolchildren's perceptions have been scarcely explored (e.g. Rayon-Viña et al., 2019) despite being a particularly interesting audience with high levels of environmental concern (i.e. an inquietude for the surrounding environment) and awareness of plastic litter (Oturai et al., 2022; Wichmann et al., 2022). Children also share a sense of responsibility (i.e. a sense of obligation to resolving the issue of plastic pollution), which seems correlated to the adoption of pro-environmental behaviors (PEBs) (defined as "behaviors that consciously seek to minimize the negative impact of one's actions on the natural and built world", after Kollmuss and Agyeman, 2002, 240; see also Jensen, 2002 for problems associated with the use of this concept) (Benyamin et al., 2018; Bettencourt et al., 2021). In addition to their awareness, concern and sense of responsibility, children can positively influence peers, family members and the broader community (Hartley et al., 2015; Salazar et al., 2022) while being careful observers of their environment, especially noticing litter in natural settings (De Veer et al., 2022).

The story-writing activity, conceived as an engagement tool and a way to explore perceptions of MPL sources, impacts and solutions in stories, was undertaken with schoolchildren from the Latin AmericanCountries (LAC) along the East Pacific Coast. In the region, MPL mainly comes from local land sources (Silva-Íñiguez and Fischer, 2003; Hidalgo-Ruiz et al., 2018; Honorato-Zimmer et al., 2019; Gaibor et al., 2020; Garces-Ordóñez et al., 2020a). The main economic activities generating MPL in the region are tourism (Williams et al., 2016), as well as fishing and aquaculture (Ribic et al., 2012; Van Gennip et al., 2019), which are fundamental activities for the economy of these countries (e.g. Chuenpagdee et al., 2011; Chevallier et al., 2021). As elsewhere, MPL has impacts on wildlife in the region (e.g. Thiel et al., 2018) with emblematic marine species threatened (e.g. sea turtles in Geary, 2019). It also affects marine ecosystems with high importance for conservation (e.g. Luna-Jorquera et al., 2019), tourism (Krelling et al., 2017) and other coastal activities (Rodríguez et al., 2020). Regional solutions to MPL include a series of measures such as policies to limit single-use plastics (Amenábar Cristi et al., 2020; Ortiz et al., 2020), fines for litterers and environmental education (Eastman et al., 2013) and better waste management systems (Valerio et al., 2020), although there is little recognition of the informal reuse of plastic waste through scavenging (Brooks et al., 2020; Medina, 2015).

While the region's sources and impacts of MPL have been widely investigated (e.g. Alfaro-Núñez et al., 2021; Gaibor et al., 2020; Garcés-Ordóñez et al., 2020a, 2020b;

Honorato-Zimmer et al., 2019; Thiel et al., 2018, 2021), only a handful of studies have investigated educational activities on the topic (e.g. Hidalgo-Ruz and Thiel, 2015; Wichmann et al., 2022) with one study evaluating children's perceptions of litter in urban and rural environments (De Veer et al., 2022). The present paper contributes to the gap of studies investigating education initiatives around MPL in Latin America (Bettencourt et al., 2021) by evaluating if a story-writing activity involving the itineraries of plastic artifacts acts as an effective engagement tool and as a window to explore local perceptions.

Methods

To explore schoolchildren's perceptions of MPL's origins, impacts and solutions and to create an engaging activity in the context of the Pandemic, we designed the project “My Story of Plastic Litter: a Journey to the Ocean” and shared it through the Latin American Network of Litter Scientists (Red de Científicos de la Basura – ReCiBa). Since 2018, the CS program ReCiBa has brought together scientists, teachers and schoolchildren (10 to 18 years old) from LAC of the Pacific Coast to generate scientific data about litter sources, distribution and impacts, and use scientific environmental education as a marine conservation strategy. ReCiBa currently works with around 800 students from different schools in the region. While most schools have participated since the first collaborative research in 2018, new schools (and/or schoolchildren) join the network each semester. So far, ReCiBa has conducted an environmental exploration (Second Semester 2018; see De Veer et al., 2022), a questionnaire survey of their local communities (First Semester 2019), and a sampling of litter interacting with biota (Second Semester 2019). For the purpose of this paper, schoolchildren will be referred to as participants of the study.

In 2020, during the global lockdowns that characterized the COVID-19 Pandemic, we sent a call to the ReCiBa network of teachers, gave an online presentation of the activity and distributed an outline of the “My Story of Plastic Litter” project to teachers interested with the dual aims of exploring elements stressed in stories written by schoolchildren on the Pacific Coast regarding MPL's sources, impacts and solutions, while providing an activity to engage with the topic when required to learn from home. The activity required participants to produce a story or a comic strip about the journey of a suggested plastic object (listed in

Appendix 1) and to answer two surveys, before and after the activity, to assess the impact of participation on their self-assessed knowledge. Activities were designed by the project team, comprising an interdisciplinary group composed of professionals in the field of marine biology, education, environmental psychology and archaeology.

The activity

Due to the Pandemic and local difficulties to access the internet, ReCiBa decided to undertake the activity through a mobile application that only required connectivity to download the story-writing instructions and the surveys, and then later upload the completed stories and surveys. The ReCiBa app guided the participants through the pro- cess by including: an informative video about the first survey, the first survey, an instruction video for the story-writing activity, a gallery with images of 26 MPL objects (previously collected by students participating in the 2019 litter sampling organized by ReCiBa; Appendix 1), a section into which they could write the story directly (or upload it as text or image), the second survey, and the parental consent. The different steps were clearly presented in the videos for the participants, and teachers were tasked to ensure that parental consent was obtained at the end of the submission to allow the analysis and publication of the stories online. Along with the ReCiBa team, teachers played an essential role to help the students use the app and to ensure access to the data. It should be noted that the remote nature of the activity makes it difficult to assess if adults helped during the creation of the stories. Yet, no story had a writing style that stood out as unlikely to be written by schoolchildren. To motivate the participants to write a story, the objects chosen were items commonly found on local beaches and recognizable as everyday items, such as a toothbrush, a plastic bag or a straw. We encouraged participants to choose an object among the gallery that can easily be found at home. They were then asked to create a story that would answer the following orienting questions in Spanish (after Schofield et al., 2020 who used these same questions to create a narrative with groups of adults and teenagers in Galapagos): (1) What is the object and where is it from? What is it made of? (2) How was it used and who used it? (3) How did it end up in the ocean? (4) How did it interact with marine life? (5) What was the consequence of this interaction? (6) What human actions or behaviors caused this outcome? What actions or behaviors may have prevented this outcome? These questions all refer to different aspects of an object's itinerary (as theorized by Joyce, 2015). Careful observation of the object might help answer those questions and fictional writing can fill those gaps to recreate the itinerary of the object from its origin (question 1) to its disposal (questions 2 and 3), leading participants to think about impacts (questions 4 and 5) and solutions (question 6). Building on those elements, participants could either write a story of 500 to 1000 words (following a structure with introduction, development and conclusion written either in first or third person), or draw a comic strip of 10 to 20 vignettes that would later be uploaded onto the project website. The stories themselves show a good understanding of the instructions by participants through the choice of an object from the gallery, the respect of the wordcount and the narrative structure present in most stories.

The surveys

To assess the effects of this activity on behavior and perception of the participants, a short questionnaire survey was administered via the app before and after the story task (Appendix 2). This included five groups of questions. First, standard demographics were reported (e.g. age, gender,country and distance to the coast). Second, the survey asked participants to state their self-assessed level of knowledge about MPL on a scale from 1 “I do not know very much” to 5 “I know a lot” (as previously used by Wyles et al., 2017). Third, participants were asked about their perceptions and experiences relating to MPL. This included stating their level of agreement (from 1 “strongly disagree” to 5 “strongly agree”) to statements about the impacts MPL can have (e.g. “It is common for wildlife to be harmed by marine plastic debris around the world”), their perceived behavioral control over the issue (e.g. “I know how I can reduce marine plastic waste”), and how important they find this issue (this was guided by theories of behavior, such as the Theory of Planned Behaviour, after Ajzen, 1985, and questions employed in previous surveys, e.g. Hartley et al., 2015 and Abate et al., 2020). Fourth, to examine self-reported behaviors, participants were asked how often they adopt certain behaviors, from picking up litter, to recycling (i.e. waste classification at home) and to encouraging others to act more sustainably, on a scale from 1 “never” to 5 “all of the time” (based on questions used by Hartley et al., 2015 and Wyles et al., 2017). Finally, participants were asked to name one thing they could do to prevent plastic litter from reaching the ocean.

The post-survey (Time 2-T2) asked the same questions as the pre- survey (Time 1-T1), but also asked additional feedback questions. Specifically, participants were asked to state how much they enjoyed the activity from 1 “I did not enjoy it at all” to 5 “I enjoyed it a lot”. They also stated their level of agreement (1 “strongly disagree” to 5 “strongly agree”) on whether they learnt something new about (a) the sources, (b) the impacts, and (c) the solutions for marine plastic pollution; and whether they would encourage others to engage in the activity.

Recruitment and participation

In the first contact phase, the ReCiBa coordination team invited 44 teachers and over 570 schoolchildren from 11 countries. Teachers had a training session on 22 October 2020 and participants submitted stories between November and December 2020. In total, 89 children participated in some aspect of the exercise. The data were considered only if participants had given consent for analysis (N = 84). Besides, surveys were only analyzed when complete (N = 79) and stories when they followed a narrative structure (N 81) (i.e. telling a fictional story with elements regarding characters, events and setting). Overall, participants in the activity were aged between 10 and 18 (13.78 ± 2.50, mean std), with more participation from female students (59 %) and from those who lived close to the sea (53 % lived within 10 km of the sea). They came from different schools in the following countries on the East Pacific Coast: Chile, Colombia, Costa Rica, Ecuador, Mexico, Panama and Peru (Fig. 1). The project was conducted during the period of the global COVID-19 Pandemic and this exercise was designed and timed to give schoolchildren in this region an activity to engage with while the schools were closed and they were experiencing isolation.

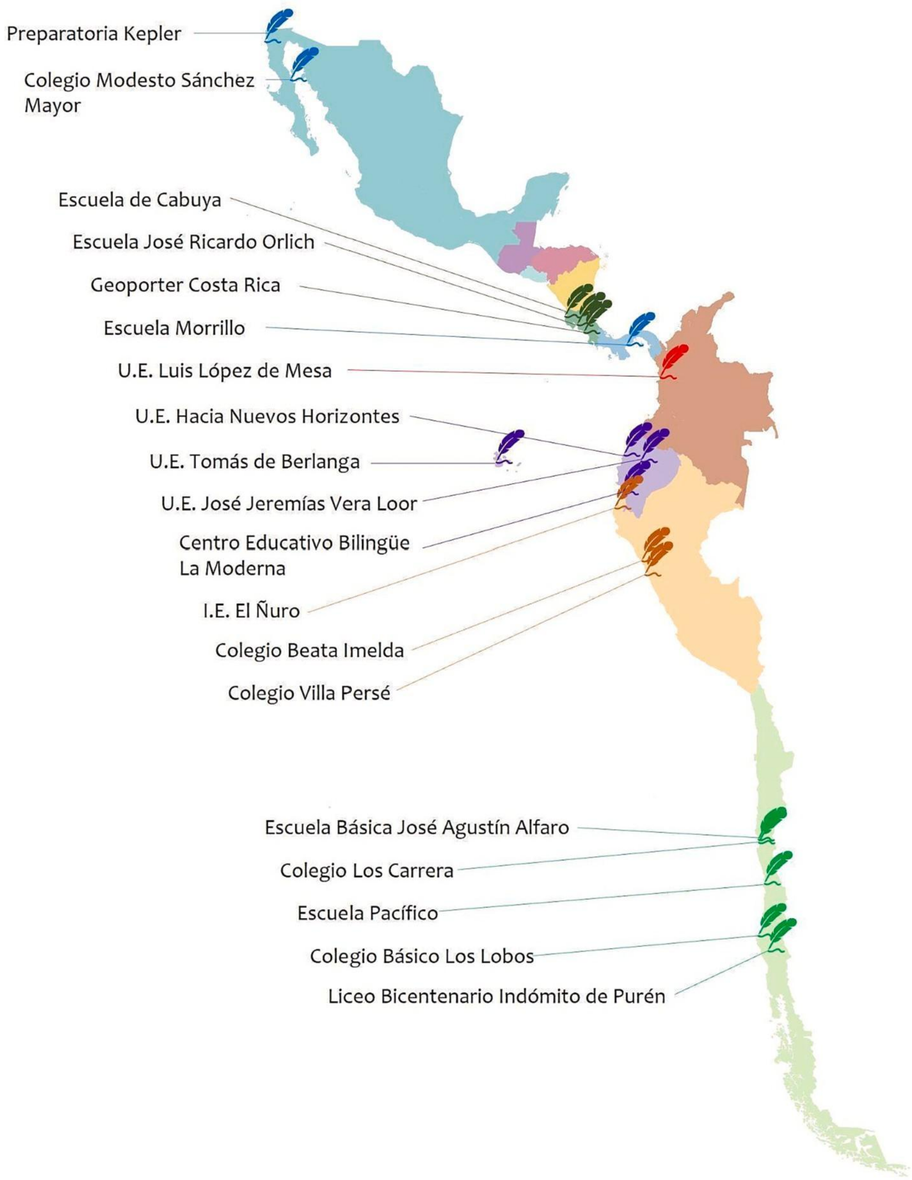

Figure 1: Map of the participating schools to the project “My Story of Plastic Litter: A Journey to the Ocean”.

Analysis

Surveys

Both the surveys and the stories offer a window of insight into the participants' perceptions on (1) sources, (2) impacts, and (3) the solutions to the issue of MPL. In addition, the evaluation of the activity as an engagement tool, reporting participants' feedback on the activity, explores any changes in their perceptions and behavioral intentions pre- and post-engagement. To examine participants' baseline views before the activity (T1) and to monitor if these changed after the activity (T2), the average scores of 79 surveys were statistically compared. As the data were not normally distributed, non-parametric statistics were used (Wilcoxon signed rank test). The demographic data are not discussed due to the small sample size.

Stories

The sample of 81 stories in Spanish was analyzed qualitatively on NVivo 2020 following thematic coding and the application of inter-coder reliability. The method can be summarized as follows (for a full description of the methods see Appendix 3).

NVivo coding

Following a hybrid approach of successive inductive (data driven) and deductive (following a set of predetermined codes) coding (see Appendix 3), themes were compared across stories based on the presence of codes and their popularity. A summary of the overarching codes (being aggregate categories of all individual codes) is presented in the following section (see Appendix 4 for the list of all code, their description, and popularity). Numbers reported in the results section correspond to the quantity of stories presenting the codes (N = file) rather than the number of times a code was mentioned per story (n = references). As most codes that aggregated (AC) within an overarching code (OC) were not exclusive, several AC belonging to one OC can appear in the same file; therefore N of the overarching code was not always equal to the sum of N of aggregated codes ($N_{OC} \leq \sum N_{AC}$).

Inter-coder reliability (ICR)

Coding reliability was determined through ICR on a sample size (in English) of over 10 % between two independent researchers, respecting the sample size recommendation of O'Connor and Joffe (2020). ICR was undertaken in NVivo 2020 providing both a measure of agreement and a Kappa Coefficient (Woolf and Silver, 2018), the latter having the biggest consensus (McDonald et al., 2019) as it is accounting for the probability of agreeing by chance (Pykes, 2020). Our results (Appendix 5) yielded a 0.57 Kappa corresponding to a moderate agreement on Landis and Koch's (1977) scale and an average agreement of 98.82 %. The Kappa Coefficient on NVivo is based on character level and therefore is unsuitable for content analysis that relies mostly on sentences and paragraphs (Kim et al., 2016). While the Kappa Coefficient tends to underestimate the concordance, the average agreement overestimates it (McHugh, 2012). To address those limitations of both coefficients, we undertook an analysis of all disagreements (Appendix 6) and agreed on some modifications to the codebook.

The codebook

The codebook was divided into four main categories encompassing codes belonging to the following overarching themes: the object as a user product, the object as waste, the solutions, and the structure of the story. All codes related to the use of the object (by whom and for how long) as well as the type of object and the emotions it felt while in use, were coded under the first theme. The second overarching theme encompassed the factors leading to the object becoming waste (in cultural and natural settings), its emotions and interactions with the environment along with their consequences (for the animals involved). The next theme included individual codes for the solutions that can either be preventive, aiming at avoiding litter entering the ocean in the first place, or reactive, offering solutions to removing MPL. Coding also considered the people exhorted by the story's author to take action. The fourth and final overarching theme gathered codes discussing the location where the story takes place ("country and movement of the object") and the protagonist of the story. The first three of the four overarching themes, respectively, allowed us to analyze: (1) the sources (better understood through the use of plastic as a product), (2) the impacts (visible in the codes regarding the plastic object as waste), and (3) the solutions to MPL. The fourth overarching theme offered contextual information about the role of the object and the extent of its journey as waste contributing to our understanding of the sources (Table 1).

Results

In choosing among a series of domestic plastic litter objects found on beaches on the East Pacific coast, students indicated a preference for a handful of objects. Out of the available 26 objects offered on the app, 15 suggested objects were identified in the stories. As participants had the possibility rather than the obligation to focus on an object presented in the app, some stories did not give enough elements to identify the object (N = 10, 12%; Fig. 2) or focused on objects that were not in the list (a biodegradable plastic ring, seahorse and dinosaur toys), resulting in total of 18 different objects discussed in the stories. The most common items featured in the stories (and coded as such) were plastic bottles (N = 11 of the 81 stories; 14 % where percentages are rounded to full numbers), toys if considered together (N = 11; 14 %), plastic bags (N = 10; 12 %) and straws (N = 8; 10 %; Fig. 2). The stories mostly focused on objects that were used for less than a day before being discarded (N = 30; 37 %), with the use-life of objects being determined through temporal elements provided in the story (e.g. buying an item in the morning and losing it on the beach in the afternoon). When examining how the objects were used by characters within the stories, most were used by children and teens (N = 36; 44 %) compared to adults (N = 18; 22 %).

Table 1: Relationship between the guiding questions for the stories, the overarching themes in coding and the presentation of the results in this paper.

Questions	**Overarching Themes**	**Results**
What was the object and where is it from? What is it made of?	Object as a user product/ Structure of the story	Sources
How was it used?	Object as a user product	Sources
How did it end up in the ocean?	Object as waste/Structure of the story	Sources
How did it interact with marine life?	Object as waste	Impacts
What was the consequence of this interaction?	Object as waste	Impacts
What human actions or behavior caused this outcome? What actions or behavior may have prevented this outcome?	Solutions	Solutions

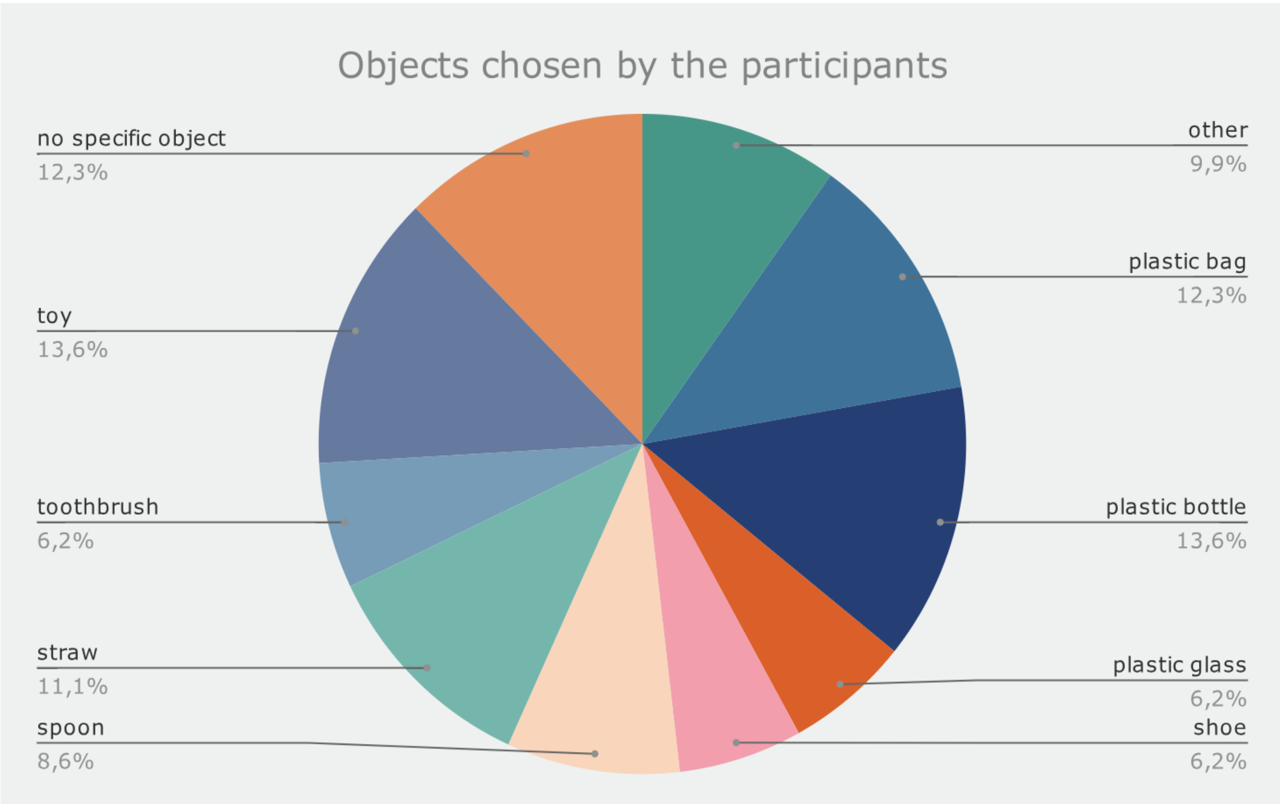

Figure 2: Choice of objects by the participants. N = 81 stories, each with one object choice.

Perceived sources and pathways of MPL

The stories emphasized the diversity of factors leading to objects becoming litter, including natural elements and human behaviors, and the humanisation of objects having positive emotions as a product, often changing to negative once the objects became waste.

The pathways of MPL to enter the environment are diverse, which was reflected in the stories focusing on land and regional sources. A pattern emerged with most countries mentioned being in Latin America (only 11 stories mention other countries: three in the US, two in the UK, one in Japan, one in India, one in Malaysia and three in China). In terms of types of location for the story, the object as a product was often used on the beach (N = 21; 26 %) where it was sometimes disposed of (e.g. *The boy walked along the beach and when the juice ran out, he threw me [the straw] and the glass to the ground.*). Stories stressed that natural elements can cause the objects to end up in the sea (N = 38; 47 %). Among those natural elements, sea movement was the most recurrent (N = 19; 23 %) with ten participants (12 %) referring to the tide and eight to the waves (10 %). Other stories identified wind (N = 13; 16 %), rivers (N = 5; 6 %), animals (N = 5; 6 %) and rain (N = 4; 5 %) as contributing to the object becoming waste and entering the environment. This contrasts with fewer stories (N = 12; 15 %) that identified cultural factors (corresponding to human actions) as directly responsible for the object entering the sea. Among those human actions directly provoking the pollution, two stories from Ecuador mentioned trucks directly dropping waste into the ocean (e.g. *From this truck we were thrown off a very high cliff into the sea.*). Even if humans were not always depicted as directly responsible for littering, in more than half of the stories (N = 57; 70 %), the object nonetheless interacted with humans during its use as a product. The remaining stories often had a different focus (e.g. written from the perspective of marine fauna or from children participating in beach clean-ups who directly interact with the object as waste), and here little or no description of the object as a product was provided.

In the cases of human behavior leading directly and indirectly to plastic litter disposal, it wase either explicitly noted in some stories as being intentional (N = 28; 35 %) (e.g. *The boy's father said it didn't matter, that he was going to buy him another toy later and he threw me into the sand as if I [the toy] were rubbish.*), or accidental (N = 26; 32 %) (e.g. *At that* *moment his sister called him to play and he didn't realize that in an oversight he had dropped the plastic spoon.*). For the few stories that described the emotions of the culprit (N = 23; 28 %), the main emotions were either thoughtlessness (not understanding the consequences of one's actions, e.g. *Mariana didn't know the importance of throwing rubbish in the bin and without thinking twice she threw me [the plastic spoon] into the sea in a plastic bag with more rubbish.*) (N = 12; 15 %), guilt (feeling responsible for littering, e.g. *It was due to a human creation, to pollution. I felt terrible and sank into my pillow.*) (N = 7; 9 %) or indifference (explicitly not caring about the consequences of their actions, e.g. *My owner was disrespectful to the environment and left me [the plastic bag] stranded on a street.*) (N = 7; 9 %). Despite the diversity of factors considered in MPL entering the environment, a shared element was the journey of the object evident in 39 stories (48 %), with 34 stories (42 %) using a different location for the start and the end of the story. Only three stories (4 %) explicitly indicated that the object had not traveled.

In addition to the preference for certain objects, participants often chose to narrate in first person (N = 44; 54 %), mostly narrating as objects (N = 29; 36 %) instead of humans (N = 15; 19 %). Regardless of making the object the protagonist, they typically added human attributes to their chosen artifact such as thinking, talking or even emotions. Specifically, emotions associated with the object at the time of its use were largely positive (N = 21; 26 %); for example happiness, as opposed to negative emotions (N = 6; 7 %), such as sadness (Table 2). This contrasts sharply with emotions of the object as waste with only nine stories mentioning positive emotions (11 %), for example hope, compared to 21 stories (26 %) stressing negative emotions, such as powerlessness (Table 2).

Table 2: Examples of emotion codes to understand the perceived sources of marine plastic litter. When the object has human characteristics such as thinking or talking, or is given a name, the code emotion enables us to infer an emotion that the object possesses as a product.

Code	**Definition**	**Example**
Positive emotion of product	The positive emotion of the object as a product identifies positive feelings either in the present (e.g. happiness) or picturing the future (excitement).	*"The humans decided it was a good day to go out for a picnic on the beach, I was certainly excited, we were going to the beach, I was finally going to fulfill my role."*
Negative emotion of product	The negative emotion of the object as a product identifies negative feelings either in the present (e.g. sadness) or picturing the future (e.g. apprehensive).	*"The brush had been living in a supermarket for a few months, anxious for someone to buy it, yet terrified of not knowing what would become of it when it was discarded."*
Positive emotion of waste	The positive emotion of the object as waste identifies positive feelings in the present (e.g. happiness) or picturing the future (e.g. hope)	*"The spoon was very happy because it had been found and could be recycled."*
Negative emotion of waste	The negative emotion of the object as waste identifies negative feelings that relate to guilt, powerlessness or the awareness of being harmful.	*"Poor turtle, he felt like he couldn't breathe. Jeff got it caught in his throat and although he felt very bad about what was happening, there was nothing he could do about it."*

Perceived impacts of MPL

Plastic pollution has a series of impacts on our environment and on societies. The stories described here stressed the harmful impacts on wildlife, particularly on fish and turtles, leading to environmental consequences, injuries, and eventually death, while the surveys also consider societal impacts (e.g. aesthetics of the beach). When asked to consider the interactions of MPL with the environment, participants emphasize negative consequences such as the harm on wildlife. Overall, >50 % of stories show awareness of the harmful nature of plastics when interacting with wildlife in general with one or several types of interactions mentioned per story. Ingestion (N = 28; 35 %) was the most recurrent harmful interaction reported followed by entanglement (N = 21; 26 %) and intoxication (N = 5; 6 %). Non-harmful interactions (N = 14; 12 %) could be discussions, i.e. open dialogues between the animal and the object (N = 8; 10 %), or overgrowth of marine fauna (biofouling) on the object (N = 7; 9 %) (Table 3). The stories particularly noted impacts on individual species with fish and turtles being the species mostly mentioned (N = 27 each; 33 %). This focus on turtles was evident through mentions of different impacts such as entanglement (e.g. *Unfortunately, one turtle ended up with its flipper stuck in one of the holes in the bag.*), ingestion (e.g. *One day I went to the beach and found a bottle bitten by a turtle. The turtle thought it was bait and ate it. I went back to the beach the next day and found the turtle dead.*) and their rescue (e.g. *Later a turtle also found a piece of plastic, but it got stuck in her mouth, that turtle managed to float to the beach of Bahía de Caráquez, where a group of people picked her up to try to help her.*). Such harmful interactions were also recorded for fish (e.g. *He [the fish] could not get out and every sudden movement he made caused cuts on his body and this caused him a lot of pain.*), along with non-harmful discussions, such as making new friendships (e.g. *Within a week Maria* [the fish] *got used to living inside me* [the bottle] *and I got used to her. Sometimes we talked when we were bored and kept each other company.*).

Table 3: Codes for the types of interactions (harmful and non-harmful) between fauna and plastic litter.

Code	**Definition**	**Example**
Ingestion	This code gathers the attempts, successful or not, from animals to eat the plastic.	*“He approached the jellyfish so he could catch it, but when he caught it and was about to eat it, he noticed that it had a very strange taste and texture. -What a strange jellyfish! -said Juan and before he could try to swallow it, the jellyfish got stuck in his mouth. -Get off, get off! -said Juan. After a while, he was finally able to spit out the jellyfish, and what was his surprise when he saw what it really was - it was a plastic bag!”*
Intoxication	This codes for animals being intoxicated by the components of plastic either by biting it or picking it up. It refers specifically to one story where an object is picked up by a dog that then gets a microbial infection.	*“But it is possible that in the time the glass was there, it could have released toxins. The glass could have been eaten by an animal or perhaps an animal could have passed near the glass and breathed in the toxins that the glass was releasing and become sick.”*
Entanglement	This codes for animals getting stuck in plastic or getting a plastic object making it impossible for them to move adequately. Examples of the stories include a tiny fish stuck in a bottle or a straw in a turtle’s nose. It includes pieces of plastic being stuck onto or in the animal’s body as long as the object being stuck is not a result of ingestion.	*“Among the bags was a lone crab that could barely move as its legs and pincers were covered in the contaminating material.”*

Code	Definition	Example
Discussion	As part of non-harmful interactions, this codes for dialogues between objects and animals. This can be about several topics.	*-"I'm not food, lady turtle!", I said, in a frightened tone.* *-"I'm sorry, Miss Bottle. It's just that I'm very hungry and my food has become scarce because of the pollution," she replied.*
Overgrowth of marine fauna	Type of non-harmful interaction between animals and the object can include the growth of organisms, either micro or macro. Organisms that are visible are considered as macro whereas non visible organisms are considered as micro.	*"But now I was becoming a new habitat for hydrozoans. These were tiny aggregates of the animal kingdom."*

As a result of these interactions, the stories often described one or several consequences for the animal (N = 37; 46 %) including injuries (N = 10; 13 %), death (N = 16; 20 %), or an impact on its environment (N = 15; 19 %) (Table 4). The abundance of plastic pollution in the environment was noted in 27 stories highlighting that the object was not the only plastic out of place (e.g. *When the storm stopped, I* [the bottle] *saw many bags, shoes, glasses, brushes, straws, bottles and many other things that had also been swept away by the tide.*). Consequences for the object were also noted, including the loss of material properties (N = 22; 27 %) (e.g. *But it* [the plastic spoon] *was already broken, deteriorated and discolored from the unexpectedly long trip it had taken.*) and the transformation into microplastics (N = 5; 6 %) (e.g. *More than half of his* [the plastic bottle] *body turned into microplastics, which were scattered all over the Latin American coastline.*). The last step of an object's itinerary as waste could be a landfill (N = 8; 10 %), a recycling center (N = 9; 11 %), a rehabilitation center for animals saved from plastic pollution (N = 8; 10 %) or a laboratory where they were studied by scientists (N = 4; 5 %).

Table 4: Consequences of the interaction between fauna and plastic litter

Code	**Definition**	**Example**
Animal's death	This codes for the interaction with the object resulting in the death of the animal.	*"Tomás also told them that he had seen many animals that had died because of the plastic bags."*
Injuries	As a result of the interaction between the object and the animal, this codes for the object injuring the animal without being a fatal injury.	*"They had to take Manta to an exotic animal vet so that they could remove the straw from his mouth, which had injured Manta's palate and throat."*
Impact on the environ-ment	This codes for the impact of the presence of the object on the animal's environment that does not cause injuries or death of the animals but that impacts their surroundings. It can be a lack of visibility due to the quantity of waste, etc…	*"We all hope that one day we will be able to get out of the sea, because as far as we know we are making a lot of pollution."*

Whilst the impacts of MPL on wildlife were strongly emphasized in the stories, when directly asked about multiple impacts in the pre-post surveys, this was still seen as being important. However, the greatest impact was the effects of beach aesthetics. In the pre-survey, participants overall were aware of the multiple impacts MPL can have. They stated that MPL harms wildlife (4.43 ± 0.99) and enters the food chain (4.25 ± 1.03), but they mostly emphasized that it affects the appearance of beaches (4.84 ± 0.56; mean ± standard deviation; scale from 1 to 5, with the highest values indicating full agreement). These levels of agreement did not change significantly with the activity and nor did the fact that they mostly emphasized beach aesthetics before impact on wildlife and the food chain ($p > 0.12$). Thus the surveys demonstrated that the participants were aware that MPL has multiple impacts, especially in terms of aesthetics, but the stories tended to focus on impacts on the wildlife.

Perceived solutions to MPL

When volunteering possible solutions to help address MPL, a focus was on preventative measures (stopping items from becoming MPL) rather than on reactive measures (cleaning up existing MPL). This was noted in both the stories and in the surveys with the most popular solution respectively being adequate disposal of litter and recycling.

Overall, 77 % (N = 62) of stories noted possible solution(s) to address MPL, of which the majority (N = 42; 52 %) stressed preventive solutions. These were divided into: a) personal changes of behavior (N = 30; 37 %), either disposing of litter (N = 22; 27 %), recycling (N = 7; 9 %), reducing plastic use (N = 4; 5 %) or reusing plastic items (N = 1; 1 %), and b) social actions (N = 16; 20 %), such as education (N = 9; 11 %) and convincing the community of the importance of the issue (N = 6; 7 %). Some stories also included reactive solutions (N = 32; 40 %), proposing to pick up the litter (N = 20; 25 %), either by individual (N = 10; 12 %) or community (N = 10; 12 %) actions. Recycling the discarded waste was also mentioned (N = 6; 7 %) as a reactive solution, alongside the work of organizations arranging clean ups, for example (N = 10; 12 %), and the reuse of discarded objects (N = 4; 5 %) (Table 5).

Table 5: Codes for the types of solutions (RS= Reactive solution, PS= Preventive solution)

Code	**Definition**	**Example**
RS - Recycling	This codes for the recycling of waste, contrasting with recycling of products at home. This code refers to initiatives where the waste is recycled either by individuals or by groups.	*I learned that not only were there bottles that humans were leaving in the garbage cans for recycling, but they were also bringing in bottles that had previously been thrown into the sea.*
RS - Reuse	This codes for reuse of a littered object (hence a reactive solution) to be turned into another object by the person picking it up.	*I used it to make a small flowerpot and put a pretty flower in it, which now accompanies Susana.*
RS - Picking up the litter	This category refers to the litter inland or on the beach being picked up. It can be picked up either by individual actions or through community actions. It does not include any investigation of the litter, this will be coded under “work of organizations”.	*“Fortunately, a group of young people became aware of this huge problem and decided to create a team with the aim of collecting all this rubbish and changing the mentality of the population.”*
RS - Waste processing	Litter being burnt (incinerated) or processed in a landfill.	*“To them it all seemed so absurd as there was so much rubbish arriving every day and more than they burned, creating an endless cycle.”*
RS - work of organizations	This code includes mentions of environmental groups, campaigns, or work like ReCiBa’s that help picking up the litter and analyze it.	*“If there is anything positive about this, it is the campaigns that some organizations are campaigning against this kind of thing, working to help protect our planet.”*

Code	Definition	Example
PS - social action	This codes for actions that depend on a third person rather than a personal change. This is subdivided into: education, politics, convince the community, convince the family and change of object design. This category will identify the changes needed as coming from above.	*“The environmentalists put up signs all along the coast and, finally, called on the authorities to fine anyone who leaves plastic bags or plastic waste anywhere.”*
PS - personal - change of attitude	This codes for encouraging a change of attitude to prevent litter from entering the ocean. It can either be deciding to recycle, to reuse objects, reduce consumption, to dispose properly.	*“Sam and Paul no longer litter on the beach or anywhere else but in a recycling or reuse bin, understanding how important it is to CARE FOR OUR PLANET.”*

Some stories mentioned recycling actions (N = 13; 16 %), either preventively (recycling plastic objects at home) or reactively (sending MPL items to recycling). Recycling was a popular solution in stories ranking just behind adequate disposal of rubbish (N = 22; 27 %) and picking up the waste (N = 20; 25 %). It should be noted that the code “recycling” was used for thematic analysis when participants used the word recycle (*reciclar* in Spanish). This term encompassed a variety of actions from industrial recycling (e.g. *They said that with a few tweaks I* [the toy wheel] *could be recycled and be in a new toy*), classifying waste at home (e.g. *Since then, she and her family have been trying to recycle as much as possible*) or even confused as re-use (e.g. *Making hand crafts from recyclables to put them to good use*), illustrating the use of recycling as a catch-all term.

The pre-survey indicated that participants were engaged from the beginning of the story-writing activity and willing to take action. Among the actions to prevent plastic litter from reaching the ocean, the most popular suggestion in the surveys was recycling (without further precision) (T1 = 26, T2 = 25) (Appendix 7). Other answers emphasized the importance of reducing plastic consumption to tackle the issue (T1 = 18; T2 = 16) while some other solutions seemed less popular. Education, for example, was only mentioned in nine stories (11 %), three times in pre-surveys (4 %) and once in post-surveys (1 %). Fines were suggested in one story (1 %), four times in the pre-survey (5 %) and three times in the post-survey (4 %).

Evaluating the activity

The surveys revealed important effects of participating in this story-writing activity. Participants claimed to significantly know more about MPL after doing the activity (3.64 ± 0.75) than before (3.50 ± 0.75, $Z = 2.20$, $p = 0.03$). In terms of perceptions, participants stated they were aware of the impacts plastic has, found it to be important to them, and were interested in learning more about the socio-environmental issues, but were less sure how their behaviors influenced MPL. These perceptions were seen to be stable, and did not change between the start and the end of the activity ($p > 0.12$, see Appendix 8). Despite the participants having already stated that they were engaging in different PEBs such as recycling at home, encouraging others to behave more sustainably and picking up trash, all of these behaviors were found to significantly increase after engaging in this activity (Fig. 3; see Appendix 8 for full statistical analyses). Recycling remains the most popular PEB adopted (T1 and T2), confirming what had been found when participants were asked to name one action to avoid plastic litter from reaching the ocean.

The feedback questions indicate a positive impression of the schoolchildren towards this activity. All participants stated that they enjoyed the activity (range 3–5 out of 5), with the average response being 4.58 (± 0.57). Participants were very likely to recommend others to take part in the future (4.36 ± 1.00). They also agreed that they learned about the potential impacts of MPL by doing this activity (4.36 ± 0.82), what they could do about it (4.33 ± 0.85), and also that they had learned something new (4.31 ± 0.85).

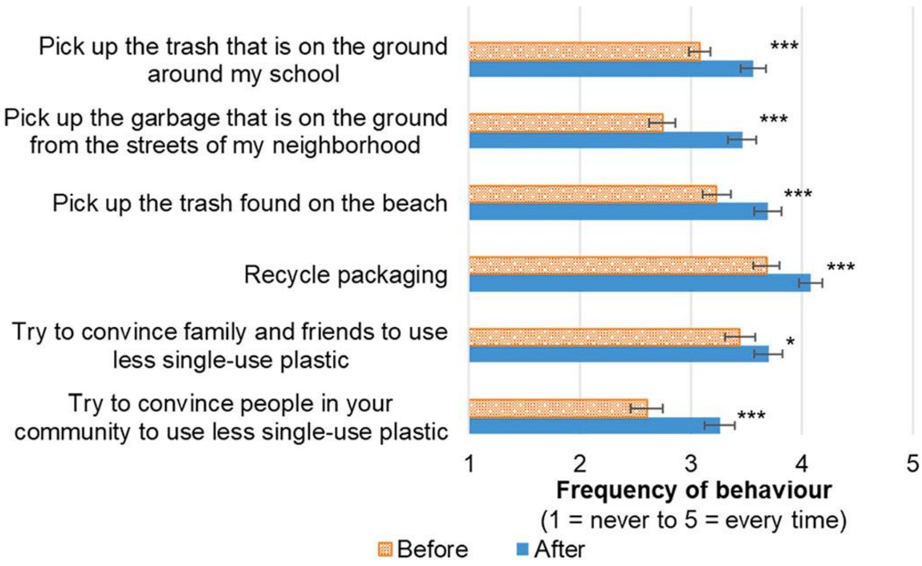

Figure 3: Impact of the activity on pro-environmental behaviors. Bar chart shows average response (and standard error) to each behavior before and after the activity, all of which statistically improved over time (as indicated by *).

Note: Difference was statistically significant at $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***.

Discussion

This paper examines an inclusive activity that schoolchildren in Latin America could remotely engage with during national lockdowns of the COVID-19 Pandemic. As well as assessing the activity as an engagement tool, the contents of the stories were examined to see what the children stressed in the object itineraries of MPL. Results indicate that partici- pants have a good understanding of MPL sources being mostly terrestrial and local in the East Pacific and of the bio-ecological impacts of MPL, especially on emblematic and locally important animals. A diversity of solutions are presented in the stories while surveys tend to suggest recycling more often. In this section, we evaluate how perceptions of MPL sources, impacts and solutions compare to the scientific reality through the latest studies of MPL in the region and to other studies of adult and children perceptions. The efficacy of the method to engage participants and boost PEBs is assessed to unravel how stories could help to approach perceptions and motivate people to take action.

Perceived sources and pathways of MPL

The setup of most stories in LAC with their emphasis on local sources, from activities in natural environments (e.g. beach), is consistent with several environmental studies identifying that MPL mostly comes from land sources and is associated with recreational activities, such as tourism (Williams et al., 2016). The prominence of local terrestrial sources is attested on continental East Pacific beaches (e.g. Honorato- Zimmer et al., 2019; Gaibor et al., 2020; Garcés-Ordóñez et al., 2020b). While a variety of factors are being presented by participants, the stories often took place on the beach and beach littering, accidental or intentional, was a recurrent cause identified in our data. A similar trend was identified by Hartley et al. (2015) where children identified dropping litter as the main cause of plastic pollution and by Eastman et al. (2013) who found that many Chilean survey participants had admitted to have littered in the past. The stories were also consistent with a study by Wyles et al. (2016) that emphasized the assumed intentional nature in littering behaviors and disrespectful attitudes towards public litter when compared to fishing litter. The focus of this study on domestic (or public) MPL might have influenced how students wrote about these items. Yet, stories still reflect an awareness of the local context and identify (often intentional) littering behavior as one contributor to plastic pollution.

Among the most common types of objects chosen by the participants in the stories were plastic bottles and plastic bags. The importance of bottles and bags is consistent with these items being the third and fifth most common objects, respectively, found in beach clean-ups (Ocean Conservancy, 2018). It indicates a close agreement between perceptions and recent data on MPL, particularly the short use-life of >60 % of macroplastics found on beaches in Colombia (Garcés-Ordóñez et al., 2020a), reflected in the stories by most objects being discarded after one day. This also corroborates negative emotions associated with single-use plastics (by definition having a very short use-life), linked to an awareness of their impact on the environment (Van Rensburg et al., 2020). Negative emotions associated with the objects as waste in the stories are consistent with perceptions of public litter found in previous studies compared to fishing litter (Wyles et al., 2016). This contrasts to positive emotions associated with the object in use (see Table 2). The type of litter presented to the students confirmed known perceptions of the objects and a focus on commonly found MPL items that are representative of plastic pollution.

In our study, participants wrote stories where children and teens were mostly the ones interacting with plastic, which might induce reflection about one's own behaviors and responsibility. This contrasts with the results of a survey by Hartley et al. (2018), which identified that some stakeholders including industries, retailers and governments are perceived as responsible for litter production and less motivated to solve the issue than respondents. It is noteworthy to say that, contrasting with other studies, the stories were not designed to assess children's comprehensive knowledge and perceptions about MPL. Participants may have been aware of these other contributors, yet chose elements that made a more engaging story or were easier to relate to (e.g. reflecting on their own experiences).

Focusing on one object and trying to identify the start of its itinerary led participants to think about everyday situations and behaviors related to the use and consumption of those domestic items that they could choose from. Participants also recognised the geographical journey that an item could undertake, truly exploring the dynamic concept of object itineraries. This framework also allowed them to reflect upon the ease and rapidity of the transition from product to waste while showing the diversity of pathways for an object to enter the environment.

Perceived impacts of MPL

The high awareness about the impacts of plastic pollution in this study confirms previous trends for schoolchildren identified in studies across the world (Heidbreder et al., 2019; Oturai et al., 2022; Wichmann et al., 2022). The survey responses demonstrated that the schoolchildren were aware of the multiple impacts (e.g. aesthetic consequences for people, impacts on wildlife and the potential risk to the marine food chain). However, it was through the stories that the children were able to emphasize and potentially dramatize these impacts and further demonstrate their understanding of them. A notable trend in these stories was that they focused primarily on bio-ecological impacts (on landscape and wildlife), which have also been perceived as more important in a study by Soares et al. (2021) of public perceptions from individuals aged between 18 and 69 years. While age and socio-cultural contexts might also influence those trends, there seems to be something more tangible and visible about bio-ecological impacts.

The bio-ecological impacts were highly prevalent but also diverse in the details provided in the stories. The awareness of impacts on marine wildlife was evident with harmful interactions appearing in more than half of the stories. This emphasis on wildlife could be a result of the story-writing process and the choice of more impactful and active scenarios. Both the orienting questions to create the stories ("How did the object interact with marine life?") and ReCiBa's previously published stories (The sisterhood of the turtles) might also have influenced participants to reflect on interactions with wildlife. Stories reveal awareness of potential harmful impacts of MPL beyond the impact on aesthetics stressed in the surveys. This aligns with schoolchildren's perceptions of MPL's impacts in the UK (Hartley et al., 2015) and with Chilean adults reporting to be "absolutely aware" of impacts of single-use plastic bags on the environment and on marine animals (Amenábar Cristi et al., 2020). While the focus on bio-ecological impacts might have been influenced by the type of activity as part of ReCiBa and the instructions, it can also reflect a specific concern for these impacts on wildlife and landscape (as demonstrated by Soares et al., 2021).

When it comes to impacts on marine wildlife, there was a particular emphasis on fish and sea turtles in the stories. The focus on turtles could be understood given their emblematic status for raising awareness about the impacts of plastic pollution (Geary, 2019). As ReCiBa had published a book (cited above), the focus on turtles in the stories could also reflect familiarity with the book and turtles as threatened species in the region. Often participants note the entanglement of sea turtles, the ingestion of plastics and their eventual rescue. While elements about nesting are emphasized in ReCiBa's book, participants rather focused on the impact of plastic for the turtles at sea, sometimes discussing feelings of powerlessness of the object when hurting the turtle (see Table 2). Even though not as emblematic as turtles for the fight against plastic pollution, fish were mentioned equally as often in the stories and often described by the participants as suffering physically and emotionally from plastic pollution. The way fish were depicted by schoolchildren further contributes to results of a study by Rucinque et al. (2017) revealing that educated adults in Bogota and Curitiba generally perceive fish as sentient beings capable of feeling pain. While the level of education and regional context might influence those results, it seems that children also show this consideration, and almost empathy, through the content of their stories. This focus on fish could also be a result of the local socio-economic situation on the Pacific Coast where fish is an important and relatable resource for small- (Chuenpagdee et al., 2011; Chevallier et al., 2021) and large-scale fisheries (Martin et al., 2016). The focus on fish and turtles in stories might reflect their local importance and emblematic nature in the fight against plastic pollution, as well as familiarity with ReCiBa's publication. Greater empathy and relatedness to these animals due to their local importance could also have influenced participants to explore how MPL impacted them.

In brief, impacts were also explored in the stories as a part of the object itineraries: objects pass from one context (that of product) to another (that of waste) through a set of encounters (with animals and humans). Those interactions can leave marks on the objects, which inspired participants to explore how objects lost some of their material properties while considering the consequences of such unfortunate encounters.

Perceived solutions to MPL

Several solutions, reactive and preventive, to reduce plastic pollution were explored in the stories. An emphasis on preventive solutions contrasts with findings from Wichmann et al. (2022) identifying a focus on downstream solutions in surveys undertaken as part of a CS project. Among preventive solutions, proper disposal of litter appears to be the most popular in the stories, which has also been evidenced in Hartley et al.'s (2015) study of children's self-reported behavior to reduce litter. The most popular reactive solution in the stories was picking up the litter, which also appeared as a commonly adopted PEB after taking part in the activity. This corroborates findings of Locritani et al. (2019) who identified an increase of almost 70 % in the post-CS activity survey when participants (students aged 16–17 years old) indicated an inclination to pick up the litter.

The presented solutions are shaped by a series of factors, such as age. Notably, litter-picking behaviors with younger students showed a drop after the CS activity while older students have a more stable attitude (Oturai et al., 2022). In that perspective, Eastman et al. (2013) identified a preference for environmental education followed by the implementation of fines in a study of adult beach users' attitudes towards littering. While stories emphasize the importance of education at the same level as recycling (both as preventive and reactive solutions), the implementation of fines was barely suggested in stories and surveys. Little emphasis on this type of solution might be related to the complexity of the issue with limitations for plastic use depending on national and subnational legislations (Ortiz et al., 2020). With plastic pollution being an increased threat to LAC beaches after the COVID-19 Pandemic (Alfonso et al., 2021), there is hope for more uniformity on the matter, from regulatory policies to information instruments, thanks to the recent Pacific Alliance (Ortiz et al., 2020) and the forthcoming UN Global Plastics Treaty where Ecuador and Peru will represent LAC and the Caribbean. This difference in proposed solutions might reflect different beliefs and acceptance due to demographics and local context, as well as different roles and capacity of action within the household.

A solution that appears in both reactive and preventive categories was recycling. If recycling is considered as both household waste classification and at an industrial scale, the use of this term appeared as the third most popular suggestion in the stories and the most popular in the surveys. While this focus on recycling as the chosen action to prevent plastic litter from reaching the ocean in surveys might result from the need to give “expected” answers, the mention of recycling in stories seems to indicate a confusion as to what it actually encompasses. It further illustrates the use of recycling (*reciclar*) as a catch-all term to discuss both waste classification and industrial recycling of plastics into new materials. This confusion about what recycling is (Alexander et al., 2009) adds to uncertainties regarding how to adopt this behavior at home (Burgess et al., 2021).

This focus on recycling could also be related to a regional educational discourse favoring the three Rs (Reduce, Reuse, Recycle). For example, some educational projects in LAC even present Coca Cola as an environmentally-responsible company that practices recycling (in Pelaez and Hernández, 2019). But in practice, the LAC region industrially recycles only 4.5 % of its waste (Brooks et al., 2020). While this rate does not account for informal practices of recycling (or scavenging) (Brooks et al., 2020; Medina, 2015), our data could reflect the local importance of informal recycling practices. While it fits with a regional discourse, the focus on recycling suggests confusion regarding its meaning and could suggest the importance of informal practices not reflected by regional recycling rates.

After inspiring participants to track the origins of the objects and evaluate their impacts, the objects here served as a basis to envision solutions, from plastic production to waste management. While the activity was not designed to present participants with a review of available solutions, they considered them in the stories. Thinking of a specific object, and narrating its itinerary, offers a way to think about solutions in a more creative and diverse way than surveys, given that several solutions were often mentioned in one story.

Story writing for engagement and PEBs

The activity of story writing has two main contributions: an increase of self-assessed knowledge on the topic of plastic pollution and an impact on PEBs. Similarly to outcomes of CS projects (e.g. Locritani et al., 2019) and beach clean-ups (e.g. Veiga et al., 2016; Owens, 2018), the story-writing activity led to an increase in self-assessed knowledge about plastic pollution. With all PEBs reported to significantly increase after the story-writing activity, those results seem to align with benefits of beach clean-up activities (e.g. Wyles et al., 2017; Owens, 2018) and education initiatives (e.g. Hartley et al., 2015). Yet, all initiatives do not impact PEBs equally. For example, Oturai et al. (2022) demonstrated that the CS activity *The Mass Experiment* did not impact PEBs significantly. A series of factors might explain differences with our study such as the local context (Denmark vs LAC), the type of activity (CS vs story writing), the survey design (PEBs occurring in the previous week vs occurrence of PEBs from never to always) and the age of participants. Story writing might have helped participants to think more deeply about the impacts of human behavior and the importance of PEBs to address the issue of MPL. Notably, age has been demonstrated to impact PEBs with older students showing more stability in their adoption (Oturai et al., 2022), which could be reflected in the age category of our sample. Another study yielded similar results with no significant change in PEBs of Chilean students participating in a beach-sampling CS project (Wichmann et al., 2022). Wichmann et al. (2022) also suggested that a direct consideration of human behavior in any project might be essential to boost PEBs, corroborating previous studies (e.g. Baur and Haase, 2013).

Mechanisms of story writing, analyzing the journey of an object interacting with a series of actors to create the story, offer participants a more in-depth consideration of human behaviors in the object itinerary. Besides, agreeing to share their stories on the website provides another layer to the reflection on one's behaviors and actions, rendering them visible by other participants and the general public. But story writing also implies making choices about what constitutes a better story and therefore the stories allow us to explore perceptions (not necessarily in a comprehensive way) rather than being a direct assessment of participants' knowledge on the topic (see Gibson, 1986, Cassam, 2008, Brewer, 2011 for discussions on perception and knowledge). By accepting the gap between perceptions, intentions, and (self-reported) behaviors, we still recognise the potential of the activity as a more organic exploratory tool to engage schoolchildren with the topic and boost PEBs. While our much smaller sample size might also play a role in those positive PEB results, future studies should assess if story writing is confirmed as an efficient tool to boost PEBs.

There is a diversity of PEBs that can be adopted, and the activity seems to have particularly boosted recycling (waste classification), which was the most commonly adopted behavior before and after the activity, as well as the most recurrent action suggested in surveys. The emphasis on recycling in the surveys might be a result of it being a popular solution in the region and a commonly self-reported behavior, especially among schoolchildren. High self-reports of recycling (varying regionally between 40 % and 82 % of respondents between the age of 16 and 77) have been identified by Kiessling et al. (2017) along the Pacific Coast, suggesting a regional belief in the solution. With the method of self-report prone to overestimates (Chao et al., 2021) and not directly reflecting recycling behavior (Kiessling et al., 2017), our data, self-reported behaviors from schoolchildren, contrasts with lower local recycling rates and could be typical for the audience of this study. Schoolchildren are indeed particularly fond of this solution, as evidenced by Salazar et al. (2022) who found that children were 11 % more likely to mention recycling actions than their parents. The preference for this solution by schoolchildren could be understood further through two elements known to impact (self-reported) recycling behavior: their higher institutional trust (Harring et al., 2019), and their environmental awareness and concern (Chao et al., 2021). Our data also indicate a confusion to what recycling actually refers to, leading participants to use this catch-all term to refer to industrial recycling and waste classification at home. Other boosted PEBs in our surveys include litter-picking behaviors more likely to be adopted on beaches than in participants' neighborhoods. This difference might reflect a specific concern for the natural environment, already identified by Wyles et al. (2017) in beach clean-ups, and corroborates findings of children's litter blindness in urban areas compared to natural environments demonstrated by De Veer et al. (2022). A different focus on solutions such as recycling and litter picking in natural environments can be better understood by considering the particularities of schoolchildren as participants of this study.

The story-writing activity can therefore be considered as a good engagement tool that enhances a series of PEBs along with being an enjoyable and recommendable experience. Story writing, an inclusive exercise easily adopted in times of uncertainties, has been shown to be an interesting method to explore perceptions of MPL as artifacts and engage schoolchildren to reconstruct object itineraries. The activity was designed to allow participants to grasp and reflect upon the complexity of a plastic object itinerary, evidencing the links with different actors and their behaviors rather than providing a way of learning about different solutions to plastic pollution. While this study offered a window into participants' perceptions, future work could explore how those perceptions developed by identifying common sources of information in the region regarding sources and impacts of MPL and the available solutions. With participants coming from different countries and socio-economic contexts, it was beyond the scope to provide students with further recommendations for solutions to MPL. There is, however, scope for further studies to include the latter and to compare the perceptions from other demographic groups or in other contexts, for example oceanic islands characterized by non-local sources of MPL (e.g. Thiel et al., 2021). A similar study including more industrial items (such as fishing litter) could also explore how these are perceived and contribute to literature on the different attitudes towards fishing and public litter (e.g. Wyles et al., 2016), the latter being the topic of this study.

Conclusion

In addition to the story-writing activity being a good tool to increase self-assessed knowledge of MPL and boost PEBs, our data suggest a good understanding of beach litter's sources and impacts by schoolchildren on the East Pacific Coast participating in the program. In comparison, the diversity of solutions was fully explored in stories, showing a preference for preventive solutions, but was dominated by recycling in surveys (suggested actions and PEBs).

Sources of MPL, mostly the result of human behaviors, were well identified in the stories and surveys, and reflect a good grasp of the topic's latest studies in the region. The diversity of pathways for litter to enter the ocean evoked in stories reflect the different sources including recreational activities and coincides with most MPL in the region coming from local land sources. The schoolchildrens' choice of objects reflects an awareness of the types of MPL items commonly found on the beach, such as plastic bags and bottles. Participants were mostly aware of bio-ecological impacts of MPL on the landscape (in surveys) and the wildlife (in stories). Harmful interactions are recurrent in the stories, showing an understanding of the impacts of MPL on wildlife. The choice of fish and turtle reflect their respective local importance and the turtle's emblematic nature as protagonist of ReCiBa's tale “The sisterhood of the turtles”.

With recycling as the most popular solution in the surveys, we argue that our survey data might reflect the efficiency of the “recycling myth” where recycling is the ideal solution presented by industries, governments and even by consumers (Buffington, 2015). It also confirms the belief put into recycling as a solution even when participants do not refer to the same behavior highlighting the confusion with the term. Stories offered more flexibility to schoolchildren not repeating expected answers as they mostly emphasized preventive solutions with proper disposal of litter first. The diversity of solutions across the stories and their non-exclusive consideration by schoolchildren illustrate a good grasp of the potential of recycling as a complementary solution only while shifting our economy away from consumerism and disposability.

In conclusion, the story-writing activity has been shown to be both a valuable engagement tool efficient to increase PEBs amidst the COVID-19 Pandemic and a method to gather complementary data to explore perceptions of MPL's sources, impacts and solutions. While messages in glass bottles once floated on ocean currents, carrying with them the hopes of their senders that help may one day arrive, those same currents now carry plastic waste, much of it in the form of plastic bottles (Ryan et al., 2019, 2021). In this paper we have shown how those plastic bottles themselves, alongside all other plastic waste, continue to carry messages not so far removed from the ones sent by stranded sailors: that help is urgently needed. This paper has shown that children also understand this message but that more work is needed to help them evaluate the solutions.

Ethical Consent

Parental and schoolchildren consents were asked for survey analysis, stories analysis and to share stories on the Zenodo website https://doi.org/10.5281/zenodo.7411595. The project was reviewed and approved by the Scientific Ethics Committee of Universidad Católica del Norte (CEC UCN n° 16/2020).

CRediT authorship contribution statement

Estelle Praet: Methodology, Formal analysis, Visualization, Writing– original draft, Data curation, Writing – review & editing. **Jostein Baeza-Álvarez**: Methodology, Visualization, Writing – review & editing. Diamela De Veer: Conceptualization, Investigation, Resources, Writing – review & editing, Data curation. **Geraldine Holtmann-Ahumada**: Project administration, Investigation, Data curation. **Jen S. Jones**: Conceptualization, Writing – review & editing. Sarah Langford: Conceptualization. **Jessica Michel Dearte**: Conceptualization, Resources. **John Schofield**: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Martin Thiel**: Conceptualization, Investigation, Resources, Project administration, Writing – original draft, Writing – review & editing. **Kayleigh J. Wyles**: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Supplementary data to this article can be found online at https://doi. org/10.1016/j.marpolbul.2022.114457.

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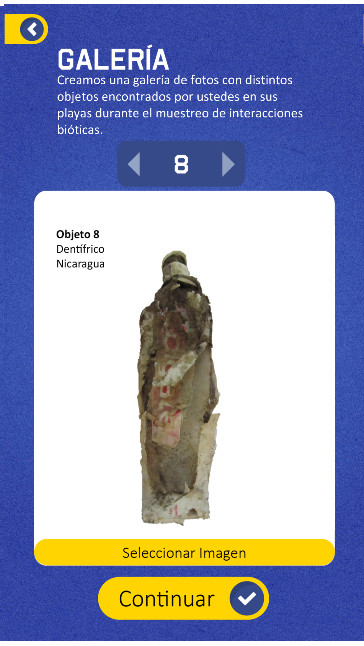
Supplementary materials

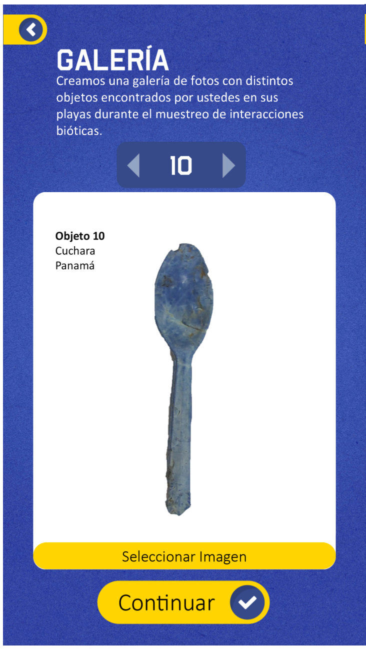
Appendix 1 - List of objects presented to the participants

These are the 26 objects that schoolchildren could choose in the application to create their story. All of them were found during the biotic interactions sampling (2nd semester 2019), a previous collaborative research conducted by ReCiBa. Several objects present epibionts growing on the objects because they come from marine sources.


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
7
Objeto 7
Desodorante
Guatemala
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
8
Objeto 8
Dentífrico
Nicaragua
Seleccionar Imagen
Continuar

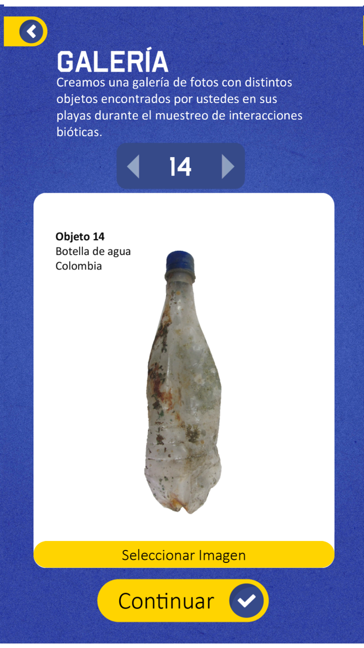

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
9
Objeto 9
Encendedor
Costa Rica
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
10
Objeto 10
Cuchara
Panamá
Seleccionar Imagen
Continuar

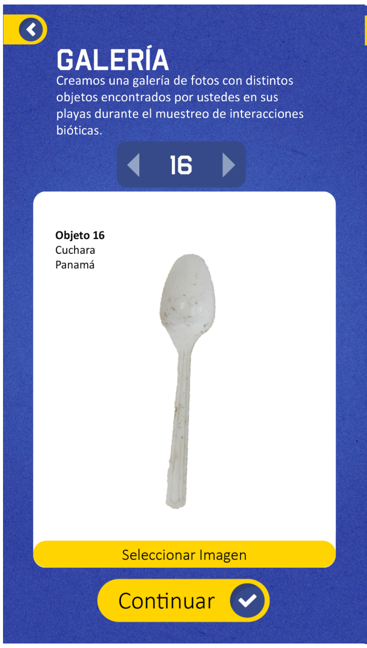

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
11
Objeto 11
Desodorante
Nicaragua
Seleccionar Imagen
Continuar

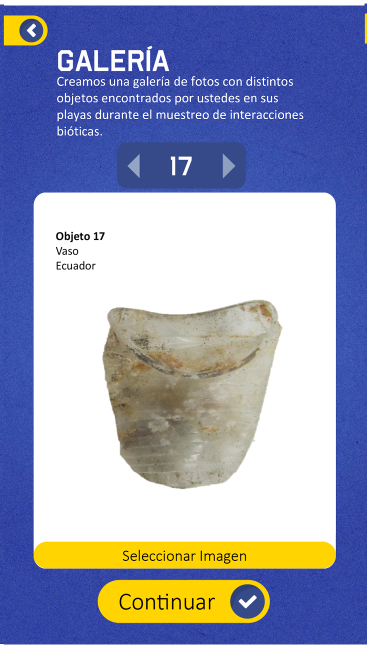

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
12
Objeto 12
Pinza de ropa
Panamá
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
13
Objeto 13
Botella de aceite para cocinar
Ecuador
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
14
Objeto 14
Botella de agua
Colombia
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
15
Objeto 15
Botella de aceite para motor
Costa Rica
Seleccionar Imagen
Continuar

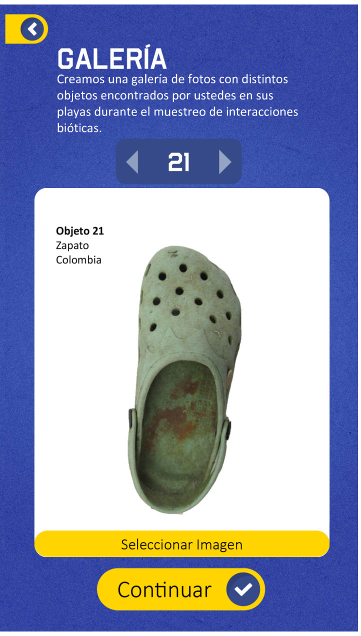

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
16
Objeto 16
Cuchara
Panamá
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
17
Objeto 17
Vaso
Ecuador
Seleccionar Imagen
Continuar

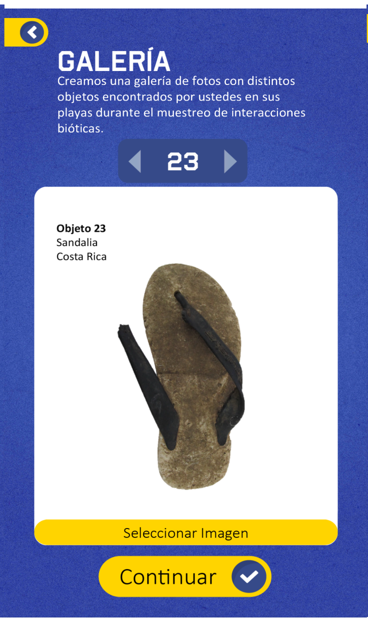

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
18
Objeto 18
Botella
Ecuador
Seleccionar Imagen
Continuar

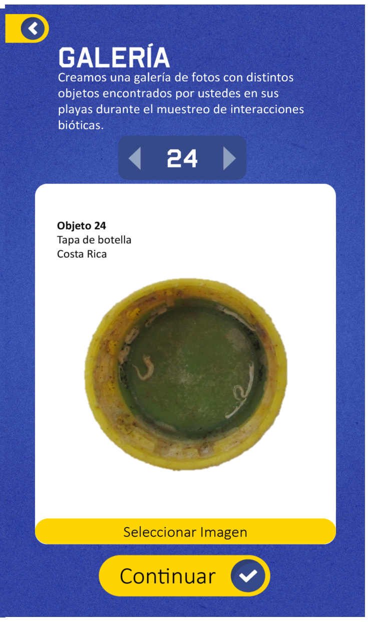

GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
19
Objeto 19
Recipiente de suplemento alimenticio
Ecuador
KOLA ANULADA
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
20
Objeto 20
Botella de perfume
Colombia
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
21
Objeto 21
Zapato
Colombia
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
22
Objeto 22
Aleta de buceo
Costa Rica
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
23
Objeto 23
Sandalia
Costa Rica
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
24
Objeto 24
Tapa de botella
Costa Rica
Seleccionar Imagen
Continuar


GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
25
Objeto 25
Bolsa
Chile
Seleccionar Imagen
Continuar
GALERÍA
Creamos una galería de fotos con distintos objetos encontrados por ustedes en sus playas durante el muestreo de interacciones bióticas.
26
Objeto 26
Bombilla, pajilla
Chile
Seleccionar Imagen
Continuar

Appendix 2 - Surveys

During the project “My Story of Plastic litter: a journey to the ocean”, schoolchildren and teachers answered a questionnaire through the application. Schoolchildren took part in a survey before and after writing a story about plastic litter whereas teachers responded to questions about the participation of their students to ReCiBa and more specifically this activity. In this document, the reader can find the questionnaire in Spanish and English.

Demographic information

• ¿Cuál es su nombre completo?	• What is your full name?
• ¿Cuántos años tiene?	• How old are you?
• Seleccione su género: ○ Femenino ○ Masculino ○ Prefiero no decirlo	• Select your gender: ○ Female ○ Male ○ I prefer not to say
• ¿En qué país vive?	• In what country do you live?
• ¿Cuál es el nombre de su escuela?	• What is the full name of your school?
• ¿Cuál es el nombre de su localidad?	• What is the name of your locality?

Pre-activity schoolchildren questionnaire

• Completa las preguntas Información Estamos realizando una investigación y queremos saber tu opinión sobre la basura	• Complete the questions Information We are doing research and we want to know your opinion about plastic litter, your opinion is very

plástica ¡Tú opinión es muy importante! Si tienes dudas pregunta a tu profesor o profesora ¡gracias!	important! If you have questions, please contact your teacher, thank you!
• ¿Tiene computadora o tablet en casa? ○ No ○ Sí, solo una computadora o tablet, sin internet ○ Sí, una computadora o tablet e internet.	• Do you have a computer or a tablet at home? ○ No ○ Yes, I have a computer or a tablet, without Internet ○ Yes, I have a computer or a tablet with Internet
• ¿Con qué frecuencia visitas la playa? ○ Cada día ○ Cada semana ○ Cada mes ○ Unas cuantas veces al año ○ Una vez al año o menos ○ Nunca	• How often do you visit the beach? ○ Every day ○ Every week ○ Every month ○ A few times a year ○ Once a year or less ○ Never
• Basura marina plástica La basura marina plástica se produce cuando objetos desechados de plástico ingresan a los mares, océanos y costas debido a las actividades humanas. Los objetos de plástico pueden ser cosas como bolsas de plástico y envoltorios de alimentos, botellas de plástico, redes de pesca y cuerdas y partículas diminutas que se usan en cosas como lavado de cara y pasta de dientes.	• Plastic marine litter Plastic marine litter is produced when discarded plastic objects enter the seas, oceans and coast due to human activities. Plastic objects can be things such as plastic bags and wrappers, plastic bottles, fishing nets and ropes and tiny particles used in cosmetic products and toothpaste.
• ¿Cuánto cree que sabe sobre la basura marina plástica?	• How much do you think you know about marine plastic litter? 1 (I know nothing) - 5 (I know a lot)

1 (no se nada) - 5 (sé muchísimo)	
• ¿Está de acuerdo o en desacuerdo con las siguientes declaraciones generales? Utilice la escala completa de "totalmente en desacuerdo" (1) a "totalmente de acuerdo" (5) para responder. • La basura marina plástica afecta muchísimo al aspecto de las playas. • Es común que la basura marina plástica dañe la vida silvestre en todo el mundo. • La cadena alimentaria marina contiene pequeños trozos de desechos plásticos marinos (por ejemplo, animales grandes que comen animales más pequeños que han comido plástico) • La forma en que mi familia y yo tratamos la basura de nuestra casa puede afectar la basura que hay en el mar. • Sé cómo puedo reducir la basura plástica marina.	• 10. Do you agree or disagree with the following general statements? Your answer should be on the scale between "I totally disagree"(1) to "I totally agree" (5). • Marine plastic litter severely affects the appearance of the beach. • It is common that marine plastic litter hurts wildlife all over the world. • The marine food chain contains small pieces of plastic marine litter (for example, big animals eat smaller animals that ate plastic before). • The way that my family and I handle domestic litter can affect litter that is in the sea. • I know how to reduce marine plastic litter.
• ¿Qué interés tiene usted en aprender más sobre la basura marina plástica? 1 (nada de interés) - 5 (mucho interés)	• What interest do you have in learning more about marine plastic litter? 1 (No interest) - 5 (A lot of interest)
• ¿Qué importancia tiene para ti reducir la basura marina plástica? 1 (ninguna importancia) - 5 (muchísima importancia)	• How important is it for you to reduce marine plastic litter? 1 (No importance) - 5 (A lot of importance)
• ¿Cuánta basura ha visto en los siguientes lugares?	• How much litter have you seen in the following places?

<table>
<tr>
<td>

- Alrededor de su escuela
- En las calles de su barrio
- En la playa que más visita

1(Está muy sucio) - 5 (Está muy limpio)

</td>
<td>

- The school surroundings
- Your neighborhood's streets.
- The beach that you visit more frequently.

1 (It is very dirty) - 5 (It is very clean)

</td>
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<td>

- ¿Con qué frecuencia hace las siguientes cosas?
    - Recoger la basura que se encuentra en el suelo alrededor de mi escuela
    - Recoger la basura que se encuentra en el suelo de las calles de mi vecindario.
    - Recoger la basura que se encuentra en la playa.
    - Reciclar envases.
    - Intentar convencer a familiares y amigos para que utilicen menos plástico de un solo uso.
    - Intentar convencer a las personas de su comunidad para que utilicen menos plástico de un solo uso.

Escala:

- Nunca
- Rara vez
- A veces
- Bastante
- Todo el tiempo

</td>
<td>

- How often do you do the following things?
    - Collect litter that is on the ground around my school.
    - Collect litter that is in the streets of my neighborhood.
    - Collect litter that is on the beach.
    - Recycle containers.
    - Try to persuade relatives and friends to reduce the use of single-use plastic.
    - Try to persuade people of my community to reduce the use of single-use plastic.

Scale:

- Never
- Rarely
- Sometimes
- Often
- Everytime

</td>
</tr>
</table>

• ¿Qué artículos reciclas en casa? (marque todo lo que corresponda) ◦ Cartón y / o papel ◦ Vidrio ◦ Bolsas de plástico ◦ Botellas de plástico ◦ Contenedores de plástico ◦ Metales, por ejemplo, latas ◦ No podemos o no reciclamos en casa	• What articles do you recycle at home? (Mark everything that correspond) ◦ Cardboard and/or paper ◦ Glass ◦ Plastic bags ◦ Plastic bottles ◦ Plastic containers ◦ Metals, for example cans ◦ We cannot or we do not recycle at home
• ¿Alguna vez ha estado involucrado en una limpieza de playa organizada o en una recolección de basura (adicional a las actividades de Reciba)? ◦ No ◦ Sí - 1-2 veces ◦ Sí, 3 veces o más	• Have you ever be involved in an organized beach clean up or another litter collection (apart from ReCiBa's activities) ◦ No ◦ Yes, 1-2 times ◦ Yes, three times or more
• Nombre UNA cosa que podría hacer usted para evitar que la basura plástica llegue al océano.	• Name one thing that you could do to avoid plastic litter arriving in the ocean.
• ¿Nos da permiso para usar las respuestas de este cuestionario en nuestra investigación? ◦ Sí/No	• Do you consent for us to use yours answers to this questionnaire in our research? ◦ Yes/No

Post-activity schoolchildren questionnaire

• ¿Cuánto cree que sabe sobre la basura marina plástica? 1 (no sé nada) - 5 (sé muchísimo)	• How much do you think you know about marine plastic litter? 1 (I know nothing) - 5(I know a lot)
• ¿Está de acuerdo o en desacuerdo con las siguientes declaraciones generales? Utilice la escala completa de “totalmente en desacuerdo” (1) a “totalmente de acuerdo” (5) para responder • La basura marina plástica afecta muchísimo al aspecto de las playas. • Es común que la basura marina plástica dañe la vida silvestre en todo el mundo. • La cadena alimentaria marina contiene pequeños trozos de desechos plásticos marinos (por ejemplo, animales grandes que comen animales más pequeños que han comido plástico) • La forma en que mi familia y yo tratamos la basura de nuestra casa puede afectar la basura que hay en el mar. • Sé cómo puedo reducir la basura plástica marina.	• Do you agree or disagree with the following general statements? Your answer should be on the scale between “I totally disagree”(1) to “I totally agree” (5). • Marine plastic litter severely affects the appearance of the beach. • It is common that marine plastic litter hurts wildlife all over the world. • The marine food chain contains small pieces of plastic marine litter (for example, big animals eat smaller animals that ate plastic before). • The way that my family and I handle domestic litter can affect litter that is in the sea. • I know how to reduce marine plastic litter.
• ¿Qué interés tiene usted en aprender más sobre la basura marina plástica? 1 (nada de interés) - 5 (mucho interés)	• What interest do you have in learning more about marine plastic litter? 1 (No interest) - 5 (A lot of interest)

• ¿Qué importancia tiene para ti reducir la basura marina plástica? 1 (ninguna importancia) - 5 (muchísima importancia)	• How important is it for you to reduce marine plastic litter? 1 (No importance) - 5(A lot of importance)

• ¿Cuánta basura ha visto en los siguientes lugares?
  ○ Alrededor de su escuela
  ○ En las calles de su barrio
  ○ En la playa que más visita
 	
1 (Está muy sucio) - 5(Está muy limpio)
	• How much litter have you seen in the following places?
	  ○ The school surroundings
	  ○ Your neighborhood's streets.
	  ○ The beach that you visit more frequently.
	
	1 (It is very dirty) - 5 (It is very clean)

• ¿Con qué frecuencia hará las siguientes cosas?
  ○ Recoger la basura que se encuentra en el suelo alrededor de mi escuela
  ○ Recoger la basura que se encuentra en el suelo de las calles de mi vecindario.
  ○ Recoger la basura que se encuentra en la playa.
  ○ Reciclar envases.
  ○ Intentar convencer a familiares y amigos para que utilicen menos plástico de un solo uso.
  ○ Intentar convencer a las personas de su comunidad para que utilicen menos plástico de un solo uso.
• Escala:
	• How often will you do the following things in the future?
	  ○ Collect litter that is on the ground around my school.
	  ○ Collect litter that is in the streets of my neighborhood.
	  ○ Collect litter that is on the beach.
	  ○ Recycle containers.
	  ○ Try to persuade relatives and friends to reduce the use of single-use plastic.
	  ○ Try to persuade people of my community to reduce the use of single-use plastic.
	
	• Scale:
	  • Never
	  • Rarely

• Nunca • Rara vez • A veces • Bastante • Todo el tiempo	• Sometimes • Often • Everytime
• Nombre UNA cosa que podría hacer usted para evitar que la basura plástica llegue al océano.	• Name one thing that you could do to avoid plastic litter arriving in the ocean.
• Ahora piense en la actividad de la historia ¡nos gustaría saber qué te pareció!	• Now think about the story activity, we would like to know what you thought about it!
• ¿Cuánto disfrutó de esta actividad? No lo disfruté nada  lo disfruté muchísimo.	• How much did you enjoy this activity? I did not enjoy it at all  I enjoyed it a lot
• ¿Está de acuerdo o en desacuerdo con las siguientes declaraciones generales? 1 (Totalmente en desacuerdo) - 5 (Totalmente de acuerdo) • Aprendí algo en lo que respecta a la basura marina haciendo esta actividad. • Aprendí algo nuevo sobre los impactos que la basura marina puede tener en la vida silvestre al hacer esta actividad.	• Do you agree or disagree with the following statements? 1 (I totally disagree) - 5(I totally disagree) • I learned something about marine litter doing this activity. • I learned something new about the impacts of marine plastic pollution on wildlife doing this activity. • I learnt something new about what we can do to reduce marine plastic litter doing this activity.

● Aprendí algo nuevo sobre lo que podemos hacer para reducir la basura marina plástica al realizar esta actividad. ● Animaría a familiares y amigos a realizar esta actividad.	● I would encourage relatives and friends to do this activity.
● ¿Está de acuerdo con que compartamos su historia en nuestro sitio web para que todos y todas puedan leerla? ○ Sí, con mi nombre completo ○ Sí, pero sin mi nombre ○ No	● Do you consent to share your story on our website to be read by everyone? ○ Yes, with my complete name ○ Yes, but without my name ○ No
● ¿Nos da permiso para utilizar sus respuestas a esta encuesta en nuestra investigación? ○ Sí/No	● Do you consent for us to use your answers to the survey in our research? ○ Yes/No
● Háganos saber cualquier otro comentario que tenga ¡Gracias por participar!	● If you have any comments, let us know. Thank you for participating!

Appendix 3 - Coding strategy

Qualitative analysis of the stories followed the methods of thematic analysis which allows for flexibility (Braun & Clarke, 2006) across a wide range of research questions (Nowell et al., 2017:2) and the identification of patterns in the data with emerging themes becoming the categories of analysis (Fereday and Muir-Cochrane, 2006: 82). Initial coding by one researcher established codes corresponding to recurrent themes and topics across stories with no previous template. This initial process is inspired from inductive coding that is data driven (Boyatzis, 1998 in Fereday and Muir-Cochrane, 2006: 82). Codes were then discussed with the whole team, and redefined through several meetings between February and June 2021. The thematic codes were finally organised into the final codebook (Appendix 4) that served as a basis for the coding of all narratives. This second process uses methods of deductive coding defined as the application of established codebooks to the data before an in-depth interpretation (Fereday and Muir-Cochrane, 2006: 83). The thematic analysis used in this project is hybrid combining inductive and deductive coding, following Fereday and Muir-Cochrane (2006) with the difference that the hybrid coding of this project was done through a succession of inductive and then deductive coding rather than simultaneously.

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Appendix 4 - Codebook with examples

Code	Description	Pathway	Example	Files	References
less than a day	The object can be used less than a day. This typically refers to single-use plastics that are not reused and directly discarded after use. For instance, a straw being left or disposed of after its use. It can also be the case for plastic bags that are said to be not reused.	object as a product > how was the object used and who used it > length of use of the object	The boy walked along the beach and when he finished the juice, he threw me and the glass on the ground.	30	30
between days and months	This codes for a length of use that is more than a day but less than a year. For instance, toothbrushes are usually used a couple of months before being disposed of. This should be coded under this category.		However, after three months, they had to get rid of it.	12	12

Code	Description	Pathway	Example	Files	References
over a year	This length of use typically refers to the use of an object over a year. That is typical the case for toys, unless when explicitly stated. A toy might be broken or lost before that although that remains accidental.		He and his young son have been using my service for as long as I can remember.	6	6
adults	The category of adults refers to people that are not at school anymore and interact with the object. It can be the family of the children, other adults. This code mostly contrasts with the "children/teens" category.	object as a product > how was the object used and who used it > who interacts with the object?	One day a woman took the bag I was in and, after many turns and trips, we arrived at a kiosk on the beach.	15	15
children/teens	This code considers together children and teens because most stories do not specify the age of the people interacting with the object.		Actually, the toothbrush was for the youngest daughter of two adults, and her name was Alicia.	32	32

Code	Description	Pathway	Example	Files	References
	This is contrasting with the role of adults.				
feeling apprehensive	This codes for the negative feeling of apprehension towards a future event.	object as a product > what is the object > emotions of the object > negative	The toothbrush had been living in a supermarket for a few months, anxious for someone to buy it, yet terrified of not knowing what would become of it when it was discarded.	4	4
feeling sad	This codes for the object feeling in the present sadness.		He was sad because his mother had been forgotten in the sea and ended up floating in the ocean.	2	2
feeling of excitement	When the object is looking forward to being used, sold, or getting to know the world, we code this under "feeling of excitement". it also includes excitement to go somewhere or meet someone. It is a positive feeling regarding any future event.	object as a product > what is the object > emotions of the object > positive	He was handed the teddy bear in the blue bag which was excitedly waiting to be used.	12	12

Code	Description	Pathway	Example	Files	References
feeling of happiness	This codes for object mentioning their happiness in the present. It can be for instance when the object gets to be functional in their intended use. It is only restricted to the object as a product rather than as waste.		I had finally served my purpose and it felt amazing, it was now a plastic spoon that had served its purpose.	9	9
biodegradable plastic ring	The type of object codes for the category of object (the main object in the story) explicitly mentioned in the text. The categories are self explanatory and a definition per object type does not seem useful as those items are literally mentioned in the stories. It should just be noted that	object as a product > what is the object > type of object	What he didn't know was that it wasn't food but biodegradable rings.	1	1
clothes pin			I'm Flo, a clothes pin.	1	1
diving fin			-They threw me away like I was rubbish! -says Mandy, the diving fin, "even though I am (whispers).	2	2
glass			There were perfumes of princesses like Diana, Aurora, Belle, Merida and like me, Elsa from Frozen.	1	1
hat			I am a cute and colourful hat.	2	2

Code	Description	Pathway	Example	Files	References
oil container	all specific toys were grouped under the “toy” category.		When she and Angela returned, they saw some men throwing many bottles of motor oil, all that rubbish, into the sea!	2	2
plastic bag			Thanks to this process, a little blue plastic bag was born, unaware of all that lay ahead.	10	10
plastic bottle			Everyone forgot the water bottle	11	11
plastic glass			Once upon a time, there was a little plastic cup that was very sad.	5	5
shoe			Hello! As you can see, I am a flip-flop, and I live in the city of Lima, Peru.	5	5
spoon			I am a plastic spoon and I was created in a factory in London many years ago.	7	7

Code	Description	Pathway	Example	Files	References
straw			Hello! I'm the straw and this is my story.	8	9
toothbrush			She uses her toothbrush every day.	5	5
toy - action figure			My name is Juan and I am an action figure.	2	2
toy- dinosaur			But this time I had been given a very nice toy dinosaur which I called Rex and I decided to take him along.	1	1
toy- horse			I am one of them, a plastic figure in the shape of a horse.	1	1
toy- seahorse			When he turned three, his parents gave him a very special toy. It was a seahorse.	1	1
toy - wheel			I am Manuel, the toy wheel.	6	6

Code	Description	Pathway	Example	Files	References
awareness of being harmful	This codes for the object becoming aware of its impact on the environment. It is distinct from guilt that appears to be another emotion that can result from this awareness. However, the awareness sometimes does not end up being guilt.	object as waste > emotions of the object > negative	We plastic items are very harmful to them, we can hurt them and even kill them!	21	25
feeling of guilt	This codes for the object using the word guilt or guilty. Guilt is a feeling that has to do with a past event. It also codes for feeling of responsibility for its presence as waste in the environment. This feeling of guilt can be felt by the object as being responsible for harming the environment, for being “out of place”.		He felt so guilty for being in the wrong place and unfortunately all they got were more unpleasant results.	5	6

Code	Description	Pathway	Example	Files	References
feeling powerless	This codes for the object feeling powerless facing its situation. It is a feeling anchored in the present. Powerless corresponds to the impossibility of doing anything to change its situation.		I felt very bad for them but there was nothing I could do.	18	24
feeling of happiness	This codes for happiness felt by the object when being recycled, properly disposed of, or incinerated.	object as waste > emotions of the object > positive	The spoon was very happy because it had been found and could be recycled.	7	7
feeling of hope	This codes for the object feeling hope, for instance, regarding the possibility of being recycled. The object could also feel hopeful when being picked up by humans on the beach. It "hopes" for similar actions and a better future. It can be shown with the use of words such as "hope" and "wish".		I really hope that in the future humans will stop forgetting or disposing of objects in inappropriate places so that my hydrozoan friends can be happy in their natural habitat.	4	4

Code	Description	Pathway	Example	Files	References
bird	This codes for all animals interacting with and being noticed by the object, either on the beach or in the sea. Macro-organisms are not considered here as they are considered in plastic deterioration. The different categories of animals are not described individually as they are quite self-explanatory.	object as waste > how did the object interact with its environment > animals interacting with plastic	There the spoon met seagulls and jumping fish of different sizes.	6	6
crustaceans			Among the bags was a lone crab that could barely move as its legs and pincers were covered in the contaminating material.	6	6
dog			Dogs, like any small child, don't know what they put in their mouths. They just do it. Apparently, Thunder had put Nico in his mouth.	1	1
dolphin			A dolphin told them that he saw a plastic bag fly in and land on the surface of the water.	1	1
fish (not shark)			The fish tried to eat him and Jesus was all damaged.	27	29
jellyfish			On the way I met many different animals, such as whales, fish, octopus, jellyfish, seahorses and the	1	1

Code	Description	Pathway	Example	Files	References
			ones that scare me the most, the sharks.		
octopus			We met a lot of fish and octopus and they mistook us for food.	4	4
sea lion			There were sea lions, turtles, fish and sharks among the rubbish, some trapped and some stuck.	1	1
seahorse			On the way I met many different animals, such as whales, fish, octopus, jellyfish, seahorses and the ones that scare me the most, the sharks.	1	1
shark			One day I was floating peacefully, aimlessly, when a shark took me to the depths of the sea, where everything is dark.	4	5

Code	Description	Pathway	Example	Files	References
squid			An octopus told them that he had fallen in love last summer, but it turned out that his love was made of plastic.	1	1
turtle			Unfortunately, one turtle ended up with its flipper stuck in one of the holes in the bag.	27	27
whale			I got stuck with all of them and I couldn't escape, until something came out of the water, it was a giant fish, it was a whale!	7	7
divers	Divers and snorkelers might encounter the object as waste in the sea/ocean.	object as waste > how did the object interact with its environment > humans interacting with the waste >	There I could see some divers. They were frightened because I had attached myself to the turtle and together with the other rubbish it looked like a shark. The divers ran away as I had chased them away.	1	1

Code	Description	Pathway	Example	Files	References
fishermen	Fishermen can notice the presence of waste, pick it up and bring it back to land. They can also notice it and throw it back in the sea.	human actors of the interaction	One of the fishermen decided to take me to his home.	2	2
general public	This codes for the general public taking action towards the waste: it can be picking it up, noticing it or even studying it without being a citizen scientist or taking part in such a programme.		Many people were collecting lids, bags and toys like me.	21	23
professional and citizen scientists	This codes for people studying the waste or the epibiomes associated to it once the waste has been picked up. This code includes both professional and citizen scientists.		At the tip of my eyes, a group of unique, white children peek out, calling themselves garbage scientists, and they will take me to a place to investigate and photograph.	14	15
recyclers	This codes for people whose job is to be recyclers and to pick up the waste.		Apparently these humans were working at a place called "Let's Recycle ".	5	5

Code	Description	Pathway	Example	Files	References
veterinarians	This code for veterinarians interacting with the object while trying to save an animal.		They had to take Manta to an exotic animal vet so that they could remove the straw from his mouth, which had injured Manta's palate and throat.	8	8
disposed of	This codes for the object being disposed of once it has been studied or picked up. It can be thrown in a bin as long as it does not involve recycling it and making another object of it. This code usually emphasises disposing of the object adequately (in the correct bin).	object as waste > how did the object interact with its environment > humans interacting with the waste > outcome of the interaction	At home I took it out of the bag and put it in the bin where it belonged.	8	8
recycling	This codes for the recycling of the object after it has been picked up or studied. It can either be recycling in a recycling facility or at home by giving a new use to the object.		They said that with a few tweaks it could be recycled and be in a new toy.	20	20

Code	Description	Pathway	Example	Files	References
noticing the waste without acting	This codes for the type of interaction that just consists of noticing the waste without further action.	object as waste > how did the object interact with its environment > humans interacting with the waste > type of interaction	I saw many people passing by me and no one picked me up.	3	3
picking up the waste	This codes for a type of interaction where humans pick up the waste.		Until one day it was picked up by people who dedicate their time to this great work.	39	39
studying the waste	This codes for actions where humans study the waste (for example, as part of a citizen science program through photographs or studying the epibions).		And they took them to the scientists for analysis.	6	6
entanglement	This codes for animals getting stuck in plastic or getting a plastic object making it impossible for them to move adequately. Examples of the stories include a tiny fish stuck in a bottle or a straw in a turtle's nose. It includes pieces of plastic being stuck onto or in the animal's body as	object as waste > how did the object interact with its environment > type of interaction between animal and waste > harmful	He had a yellow straw embedded in his nostrils.	21	27

Code	Description	Pathway	Example	Files	References
	long as the object being stuck is not a result of ingestion.				
ingestion	This code gathers the attempts, successful or not, from animals to eat the plastic.		Once they tried to eat me and took a part of my body.	28	31
intoxication	This codes for animals being intoxicated by the components of plastic either by biting it or picking it up. It refers specifically to one story where an object is picked up by a dog that then gets a microbial infection.		They took him to the vet and he explained that it was because of something he had eaten that had given him an infection in his stomach. When they heard this, they knew instantly that it was because of the toothbrush he had had between his teeth the time they went to the beach.	5	5
discussion	This codes for discussions between objects and animals. This can be about several topics.	object as waste > how did the object interact with its	After several hours Ricky was still being swept by the currents and in the course of this he met a fish and	7	8

Code	Description	Pathway	Example	Files	References
		environment > type of interaction between animal and waste > not harmful	asked him, "Hey buddy, where am I going?		
overgrowth of crustaceans	Macro-organisms growing onto plastic are any organism visible to the naked eye. In our stories, we only have three types of macro-organisms mentioned: crustaceans, hidrozoos and molluscs.		They were barnacles, if I am not wrong	2	2
overgrowth of hidrozoos			But now I was becoming a new habitat for hydrozoans. These were tiny attachments of the animal kingdom.	1	1
overgrowth of molluscs			The straw had a lot of shells stuck to the plastic and was then disposed of in the recycling bin.	2	2
overgrowth of microorganisms	Micro-organisms can also appear onto plastics and are not visible to the naked eye. Some stories include mention of organisms that are not visible but are toxic.		All that was left of me were little toxic remnants of my body all over the place. I have no doubt that some animal was going to consume them.	1	1

Code	Description	Pathway	Example	Files	References
fisherman	This code refers to one story specifically where the fisherman accidentally picks up the litter on the side of his boat and the object then enters the sea this way.	object as waste > how does the object become waste > factors leading to the arrival of the object to the ocean > cultural	A fisherman inadvertently pushed his boat out to sea and took the wheel with him into the open sea.	1	1
general public	This codes for humans being responsible for the object entering the sea. If the object is left on the sand and then gets into the sea, this will be coded under tide. But if the person throws the object in the sea then it gets coded under humans.		They made bonfires, they left leftover food buried in the sand on the beach. Other people left their leftover food everywhere, because they didn't mind leaving their waste there.	7	7
object	This code for the object itself getting into the sea.		Once on the spot, the little cup was very excited to enter the sea and meet his mother again, so he kept rolling and rolling until he reached the sea.	1	1

Code	Description	Pathway	Example	Files	References
truck dropping waste	Several stories mention the presence of a truck dropping its content directly into the sea. This is what this code is for.		The truck stopped and suddenly we were in the sea. Then Fundita told me that we had fallen in.	2	2
animal	Any animal can take up voluntarily or involuntarily litter and drop it in the ocean. This has been the case in several stories of dogs picking up a bottle and leaving it in the sea when they entered it.	object as waste > how does the object become waste > factors leading to the arrival of the object to the ocean > natural	The dogs came and chewed the bags open and dragged the rubbish along, leaving the beach dirty.	5	5
rain	This codes for rain washing down the streets and the environment, resulting in movement of the object towards the sea.		He threw it in the street, the rain fell, the rain washed it into the river and it was washed into the sea.	4	4
river	This codes for the presence of a river leading to the ocean. The litter can arrive to the river and then eventually enter the ocean.		He threw it in the street, the rain fell, the rain washed it into the river and it was washed into the sea.	5	5

Code	Description	Pathway	Example	Files	References
tide	This codes for the tide being responsible for the entry of the object within the ocean. This most often corresponds to objects being abandoned on the beach.		Days, nights, weeks and months passed. The spoon was buried in the sand. Until one swelly afternoon a very big wave swept it out to sea.	10	10
wind	This codes for the action of wind provoking the movement of the litter and it getting closer to the ocean/sea.		The sea breeze grew stronger as the sun went down and soon the straw was blown away from where they were.	8	8
accidental origin	This codes for an unintended action leading to the object being discarded. It includes the object being forgotten or lost during a moment of inattention.	object as waste > how does the object become waste > what human actions or behaviours caused this outcome > behaviour behind the action	The boy's parents got him back but I dropped out and no one noticed I was gone.	26	27
intentional origin	This codes for an intended act of leaving the object, throwing it away not properly or disposing of it. This does not mean that the action is on purpose to harm the ocean. It just		So he grabbed Nico and pulled him with all his might in the direction of the ocean.	28	28

Code	Description	Pathway	Example	Files	References
	means that the person was aware of discarding it in the environment contrasting with the accidental origin of the object coded previously.				
feeling guilty	This codes for the person responsible for the act feeling guilty despite of it being either intentional or accidental. Guilt can happen directly after the object being thrown or much more after. Guilt shows by a feeling of responsibility or regret regarding a specific behaviour leading or contributing to the object being discarded. This feeling of guilt can lead to behavioural changes.	object as waste > how does the object become waste > what human actions or behaviours caused this outcome > inferring emotion of the culprit	Sam and Paul were very sorry and felt they had to change.	7	7

Code	Description	Pathway	Example	Files	References
indifference	This codes for actions of people that do not care and show an indifferent attitude towards marine litter and their own behaviour. It is typically identified in sentences mentioning: the person did not care. It is different from thoughtlessness because the later reflects the absence of knowledge about some consequences of our actions.		They followed and watched as the people who lived nearby dumped their rubbish on the sand and spilled everything, without caring.	7	7
thoughtlessness	This codes for the lack of awareness of consequences of one's actions or the lack of education about the topic of litter and waste disposal. It does not reflect indifference, rather a lack of knowledge about the consequences.		Unaware of the harm my owner was causing by leaving me there, I became fish food;	12	13
animal injured	This codes for the object injuring the animal without being a fatal injury.	object as waste > what was the	In addition, Adrian had seen turtles eating plastic bottles and seals	10	10

Code	Description	Pathway	Example	Files	References
		consequence of this interaction > animal	injured by nets left at sea by fishermen and many fish with stomach ailments.		
death of the animal	This codes for the interaction with the object resulting in the death of the animal.		The veterinarian and expert did her best. But it was too late and he would not survive.	16	16
impact on the animal's environment	This codes for impact of the presence of the object on the animal's environment that does not cause injuries or death of the animals but that impacts their surroundings. It can be a lack of visibility due to the quantity of waste, etc…		Thanks to all of us, the life of fish in the sea is becoming more and more difficult.	15	15
abundance of plastic pollution	This codes for comments from the protagonist noticing the abundance of plastics in the sea.	object as waste > what was the consequence of this interaction > awareness of the	I soon discovered that among all of them, there were more like me. There were even plastics that looked like seaweed, and I had only just realised it.	27	28

Code	Description	Pathway	Example	Files	References
other pollution	This codes for the mention of other pollution noticed, inland or maritime. This notably acknowledges chemical pollution and oil leaking.	pollution in the environment	It was about the pollution left behind by ships.	4	4
action of waves	This code for the destruction of the object by the action of waves.	object as waste > what was the consequence of this interaction > object > factor of deterioration > abiotic	My body totally destroyed, the waves left little of me.	1	1
exposure to sun	This codes for the exposure of the object to the sun, leading to a loss of colour or a loss of shape.	object as waste > what was the consequence of this interaction > object > factor of deterioration > abiotic	I am still in the sea after so long, the sun is burning me and several parts of me have separated, I see animals eating me and I see them die every day.	1	1
animal bites	This codes for animal bites being the reason for the degradation of objects. Fishes and marine mammals can bite the object.	object as waste > what was the consequence of this interaction > object > factor of deterioration > biotic	One day I went to the beach and found a bottle bitten by a turtle.	12	13
growth of organisms	This codes for the growth of organisms responsible for the deterioration of objects.	object as waste > what was the consequence of this interaction > object > factor of deterioration > biotic	They also had living things attached to them.	11	11

Code	Description	Pathway	Example	Files	References
not specified	This codes for stories noticing the deterioration of the object although without specifying the factors of deterioration. It is often the case for stories saying, after a long time at sea, the object lost its colour/shape/… Sentences usually emphasise the time spent without mentioning clearly what kind of impacts it had.	object as waste > what was the consequence of this interaction > object > factor of deterioration	He did it for so long that he got little holes in his body, which made it easier for him to move.	9	9
broken into microplastics	This codes for the transformation of macroplastic into microplastics, either explicitly or mentioning the breaking of the object into tiny particles of plastic.	object as waste > what was the consequence of this interaction > object > type of deterioration	More than half of his body was turned into microplastics, which were scattered all over the Latin American coastline.	5	5
buoyancy	This codes for a loss or gain of floatability of the object, going either from sinking to floating or from floating to sinking. This codes for	object as waste > what was the consequence of this interaction > object >	Suddenly my lid came off me and the water filled me up and I sank.	8	8

Code	Description	Pathway	Example	Files	References
	any mention of buoyancy or float ability.	type of deterioration > loss of material properties			
colour	This codes for a change of colour, that can be due to whitening through exposure to the sun) or due to the growth of algae turning the object into a greenish colour. Both cases happen in the stories.		But it was already broken, worn and discoloured from the unexpectedly long journey it had taken.	9	9
shape	A change in shape might also occur for the object. It especially codes for the change of the object due to small holes, change in overall shape, …		Over the years I have lost my beautiful blue colour due to sun damage and also my shape, as I lost parts of my body.	7	7
size	This codes for a loss in size of the object in stories stating that the object loses parts.		Every day he was losing parts of his body and he also had fungus on his body due to the water.	4	4

Code	Description	Pathway	Example	Files	References
disposal or throwing	This code reflects a change of behaviour in disposing or throwing the waste. It can include paying more attention, disposing of them properly.	solution > what actions could have prevented this outcome > preventive solutions > personal - change of attitude	I really hope that in the future humans will stop forgetting or disposing of objects in inappropriate places so that my hydrozoan friends can be happy in their natural habitat.	22	23
reuse	This codes for an object being reused and/or re-purposed by individuals before its disposal. It contrasts with industrial recycling.		But Gabriela said to Daniela, "Just as they had used the bottles to carry water, maybe they could use them for something else," and Daniela asked, "But what can we use them for?" and Gabriela replied, "We can use Cristal and Cielo as vases.	1	1
recycling	This codes for recycling as a preventive solution. That means recycling objects at home by throwing litter in respective recycling bins. It contrasts with industrial recycling of waste and with reuse of a product before its disposal.		Since then, she and her family have been trying to recycle as much as possible.	7	7

Code	Description	Pathway	Example	Files	References
reduction of consumption	This codes for a reduction in use and consumption of plastics so they do not enter our environment.		If you are reading this, please do not use plastic bags and if you do use them, please dispose of them properly so that they do not end up among the nine million tonnes of rubbish thrown away every year.	4	5
change of object design	This code applies to suggestions in design of objects to avoid litter ending up in the sea.	solution > what actions could have prevented this outcome > preventive solutions > social - action	by putting little straps on each side to be tied to the heads of our owners so that we don't get to that beautiful place called the beach where we can all enjoy them.	1	1
convince the community	This code gathers solutions to influence the community to use less single-use plastic. This is one of the survey questions that could be important to notice in the stories.		Fortunately, a group of young people became aware of this huge problem and decided to create a team with the aim of collecting all this rubbish and changing the mentality of the population.	6	6

Code	Description	Pathway	Example	Files	References
convince the family	This codes for solutions to try to convince the family to use less single-use plastic. This is one of the survey questions and it would be interesting to see if it is present in the stories.		I taught a lesson to my relatives and to my colleagues and to all the people who knew me.	2	2
education	This codes for informing and educating about litter and its consequences in the environment either through posters, classes, sharing knowledge, inciting people to do things. This can take place within a family, amongst friends or in an educational setting.		When people saw all that rubbish washing up on their beaches and docks, and affecting all their animals, they started to pick it up, protest against pollution and educate themselves about the issue.	9	9
politics	This codes for any implication of politics and/or politicians in helping implement measures (through fines or panels) or recognizing successful projects.		The environmentalists put up signs all along the coast and, finally, called on the authorities to fine anyone who leaves plastic bags or plastic waste anywhere.	3	4

Code	Description	Pathway	Example	Files	References
picking up - community	This codes for picking up the litter as part of a group. This relates to community actions such as beach clean-ups. Community actions go beyond the nuclear family.	solution > what actions could have prevented this outcome > reactive solution	That's why I am now part of the beach cleaning brigade in the reserve.	10	10
picking up -individual	This codes for individual actions of picking up the litter. It can either be the action of one individual or of this individual with his/her family. Individual actions become community actions once there is more than one nuclear family involved.		So he decided to pick up the plastic bottles and rubbish on the beach.	10	11
reuse	This codes for reuse of a littered object (hence a reactive solution) to be turned into another object by the person picking it up.		On the way home, I heard him say that he was going to reuse me to make a nice toy for his daughter.	4	5

Code	Description	Pathway	Example	Files	References
recycling	This codes for industrial recycling of waste, contrasting with recycling of products at home (disposal in recycling bins).		I learned that not only were there bottles that humans were leaving in the recycling bins, but they were also bringing bottles that had previously been thrown into the sea.	6	6
waste processing	Litter being burnt (incinerated) or processed in a landfill.		To them it all seemed so absurd as there was so much rubbish arriving every day and more than they burned, creating an endless cycle.	1	1
work of organisations	This code includes mentions of environmental groups, campaigns, or work like Reciba’s that help picking up the litter and analyse it.		If there is anything positive about this, it is the campaigns that some organisations are running against this kind of thing, working to help protect our planet.	10	10
broader level (society, institution)	This codes for solutions needed to be implemented at a global level, asking politicians or policy-makers for instance.	solution > who should take action	Dad: Let's talk to the authorities. We arrived at the district municipality.	1	1

Code	Description	Pathway	Example	Files	References
the protagonist	This code includes both the protagonist of the story taking action or the main character when the story is told from an external narrator (3rd person).	solution > who should take action > individuals	I am Rodrigo, I took Bili with me. Now I use Bili for many things, such as: to carry shampoo, soap, toothpaste and toothbrush, I use it as a bag for slippers and also for shopping, among many other things.	5	5
the reader	This codes for calling the reader out on potential behaviours and asking to take actions.		And you, please start at home and you will see that you can be a hero to the world!	8	8
exclusive	This codes for the call for action on people excluding the protagonist and saying people should take action and recycle, with no “we” or “let’s”. Exclusive includes the 3rd person plural "they" as it does not include the protagonist.	solution > who should take action > society	But above all that people are aware and responsible, that they act for the good of the community and of the people.	4	4
inclusive	This code for the call on people to take action in an inclusive way, such as : let’s all take care of the planet.		It's everyone's fault. What will we leave to future generations? Nothing, it seems! We must respect mother	11	11

Code	Description	Pathway	Example	Files	References
			nature! The earth does not belong to us!		
Brazil	All countries mentioned are coded here and the codes are self explanatory.	structure of the story > location > country	The bag floated for two years and four months until it washed up on a beach in Brazil.	1	1
Chile			It was then that Susana, ready and full of drink, set off on her journey from the Coca-Cola factory to a small shop in Purén.	8	8
China			My life began in a factory in China. I was born in 1988 and, as far as I remember, I was a plastic straw.	3	3
Colombia			Once in Mecana, the fun ran by itself.	1	1
Costa Rica			She lived in Palmas del Rio, a community located in the district of Barranca in the province of Puntarenas, Costa Rica.	2	2

Code	Description	Pathway	Example	Files	References
Ecuador			Her family had a house on one of the most beautiful islands in Ecuador, Puná Island.	11	12
India			I then travelled two weeks overland to Mumbai, India.	1	1
Italy			There I was packed up and met my 30 siblings and finally we were sent to Milan, Italy.	1	1
Japan			It then landed on the sand of a beach in Japan, where it did not last long as people threw it back into the sea.	1	1
Malaysia			I was supposed to be in Malaysia.	1	1
Mexico			I could tell we were in Mexico by the people's accents.	2	2

Code	Description	Pathway	Example	Files	References
Panama			I stay buried on Panama's Star Beach, waiting for someone to rescue me, although I know no one will.	1	1
Peru			Nico was bought in 2018 by a random family from Lima, Peru.	4	4
UK			I am a plastic spoon and I was created in a factory in London many years ago.	2	2
US			When I got to the shore, I found a flip-flop lying on the shore, he told me that this beach is called Laguna Beach, in California.	3	3
Story starts in another place as it ends	This codes for stories that start and ends in a different region or country, reflecting the travel of the object. Stories evoking travel of the main characters will also be coded under this code.	structure of the story > location > movement	There was a sign, Tongoy - exactly, that must be it! Chile, Coquimbo! Yes, at least I knew where I was.	34	34

Code	Description	Pathway	Example	Files	References
same place - object has not travelled	This code is for stories that stay at a local level, i.e. in the same country.		So we went to look for the toothbrush on the beach and we were lucky to find it.	3	3
same place - object has travelled	This codes for a story where the object travels outside of the region but accidentally comes back to the country it had been discarded.		One beautiful Friday the swordfish was caught by fishermen's nets and I finally returned as a micro-plastic to dry land in San Pedro, in the same place where I had started my adventure.	5	5
beach	This codes for the beach as a place where the object is used, either when someone plays on the beach, has lunch there, …	structure of the story > location > place > object as product	I heard we were on the beach.	21	21
home	This code gathers objects used as products at home.		My house is very nice and big, there are many rooms, wardrobes and beds.	3	3

Code	Description	Pathway	Example	Files	References
industry	This codes for any type of industrial setting described during the production phase of the object.		I was born in a factory.	20	20
restaurant	This codes for a restaurant as a place where objects such as straws and bottles can be used. It also includes small food stalls (ice-cream shops, etc).		Fiesta Cangreja is a restaurant in the marine bay of Coquimbo.	3	3
sea	This codes for the sea as a place where the object is used. This is mostly related to toys used in the sea or to snorkelling gear.		She also used us for diving, her favourite sport.	2	2
shop	This codes for small shops where the object might be sold or used. It contrasts to supermarkets by the scale. It will be coded to shop any time it says shop/tienda.		We were given to her in some marine sports shop over there in Costa Rica.	15	15

Code	Description	Pathway	Example	Files	References
supermarket	This codes for the supermarket as a place where the object is sold. Only places literally called supermarkets are coded under this code, any other shop is coded under "shop".		I, like many of my fellow spoons, were displayed for several weeks in the supermarket, to be sold.	12	12
laboratory	This codes for any scientific setting where the object can be analysed after it has been picked up as waste.	structure of the story > location > place > object as waste	Then the rest of the plastics told me it was a laboratory.	4	4
landfill	This codes for the arrival of the object as waste to a landfill.		I was taken to a landfill near a beach, which hardly anyone visited because there was so much rubbish.	8	8
recycling area	This codes for waste going to a recycling area and being turned into another object. It has to be differentiated from landfill where the object is just thrown without any potential for recycling and reuse mentioned in the text.		El biólogo marino me llevó a un lugar de reciclaje.	9	9

Code	Description	Pathway	Example	Files	References
rehabilitation centre	Rehabilitation centre codes for places where animals are saved and rehabilitated. It can also be referring to centres where vet operate.		At that moment, some people were passing by and saw the tortoise about to suffocate to death, so they decided to take it to the nearby veterinary hospital.	8	8
protagonist is a third person	The protagonist is external and used the third person of singular.	structure of the story > protagonist	In a small corner of the ocean, in a sea cavern, there lived an octopus called Adrian.	37	37
protagonist is human	The protagonist is a human being and uses the 1st person of singular.		Hello! My name is Rodrigo and today I am going to tell you the story of Bili the plastic bag.	15	15
protagonist is the object	The protagonist is an object and uses the first person singular.		Hello everybody! I'm Manuel, the toy wheel.	29	29

Appendix 5 - Results of the inter-coder reliability (ICR) analysis

ICR aims at calculating the level of agreement between coders. Here, ICR was undertaken on a 10% sample of the dataset (stories). The different types of query are based on agreement at the character, sentence and paragraph level. The overall unweighted kappa and the average agreement were calculated on NVivo 20 while the average kappa coefficient was calculated with an average formula on Excel of all kappa agreement per code and per file.

Type of query	**Codes**	**Overall unweighted kappa**	**Average kappa coefficient**	**Average agreement**
ICR based on character	All codes (aggregated)	0.57	0.83	98.82
ICR based on sentence	All codes (aggregated)	0.59	0.83	99.01
ICR based on paragraph	All codes (aggregated)	0.72	0.86	98.14

Appendix 6 - NVivo disagreements

Summary of the disagreements

After calculating inter-coder reliability, all codes that had a kappa measure less than 1 (where 1 is full agreement) were analysed manually and evaluated across all files. After this analysis, 64 disagreements were found to reflect actual disagreements between coders, and were therefore addressed leading to some changes in the final codebook (Appendix 4). Yet, 55 measures of disagreement did not reflect a disagreement on the presence of the code itself, rather on its location within the text or its extent. A closer look at the disagreement types illustrates this trend (Figure a).

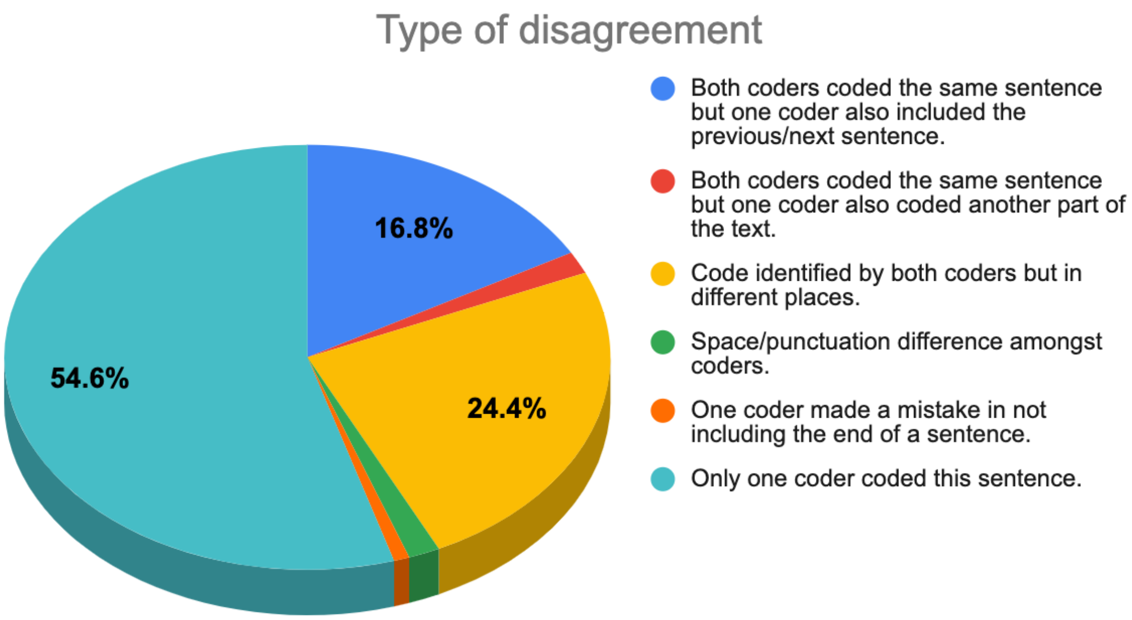


Figure a: Distribution of the types of disagreement between coders during the ICR.

Detailed analysis of disagreements

This table details all the disagreements between coders where NVivo calculated kappa values to be less than 1. All kappa values <1 were considered across all files (=stories). They were evaluated as real disagreement (RD) in the last column.

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
between days and months	939	0.86	97.17	Every morning she brushes her teeth with her brush.	She uses her toothbrush every day. Every morning she brushes her teeth with her brush.	Code identified by both coders but in different places	no
between days and months	948	-0.03	84.98	(The next day) We are already on our way to the beach.	Hello! As you can see, I am a flip-flop, and I live in the city of Lima, Peru. My house is very nice and big, with many rooms, closets and beds. I always walk through the streets of Lima, especially when it is very hot. They also take me from time to time to a place where there is water in a large tank, I think they call it a swimming pool, but I'm not sure. I live with a ten-	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					year-old boy who likes the beach a lot. Since he doesn't have school tomorrow, we're going to go to the beach		
between days and months	952	0.64	95.94	Time passed and the plastic cup felt that it could not take it anymore; it wanted to see its mother as soon as possible!	The family resumed their journey, the heartbroken little cup only consoled by the idea that it might see its mother again. Time passed and the plastic cup felt that it could not take it anymore; it wanted to see its mother as soon as possible!	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
less than a day	943	-0.04	89.13	In the fall, the wheel of the motorcycle broke off, so a happy day turned into a sad day.	As expected, Dalia was very happy and she went to the beach to play with her motorcycle. She had a great time playing, jumping and enjoying herself while her dog	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					watched her from afar, wanting to play with her too. The dog lunged and, without meaning, pushed Dalia and she and the motorcycle fell to the sand.		
less than a day	946	-0.02	93.08	"We'll buy you another", Danny said, to reassure Miller.	They approached the till to pay for it, a young lady attended them very kindly, and they paid and left. They later bought an ice cream, which they ate quickly, as they were about to start their trip to Briceño Beach, a very beautiful beach in Manabí, Ecuador.	Code identified by both coders but in different places	no
adults	939	0.65	97.25	She uses her toothbrush every day.	My aunt Maria lives near the sea. She uses her toothbrush every day.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
adults	940	0.99	99.96	A lady who seemed very friendly took Bili.	A lady who seemed very friendly took Bili.	Space/punctuation difference amongst coders.	no
adults	947	-0.02	96.47	One day, I was sitting on a shelf when suddenly a man took me and exchanged me for some round objects that humans call coins.	When the sun began to set, the man went off and left me there.	Code identified by both coders but in different places	no
children and teens	938	-0.1	81.73	On the beach, Lola got hungry and ate her food and forgot to put her spoon away.	Once upon a time there was a girl named Lola who liked to go to the beach.	Code identified by both coders but in different places	no
children and teens	940	0	94.55	none	He was excited and used all his strength to get to the shore in time and in this way he managed to get the children to take him out of the water.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
children and teens	943	-0.03	94.59	As expected, Dalia was very happy and she went to the beach to play with her motorcycle.	It was summer and in the department store there was the little motorcycle waiting for a child to play with it.	Code identified by both coders but in different places	no
children and teens	948	0.19	88.06	I live with a ten-year-old boy who likes the beach a lot.	Hello! As you can see, I am a flip-flop, and I live in the city of Lima, Peru. My house is very nice and big, with many rooms, closets and beds. I always walk through the streets of Lima, especially when it is very hot. They also take me from time to time to a place where there is water in a large tank, I think they call it a swimming pool, but I'm not sure. I live with a ten-year-old boy who likes the beach a lot. Since he doesn't have school tomorrow, we're going to go to the beach.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
Feeling of excitement	952	0	94.99	The cup wanted to get to that place soon to meet its mother again, but as luck would have it, the family decided to make a stop to visit some relatives.	none	Only one coder coded this sentence.	yes
Feeling of fear	940	0	97.67	none	Bili was worried. "What's going to happen to me?" he wondered.	Only one coder coded this sentence.	yes
Feeling of happiness due to fulfilling its function	940	0	96.24	none	Bili loves to help me with all these things, because he likes to do his job well and see new places.	Only one coder coded this sentence.	yes
Feeling of happiness due to fulfilling its function	948	0	86.48	none	Hello! As you can see, I am a flip-flop, and I live in the city of Lima, Peru. My house is very nice and big, with many rooms, closets and beds. I always walk through the streets of Lima, especially when it	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					is very hot. They also take me from time to time to a place where there is water in a large tank, I think they call it a swimming pool, but I'm not sure. I live with a ten-year-old boy who likes the beach a lot. Since he doesn't have school tomorrow, we're going to go to the beach.		
Feeling of happiness due to fulfilling its function	952	0	94.66	none	Something unexpected happened and the family decided to go right to that place, and then the cup became happy, so happy that it spilled a bit of delicious Sprite.	Only one coder coded this sentence.	yes
Plastic bag	949	-0.01	98.5	The three friends, and the plastic bag	It was a plastic bag!	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
Shoe	948	0.58	98.72	As you can seen I am a flip-flop, and I live in the city of Lima, Peru.	Hello! As you can seen I am a flip-flop,	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
Wheel	943	-0.03	94.92	Dalia dragged the motorcycle away but the wheel stayed there on the beach, abandoned to its fate.	In the fall, the wheel of the motorcycle broke off, so a happy day turned into a sad day.	Code identified by both coders but in different places	no
Wheel	946	-0.02	95.58	Miller carefully got off the dump truck to see what had happened and confirmed what he feared; a tyre had come off his dump truck.	By then, the waves had already washed away the dump truck's loose tyre.	Code identified by both coders but in different places	no
Feeling of guilt	943	0	98.74	none	It felt so guilty for being in the wrong place.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
Feeling of guilt	947	0.24	95.55	It felt very sorry for the hungry turtle. At that moment, I realized that I, along with all the other things around me, were polluting the sea and that is why Lila and many other animals were dying from drowning or starvation since we were damaging their home, which is the sea.	It felt very sorry for the hungry turtle.	Both coders coded the same sentence but one coder also coded another part of the text.	no
Feeling of guilt	952	0	91.6	none	When it realized that some of them were still moving, it couldn't take it anymore and at that moment, the cup abandoned its dream and squeezed itself to such an extent that the small holes in its body expanded, causing the death of the little plastic cup.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
Feeling of hope	943	0	95.88	The wheel then made a wish with all its might. "I wish to be found and recycled, but not just me; all of these objects that are floating in the ocean."	none	Only one coder coded this sentence.	yes
Feeling of hope	948	0	97.62	I regained my hope, but I knew that this place was not my home, that it was different.	none	Only one coder coded this sentence.	yes
Feeling powerless	940	0	92.74	none	Bili was very sad and he wondered how he had ended up in the river, carried away by the strong currents. After a long time, Bili reached the open sea and floated out into the waters of the sea.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
Feeling powerless	943	0.48	93.69	The wheel was a stranger there and it wanted to get away. It didn't want to hurt them, but it was almost impossible not to. It was not the wheel's fault that it had been abandoned, and it did not want to harm those who did not know that interacting with it was dangerous or toxic.	The wheel then realized that it was unintentionally hurting these animals. The wheel was a stranger there and it wanted to get away. It didn't want to hurt them, but it was almost impossible not to.	1) Both coders coded the same sentence but one coder also coded another part of the text. 2) Both coders coded the same sentence but one coder also included the previous/next sentence.	no
Feeling powerless	948	-0.02	96.16	I didn't know, but there was nothing I could do to get back.	I was beginning to despair, as the current carried me and I did not where.	Code identified by both coders but in different places	no
fish not shark	952	-0.02	91.99	There were lots of dead fish.	The cup did this for so long that small holes appeared in its body, which made it easier for it to move. But what it hadn't realized	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					was the amount of tiny fish it had caught, which died when it expelled the water.		
shark	948	0.87	99.25	One day I was floating calmly and aimlessly, when a shark took me to the depths of the sea, where everything is dark.	One day I was floating calmly and aimlessly, when a shark took me to the depths of the sea	One coder made a mistake in not including the end of a sentence.	no
turtle	947	0.57	97.85	The next morning I woke up with a start as a sea turtle was trying to eat me.	I fell asleep tp the gentle movement of the ocean waves. The next morning I woke up with a start as a sea turtle was trying to eat me. "Mrs Turtle! I'm not food'" I said, in a surprised tone.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
recyclers	940	0	97.89	There he saw that some children were picking up garbage.	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
recyclers	947	0	95.79	The wheel's wish was so powerful that just at that moment some young people passed by the island and when they saw the waste they began to pick it all up.	none	Only one coder coded this sentence.	yes
scientists	938	0.43	80.43	Later a person found the turtle and immediately called some scientists who study garbage.	Later a person found the turtle and immediately called some scientists who study garbage. These scientists managed to save the life of the turtle and Lola understood from that moment that you should never throw litter or leave plastic stuff on the beach.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
scientists	940	0	95.37	none	Bili was very grateful and asked them who they were. The children answered that they were from the Sigma Club of the Villa school and that they were part of the ReCiBa network.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
animal get stuck in plastic	946	0	98.33	Later a turtle also found a piece of plastic, which got stuck in her mouth.	none	Only one coder coded this sentence.	yes
animal get stuck in plastic	947	0	98.85	She was lying on the sand with a net tangled around her body.	none	Only one coder coded this sentence.	yes
animal get stuck in plastic	949	0	96.4	Poor Nicolás fought and fought to get rid of whatever it was that didn't let him see, and besides that, the object prevented him from breathing!	none	Only one coder coded this sentence.	yes
animal get stuck in plastic	952	0.66	96.54	But what it hadn't realized was the amount of tiny fish it had caught, which died when it expelled the water.	The cup did this for so long that small holes appeared in its body, which made it easier for it to move. But what it hadn't realized was the amount of tiny fish it had	Both coders coded the same sentence but one coder also included the previous/next sentence.	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					caught, which died when it expelled the water.		
animals eat the plastic	946	0.99	99.98	The fish mistook it for food, and Chomp! one of the fish ate a piece of microplastic.	The fish mistook it for food, and Chomp! one of the fish ate a piece of microplastic.	Space/punctuation difference amongst coders.	no
animals eat the plastic	947	0.72	98.92	The next morning I woke up with a start as a sea turtle was trying to eat me.	The next morning I woke up with a start as a sea turtle was trying to eat me. "Mrs Turtle! I'm not food!" I said, in a surprised tone.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
animals eat the plastic	949	0.64	96.53	"What a strange jellyfish!" said Juan and before he tried to swallow it, the jellyfish caught in his mouth. "Get off! Get off!" Juan said. After a while, he was finally	After a while, he was finally able to spit out the jellyfish, and what a surprise when he saw what it really was. It was a plastic bag!	Both coders coded the same sentence but one coder also included the	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
				able to spit out the jellyfish, and what a surprise when he saw what it really was. It was a plastic bag!		previous/next sentence.	
crustaceans	947	0.41	96.32	I was turning green and some tourists called barnacles were on my back. At first there were only two barnacles, but then more and more joined them. After a few days, there were so many barnacles that I hardly looked like a bottle but more like a hotel for barnacles.	I was turning green and some tourists called barnacles were on my back.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
micro-organisms	943	0	98.25	none	Little by little, strange organisms began to stick to the wheel	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
object talks with the animal	947	0.35	96.38	"Mrs Turtkle! I'm not food" I said, in a surprised tone. "Sorry Miss Bottle. It's just that I'm very hungry and my food has become scarce due to pollution,' she replied.	The next morning I woke up with a start as a sea turtle was trying to eat me. "Mrs Turtkle! I'm not food" I said, in a surprised tone.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
tide	946	0	98.44	By then, the waves had already washed away the dump truck's loose tyre.	none	Only one coder coded this sentence.	yes
wind	949	0	97.75	A dolphin told them that he saw a plastic bag fly up and land on the surface of the water.	none	Only one coder coded this sentence.	yes
accidental origin	940	0	92.37	none	When the truck reached the landfill, Billi was dumped onto a larger garbage. This mound was the closest to the river. As he was	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					falling on the garbage mound, Bili slipped and rolled into the river.		
accidental origin	943	-0.03	94.32	Dalia dragged the motorcycle away but the wheel stayed there on the beach, abandoned to its fate.	Without realizing it, a fisherman who was pushing his boat out to sea, took the wheel with him to the open sea.	Code identified by both coders but in different places	no
intentional origin	939	0.54	94.09	She put it aside and then throw it into the sea.	One day when her brush was worn out, my aunt changed it for a new brush. She put it aside and then throw it into the sea.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
intentional origin	940	0	96.28	He was ready to be reused but as soon as the lady got her shopping out, she threw him in the trash!	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
intentional origin	952	0	98.42	It rolled and rolled until it reached the water.	none	Only one coder coded this sentence.	yes
feeling guilty	943	0	97.32	It felt so guilty for being in the wrong place and sadly all they got was more unpleasant results.	none	Only one coder coded this sentence.	yes
feeling guilty	952	0	95.85	After several days, the little cup felt something inside and when it looked it was scared and at the same time it felt guilty.	none	Only one coder coded this sentence.	yes
indifference	949	0	94.13	The purpose of this short story is to create awareness that sometimes humanity does not reflect on how its actions affect nature, either because they do not know or because they do not want	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
				to know about what is happening in the world.			
thoughtlessness	939	0	91.67	I said, "Auntie, why did you throw the brush into the sea?" To which she replied, "It no longer works".	none	Only one coder coded this sentence.	yes
thoughtlessness	940	0	96.28	He was ready to be reused but as soon as the lady got her shopping out, she threw him in the trash!	none	Only one coder coded this sentence.	yes
thoughtlessness	949	0	94.13	The purpose of this short story is to create awareness that sometimes humanity does not reflect on how its actions affect nature, either because they do not know or because they do not want	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
				to know about what is happening in the world.			
animal injured	938	0.72	89.32	Later a person found the turtle and immediately called some scientists who study garbage. These scientists managed to save the life of the turtle and Lola understood from that moment that you should never throw litter or leave plastic stuff on the beach.	These scientists managed to save the life of the turtle and Lola understood from that moment that you should never throw litter or leave plastic stuff on the beach.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
animal injured	946	-0.02	95.43	The turtle managed to arrive at the beach of Bahía de Caráquez, where a group of people picked it up to try to help it.	After an hour, the poor little fish started to feel bad and then fainted, just like that.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
death of the animal	946	0	98.04	After an hour, the poor little fish started to feel bad and then fainted, just like that.	none	Only one coder coded this sentence.	yes
death of the animal	949	-0.03	93.26	Tomás also told them that he had seen many animals that had died from the plastic bags.	"The plastic bags come from humans, who make them, and then discard them. Every year millions of pieces of human waste fall into the sea, and therefore thousands of animals are dying.	Code identified by both coders but in different places	no
death of the animal	952	-0.02	91.99	There were lots of dead fish.	The cup did this for so long that small holes appeared in its body, which made it easier for it to move. But what it hadn't realized was the amount of tiny fish it had caught, which died when it expelled the water.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
impact on the animal environment	947	0	97.87	"Sorry, Miss Bottle. It's just that I'm very hungry and my food has become scarce due to pollution," she replied.	none	Only one coder coded this sentence.	no
abundance of plastic pollution	943	-0.02	96.42	Every week a new object arrived on the beach	ever	Code identified by both coders but in different places	no
abundance of plastic pollution	947	-0.03	94.29	When the storm stopped, I saw many bags, shoes, glasses, brushes, straws bottles and many other things that had also been washed away by the tide.	I saw how the animals that were close to us moved away. At that moment, I realized that I, along with the other things around me, were polluting the sea.	Code identified by both coders but in different places	no
abundance of plastic pollution	949	0.74	98.15	Every year millions of pieces of human waste fall into the sea, and therefore thousands of animals are dying.	"The plastic bags come from humans, who make them, and then discard them. Every year millions of pieces of human waste fall into the sea, and therefore thousands of animals are dying.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
growth of organisms	943	0	98.25	Little by little, strange organisms began to stick to the wheel	none	Only one coder coded this sentence.	yes
not specified	946	0	98.15	About six years passed, and the tyre was still floating from one current to another.	none	Only one coder coded this sentence.	yes
not specified	952	0	96.57	The cup did this for so long that small holes appeared in its body, which made it easier for it to move.	none	Only one coder coded this sentence.	yes
broken into microplastics	946	0.49	98.31	It was transformed into microplastics. In this way, little by little the wheel turned into small pieces of plastic.	It was transformed into microplastics.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
buyoancy	940	0	97.74	After floating for a long time, Bili entered shallow waters.	none	Only one coder coded this sentence.	yes
buyoancy	947	0	98.76	Suddenly, my lid came off and I was filled up with water and sank.	none	Only one coder coded this sentence.	yes
buyoancy	948	0	98.04	Then as if by a miracle, a sea current dragged me to the surface again.	none	Only one coder coded this sentence.	yes
buyoancy	952	0	96.57	The cup did this for so long that small holes appeared in its body, which made it easier for it to move.	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
colour	947	0.51	98.65	I realized that my colour was changing. I was turning green and some tourists called barnacles were on my back.	I realized that my colour was changing.	Only one coder coded this sentence.	yes
shape	947	-0.01	97.64	I was green, bent, and covered in barnacles, and I felt terrible about my appearance.	she squashed me and I was all bent	Code identified by both coders but in different places	no
shape	952	-0.05	87.18	The cup did this for so long that small holes appeared in its body, which made it easier for it to move.	There were lots of dead fish. When it realized that some of them were still moving, it couldn't take it anymore and at that moment, the cup abandoned its dream and squeezed itself to such an extent that the small holes in its body expanded, causing the death of the little plastic cup.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
recycling	939	0.7	91.1	Then I added, "I understand, but you can reuse it. " She looked at me and asked, "How can I reuse it?" "You can use it to clean shoes or to wash bottle nozzles, among other things," I replied.	She looked at me and asked, "How can I reuse it?" "You can use it to clean shoes or to wash bottle nozzles, among other things," I replied. It's true. You are right! She said. So we went to look for the brush on the beach.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
recycling	940	0	96.28	none	He was ready to be reused but as soon as the lady got her shopping out, she threw him in the trash!	Only one coder coded this sentence.	yes
reduction of consumption	947	0	99.67	But human beings don't understand that and they continue to produce more rubbish and they don't deposit us in the right place but throw us wherever they want.	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
convince the family	939	0	93.37	Then I added, "I understand, but you can reuse it. " "We can reuse them," I told her.	none	Only one coder coded this sentence.	yes
education	943	0	95.98	Once in the hands of the scientists, the wheel would be analysed and thus help to create awareness of the importance of not leaving waste anywhere.	none	Only one coder coded this sentence.	yes
education	947	0	97.02	But human beings don’t understand that and they continue to produce more rubbish and they don’t deposit us in the right place but throw us wherever they want.	none	Only one coder coded this sentence.	yes
recycling	940	0	96.65	Now I use Bili for many things such as carrying shampoo, soap, toothpaste and toothbrush.	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
waste processing	947	0	97.06	none	"You and I belong here, in the landfill because we are rubbish that pollutes Planet Earth and they bring us here to this place so that we no longer pollute."	Only one coder coded this sentence.	yes
work of organisations	943	0	95.98	Once in the hands of the scientists, the wheel would be analysed and thus help to create awareness of the importance of not leaving waste anywhere.	none	Only one coder coded this sentence.	yes
the protagonist	938	0	87.66	none	Lola understood from that moment that you should never throw litter or leave plastic stuff on the beach.	Only one coder coded this sentence.	yes
the protagonist	939	0	96.36	We cleaned it well so we could reuse it later.	none	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
the protagonist	940	0	96.65	Now I use Bili for many things such as carrying shampoo, soap, toothpaste and toothbrush.	none	Only one coder coded this sentence.	yes
the reader	938	0.34	80.43	These scientists managed to save the life of the turtle and Lola understood from that moment that you should never throw litter or leave plastic stuff on the beach. For that reason you should never throw litter on the beach.	For that reason you should never throw litter on the beach.	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
exclusive	946	0	97.89	With the passing of time, human beings are understanding, learning and becoming more responsible.	none	Only one coder coded this sentence.	yes
inclusive	938	0	93	none	For that reason you should never throw litter on the beach.	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
inclusive	943	-0.03	93.09	May our steps through this home called Earth be clean and leave traces of light for those who come behind.	Once in the hands of the scientists, the wheel would be analysed and thus help to create awareness of the importance of not leaving waste anywhere.	Code identified by both coders but in different places	no
inclusive	946	0	97.89	none	With the passing of time, human beings are understanding, learning and becoming more responsible.	Only one coder coded this sentence.	yes
inclusive	947	0	97.02	none	But human beings don’t understand that and they continue to produce more rubbish and they don’t deposit us in the right place but throw us wherever they want.	Only one coder coded this sentence.	yes
inclusive	949	0.94	99.28	We are getting closer and closer to our own extinction. All this must make us reflect and think more than once about the things we are doing. For we may come to that	We are getting closer and closer to our own extinction. All this must make us reflect and think more than once about the things we are doing. For we may come to that	Both coders coded the same sentence but one coder also included the	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
				day when there is no going back, when our repentance is not enough.	day when there is no going back, when our repentance is not enough. By then it will be too late.	previous/next sentence.	
story starts in another place as it ends	940	-0.02	96.09	One day, Bili arrived in Villa del Salvador.	After floating for a long time, Bili entered shallow waters.	Code identified by both coders but in different places	no
story starts in another place as it ends	946	0	97.38	none	The turtle managed to arrive at the beach of Bahia de Caraquez, where a group of people picked it up to try to help it.	Only one coder coded this sentence.	yes
story starts in another place as it ends	948	-0.02	94.83	This is my sad end, the end of a flip-flop that never saw its family again and stayed in California, like marine rubbish.	He told me that this beach was called Laguna Beach, in California.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
story starts in another place as it ends	952	0	97.36	The plastic cup filled itself to control its movement as it advanced in the sea.	none	Only one coder coded this sentence.	yes
the object has not travelled	949	0	96.88	none	They had met the previous year, on the shores of Loreto Bay, and they had agreed that this year, they would meet again there.	Only one coder coded this sentence.	yes
the object has not travelled	952	0	81.22	none	Once there, the little cup was very excited to enter the sea and meet its mother again. It rolled and rolled until it reached the water. When it got in, the little cup realized that meeting its mother was not going to be as easy as it thought. It could see how vast the sea was and yet this was not enough to stop it. The plastic cup filled itself to control its movement	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					as it advanced in the sea. When it sank too much, it released a little water and when it got too high, it filled up in order to sink. It was doing this for hours and hours trying to find its mother.		
beach	939	0	96.36	none	So we went to look for the brush on the beach.	Only one coder coded this sentence.	yes
beach	946	-0.03	93.65	The family was very relaxed on the beach, with the parents enjoying that wonderful air and Miller happily playing with his dump truck.	They later bought an ice cream, which they ate quickly, as they were about to start their trip to Briceño Beach, a very beautiful beach in Manabí, Ecuador.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
beach	947	0	98.7	After a while, we arrived at a hot place that the man called a beach.	none	Only one coder coded this sentence.	yes
beach	948	-0.02	96.53	(The next day) We are already on our way to the beach.	The next day at dawn, around 8 in the morning, we went to the beach.	Code identified by both coders but in different places	no
industry	946	-0.03	93.8	It all started one afternoon, here at this factory where Juan, Pedro and Andrés were finishing the manufacture of some toy dump trucks to complete the shipment that would be delivered to a large toyshop.	We were inside a large factory that generated a lot of environmental pollution.	Code identified by both coders but in different places	no
sea	952	0	90.84	none	To clean up the mess, the family stopped in a parking lot. This made the little cup even more desperate, but it learned its lesson	Only one coder coded this sentence.	yes

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
					and decided to stay calm so as not to cause another delay. Once there, the little cup was very excited to enter the sea and meet its mother again.		
laboratory	943	0	98.33	They took the waste objects to the scientists to be analysed.	none	Only one coder coded this sentence.	yes
landfill	940	0	96.92	When the truck reached the landfill, Bili was dumped onto a large pile of garbage.	none	Only one coder coded this sentence.	yes
rehabilitation centre	946	0	98.29	After a few weeks, when the turtle had recovered, they returned it to the sea.	none	Only one coder coded this sentence.	yes

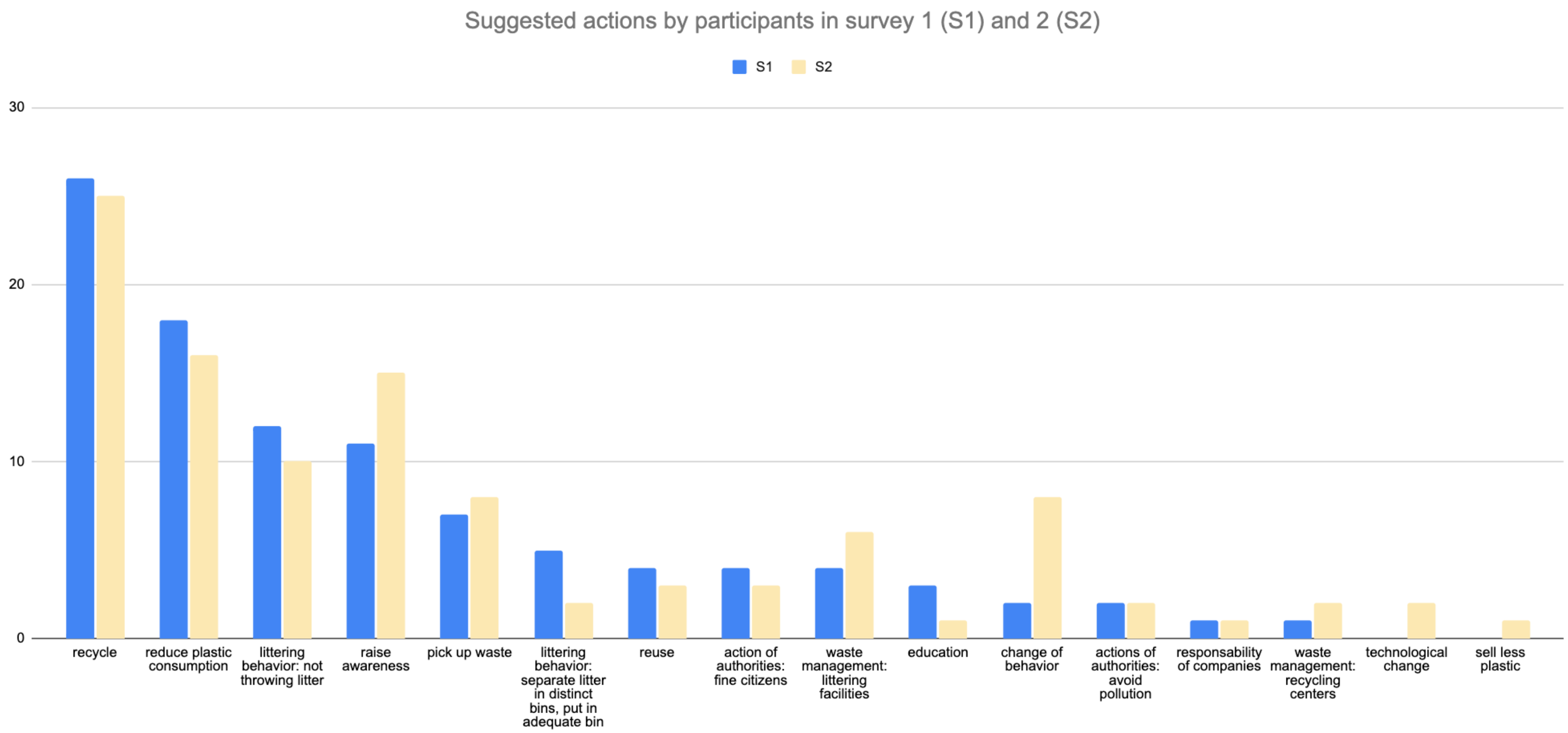
Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
rehabilitation centre	947	0	97.15	One person took it and said that he was going to take her to a place where they would take good care of her and remove the net that was all tangled up.	none	Only one coder coded this sentence.	yes
protagonist is a third person	938	0.73	96.44	Once upon a time there was a girl named Lola who liked to go to the beach.	Once upon a time there was a girl named Lola	Both coders coded the same sentence but one coder also included the previous/next sentence.	no
protagonist is a third person	943	-0.04	92.95	It was sumer and in the department store there was the little motorcycle waiting for a child to play with it.	At that moment, Dalia's parents entered the store. As soon as they saw the motorcycle, they loved it and they knew it was exactly what Dalia wanted.	Code identified by both coders but in different places	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
protagonist is a third person	946	-0.03	90.66	We were inside a large factory that generated a lot of environmental pollution.	All the toys were already in place in that toyshop. A family was buying a toy for their son Miller Say, as Christmas was coming. Look, Dad! It's great! Miller said. "Do you like it, Miller?" said Sara Alés, Miller's mother. I think it's very nice! said Danny Say, Miller's father, who then asked, "What do you say Miller? Shall we take it?"	Code identified by both coders but in different places	no
protagonist is human	939	-0.03	92.88	My aunt Maria lives near the sea.	That day I went to visit her and saw what she had done.	Code identified by both coders but in different places	no
protagonist is human	940	0.96	99.73	My name is Rodrigo and today I am going to tell you the story of Bili the plastic bag.	Hello! My name is Rodrigo and today I am going to tell you the story of Bili the plastic bag.	Both coders coded the same sentence but one coder also included the	no

Code	File	Kappa	Agreement	Sentence coded by coder 1	Sentence coded by coder 2	Problem	RD
						previous/next sentence.	

Appendix 7 - Action to avoid plastic pollution

When asked to name one action to avoid plastic litter from reaching the ocean, participants suggested different actions in the pre-survey 1 (S1) at T1 and the after survey (S2) at T2. Those suggestions were then categorised into different types by EP.



Appendix 8 - Results of the evaluation of the activity

Note: gradual scale [a]From 1-I don't know anything to 5-I know a lot; scale [b] 1-I strongly disagree to 5- I strongly agree; gradual scale [c] From 1-no interest to 5-A lot of interest; scale [d] 1-No importance to 5- A lot of importance [e] 1-Never, 2-Rarely, 3-Sometimes, 4-Often, 5-Every time

Item	Before		After		Difference
	M	SD	M	SD	Inferential statistics
Self-reported knowledge					
How much do you think you know about plastic marine litter? [a]	3.50	0.75	3.64	0.75	$Z = 2.20$, $p = .03$
Perceptions					
Plastic marine litter greatly affects the appearance of beaches. [b]	4.84	0.56	4.75	0.58	$p = .12$
It is common for plastic marine litter to harm wildlife around the world. [b]	4.43	0.99	4.44	0.93	$p = .89$
The marine food chain contains small pieces of marine plastic debris (for example, large animals that eat smaller animals that have eaten plastic) [b]	4.25	1.03	4.36	1.00	$p = .27$
The way my family and I treat our household garbage can affect the garbage in the sea. [b]	3.20	1.29	3.20	1.30	$p = .80$

Item	Before		After		Difference
	M	SD	M	SD	Inferential statistics
What is your interest in learning more about plastic marine litter? [c]	4.51	0.73	4.48	0.76	$p = .52$
How important is it to you to reduce plastic marine litter? [d]	4.79	0.47	4.74	0.59	$p = .36$
Self-reported behaviour					
Pick up the trash that is on the ground around my school.[e]	3.08	0.85	3.56	1.03	$Z = 3.50, p < .001$
Pick up the garbage that is on the ground from the streets of my neighborhood. [e]	2.74	1.03	3.46	1.15	$Z = 4.77, p < .001$
Pick up the trash found on the beach. [e]	3.23	1.12	3.69	1.09	$Z = 4.61, p < .001$
Recycle packaging. [e]	3.68	1.06	4.08	0.96	$Z = 3.33, p = .001$
Try to convince family and friends to use less single-use plastic. [e]	3.44	1.22	3.70	1.14	$Z = 2.20, p = .03$
Try to convince people in your community to use less single-use plastic. [e]	2.60	1.29	3.26	1.23	$Z = 4.64, p < .001$

Statement of authorship

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Research Degree Thesis Statement of Authorship

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Description of the candidate's contribution to the work	Co-design of Methodology, Investigation, All data analysis (except statistics of surveys), Visualization, Lead author for original draft, Data curation, Lead author for final draft, Submission.
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(i) the candidate has accurately represented their contribution to the work;

(ii) if required, permission is granted for the candidate to include the work in their thesis (note that this is separate from copyright considerations).

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Signature of the co-author	MARTIN THIEL Firmado digitalmente por MARTIN THIEL Nombre de reconocimiento (DN): c=CL, st=COQUIMBO, l=ELQUI, o=MARTIN THIEL, ou=*, cn=MARTIN THIEL , email=THIEL@UCN.CL Fecha: 2023.03.27 17:16:03 -03'00'
Date (DD/MM/YY)	

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Copy and paste additional co-author panels as needed.

*Note that where a paper has multiple authors, the statement of authorship can focus on the key contributing/corresponding authors.
**The description of the candidate and co-authors contribution to the work may be framed in a manner appropriate to the area of research but should always include reference to key elements (e.g. for laboratory-based research this might include formulation of ideas, design of methodology, experimental work, data analysis and presentation, writing). Candidates and co-authors may find

it helpful to consider the CRediT (Contributor Roles Taxonomy) approach to recognising individual author contributions.

Chapter 5 - Story-writing workshops as archaeological interventions: local perceptions of Galapagos marine plastic litter

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Abstract

Marine plastic pollution is an issue that threatens most places around the world, including the remote and unique Galapagos archipelago. We used the archaeological framework of object itineraries as part of a story-writing workshop to explore perceptions of marine plastic litter (MPL) by students from two schools in Puerto Ayora, Santa Cruz. Their stories, adopting an archaeological approach to plastic litter as artefacts, told the itinerary of MPL collected on Galapagos shores. We also analysed surveys evaluating their self-reported knowledge, pro-environmental behaviours (PEBs) and perceptions of the issue of MPL before and after the workshop. Our findings showed good awareness of MPL origins and impacts, reflecting the specific pathways of litter reaching this Pacific archipelago from mainland South America, regional marine activities including fishing in and around the Galapagos Marine Reserve, and local sources although those are thought to be limited. Yet, the lack of focus on solutions in the stories and the emphasis on recycling PEBs suggest more targeted activities are required to address the need of complementary solutions and to place more emphasis on reducing plastic use.

Keywords

object itinerary, marine plastic pollution, education, contemporary archaeology, pro-environmental behaviours

Background to the Study

The archipelago of Galapagos, located around 1000 kilometres west of mainland South America, is valued worldwide for its unique biodiversity and landscapes at the core of its inscription as UNESCO World Heritage Site since 1978. Despite the remote nature of the islands, the global connectivity of Galapagos through time (Hennessy 2019), along with an increasing population living and visiting the islands, have contributed to a series of anthropic threats to the archipelago (Alava et al. 2022). Amongst these is the presence of marine plastic pollution, an issue at the core of several studies (Jones et al. 2021; 2022; Muñoz-Pérez et al. 2023; Sánchez-García and Sanz-Lázaro 2023). Oceanography has contributed to identifying potential sources and pathways (van Sebille et al. 2019), while marine biology has helped determine the threats that local wildlife is exposed to (Jones et al. 2021; Muñoz-Pérez et al. 2023). Several initiatives contribute to an approach toward a plastic-free archipelago offering both preventive (i.e. avoiding plastic to enter the environment in the first place) and reactive (i.e. addressing plastics already in the environment) solutions.

The archipelago receives marine plastic litter (MPL) from mainland South America, regional marine sources and local sources. With Galapagos being at the confluence of several currents including the Humboldt and Panama currents, the islands are exposed to receiving the MPL which they carry. Computer modelling of floating microplastic on oceanic currents estimated that Galapagos receives MPL in this way from mainland South America, notably Ecuador, Peru and Colombia (van Sebille et al. 2019). These models suggest that the plastic's journey from coastal South America will last a few months and that currents do not carry MPL to Galapagos from further afield, notably Asia (van Sebille et al. 2019). Monitoring of plastic density found that windward shores on Galapagos (Muñoz-Pérez et al. 2023; Sánchez-García and Sanz-Lázaro 2023) and east-facing beaches exposed to the Humbold current (Jones et al. 2021) received higher macroplastic quantities. But western shores also receive MPL, mostly from local sources (from within the marine reserve) (Ypma et al. 2022).

A study of 20 remote shorelines across the archipelago found that hard plastic fragments were the most common objects followed by fishing-related items and plastic beverage bottles (Muñoz-Pérez et al. 2023). A closer look at macroplastics revealed that bottles primarily had labels from Peru, Ecuador and China and were branded from the AjeGroup, The Coca Cola Company, and Tingy Holding Corporation (Muñoz-Pérez et al. 2023). Several studies identified fishing industries, notably Asian, as important contributors to the issue of marine plastic pollution (Muñoz-Pérez et al. 2023; Sánchez-García and Sanz-Lázaro 2023). The importance of mainland and marine sources coincides with the estimates of minor (land) local input, such as beach littering and waste mismanagement, provided by Jones et al. (2021) for San Cristobal. When it comes to microplastic pollution, the levels do not seem to be proportional to macro and meso-plastic quantities suggesting that microplastics reach the archipelago already fragmented (Sánchez-García and Sanz-Lázaro 2023).

Impacts of MPL constitute one the main challenges for the archipelago. When it comes to bio-ecological impacts, Galapagos wildlife is threatened by MPL, with 52 marine species identified through Citizen Science monitoring as at risk from ingestion and entanglement with plastic (Muñoz-Pérez et al. 2023). This confirms the high threat scores for 27 marine vertebrates identified by Jones et al. (2021). Microplastic was found in seven marine invertebrate species confirming that ingestion of plastics occurs in and around the archipelago (Jones et al. 2021). MPL also triggers a series of socio-economic impacts, with Galapagos marine activities being affected by plastic waste at sea. Abandoned, lost or discarded fishing gear, for example, can cause collisions with local fishing vessels, damaging the boats and posing a safety risk to crew members (Cardenas et al. in press.). In Galapagos, there have already been collisions with Fish Aggregating Devices (FADs) and entanglements with plastic covers and fishing nets, resulting in engine damage (Cárdenas et al. in press.). With MPL known to potentially provoke a decrease in the tourism industry in Brazil (Krelling et al. 2017), and affect coastal activities in the Azores (Rodríguez et al. 2020), its impacts on Galapagos tourism and the livelihoods of local populations remain to be fully considered and studied.

A wide range of solutions are being explored to reduce plastic consumption and pollution in Galapagos. Reactive solutions include transforming plastic waste into art to raise awareness (e.g. a sculpture of cigarette butts by Miguel Andagana), jewellery (e.g. Precious Plastics - Carolina Proaño; Upcycling - Mayra Hernandez), and building materials (Plastic Bricks Project by Funcavid - Edwin Chillagana). The Galapagos National Park Directorate

(GNPD) also leads the Coastal Cleanup Programme in coordination with other organisations such as: Conservation International, Frente Insular, EPI/ECOS, the National Navy, the local fishing sector, the Surf Club, TUNACONS, and other local initiatives. The use of virtual models of macroplastic movement are also being explored to identify areas where clean-ups are most needed (Ypma et al. 2022). Preventive solutions include offering alternatives to avoid plastic use such as implementing water refill stations on the archipelago and offering more sustainable options in local businesses (e.g. Iguana Cups being reusable plastic cups). The projects "+Vida - Basura" (More life, less waste) and "Sin plástico sabe mejor" (Without plastic, it tastes better), both led by the GNPD, also focus on reducing plastic use. Materiom and the University of Exeter are developing biodegradable bioplastics made from locally sourced natural ingredients. Their use will be explored to offer an alternative to the most commonly used plastics in Santa Cruz. Several youth movements ("Tibu Embajadores", "Molas", "Manitos in Acción / Jóvenes en Acción", "GECO" among others) try to raise awareness on the issue through educational activities. From that perspective, Citizen Scientists contribute to MPL monitoring through microplastic sampling (Jones et al. 2022).

Workshops as archaeological interventions

Despite this interest in the topic and the existence of programmes to address plastic pollution (Pacific Plastics: Science to Solutions - PPSS; Plastic Free Galapagos Programme - PFGP), several issues remain in identifying major contributors to MPL, more specifically differentiating between marine and mainland sources for domestic items that could come either from continental Ecuador or from stationing marine vessels. In that perspective, archaeology proves particularly helpful as a discipline focusing on re-constructing artefact itineraries (Joyce 2015), questioning the origin, pathway and use of these objects. With the global presence of plastic turning the latter into a topic of interest for archaeologists, either as components of drift matter (Pétursdóttir 2020), as modern material culture (Wooten 2020), or as topics of narratives (Schofield et al. 2020), this study explores the use of an archaeological framework to approach local perceptions of MPL.

Building on the potential of archaeology to address contemporary challenges (e.g. Harrisson and Schofield 2010) and on the gap of knowledge in local perceptions of MPL in

Galapagos, we used the framework of object itineraries (Joyce 2015) to undertake story-writing workshops. We were particularly interested to work with young Galapagueños/as as their views are almost never represented in the literature. Schoolchildren have also proven to be a particularly good audience for story-writing exercises (Aerila et al. 2016; Fanini and Fahd 2009) and particularly concerned by the topic of marine litter (Hartley et al. 2015). Story-writing workshops were developed as archaeological interventions, combining the archaeological concept of object itineraries with a narrative approach common in qualitative research (Savin-Baden and Howell Major 2013).

The archaeological framework, that of object itinerary, proved particularly useful to engage students on the topic of MPL, allowing them to look carefully at the objects and consider the geographical and temporal span of their journey, which particularly fitted the global and ubiquitous nature of MPL in Galapagos. Students explored this idea in the stories they produced, considering the interactions of the object with non-humans, how it contributed to broader landscapes of the archipelago, and the complexity of the itinerary among other elements (for a full discussion, see Praet et al. 2023b). Archaeology played an active role in the workshop presentation, often starting by asking students what they thought archaeology was, and how it could help understand marine plastic pollution.

Using the concept of object itineraries, students could reconstitute an object's journey, following a narrative structure. In this project, narrative is considered as a research approach as well as a research product, and offers both data to analyse and a way of understanding human experience (Savin-Baden and Howell Major 2013, Chapter 15). We are convinced that multiple lines of evidence (here stories and surveys) are needed to address perceptions. Yet, we recognise the limitations of narrative analysis, especially as creating call to participants' imagination and reflection on what makes a story more engaging, and may therefore not be a direct representation of their perceptions (Praet et al. 2023a). As the writing process is as important as the story itself as a product (Savin-Baden and Howell Major 2013, 227), this paper offers an analysis of stories' content and of surveys to address perceptions and the impact of the workshop on participants.

Methods

Activity

The activity was designed and undertaken by both authors who are aware that their positionality may have influenced data collection and analysis (see Appendix 1 for their positionality statements). Workshops were inspired by the online activity of story-writing designed by a collaborative team on the Eastern Pacific during the Covid-19 lockdowns in 2020 (Praet et al. 2023a). In August 2022, we organised a series of two workshops developed using an archaeological framework to better understand marine plastic pollution in the archipelago. After an introduction defining archaeology, we presented a MPL object to the students to get them to think about the journey that this artefact might have taken. Then, they were put into groups and each group/student (depending on the class size) was assigned an object amongst a series of 11 objects collected in previous coastal clean-ups and representing recurrent and easily identifiable MPL. They were asked to answer a series of questions about it:

1) What is the object?
2) How old is the object?
3) Where is the object from?
4) How was the object used and by whom?
5) How did the object enter the environment?
6) How did the object interact with the environment?
7) What actions might have prevented the object from entering the environment?

These questions served as a guide to help the students reconstruct the itinerary of the object. Participants had to observe the object carefully to gather relevant information and were then invited to individually write a story about the object's itinerary and hand it in at the next workshop.

Surveys

A pre- and post-survey aimed at evaluating a) self-assessed knowledge (how much each student knew about marine litter and if they knew how to prevent it), b) perceptions of origins and impacts of MPL (if marine litter comes from domestic activities, distant areas or fishing activities; if marine litter has impacts on beach aesthetics, on wildlife and on human health), c) self-reported pro-environmental behaviours (PEBs) (picking up litter, recycling, reducing plastic use, influencing the community and influencing friends and family) and d) feedback on the activity (how much they liked the activity and how likely they were to recommend it) (Appendix 2). Answers were proposed on a Likert scale and results between the pre-and post-surveys were compared to evaluate the activity's impact. For a more robust comparison, questions were taken from Praet et al. (2023a) with questions on the origins and impacts slightly modified to best reflect the specificity of the issue in Galapagos.

Recruitment and participation

We undertook the activity with two schools, Colegio Tomás de Berlanga (TdB) and Unidad Educativa Nacional Galapagos (UENG) in Puerto Ayora on Santa Cruz Island (Figure 1). Over 330 students, aged between 12 and 22 years old, participated in the activity.

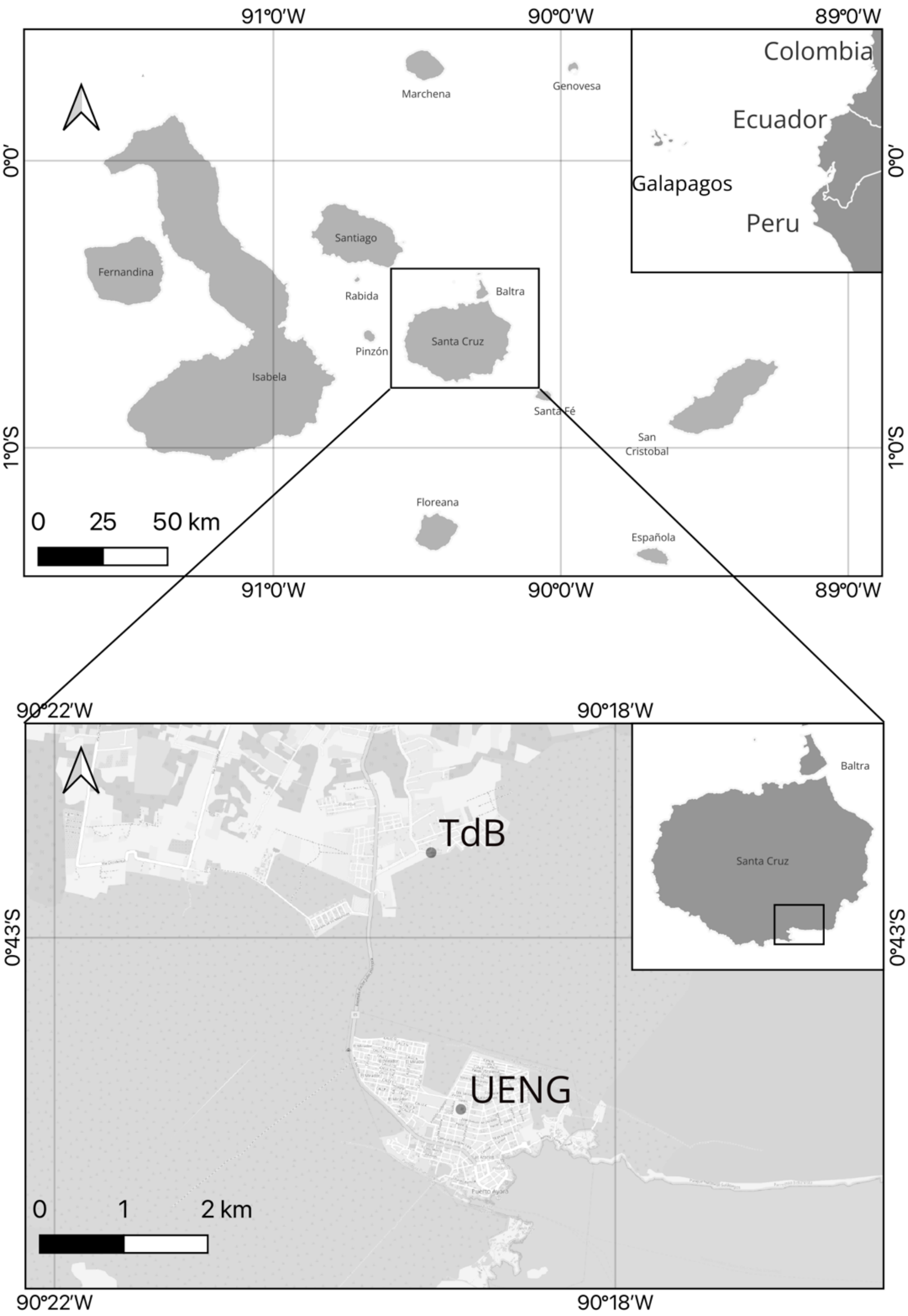

Figure 1: Map of Galapagos and the two participating schools (Tomas de Berlanga - TdB and Unidad Educativa Nacional Galapagos - UENG) in Puerto Ayora on the island of Santa Cruz

Analysis

As stated earlier, the focus of this research takes ideas of social constructivism (as one of the philosophical paradigms for qualitative research in Savin-Baden and Howell Major 2013) to investigate how young people in Galapagos construct meaning and knowledge about MPL. This research adopts a narrative approach (Savin-Baden and Howell Major 2013, Chapter 15) using stories and surveys to understand local perceptions of MPL.

Stories

We gathered 137 stories, including written stories, illustrated stories or comics, suitable for analysis (with consent and offering an itinerary of a plastic object presented in the workshop). For the qualitative analysis in NVivo, E.P. adopted a deductive coding strategy, by adapting the codebook used in our previous study (Praet et al. 2023a) for better comparisons between the two projects, the other project involving schools distributed along the East Pacific coast (see Appendix 3 for the coding strategy). For a thematic analysis using inductive coding on the topic of object itinerary, see Praet et al. (2023b).

Surveys

We received 161 surveys with parental and student consent. As the data were non-parametric (Likert scale type data), a Wilcoxon signed rank test for paired samples was conducted for the 21 questions appearing both in the pre- and post-survey. We used a pair-wise approach to clean the data (for the full detail of the number of respondents to each question, see Appendix 4).

Results

Only the most recurrent codes are reported in our results section (for a full description of the codes, along with their occurrence see Appendix 5).

Stories

Amongst the 11 objects presented to the students (see Praet et al. 2023b, Figure 2), five received most attention: the fishing sack with Chinese label (N=17; 12.4%), two PET bottles (N=18; 13.1% for Nongfu Spring water bottle and N=16; 11.7% for 220V energiser bottle, with 5 stories, 3.6%, lacking sufficient elements to further identify the PET bottle), the Copropag fishing sack (N=15; 10.9%) and the bucket (N=15; 10.9%) (Figure 2). The length of use mentioned in stories varied with objects being used between days and months (N=31; 22.6%), less than a day (N=16; 11.7%) and over a year (N=10; 7.3%). Stories indicated that objects were most often used by adults (N=76; 55.5%) instead of by children and teenagers (N=21; 15.3%). When in use, the object showed equally negative feelings (N=9; 6.6%), such as impatience (N=3; 2.2%; e.g. *I can say that it was a bit frustrating to be in a place or shop window waiting to be chosen before being consumed.*), and positive emotions (N=9; 6.6%), such as happiness (N=8; 5.8%; e.g. *Féngbao was happy because it finally finished its reason for living and would go back to wherever all the other bottles came from*).

Figure 2: An example of the frisbee (above) and the Copropag fish sack (below) used in the workshop as a basis for comics drawn by local students tracing the object's itinerary.

Sources and pathways

Stories included information regarding the process through which the object becomes waste, contributing sectors and factors, as well as the emotions felt by the object and by the person intentionally or accidentally discarding it.

As stated previously, there are different pathways for an object reaching Galapagos shores. When specified, most stories included differing start and end points (N=92; 67.2%), confirming that the object had travelled. For stories that had the same start and end location

(N=17; 12.4%), 15 (10.9%) did not suggest that the object had travelled while two did (1.5%). As the object's journey was often a global one, participants mentioned different geographical areas in the stories, notably Galapagos (N=83; 60.6%), mainland Ecuador (N=41; 30%) and China (N=34; 24.8%). When it came to locations, the object as a product was described on a boat (N=67; 48.9%), in an industry (N=51; 37.2%), on a beach (N=27; 19.7%) and/or in a shop (N=27; 19.7%).

Stories mentioned several sectors contributing to the object's entry into the environment, such as fishing industries (N=44; 32.1%, with N=26; 19% being national and N=14; 10.2% being international), tourism (N=25; 18.2%) and the general public (N=19; 13.9%) (Appendix 6). Almost half of the stories (N=68; 49.6%) described natural factors contributing to the objects becoming waste and their journey, with currents (N=41; 29.9%) and wind (N=26; 19%) being the most recurrent. Human behaviour leading to object disposal was specified in 119 stories (87%). This behaviour was mostly accidental, forgetting the object or losing it to strong natural factors, (N=79; 58%; e.g. *While the boy was playing with the toy, a very, very big wave appeared and frightened the boy so much that he ran away leaving the toy behind with the waves.*) but could be intentional, such as purposefully throwing the object away (N=45; 32.8%; e.g. *After drinking it, he threw the bottle into the sea.*).

Most of the stories were told from an external perspective (N=101; 73.7%) but some took the object's perspective (N=16; 11.7%) or an individual's perspective (N=11; 8%). Only 24 stories (17.5%) assigned an emotion to the person disposing of the object, most often indifference (N=10; 7.3%) or thoughtlessness (N=6; 4.4%) (Appendix 7). Even less stories (N=17; 12.4%) included an emotion associated with the object as waste. Most were negative (N=16; 11.7%) including sadness (N=8; 5.8%; e.g. *Bucket and Uma lived together for a long time and when they exchanged stories of their former life, Bucket remembered the times when Antonio used to play with it and became a bit sad.*) and powerlessness (N=5; 3.6% e.g. *I remember spending two months at sea, sad and useless at the same time, but also various animals such as dolphins, boobies and seals playing with me as if I were a ball.*) amongst others. Only three stories suggested a positive emotion (1.5%; e.g. *Finally! I was useful again.... I am happy to be part of recycling.*)

Impacts

In the stories, the long journey of the object was marked by interactions with wildlife, often fish and turtles, and with humans. Those interactions, often harmful in the stories, could have a series of consequences for wildlife, for the object itself and for the surrounding environment.

When specified, the journey taken by the object was described as taking over a year (N=25; 18.2%), months (N=17; 12.4%) or days (N=9; 6.6%). This journey noticed interactions with animals (N=52; 38%), most often with fish (N=16; 11.7% e.g. *The little fish were swimming calmly and feeding when they suddenly observe that some small white pieces begin to fall from the surface, they thought it was food.*) and turtles (N=14; 10.2% e.g. *Well, that was until a sea turtle swam by and I managed to get tangled on one of its frontal fins.*). Galapagos endemic species were identified such as marine iguanas (N=3; 2.9%), sea lions (N=2; 1.5%) and some native bird species such as boobies (N=1; 0.7%), pelicans (N=1; 0.7%) and frigatebirds (N=1; 0.7%). Interactions between plastics and animals could be harmful (N=29; 21.1%) (Appendix 8a), such as ingestion (N=25; 18.2%), bites (N=5; 3.6%), and entanglement (N=4; 3%), and non-harmful (N=16; 11.7%) (Appendix 8b) such as overgrowth (N=7; 5.1%), use of the object as a shelter (N=5; 3.6%), or a dialogue between the object and the animal (N=3; 2.2%). Alternatively to describing those interactions, some stories (N=18) recognised the potential impact of MPL's presence on the environment.

During its journey as waste, the object interacted with humans in 58 stories (42.3%). Most often, these were participants in litter picking (N=20; 14.6%), professional and Citizen Scientists (N=13; 9.5%) and students during the workshop (N=12; 8.8%). They most often acted and picked up the waste (N=51; 37.2%), sometimes studying it (N=20; 14.6%). Only three stories (2.2%) depicted individuals indifferent to the waste, noticing its presence without acting. The outcome of the interaction between humans and MPL was only noted in 11 stories (8%) when the object was recycled (N=5; 3.6%), reused (N=3; 2.2%) or disposed of (N=3; 2.2%). The object as waste often ended up stranded on a beach (N=81; 59.1%), in a school (N=12; 8.8%) inspiring activities about plastic pollution or in an animal's stomach (N=5; 3.6%).

Interactions with plastic could have consequences, notably for the animal, such as its death (N=15; 10.9%) and could reflect the global nature of the issue, noting an abundance of MPL in the environment (N=14; 10.2%; e.g. *I was surprised to see that I was not the only one on the beach; there were bottles, plastics, glass and litter in the sea.*). The interaction sometimes highlighted plastic as a source of pollution for the environment (N=12; 8.8%; e.g. *As time went by, the area of the sea in which it was located became degraded and polluted.*). MPL impacted the aesthetics of the beach (N=2; 1.5%; e.g. *So if the bottle was on the beach, for the species that live there, they could take it as an object to live or play in, and that would be something that would affect and give a bad image to all the people that would visit certain touristic areas.*) and human health (N=2; 1.5%; e.g. *And if we talk about the fact that fishing is practised on the islands, we, the people who eat the fish, could also be affected because we don't know what the fish ate or if perhaps it consumed some plastic.*). The object itself often showed signs of deterioration (N=53; 38.7%), such as loss of material properties (N=39; % including shape, colour, size and buoyancy), loss of parts (N=16; 11.7%) and breaking down into microplastics (N=9; 6.6%). Factors of deterioration were sometimes specified including abiotic factors (N=20; 14.6%), such as exposure to the sun (N=18; 13.1%) as well as biotic factors (N=16; 11.7%), such as animal bites (N=9; 6.6%) (Appendix 9).

Solutions

Stories tended to include more preventive suggestions than reactive actions, particularly being more careful and disposing of litter properly. In total, 48 stories (35%) discussed potential solutions either preventively (N=44; 32.1%) and/or reactively (N=8; 5.8%) (Appendix 10). Preventive solutions included a) personal actions (i.e. changes of attitude) such as being more careful (N=12; 8.8%), proper disposal (N=9; 6.6), and recycling (N=8; 5.8%), and b) social actions (i.e. requiring society or group efforts) such as raising awareness (N=8; 5.8%), offering alternatives to plastic (N=5; 3.6%) and stopping plastic production (N=3; 2.2%). Other social actions, as part of preventive solutions, were suggested: convincing the industry (N=1; 0.7%), designing policies (N=1; 0.7%) and monitoring plastic pollution (N=1; 0.7%). Reactive solutions included for example litter picking (N=6; 4.3%) or reuse of the littered object (N=3; 2.2%). As in Praet et al. (2023), recycling was used as a code for the use of the word “reciclar” in Spanish. This may hide confusion about what recycling is but several mentions of recycling differentiate it from reuse (e.g. *If the person had consumed the drink and recycled or reused it, a tragedy would not have happened.*).

Around a third of stories (N=41) included elements identifying who should take action, such as individuals (N=16; 11.7%) including the protagonist or the reader, or more generally the society, which can be expressed in an inclusive (i.e. everyone including the protagonist; N=21; 15.3% e.g. *We should all be aware of the fact that we should not throw too much plastic into the sea, as many species live in the sea and it damages the ecosystem.*) or exclusive manner (everyone not including the protagonist; N=6; 4.3%; e.g. *It is important that plastic is no longer produced because it ends up in places like the ocean, on beaches, making it a problem for the environment.*).

Surveys

Participants were aged between 12 and 22 years old (mean 15.9±1.57), mostly male (N=83; 52%) and students of the UENG (N= 130; 81%). Most participants (41.9%) reported going to the beach a few times a year and then every month (32.5%) or every week (18.1%) (Appendix 11). Half of participants (N=80) had already taken part in a beach clean-up or litter picking activity, with the GNPD, their school, family or a local ecology group, and most often on Santa Cruz beaches (Tortuga Bay, Playa La Estación, Playa los Alemanes, Laguna de las Ninfas) and urban areas (harbour, local parks). Only a handful participants travelled to other islands (e.g. Baltra, San Cristobal, …) to undertake clean-ups.

Results of the Wilcoxon test indicate that only six of the 21 questions asked in the pre-surveys (S1) and post-surveys (S2) changed significantly over time (see Appendix 12 for an overview of the results). Despite Likert scale data considered here as interval data, we still report the mean and standard deviation (SD) for better comparison with values reported in other studies.

Perceptions and self-reported knowledge

Questions evaluated the perceptions of MPL's presence, origins and impacts. Participants were asked to evaluate how much litter they noticed around the school (S1 3.1±1.26; S2 3.41±1.15; scale from 1=very dirty to 5=very clean), in their neighbourhood (S1 3.06±1.39; S2 3.15±1.32) and on the beach they most often visit (S1 3.54±1.28; S2 3.46±1.32). Participants noted the beach as the cleanest place (Appendix 13). While views of litter in the neighbourhood and on the beach did not change significantly over time, the perceived cleanliness of the area around the school increased significantly (p-value=0.02).

Regarding MPL origins (Figure 3), participants mostly agreed that marine litter came from distant areas of Galapagos (S1 4.15±1.30; S2 4.05±1.26; mean ± standard deviation; scale from 1=I fully disagree to 5=I fully agree), more than from fishing activities (S1 3.87±1.32; S2 3.91±1.21) and domestic activities in the archipelago (S1 3.55±1.47; S2 3.56±1.35), and these views did not significantly change over time (p-values > 0.05).

Regarding MPL impacts (Figure 3), participants agreed with the fact that MPL affects the appearance of beaches (S1 4.94±0.31; S2 4.79±0.74; on a scale where 1=fully disagree and 5=fully agree), and their perception of these impacts changed significantly after the activity (p-value=0.00631). But while the impacts on wildlife around the world (S1 4.54±1.09; S2 4.61±0.94) and on human health are acknowledged (S1 4.57±0.89; S2 4.58±0.90), none of those changed significantly over time. Participants scored lower when asked if the way their family and themselves handled litter at home affected litter at sea (S1 3.36±1.66; S2 3.24±1.48), but this change was not significant either.

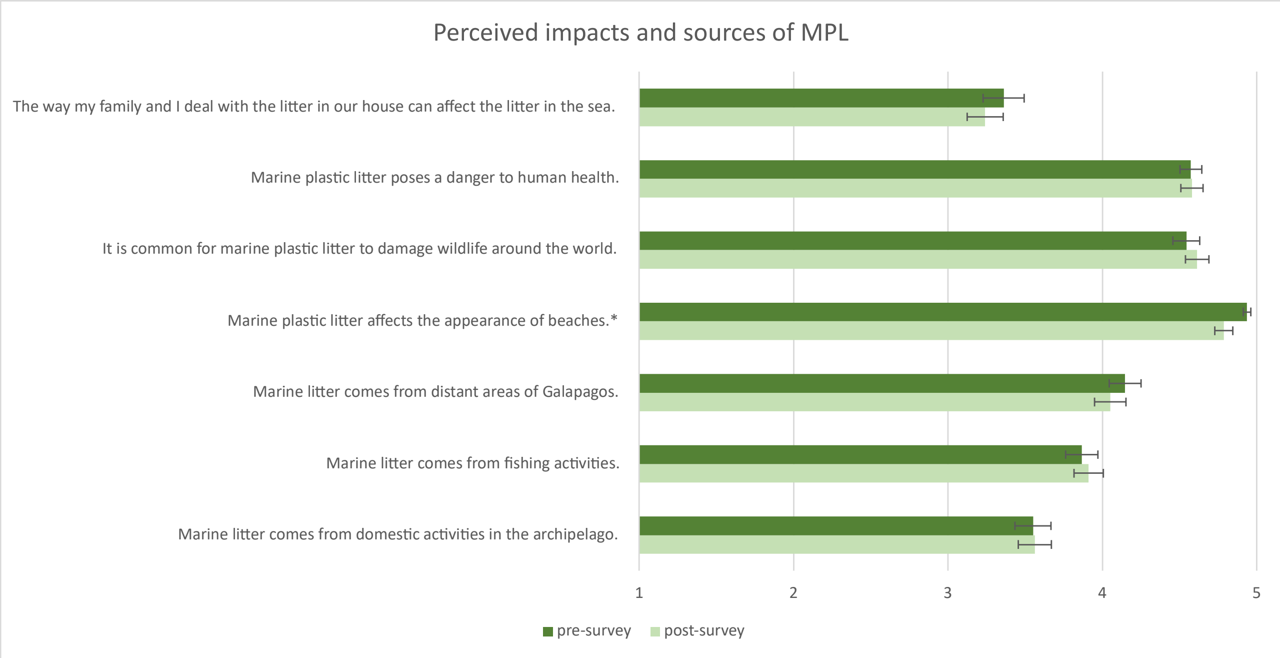

Figure 3: Change in perceived impacts and sources of MPL before (pre-survey) and after the activity (post-survey). The standard error is indicated by the error bar and * indicates behaviours with statistically significant change with p-value <0.05.

Self-reported knowledge of participants was evaluated. Participants reported having considerable knowledge about marine litter (S1 3.42±0.96; S2 3.55±1.04 where 1=I know nothing and 5=I know a lot) and knowing how to reduce marine plastic litter (S1 3.63±1.35; S2 3.71±1.24) (Appendix 14). Neither of these views changed significantly over time.

Pro-environmental behaviours

Participants were asked to provide a self-report of a series of PEBs. They stated that they rarely picked up litter on the ground around their school (S1 2.59±0.87; S2 2.36±0.90, on a scale where 1=never, 2=rarely, 3=sometimes, 4=often, 5=always) and in their neighbourhood (S1 2.41±1.04; S2 2.35±1). But they reported to sometimes pick it up when the litter is found on the beach (S1 3.18±1.16; S2 3.08±1.16). Self-reports indicated that participants often recycled (S1 4.23±0.9; S2 4.04±1.04) but only rarely avoided buying single-use plastics (S1 2.83±1.17; S2 2.9±1.2). Trying to convince family and friends to use less single-use plastic is also a behaviour that participants reported to do rarely (S1 2.91±1.3; S2 2.9±1.2), and even less when it is the wider community they have to convince

(S1 2.38±1.28; S2 2.52±1.27). Only two behaviours changed significantly over time: picking up litter around the school (p-value=0.000888) and recycling (p-value=0.00399) (Figure 4).

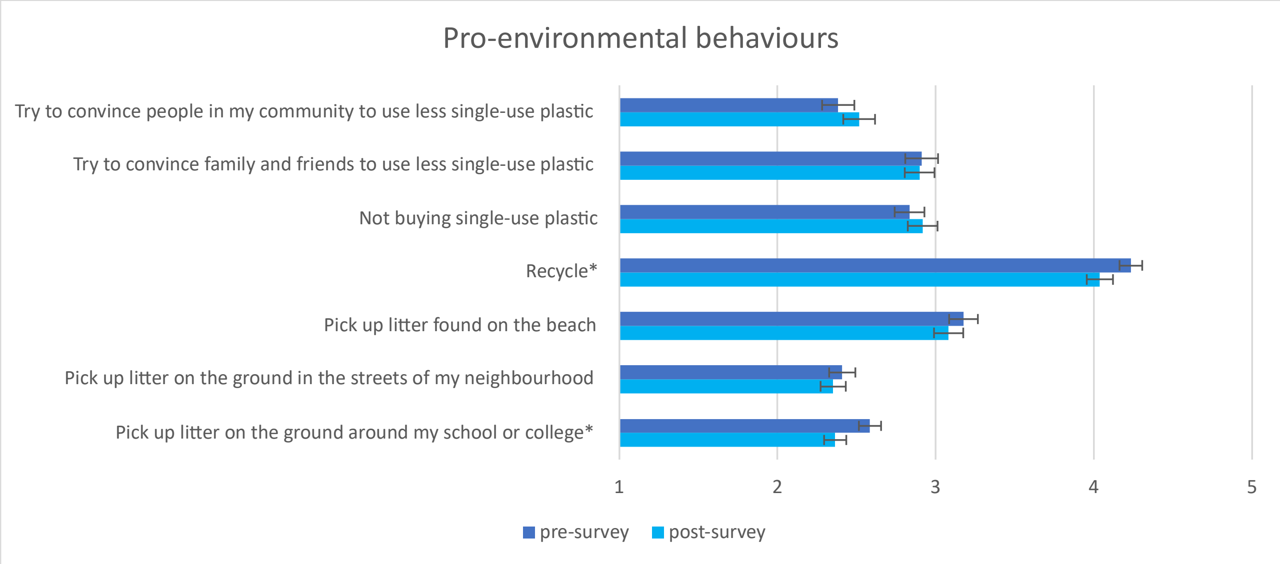

Figure 4: Change in PEBs before (pre-survey) and after the activity (post-survey). The standard error is indicated and * indicates behaviours with statistically significant change with p-value <0.05.

In the pre-survey, participants were asked to name one thing they could do to prevent MPL reaching the ocean. Participants mostly suggested recycle (16%), avoid using plastic (13.6%) and raise awareness (12.3%) (Appendix 15). Before the activity, over 95% of participants self-reported recycling behaviour. When providing an example in the survey, only over 50% of participants specified that they were separating and classifying litter in their respective bins. For more than 20% of respondents, recycling equalled reuse, often for craft activities (Appendix 16).

Evaluation of the activity

Feedback from participants was very positive to all statements (Figure 5). Participants enjoyed the activity (4.49±0.74; on a scale where 1= totally disagree and 5= totally agree). The activity boosted their self-reported learning, mostly about marine litter (4.33±1.05) and its origins (4.21±1.17). They seem to have learnt slightly less about marine litter's impacts (4.03±1.27) and actions to reduce marine litter (4±1.26). Overall, they seemed keen to encourage their family and friends to participate in the activity (4.2±1.17). They were interested in learning more about MPL (S1 4.52±0.91; S2 4.42±0.92; p-value=0.0431; where 1=not interested to 5=very interested) and found it important to reduce MPL (S1 4.73±0.61;

S2 4.61±0.78; p-value=0.0267; 1=not important to 5=very important), with responses to the last two questions changing significantly after the activity (Appendix 12).

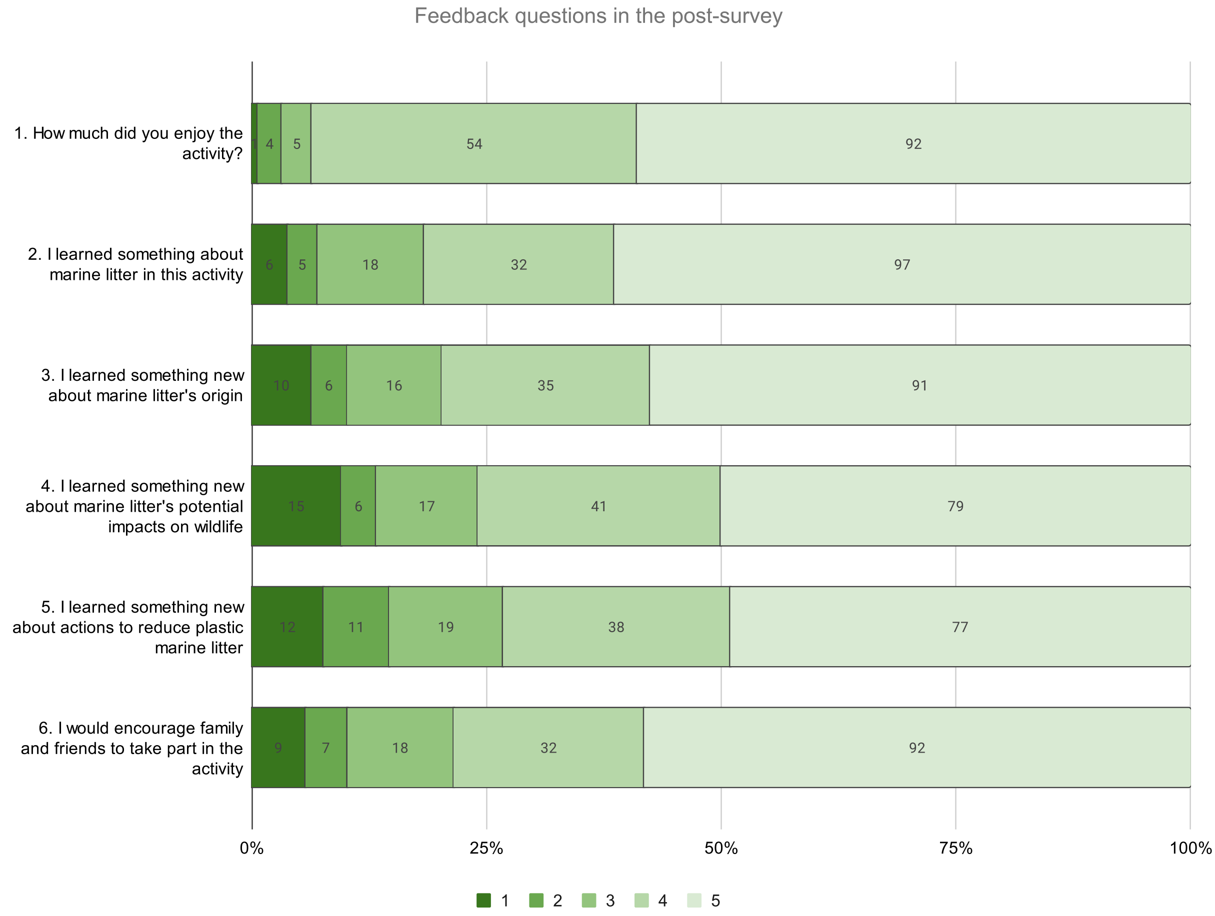

Figure 5: Distribution of answers to the feedback questions with the number and percentage of participants answering on the scale from 1 to 5. For question 1, from 1 (not at all) to 5 (a lot). For questions 2 to 6, from 1 (I totally disagree) to 5 (I totally agree).

Discussion

Our results show an awareness of sources and impacts by local students in Santa Cruz. While the specificity of Galapagos is considered in identifying marine and mainland sources, the presence of fishing-related waste is associated with accidental behaviours. Bio-ecological impacts, mostly on fish and turtles, are described and concern for beach aesthetics and human health are evident in the surveys. When it comes to presenting solutions however, stories are less expansive and surveys indicate high-levels of recycling self-reports as well as suggesting this behaviour to avoid MPL reaching the ocean.

Sources and pathways

The most common objects in the stories were fishing sacks and plastic bottles, the latter being the most commonly chosen item in our previous study (Praet et al. 2023a). While students were here assigned an object, the plastic bottle may have offered a more relatable and inspiring object to develop a story as one of the most commonly found objects in beach clean-ups (Ocean Conservancy 2018) and a recurring finding in Galapagos (Muñoz-Pérez et al. 2023). The time of use, when specified, mostly lasted between days and months, contrasting with the short use-life (less than a day) assigned to objects on the Pacific coast (Praet et al. 2023a). Stories written by Galapagos students emphasised that adults were interacting with the object which contrasts with the results from the Pacific coast where children and teens were the ones mostly interacting with the objects potentially fostering self-reflection. This difference may be linked to the presence of fishing-related plastics in this study, objects that are more difficult for students to relate to, eventually offering more scenarios where adults interact with objects. The use of fishing-related plastics may influence the nature of the object's disposal. Here the pathway of MPL is mostly associated with accidental behaviours, often forgetting or losing the object. This contrasts with the more nuanced results from our study along the Pacific coast where the most recurrent behaviour was intentional. Interestingly, the lack of intention in the behaviour associated with fishing litter was noted by Wyles et al. (2016), while intentional behaviours were associated with public littering.

The concept of object itineraries offered students the possibility to reflect about the geographical scope of the object's journey before reaching Galapagos. The global nature of MPL's journeys was recognised with most objects travelling extensively, often in the regions mostly mentioned, those being Galapagos, mainland Ecuador, and China. As the objects were all found locally, stories were often anchored in Galapagos whereas mainland Ecuador could be associated with the object being produced and/or disposed there, and carried by currents as shown by van Sebille et al. (2019). Similarly, China was associated with industrial manufacturing or with the flag under which an international fishing fleet was operating, which were also identified as an important contributor to the issue (Muñoz-Pérez et al. 2023). Almost half of the stories took the scenario of an object used on a boat, indicating that marine activities, notably fishing, tourism and a few mentions of cargo ships, are an important aspect of daily life and contribute to the issue of MPL.

Fishing industries and tourism were identified as the major contributing sectors to MPL in stories while surveys emphasised the highest agreement with litter coming from remote areas, and then with fishing activities. This tendency may be related to both the importance of fishing for the subsistence and livelihoods of people on the islands, especially since the COVID-19 Pandemic (Viteri Mejía et al. 2022) and the awareness of international fishing fleets presence around the GMR, with some stories evoking illegal shark finning practices (Alava and Paladines 2017). The latter reflects an awareness of known cases of illegal fishing that seem to have impacted residents of Galapagos including participants to the study, and a familiarity of students finding artefacts with Chinese characters on local beaches. The choice of fishing-related MPL may have influenced the sectors identified as contributors to the issue.

When natural factors are considered, oceanic currents are the most recurrently mentioned factor contributing to the arrival of the object to the archipelago. This corresponds to results from the latest studies highlighting that marine currents can carry MPL from mainland South America to the shores of Galapagos (van Sebille et al. 2019). There was a bias in certain stories that traced the MPL itinerary via currents only from mainland China, which we know to be impossible thanks to oceanographical modelling. The importance of currents and origin from remote areas and fishing activities contrast with the East Pacific coast where local terrestrial sources, such as beach littering, were mostly identified (Praet et al. 2023a). This difference may reflect the specificity of the MPL issue on oceanic islands particularly vulnerable to receiving MPL from marine activities and currents even when not inhabited (Lavers and Bond 2017). For example, a study of MPL perceptions in the Portuguese islands of Madeira and Porto Santo evidenced that mainland and ocean sources are recognised while direct release on the coast is the least mentioned source (Bettencourt et al. 2023). This specificity of the island helps us understand a potential lack of sense of responsibility as surveys indicated that participants agreed the least with a domestic origin of MPL and did not see how their own waste management could be related to the issue of MPL.

Impacts

Stories seem to focus much more on bio-ecological impacts of MPL, exactly as in our previous study (Praet et al. 2023a). For example, several stories discussed harmful interactions, most commonly ingestion of plastic, and these interactions could have a severe impact such as the animal's death. This is linked to a general awareness of plastic-related risks and impacts by students and children that have been noted in studies around the world (e.g. Oturai et al. 2022; Heidbreder et al. 2019). Yet, our surveys ranked highest the impact on the aspect of the beach (similarly as in Praet et al. 2023a), which can be seen as a threat to the unique biodiversity of Galapagos (Praet et al. 2023b) and associated with a loss of tourism and hence revenues. This prevalence of worry for the aesthetic impact provoked by plastic waste was noted on other islands relying heavily on tourism. On Amantani island (Lake Titicaca), residents and local institutions seem concerned about how the presence of this waste might affect tourist perception of the island (Gascón 2022). In Galapagos, participants strongly agreed with the impacts of MPL on human health, reflecting a concern suggested in Praet et al. (2023a) with plastics entering the food chain. Furthermore, a couple of stories explicitly stated their concern over ingestion of microplastics by fish, and then humans eating fish. For fishing-dependent islands, the awareness of impacts may be higher due to a closer relationship with ocean resources. In Cape Verde for example, the awareness of the issue is linked, at least for fishers, to finding plastics inside some fish species and noticing damage to equipment caused by marine litter (Ferreira et al. 2021).

Overall, participants were aware of the diversity of impacts and considered MPL as a global issue, one that pollutes the environment. The impact of the journey on the object was noted through signs of deterioration in more than a third of stories. Abiotic and biotic factors were both identified as contributing to this deterioration, and to an object's eventual transformation into microplastics. While plastic deterioration rates raise a lot of questions among scientists, the impact of both biotic and abiotic factors are clear (Chamas et al. 2020), and are here identified by participants.

The journey length was often described as taking over a year, which contrasts with estimates from oceanographic models (a few months) in the region. This may evidence a perception of objects staying in the environment longer, which is likely to happen especially on non-inhabited islands of the archipelago. More than a third of stories considered interaction between animals and plastic while the object was in the environment. The most common animals mentioned were fish and turtles, which corresponds to our findings on the East Pacific Coast. The emphasis on fish may be linked to the importance of small-scale fisheries for the livelihoods of Galapagos residents, a positive role that was reinforced during the pandemic when fishers contributed to the survival of the communities (Viteri Mejía et al. 2022). The emphasis on turtles may be related to their emblematic nature in the fight against plastic pollution (Geary 2019) and to their presence in Galapagos, easily spotted in the harbour of Puerto Ayora, on Santa Cruz. The recurrent mention of Galapagos species may reflect a specific concern of local students for certain species present in Galapagos. While more data is needed, one study showed good knowledge of sea lions by San Cristobal residents (Lorden et al. 2012) who cohabit with one of the biggest sea lion colonies (Salazar 2002; Denkinger et al. 2015). Building on this, proximity with wildlife visible in Santa Cruz and with the issue of MPL may create better knowledge and awareness of participants.

When humans interacted with the waste, they were often described picking it up or participating in clean-ups. Some stories described how the object could be studied or analysed as part of the workshop (Praet et al. 2023). This emphasis on clean-ups may be related to the importance of those activities locally with several institutions and citizen initiatives organising beach clean-ups. Almost half of respondents indicated that they had already taken part in a clean-up, potentially encouraging them to include this in their story and orienting their self-report of PEBs.

Solutions

Contrasting with our study on the Pacific coast where more than 75% of stories included potential solutions, less than a third of Galapagos participants included solutions in their stories. Those which did focused on preventive solutions, mostly personal behavioural change. The most common solutions were being more careful and disposing of litter properly (the latter is also the most recurrent solution in Praet et al. 2023a). While we are aware that the activity focused on the itinerary, we hoped that participants would think about solutions when considering how the situation could have been prevented (question 7).

In 27 stories, society as a whole was encouraged to take action, potentially reflecting an awareness of global dynamics affecting Galapagos and inferring a shared responsibility. The general public was also identified by Bettencourt et al. (2023) as the sector having responsibility for the issue in Madeira. While further research is needed, this may show that islanders know that society-wide actions are needed to tackle waste from marine activities and waste carried by oceanic currents from mainland sources, beside local input of litter. As local inputs constitute only a small percentage of the waste washing on Galapagos shores, this may lead to a lack of relatedness between one's own waste management and the issue of MPL. The presence of MPL may discourage people from adopting pro-environmental behaviours locally, especially as the problem is perceived as coming from elsewhere.

Almost all participants report recycling in the survey, confirming a trend of high-levels of self-reported recycling behaviour (Kiessling et al. 2017), particularly in young individuals (Salazar et al. 2022) who sometimes overestimate this PEB (Chao et al. 2021). This may be linked to the importance of recycling as a solution against plastic pollution in regional communication campaigns (e.g. the 3 and then 4 Rs: refuse, reduce, reuse, recycle) and the enforcement of litter classification rules by the municipality of Santa Cruz. In pre-surveys, recycling was the most commonly suggested action before avoiding plastic use. This tendency to suggest recycling had already been identified in Praet et al. (2023a). Here, participants may give an expected answer, maybe even more when recycling is mandatory in their neighbourhood. While recycling is a popular self-reported PEB and suggested solution, there is a confusion about what recycling is, notably differentiating between litter classification and reuse. As this confusion about the term "recycle" is a global issue (Alexander et al. 2009), future educational activities in Galapagos could make this difference clearer, and encourage a reduction of plastic consumption. Other studies have shown that solutions aim at making the waste not visible across the landscape instead of reducing plastic use and waste (Gascón 2022, 7), particularly for islands relying on tourism. While this is evident in surveys where the PEB "not buying single-use plastic" is one of the most rarely adopted, 13.7% participants still suggested avoiding plastic use to prevent waste entering the ocean.

Picking up the waste on the beach was also a PEB ranked higher than picking it up in the respondent’s school and neighbourhood. This confirms the concern for MPL’s impact on the beach appearance evident in surveys and a general concern for the natural environment which can be enhanced by beach clean-up participation (Wyles et al. 2017), an activity particularly popular in Galapagos. MPL is considered “out of place” (after Douglas 2002, 44) in those natural settings, contrasting with litter blindness in urban settings identified by De Veer et al. (2022). This tendency may be even more important in a place like Galapagos where the environment is praised for its uniqueness and its value is deeply associated with the economy of the islands depending on tourism.

Evaluation of the activity and usefulness of the framework

The activity received very positive feedback with participants interested in the topic and reporting learning about MPL. These similar results to Praet et al. (2023a) show that the activity can be organised successfully online and in person. Using the object itinerary framework proved useful to engage students on the topic, especially to make the issue less overwhelming and more relatable by focusing on macroplastics. Yet, the framework may have incited them to focus on the object’s journey, and less on solutions.

Almost a third of the question’s answers changed significantly between the pre- and post-survey. Participants’ perceptions of MPL origin did not change significantly over time nor did their self-reported knowledge of the issue. The perceived impacts of MPL on the appearance of beaches however decreased significantly, maybe influenced by a reflection about the diversity of impacts a plastic object can provoke during its journey. The perceived cleanliness in the area around the school increased significantly, which may reinforce the feeling of litter blindness in urban environments (De Veer et al. 2022).

The activity provoked a significant decrease of two PEBs: recycling and picking up litter on the ground around the school or college. While this outcome was not expected, it may be related to gaining awareness that the issue of MPL needs different solutions (as evident in the stories) and to a better differentiation between reuse and recycling. We can observe a slight (non-significant) increase in two behaviours related to plastic use and consumption: not buying single-use plastic and trying to convince family and friends to use less single-use plastic. Further studies are needed to confirm those trends and understand potential consequences of increased knowledge on the topic of plastic pollution. Understanding the complexity of the issue may lead students to have more distributed answers, and consider an array of complementary solutions.

While our study did not provoke a significant increase in all PEBs nor a significant change in self-reported knowledge of origins and impacts, more research is needed to understand how the activity was beneficial and how it can be improved. The demographics could be explored to identify factors (e.g. age, gender) that may influence the impact of the workshop and the focus of stories. The results may differ from our online activity where self-reflection at home was encouraged due to the repetitive lockdowns (Praet et al. 2023a). While the impact of the activity may not be obvious from the Wilcoxon tests, the excellent feedback indicates that participants enjoyed the activity and learnt a lot from it.

Conclusion

The analysis of surveys and stories offered insights into perceptions of the issue of MPL in Galapagos. There was an evident awareness of global pathways, notably through currents, and sources of plastic pollution across stories and surveys, with the fishing sector being identified as an important contributor. From that perspective, the prevalence of accidental behaviours leading to MPL disposal reinforces a trend of fishing litter perceived more positively than domestic litter. The prevalence of bio-ecological impacts, with a concern for aesthetics of the landscape, human health and wildlife, may be related to the specificity of Galapagos, an archipelago relying on tourism for its income and on fishing as a major food source locally. The importance of the aesthetics of the landscape and of the potential impacts of plastic pollution for the unique biodiversity may reflect an awareness of the uniqueness of Galapagos as a WHS and the value of such landscape, notably for tourism.

While this study suggests an awareness of origin and sources of MPL in Galapagos, the diversity of solutions remains overlooked. The prevalence of recycling in surveys suggests expected answers and PEBs while stories seem to encourage careful behaviour. A problem emerging from our data is that solutions were not often included in stories, reinforcing the need for targeted actions to raise awareness and improve knowledge of potential solutions. For example, educational activities could focus on offering more clarity regarding the meaning of recycling, and how this behaviour alone is insufficient to address plastic pollution, especially on islands. This would also contribute to communicating the message that the issue of plastic pollution needs a variety of solutions (Lau et al. 2020), while encouraging a diversity of PEBs.

The story-writing workshops proved to be successful engagement tools using an archaeological framework adapted to marine plastic litter, viewing these items as archaeological artefacts. The excellent feedback proves that archaeology made the workshop an enjoyable and engaging experience.

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Conflict of interest

The authors have no conflict of interest.

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Supplementary materials

Appendix 1 - Positionality Statements

In qualitative research, positioning oneself is essential to acknowledge the impact that our background, acts and beliefs might have had on the study.

EP:

I am an educated western woman who undertook these workshops from the perspective of an archaeologist. This approach might have influenced the workshops themselves as well as the content of stories. Despite having experience working in Latin America and being fluent in Spanish, it was the first time that I was working in Galapagos. My position on the topic of plastic pollution is also important to note: my research looks at plastic pollution in Galapagos, a topic that can trigger ecological anxiety and be overwhelming at times. Due to several changes in my PhD, the organisation of workshops became the core of my PhD, which means that there were important elements at stake for the workshops to work efficiently. The workshop settings were sometimes challenging with at times more than thirty students participating in one workshop. An attempt for reflexivity was undertaken by keeping notes during the workshop and thinking about positionality throughout the analysis, annotating potential biases.

AG:

I am an educated western woman who undertook these workshops from the perspective of a conservation biologist and environmental educator. I am also a permanent resident of the Galapagos Islands and have been living and working here for over twenty years. In the past five years, I have been leading educational activities and citizen science projects related to the marine plastic contamination issue in the archipelago. This is part of an overarching programme that includes physical, biological and social components. My personal experience and perceptions of the local context might have influenced the workshops themselves as well as the content of stories and answers to the surveys. At the same time, my knowledge of the local context has allowed me to avoid some misunderstandings and offer my own expertise on the topic to students when asking questions, notably about remote accumulation beaches. Apart from the educational aspect and building on pre-existing networks of environmental education in Galapagos, there were no particular elements at stake for me in undertaking the workshops.

Appendix 2 - Surveys in Spanish and English

Pre-survey/ Pre-encuesta

Pre-survey

We are doing research and we want to know your opinion about plastic waste. Your opinion is very important! If you have any doubts, ask your teacher, thank you!

1. How often do you visit the beach?

Every day ☐ Every week ☐ Every month ☐

A few times a year ☐ Once a year or less ☐ Never ☐

Plastic marine litter

Plastic marine litter occurs when discarded plastic objects enter the seas, oceans and coastlines due to human activities. Plastic objects can be things like plastic bags and food wrappers, plastic bottles, fishing nets and ropes, and tiny particles used in things like face wash and toothpaste.

1. How much do you think you know about plastic marine litter? Please rate from 1 to 5: .... 1 (I don't know anything) - 5 (I know a lot)

2. Do you agree or disagree with the following general statements? Use the full scale from strongly disagree to strongly agree to answer:
   1 (strongly disagree) - 5 (strongly agree)

Plastic marine litter greatly affects the appearance of beaches.	
It is common for plastic marine litter to damage wildlife around the world.	
Plastic marine litter poses a danger to human health.	
The way my family and I deal with our household rubbish can affect the litter in the sea.	
I know how I can reduce plastic marine litter.	

Marine litter comes from domestic activities in the archipelago.	
Marine litter comes from fishing activities.	
Marine litter comes from distant areas of Galapagos.	

3. How interested are you in learning more about plastic marine litter? ....
   1 (no interest at all) - 5 (very interested)

4. How important is it for you to reduce plastic marine litter? ....
   1 (not at all important) - 5 (very important)

5. How much litter have you seen in the following places? From 1 (very dirty) - 5 (very clean)

Around your school or college	
In the streets of your neighbourhood	
At the beach you visit most often	

6. How often do you do the following things? never (1), rarely (2), sometimes (3), often (4), always (5)?

Pick up litter on the ground around my school or college.	
Picking up litter on the ground on the streets in my neighbourhood.	
Pick up litter on the beach.	
Recycle.	
Do not buy single-use plastic.	
Try to convince family and friends to use less single-use plastic.	
Try to convince people in my community to use less single-use plastic.	

7. Do you recycle at home? Yes/No
   If yes, give an example(s)

8. Have you ever been involved in an organised beach clean-up or litter pick-up? Yes/No
   If yes, where? with whom?

9. Name ONE thing you could do to stop plastic waste from reaching the ocean.

10. Do you give us permission to use the answers from this questionnaire in our research? Yes/No

<u>Cuestionario 1</u>

Estamos realizando una investigación y queremos saber tu opinión sobre la basura plástica ¡Tú opinión es muy importante! Si tienes dudas, pregunta a tu profesor o profesora ¡gracias!

1. ¿Con qué frecuencia visitas la playa?

Cada día ☐ Cada semana ☐ Cada mes ☐

Unas cuantas veces al año ☐ Una vez al año o menos ☐ Nunca ☐

Basura marina plástica

La basura marina plástica se produce cuando objetos desechados de plástico ingresan a los mares, océanos y costas debido a las actividades humanas. Los objetos de plástico pueden ser cosas como bolsas de plástico y envoltorios de alimentos, botellas de plástico, redes de pesca y cuerdas y partículas diminutas que se usan en cosas como lavado de cara y pasta de dientes.

1. ¿Cuánto crees que sabes sobre la basura marina plástica? Califica de 1 a 5: …………………. 1 (no sé nada) - 5 (sé muchísimo)

2. ¿Estás de acuerdo o en desacuerdo con las siguientes declaraciones generales? Utiliza la escala completa de totalmente en desacuerdo a totalmente de acuerdo para responder: 1 (totalmente en desacuerdo)- 5 (totalmente de acuerdo)

La basura marina plástica afecta muchísimo al aspecto de las playas.	
Es común que la basura marina plástica dañe la vida silvestre en todo el mundo.	
La basura marina plástica representa un peligro para la salud humana.	
La forma en que mi familia y yo tratamos la basura de nuestra casa puede afectar la basura que hay en el mar.	
Sé cómo puedo reducir la basura plástica marina.	
La basura marina proviene de actividades domésticas en el archipiélago.	

La basura marina proviene de actividades pesqueras.	
La basura marina proviene de zonas lejanas de Galapagos.	

3. ¿Qué interés tienes en aprender más sobre la basura marina plástica? ……………. 1 (nada de interés) - 5 (mucho interés)
4. ¿Qué importancia tiene para tí reducir la basura marina plástica? …………………. 1 (ninguna importancia) - 5 (muchísima importancia)
5. ¿Cuánta basura has visto en los siguientes lugares? De 1(está muy sucio) a 5 (está muy limpio)

Alrededor de tu escuela o colegio	
En las calles de tu barrio	
En la playa que más visitas	

6. ¿Con qué frecuencia haces las siguientes cosas? nunca (1), rara vez (2), a veces (3), bastante (4), todo el tiempo (5)

Recoger la basura que se encuentra en el suelo alrededor de mi escuela o colegio.	
Recoger la basura que se encuentra en el suelo de las calles de mi vecindario.	
Recoger la basura que se encuentra en la playa.	
Reciclar.	
No comprar plástico de un solo uso.	
Intentar convencer a familiares y amigos para que utilicen menos plástico de un solo uso.	
Intentar convencer a las personas de mi comunidad para que utilicen menos plástico de un solo uso.	

7. ¿Reciclas en casa? Sí/No

Si lo haces, dar un(os) ejemplo(s)

8. ¿Alguna vez has estado involucrado/a en una limpieza de playa organizada o en una recolección de basura? Sí/No

   En lo afirmativo, ¿dónde? ¿con quién?

9. Nombre UNA cosa que podrías hacer para evitar que la basura plástica llegue al océano.

10. ¿Nos das permiso para usar las respuestas de este cuestionario en nuestra investigación? Sí/No

Post-survey/post-encuesta

Post-survey

1. How much do you think you know about plastic marine litter? Please rate from 1 to 5: .... 1 (I don't know anything) - 5 (I know a lot)

2. Do you agree or disagree with the following general statements? Use the full scale from strongly disagree to strongly agree to answer:
   1 (strongly disagree) - 5 (strongly agree)

Plastic marine litter greatly affects the appearance of beaches.	
It is common for plastic marine litter to damage wildlife around the world.	
Plastic marine litter poses a danger to human health.	
The way my family and I deal with our household rubbish can affect the litter in the sea.	
I know how I can reduce plastic marine litter.	
Marine litter comes from domestic activities in the archipelago.	
Marine litter comes from fishing activities.	
Marine litter comes from distant areas of Galapagos.	

3. How interested are you in learning more about plastic marine litter? ....
   1 (no interest at all) - 5 (very interested)

4. How important is it for you to reduce plastic marine litter? ....
   1 (not at all important) - 5 (very important)

5. How much litter have you seen in the following places? From 1 (very dirty) - 5 (very clean)

Around your school or college	
In the streets of your neighbourhood	
At the beach you visit most often	

6. How often do you do the following things? never (1), rarely (2), sometimes (3), often (4), always (5)?

Pick up litter on the ground around my school or college.	
Picking up litter on the ground on the streets in my neighbourhood.	
Pick up litter on the beach.	
Recycle.	
Do not buy single-use plastic.	
Try to convince family and friends to use less single-use plastic.	
Try to convince people in my community to use less single-use plastic.	

<u>Now think about the story activity - we'd love to hear what you thought of it!</u>

1. How much did you enjoy this activity?

   I did not enjoy it at all  I enjoyed it very much.

2. Do you agree or disagree with the following general statements?
   1 (I strongly disagree) to 5 (I strongly agree)

I learned something about marine litter by doing this activity.	
I learned something new about the origin of marine litter.	
I learned something new about the impacts that marine litter can have on wildlife.	

I learned something new about what we can do to reduce plastic marine litter by doing this activity.	
I would encourage family and friends to do this activity.	

3. Would you agree to us sharing your story online and/or in an exhibition?

   YES, with my full name mentioned / YES, but without mentioning my name / NO

4. Do you give us permission to use your responses to this survey in our research? YES/ NO
5. Let us know any other comments you have Thank you for participating!

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………….

Cuestionario 2

1. ¿Cuánto crees que sabe sobre la basura marina plástica? …… 1 (no sé nada) - 5 (sé muchísimo)
2. ¿Estás de acuerdo o en desacuerdo con las siguientes declaraciones generales? Utiliza la escala completa de totalmente en desacuerdo a totalmente de acuerdo para responder 1 (totalmente en desacuerdo) a 5 (totalmente de acuerdo)

La basura marina plástica afecta muchísimo al aspecto de las playas.	
Es común que la basura marina plástica dañe la vida silvestre en todo el mundo.	
La basura marina plástica representa un peligro para la salud humana.	
La forma en que mi familia y yo tratamos la basura de nuestra casa puede afectar la basura que hay en el mar.	
Sé cómo puedo reducir la basura plástica marina.	
La basura marina proviene de actividades domésticas en el archipiélago.	
La basura marina proviene de actividades pesqueras.	
La basura marina proviene de zonas lejanas de Galapagos.	

3. ¿Qué interés tienes en aprender más sobre la basura marina plástica? ……

   1 (nada de interés) - 5 (mucho interés)

4. ¿Qué importancia tiene para tí reducir la basura marina plástica? ……

   1 (ninguna importancia) - 5 (muchísima importancia)

5. ¿Cuánta basura ha visto en los siguientes lugares? De 1 (está muy sucio) a 5 (está muy limpio)

Alrededor de tu escuela o colegio	
En las calles de tu barrio	
En la playa que más visitas	

6. ¿Con qué frecuencia hace las siguientes cosas? nunca (1), rara vez (2), a veces (3), bastante (4), todo el tiempo (5)

Recoger la basura que se encuentra en el suelo alrededor de mi escuela o colegio.	
Recoger la basura que se encuentra en el suelo de las calles de mi vecindario.	
Recoger la basura que se encuentra en la playa.	
Reciclar.	
No comprar plástico de un solo uso.	
Intentar convencer a familiares y amigos para que utilicen menos plástico de un solo uso.	
Intentar convencer a las personas de mi comunidad para que utilicen menos plástico de un solo uso.	

<u>Ahora piensa en la actividad de la historia ¡nos gustaría saber qué te pareció!</u>

1. ¿Cuánto disfrutaste de esta actividad?

   No lo disfruté nada  lo disfruté muchísimo.

2. ¿Estás de acuerdo o en desacuerdo con las siguientes declaraciones generales?

   1 (totalmente en desacuerdo) a 5 (totalmente de acuerdo)

Aprendí algo con respecto a la basura marina haciendo esta actividad.	
Aprendí algo nuevo sobre el origen de la basura marina.	

Aprendí algo nuevo sobre los impactos que la basura marina puede tener en la vida silvestre.	
Aprendí algo nuevo sobre lo que podemos hacer para reducir la basura marina plástica al realizar esta actividad.	
Animaría a familiares y amigos a realizar esta actividad.	

3. ¿Estarías de acuerdo con que compartamos tu historia en línea y/o en una exhibición?

   SI, con mi nombre completo mencionado/SI, pero sin mencionar mi nombre/NO

4. ¿Nos das permiso para utilizar tus respuestas a esta encuesta en nuestra investigación? SI/NO
5. Háganos saber cualquier otro comentario que tengas ¡Gracias por participar!

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Appendix 3 - Coding strategy

- <u>NVivo</u>

After removing the stories that did not answer any of the questions, 137 stories, including comics and illustrated stories, with full consent were analysed. As the stories were all transcribed, we ensured that they were authentic (saying things about the writer's perceptions and values) and real (the researcher discovers information about participants that they might even not realise) (Savin-Baden and Howell Major 2013, 238). We here used a deductive approach by importing and adapting the codebook used in our previous study (Praet et al. 2023a, see Table 1 and Supplementary materials). As the activities had a similar design (pre- and post-survey, a set of similar orienting questions and the task of writing an artefact's journey) and only differed in the format (online for Praet et al. 2023a, in person for this study), the set codebook was a useful tool that had already been approved by a multidisciplinary team to look at perceptions of MPL by schoolchildren from Latin American countries along the Pacific coast. We explored inductive coding following a thematic approach related to the concept of object itineraries in a previous study (Praet et al. 2023b).

- <u>Codebook</u>

Just as in Praet et al. (2023a), the codebook has four overarching themes: the object as a product, the object as waste, the solutions and the story's structure. These themes allowed us to consider all aspects of the questions asked of the students (Table 1). The first theme looks at the type of object used, its emotions, who used it and for how long (questions 1, 2 and 4). The second theme gathered information about the object's journey (duration, emotions, types and consequences of interactions with the environment, animals and humans, process of becoming waste) (questions 3, 5 and 6). The third theme focused on preventive and reactive solutions along with their actors (question 7). The fourth theme provides contextual information about narrative type, location of the story and movement of the object. The use of the ReCiBa codebook allowed for direct comparison of themes present in the stories on the East Pacific and in Galapagos. It should be noted that the codes that did not appear in any of the 137 stories were deleted and a couple of codes were created within the pre-established categories (e.g. animals interacting with wildlife were sometimes species only present in Galapagos).

Table 1: Relationship between the questions asked in the workshop, the coded overarching themes and the way results are reported in this study

Questions	**Overarching themes**	**Reporting of results**
What is the object?	Object as product	Sources
How old is the object?	Object as product	Sources
Where is the object from?	Object as product/ structure of the story	Sources
How was the object used and by whom?	Object as product/ structure of the story	Sources
How did the object enter the environment?	Object as waste	Sources
How did the object interact with the environment?	Object as waste	Impacts
What actions might have prevented the object from entering the environment?	Solutions	Solutions

Appendix 4 - Number of respondents per question

A pair-wised approach was adopted for the before/after question before undertaking Wilcoxon signed rank test.

Category	Question	Answer type	Before/ after	Respondents
Relationship with nature	How often do you visit the beach?	Every day; Every week; Every month; A few times a year; Once a year or less; Never	no	160
Pro-environmental behaviour	Do you recycle at home?	Yes/No (+give an example)	no	160
Pro-environmental behaviour	Have you ever been involved in an organised beach clean-up or litter pick-up?	Yes/No If yes, where? with whom?	no	160
Solutions	Name one solution to avoid marine plastic litter to reach the ocean	Open question	no	160
Self-reported knowledge	How much do you think you know about marine litter?	Likert: 1 (I know nothing) to 5 (I know a lot)	yes	123
Self-reported knowledge	I know how I can reduce marine plastic litter.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	153
Perception of origin	Marine litter comes from domestic activities in the archipelago.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	158
Perception of origin	Marine litter comes from fishing activities.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	158

Category	Question	Answer type	Before/ after	Respondents
Perception of origin	Marine litter comes from distant areas of Galapagos.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	156
Perception of abundance	How much litter have you seen around your school or college?	Likert: 1 (very dirty) to 5 (very clean)	yes	159
Perception of abundance	How much litter have you seen around your neighbourhood?	Likert: 1 (very dirty) to 5 (very clean)	yes	157
Perception of abundance	How much litter have you seen on the beach you visit the most?	Likert: 1 (very dirty) to 5 (very clean)	yes	157
Perception of impacts	Marine plastic litter affects the appearance of beaches	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	159
Perception of impacts	It is common for marine plastic litter to damage wildlife around the world.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	158
Perception of impacts	Marine plastic litter poses a danger to human health.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	157
Perception of impacts	The way my family and I deal with the litter in our house can affect the litter in the sea.	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	yes	158
Pro-environmental behaviour	Pick up litter on the ground around my school or college.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	159
Pro-environmental behaviour	Picking up litter on the ground in the streets of my	1= never, 2= rarely, 3= sometimes, 4=often,	yes	159

Category	Question	Answer type	Before/ after	Respondents
	neighbourhood.	5= always		
Pro-environmental behaviour	Pick up litter found on the beach.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	159
Pro-environmental behaviour	Recycle.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	159
Pro-environmental behaviour	Not buying single-use plastic.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	157
Pro-environmental behaviour	Try to convince family and friends to use less single-use plastic.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	158
Pro-environmental behaviour	Trying to convince people in my community to use less single-use plastic.	1= never, 2= rarely, 3= sometimes, 4=often, 5= always	yes	159
Interest	How interested are you in learning more about marine plastic litter?	1= not interested to 5= very interested	yes	153
Interest	How important is it for you to reduce marine plastic litter?	1= not important at all to 5= very important	yes	150
Feedback	How much did you enjoy the activity?	from not at all to very much	no	156
Feedback	I learned something about marine litter in this activity	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	no	158

Category	Question	Answer type	Before/ after	Respondents
Feedback	I learned something new about marine litter's origin	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	no	158
Feedback	I learned something new about marine litter's potential impacts on wildlife	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	no	158
Feedback	I learned something new about actions to reduce plastic marine litter	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	no	157
Feedback	I would encourage family and friends to take part in the activity	Likert: 1 (I strongly disagree) to 5 (I strongly agree)	no	158
Feedback	Would you agree to share your story online and/or in an exhibition?	Yes with my name/ Yes without my name/ No	no	158

Appendix 5 - Codebook

The codebook includes the codes used to analyse the data, their description, their occurrence where files correspond to the number of stories where the code appears, and references indicate the number of times a code occurs across all stories.

Name	Description	Files	References
Object as a product	This codes for the stage when the main object in the story is a product being manufactured, stored and used. Once it is discarded, the object is not considered as a product anymore but enters the category of "object as waste".	136	325
How was the object used and who used it	This codes for the context of the object use: 1) the length of use of the object 2) the interaction of the object, either with adults or with children/teens	104	158
Length of use of the object	This codes for the "life" of the object: how long has it been used? There are three categories: 1) less than a day 2) between days and months 3) over a year. This will enable us to say how recurrent is replacing the object with a new one and to see which solutions are proposed for the type of objects. The length of use refers to the time between the first use of the object and it entering the environment as waste. The codes are used only when there are temporal elements specified in the story.	57	57
Between days and months	This codes for a length of use that is more than a day but less than a year. For instance, fishing bags or chlorine gallons are usually used a couple of months before being disposed of.	31	31

Name	Description	Files	References
Less than a day	The object can be used less than a day. This typically refers to single-use plastics that are not reused and directly discarded after use. For instance, plastic bottles that are said to be not reused.	16	16
Over a year	This length of use typically refers to the use of an object over a year. That is typical the case for toys, unless when explicitly stated. A toy might be broken or lost before that although that remains accidental.	10	10
Who interacts with the object	This codes for the category of people (either children or adults) mostly interacting with the object. It can be an adult coming back from the supermarket or a child playing with a toy.	94	101
Adults	The category of adults refers to people that are not at school anymore and interact with the object. It can be the family of the children, other adults. This code mostly contrasts with the "children/teens" category.	76	78
Children and teens	This code considers together children and teens because most stories do not specify the age of the people interacting with the object. This is contrasting with the role of adults.	21	22
What is the object	This code gathers all the elements that relate to the object being the focus of the story, going from product to waste. This includes the type of object and also its emotions as product, before becoming waste.	136	167
Emotions of the object	When the object has human characteristics such as thinking, talking or a name, this code	13	24

Name	Description	Files	References
	enables us to infer an emotion that the object possesses as product.		
Negative	This code gathers negative emotions felt by the object. It can be tiredness, impatience, apprehension, …	9	13
Apprehensive	This codes for the negative feeling of apprehension towards a future event, such as feeling nervous or preoccupied.	2	2
Bored	This code for the object being bored (i.e. finding the situation little interesting and not having much to do). It differs from impatience, a more active emotion of the object not controlling the long waiting time.	2	2
Impatient	This codes for a lack of patience or the object being tired to be waiting to be used. It differs from apprehension as it does not include concern regarding the future. It also differs from the object being bored (i.e. just finding the situation uninteresting).	3	3
Suffering	This codes for the object suffering from the situation, either mentioning it explicitly or referring to its journey in a negative way.	2	2
Tired	This codes for the object stating that it is tired, notably from the journey.	2	2
Uncertain	This code is for a general lack of understanding and clarity about the current situation.	1	1
Positive	This code gathers emotions that are positive, bringing either happiness or excitement to the object.	9	11

Name	Description	Files	References
Excited	When the object is looking forward to being used, sold, or getting to know the world, we code this under “excited”. It also includes excitement to go somewhere or meet someone. It is a positive feeling regarding any future event.	2	2
Happy	This codes for object mentioning their happiness in the present. It can be for instance when the object gets to be functional in their intended use. It is only restricted to the object as a product rather than as waste.	8	8
Type of object	The type of object codes for the category of object (the main object in the story) explicitly mentioned in the text. A description per object type does not seem useful as those items are literally mentioned in the stories. Some objects were not specifically identified and only referred to as PET bottles, hence the broader category.	136	143
Angermeyer information sign	This is an information sign with attention hours of the Angermeyer Point restaurant in Puerto Ayora, Santa Cruz (since 2001). The back of the sign has green marks, potentially from algae, and corrosion marks. It was recently broken in half (cut is fresh) after being weakened in this section.	5	6
Chinese fishing sack	This is a fishing sack that has Chinese inscriptions on it. It also shows a table with different weights from less than 100g to more than 600g.	17	18

Name	Description	Files	References
Chlorine gallon	This is a big chlorine (5%) gallon with recommended use for cisterns, swimming pools, to avoid bad smells, in food industries, in hospitals. It has a lot number (2021015), an expiry date (15/10/2023) and a production date (15/10/2021). It is an Ecuadorian company and has a contact number and email on the label.	2	2
Clorox bottle	This is a Clorox bottle (500ml) that has a label with a barcode and inscriptions of an Ecuadorian company (Montecristi for Clorox del Ecuador S.A.). It has bumps and remains of eggs laid by a winkle.	8	8
Copropag Galapagos bag	This is a fishing sack of the Galapagos traditional fishing cooperative Copropag. It has inscriptions: por favor no arrojar al mar (please do not throw it in the sea).	15	16
Frisbee	This is an orange worn yet complete frisbee. It has the inscription Mall del Sol, a famous mall in Guayaquil, mainland Ecuador.	9	10
Hulk	This is an action figurine of Marvel's Hulk. Its green colour has faded on its back and its joints are corroded. It is also missing the head.	12	12
Life buoy	This codes for an orange plastic life buoy. It has several inscriptions on it: 5556 (model), 2.5kg (weight), Life buoys (brand), SOLAS96 (compliance with Safety Of Life At Sea regulation), MSO.81.(70) (regulation on testing of life-saving appliances). It is only a section of the life buoy and it lacks the foam.	14	14

Name	Description	Files	References
PET beverage bottle	This codes for PET bottles for beverages when not specified if they are the 220V or Nongfu Spring bottle.	39	41
220V bottle	This is a blue 220V bottle. It is an energy drink sold for 1$ (price is on the cap). It has a barcode with information on the origin: the bottle is produced by the Tesalia Springs Company, an Ecuadorian company. There is a date that is difficult to read on the bottle cap.	16	16
Nongfu Spring bottle	This is a bottle that has a weathered label that represented a mountain. The bottle cap has an inscription: Nongfu Springs. It also includes a date: 2019/07/31 and a number: 222950 Y5. On the bottom, it has the plastic category 1 (corresponding to Polyethylene Terephthalate - PET).	18	19
Object as waste	This code gathers all elements relating to the object as waste, once it does not fulfil its intended use but is abandoned and enters the environment as waste, as a matter out of place. It also calls for elements when the objects enter recycling plants or landfills and is considered as waste, rather than as a product.	136	969
Duration of the journey	This relates to the length of the journey (days, months or years) from temporal elements specified in the stories.	51	53
Between a day and a month	This codes for any journey lasting less than a month.	9	9
Between a month and a year	This codes for any journey lasting between a month and a year.	17	19
Over a year	This codes for any journey lasting over a year.	25	25

Name	Description	Files	References
Emotions of the object	When the object has human features such as thinking, talking or a name, this code enables us to infer an emotion such as hope, feeling powerless, guilty or so.	17	28
Negative	This code gathers negative emotions.	16	25
Awareness of being harmful	This codes for the object becoming aware of its impact on the environment.	3	3
Fear	This codes for the object as waste feeling afraid.	2	2
Powerlessness	This codes for the object feeling powerless facing its situation. It is a feeling anchored in the present. Powerless corresponds to the impossibility of doing anything to change its situation.	5	5
Sadness	This codes for the object as waste feeling sad.	8	11
Sense of futility	This codes for perceiving the object's life as futile or not seeing the point of it.	2	2
Tired		1	1
Positive	This code gathers positive emotions.	3	3
Happiness	This codes for happiness felt by the object. It can be happiness when being nostalgic or happy about the outcome of the situation (when being picked up for example).	3	3
How did the object interact with its environment	This codes for the part of the story where the object as waste interacts with its surrounding environment. It can interact with animals and humans in different ways.	97	320

Name	Description	Files	References
Animals interacting with plastics	This code gathers sections discussing interactions between animals and plastics: their nature (subdivided into harmful and non-harmful), and the type of animals involved.	52	139
Type of animals	This codes for all animals interacting with and being noticed by the object, either on the beach or in the sea.	44	68
Bird		9	9
Crab		4	4
Dolphin		2	2
Fish		16	16
Iguana		3	3
Micro-organisms	This codes for mentions of the plastic as support for micro-organisms.	5	5
Molluscs and crustaceans	This code excludes crabs although they are crustaceans.	6	6
Rat		1	1
Sea lion		2	2
Shark		3	3
Turtle		14	14
Whale		2	2

Name	Description	Files	References
Type of interaction between animal and waste	This codes for the type of interaction between the object and the environment, for example: a discussion between both, the animal trying to eat the object, or eating it, an intoxication of the animal upon contact with the object, the animal getting stuck in the plastic or the plastic sticking onto the animal, growth of organisms on the object, either micro or macro-organisms.	40	71
Harmful	This codes for the interactions being specified and harmful towards the animal such as intoxication, entanglement, ingestion.	29	42
Asphyxia	This code refers to the literal mention of asphyxia because of plastic provoking death.	2	2
Bites	This codes for animals biting the plastic object. While it can lead to its ingestion, it does not always imply ingestion of the object.	5	7
Entanglement	This codes for animals getting entangled/wrapped/trapped in plastic objects.	4	4
Ingestion	This codes for animals ingesting the plastic objects or parts of it.	25	28
Intoxication	This codes for animals being intoxicated by the components of plastic. It refers to the plastic toxicity specifically.	1	1
Not harmful	This codes for interactions that are not harmful towards the animal such as discussion and overgrowth.	16	29
Dialogue	This code for animals and plastic objects having conversations together.	3	6

Name	Description	Files	References
Game	This codes for animals playing with plastic objects.	2	2
Mode of transport	This codes for the plastic being used as mode of transportation for the animal.	1	1
Nest	This codes for the plastic being used as part of a bird's nest.	2	2
Overgrowth	Type of interaction between animals and the object can include the growth of organisms, either micro or macro. Organisms that are visible are considered as macro whereas non visible organisms are considered as micro-organisms.	7	9
Macro-organisms	Macro-organisms growing onto plastic are any organism visible to the naked eye. In our stories, we only have three types of macro-organisms mentioned: crustaceans, molluscs and algae.	6	8
Algae		2	2
Crusta-ceans		3	3
Molluscs		2	2
Micro-organisms	Micro-organisms can also grow onto plastics and are not visible to the naked eye. Some stories include mention of organisms that are not visible but cause harm.	1	1
Place to lay eggs	This refers to the use of plastics as a place to lay eggs, notably in the case of the Clorox bottle where a mollusc laid eggs.	2	2

Name	Description	Files	References
Shelter	This codes for the plastic object being used as a shelter or refuge space by an animal.	5	5
Humans interacting with the waste	This codes for people interacting with the object once it is considered waste. It can be divers or recyclers picking up the litter on the beach, scientists in a laboratory, … The interaction is not limited to picking up the waste but includes anything from noticing it, picking it up, studying it once on land or leaving it in the sea.	58	158
Human actors of the interaction	This codes for who actually picks up/studies/notices the waste.	54	71
Fishers	Fishers can notice the presence of waste, pick it up and bring it back to land.	2	2
General public	This codes for the general public taking action towards the waste: it can be picking it up, noticing it or even studying it without being a citizen scientist, a fisher or taking part in such a programme.	7	7
Participants in litter picking	This codes for participants in coastal clean-ups or urban litter picking. Those events can be community based.	20	20
Professional and citizen scientists	This codes for professional and citizen scientists picking up or studying the waste.	13	13
Recyclers	This codes for professionals picking up the waste and/or recycling it as part of local waste management.	3	3
Staff from Galapagos institution	This codes for the staff from the Galapagos National Park Directorate (GNPD), the Charles Darwin Foundation, the Galapagos Marine	11	11

Name	Description	Files	References
	Reserve (GMR) or any other institution, notably picking up the waste or studying it.		
Students during the workshop	This codes for actions of students during the workshop, notably studying the waste.	12	13
Tourists	National or international tourists can also react to the presence of waste in the environment.	1	1
Outcome of the interaction	This code gathers actions once the waste has been noticed, picked up or studied.	11	12
Disposal	This codes for the object being disposed of once it has been studied or picked up. It can be thrown in a bin as long as it does not involve recycling it or re-use, making another object of it. This code usually emphasises disposing of the object adequately (in the correct bin).	3	3
Re-use	This codes for re-use of objects for a similar or different purpose. It contrasts with industrial recycling.	3	4
Recycling	This codes for stories literally using the word recycling. This occurs after the object is picked up and can suggest industrial recycling.	5	5
Type of interaction	This gathers codes regarding attitudes and actions towards the waste: noticing it, picking it up, and studying the waste.	56	75
Noticing the waste without acting	This codes for human actors noticing the waste without further action.	3	3
Picking up the waste	This codes for human actors picking up the waste, either individually, or as part of community actions such as beach clean-ups.	51	52

Name	Description	Files	References
Studying the waste	This codes for human actors studying the waste and extracting information about it.	20	20
Potential consequences of plastic presence in the environment	This codes for general statements evoking the potential threats that plastic poses to the environment. It is often suggested as a potential outcome, emphasising the danger of plastics presence in the environment.	20	23
How does the object become waste	This category will allow us to understand the (human and environmental) factors leading to littering, the events happening once the object is waste and the human behaviour behind this practice.	133	399
Factors contributing to the object's journey	This code describes how the object entered the sea after being forgotten, thrown or lost. It can be through natural events (tide, river, wind) and/or human action (sectors). These sub-codes are not mutually exclusive and certain story combine the presence of rain, river and ocean, whereas others only mention one contributing factor/sector. Following Schiffer (1976), a distinction is made between natural factors and cultural ones.	123	248
Cultural - Contributing sectors	Anything related to humans' actions (rather than human biological processes) will be cultural. Sectors and individual contributing can do so accidentally or intentionally.	115	152
Fishing industry	This codes for fishing industries independently from the scale as contributors to the object entering the environment. They can be specifically identified as international fishing fleets or national fishing vessels or fishers.	44	57

Name	Description	Files	References
International	This codes for international fishing fleets, often Asian ones, contributing to the object's entry into the environment.	14	19
National	This code gathers national fishing vessels (Ecuadorian) as well as local fishing boats from Galapagos.	26	30
General public	This codes for humans being responsible for the object entering the sea. General public refers to people in general, without specifying if they are for example tourists, local, or fishermen.	19	20
Health sector	This codes for mentions of health institutions (e.g. hospital) responsible for the disposal of the object.	1	1
Local people	This code identifies local people as contributors to the entry of the object into the environment. It can be accidental or intentional.	17	24
Mainland activities	This code gathers descriptions of activities in mainland Ecuador that contribute to the arrival of the object in the environment.	8	9
Marine activities	This codes for activities at sea that are not fishing nor cruise tourism. For example, they can describe transportation. They might also just lack specific elements to determine which type of marine activity is described.	11	12
Plastic industries	This codes for the responsibility of industries producing plastic objects and the role they play in plastics' disposal.	3	3

Name	Description	Files	References
Tourism	This code gathers tourism as a factor contributing to the object's entry into the environment. It can be maritime or terrestrial tourism, and refer directly to tourists contributing to the issue, or to the activities related to tourism (e.g. tourism boat, …).	25	25
Natural	Following Schiffer, natural factors are the result of nature's processes, and environmental and animal actions will be classed as natural factors.	68	96
Animal	Any animal can take up voluntarily or involuntarily litter and drop it in the ocean.	1	1
Currents	This codes for currents identified as contributors to the object's journey.	41	44
Rain	This codes for rain washing down the streets and the environment, resulting in movement of the object towards the sea.	2	2
Rocks	This codes for rocks having an impact on the object's journey, often getting the object stuck in the environment.	8	8
Tide	This codes for the tide being responsible for the entry of the object within the ocean. This most often corresponds to objects being abandoned on the beach.	10	10
Wave	This codes for actions of waves that contribute to the object's journey.	5	5
Wind	This codes for the action of wind provoking the movement of the litter and it getting closer to the ocean/sea.	26	26

Name	Description	Files	References
What human actions or behaviours caused this outcome	This question will allow us to understand the behaviours behind littering and the emotions associated to it.	120	151
Behaviour behind the action	This codes for the behaviour behind the action that led to the discard of the object: was it an intentional act or an accident?	119	125
Accidental origin	This codes for an unintended action leading to the object being discarded. It includes the object being forgotten or lost during a moment of inattention.	79	80
Intentional origin	This codes for an intended act of leaving the object, throwing it away not properly or disposing of it. This does not mean that the action is on purpose to harm the ocean. It just means that the person was aware of discarding it in the environment contrasting with the accidental origin.	45	45
Inferring emotions of the culprit	This codes for emotions of the culprit, as the one responsible of discarding the litter. Does that person act guilty, indifferent, sad or thoughtless?	24	26
Feeling guilty	This codes for the person responsible for the act feeling guilty despite of it being either intentional or accidental. Guilt can happen directly after the object being thrown or much more after. Guilt shows by a feeling of responsibility or regret regarding a specific behaviour leading or contributing to the object being discarded. This feeling of guilt can lead to behavioural changes.	4	4

Name	Description	Files	References
Indifference	This codes for actions of people that do not care and show an indifferent attitude towards marine litter and their own behaviour. It is different from thoughtlessness because the later reflects the absence of knowledge about some consequences of our actions.	10	10
Sadness	This codes for the culprit acting (e.g. crying) and feeling sad when the object becomes waste (most often accidentally).	5	5
Thoughtlessness	This codes for the lack of awareness of consequences of one's actions or the lack of education about the topic of litter and waste disposal. It does not reflect indifference, rather a lack of knowledge about the consequences.	6	7
What was the consequence of this interaction	This codes for the consequences of the interaction between the object and the environment. These interactions have consequences for: a) animal => impact on health B) object = > deterioration c) environment and us	75	169
Environment	This codes for impacts of plastic presence on the environment generally, on animals and on human health.	36	48
Abundance of plastic pollution	This codes for sections of the stories noticing the abundance of plastics in the sea or on the beach.	14	17
Aesthetics of the environment	This may create an impact on the aesthetics of the environment, and notably have repercussions on tourism.	2	2
Death of the animal	This codes for a deadly outcome for the animal when interacting with the plastic object.	15	15

Name	Description	Files	References
Human health	This codes for impacts of the plastic on human health, notably when discussing the ingestion of micro-plastics that are present in fish that humans consume.	2	2
Pollution	This codes for impact of the presence of the object on the environment in the form of pollution. The object is perceived as a contaminant.	12	12
Object	This codes for the impact of the interaction on the object itself, subdivided into the type of deterioration and the factor of deterioration.	60	121
Factor of deterioration	This code looks at the potential factors of deterioration divided into biotic and abiotic elements.	34	50
Abiotic	This codes for abiotic factors of deterioration (physicochemical reactions) such as sea salt, sun, action of waves, ….	20	32
Exposure to sun	This codes for the exposure of the object to the sun, leading for example to a loss of colour or a loss of shape.	18	19
Rain	This codes for rain contributing to the object's deterioration.	3	3
Seawater	This codes for seawater being identified as a factor contributing to the object's deterioration.	7	8
Waves	This code for the deterioration of the object by the action of waves.	1	1
Biotic	This codes for biotic actions (led by living organisms) causing the object to deteriorate. In this case, biotic actions are undertaken by animals only.	16	16

Name	Description	Files	References
Animal bites	This codes for animal bites being the reason for the degradation of objects. For example, fish, birds and marine mammals can bite the object.	9	9
Growth of organisms	This codes for the growth of organisms (micro or macro) contributing to the deterioration of objects.	6	6
Not specified	This codes for stories noticing the deterioration of the object although without specifying the factors of deterioration. It is often the case for stories saying, after a long time at sea, the object lost its colour/shape/… Sentences usually emphasise the time spent without mentioning clearly what kind of impacts it had.	2	2
Type of deterioration	This codes for the type of deterioration noticed in the object. The object can: 1) break into micro-plastics 2) loose parts 3) loose material properties including buoyancy, size, shape, size, smell and colour.	53	71
Breaking into microplastics	This codes for the transformation of macroplastic into microplastics, either explicitly or mentioning the breaking of the object into tiny particles of plastic.	9	9
Loss of material properties	This codes for the object deteriorating by losing material properties such as buoyancy, size, shape, smell, or colour.	39	44
Buoyancy	This codes for objects seeing changes from floating to sinking (or the other way around). This codes for any mention of buoyancy.	1	1
Colour	This codes for a change of colour, that can be due to whitening through exposure to the sun or due to the growth of algae turning the object	16	17

Name	Description	Files	References
	into a greenish colour. Both cases happen in the stories.		
Shape	A change in shape might also occur for the object, notably for plastic bottles being squashed.	7	7
Size	This codes objects that notice a change in size, that can be due to loss of parts or shrinking.	1	1
Smell		2	2
Loss of parts	This codes for an object losing parts due to biotic or abiotic factors. It differs from material properties such as shape, colour, size and buoyancy that do not necessarily imply that the object has lost some elements.	16	16
Solution		48	117
What actions could have prevented this outcome	This includes the solutions that the story offers either as an encouragement, as general ideas or as portrayed in the story itself.	47	73
Preventive solutions	This code focuses on preventive actions to limit plastic pollution. Preventive actions include personal changes (doing by an individual) and social actions (requiring broader actions often by a third party).	44	63
Personal- Change of attitude	This codes for encouraging a personal change of attitude to prevent litter from entering the ocean. It can either be deciding to recycle, to reuse objects, reduce consumption, to dispose properly.	31	43
Be more careful	This codes for being more careful when using plastic objects and paying more attention to	12	13

Name	Description	Files	References
	avoid contributing to the plastic object's entry in the environment.		
Look after Galapagos	This codes for suggestions to care more and look after Galapagos and its biodiversity and unique environment.	5	5
Proper disposal	This code refers to disposing of litter properly: not throwing it in the environment, put litter in a bin.	9	9
Re-use	This codes for an object being re-used and/or re-purposed by individuals before its disposal.	4	4
Recycling	This codes for literal mentions of recycling by participants. This usually means classifying litter at home but can also refer to industrial recycling. It differs from objects being re-used or re-purposed.	8	8
Reduction of consumption	This codes for a reduction in use and consumption of plastics so they do not enter our environment.	4	4
Social- Action	This codes for actions that depend on a third person rather than a personal change. This is subdivided into: raising awareness, monitor plastic pollution, convincing the industry, policies, stopping plastic production, and offering alternatives to the use of plastic.	16	20
Alternative to plastic	This code applies to suggestions of using alternatives to plastic by changing the material and/or the design of objects to avoid plastic litter ending up in the sea.	5	5

Name	Description	Files	References
Awareness	This codes for raising awareness about plastic pollution and share the knowledge on the topic with the population.	8	8
Convince the industry	This code gathers solutions to influence the industry about the impacts of plastics on the environment.	1	2
Monitor plastic pollution	This code is for monitoring, for example through the use of drones, of plastic pollution.	1	1
Policies	This codes for any suggested measures or policies to limit plastic pollution.	1	1
Stop plastic production	This codes for suggestion to avoid producing plastic or stopping the production.	3	3
Reactive solutions	This codes for solutions to tackle the plastic pollution that we are currently facing, such as beach clean-ups and recycling the plastic picked up on the beach. It does not code for actions aiming at avoiding plastic getting there in the first place.	8	10
Litter picking	This codes for picking up the litter as part of a group or as individuals. This relates to community actions such as beach clean-ups or the general public feeling responsible and picking up the waste.	6	6
Re-use	This codes for re-use of a littered object (hence a reactive solution) for the same or different purpose.	3	3
Waste processing	This codes for professional waste processing such as litter being incinerated or processed in a landfill.	1	1

Name	Description	Files	References
Who should take action	This codes for the recommendation to take action and whose responsibility it is. Stories can suggest action from individuals or from the society more broadly.	41	44
Individuals	This codes for individuals being asked to take action, either the reader or the protagonist. It is different than action required at the society-level.	16	16
Protagonist	This code includes both the protagonist of the story taking action or the main character when the story is told from an external narrator (3rd person).	14	14
Reader	This codes for calling the reader out on potential behaviours and asking to take actions.	2	2
Society	This codes for general recommendations that are directed towards people in general rather than asking actions from specific individuals. It also includes recommendations that do not ask anyone specifically. It can be inclusive or exclusive.	27	28
Exclusive	This codes for the call for action on people excluding the protagonist and saying people should take action and recycle, with no “we” or “let’s”. Exclusive includes the third person plural "they" as it does not include the protagonist.	6	6
Inclusive	This code for the call on people to take action in an inclusive way, such as: let’s all take care of the planet.	21	22
Structure of the story	This code gathers all contextual elements of the story regarding its structure through a) the	137	783

Name	Description	Files	References
	location where the story takes place, and b) the protagonist of the story.		
Location	The location code gathers elements about: 1) the country where the story takes place 2) the movement: does the story starts and ends in the same place? 3) the place where the story occurs: a restaurant, a manufacture, … All places and countries mentioned in the story are considered, from the object as product to the object as waste.	135	652
Geography	All countries mentioned in the stories are coded here. They can be mentioned as the place of production, use or discard, and several countries can be mentioned in one story.	104	185
Americas	This codes for countries on the American continent mentioned in the stories. A difference is made between Galapagos and mainland Ecuador for a better understanding of the context.	96	147
Caribbean		1	1
Chile		1	1
Colombia		3	3
Galapagos	This code refers to elements identifying Galapagos (e.g. beach, shops).	83	95
Mainland Ecuador	This codes for elements identifying places or trends in continental Ecuador.	41	42
Mexico		1	1
USA		2	2

Name	Description	Files	References
Asia	This codes for the Asian continent being mentioned, with sometimes countries being specifically identified.	35	37
China		34	34
Europe	This codes for mentions of Europe in the stories.	1	1
Movement	This codes for the journey of the object, trying to highlight the trends in object production, use and disposal. Do children think the problem is national or international?	106	120
Story starts in another place as it ends	This codes for stories that start and ends in a different region or country, reflecting the travel of the object. Stories evoking travel of the main characters will also be coded under this code.	92	103
Story starts in the same place as it ends	This code is used for stories starting and finishing in the same place. There are two variations: a) the story starts and ends in the same place/region but the object still travels and accidentally ends up in the same place. b) the story starts and ends in the same place/region and there is no notice of travel of the object in the story.	17	17
The object has not travelled	This code is for stories that stay at a local level, i.e. in the same area. For example, in Galapagos, this may be in the same island. Discussing several islands will be considered as a journey of the object.	15	15
The object has travelled	This codes for a story where the object travels outside of the region/country of origin but accidentally comes back the region/country it had been discarded.	2	2

Name	Description	Files	References
Place	This codes for the places where the object goes. It is separated between: a) the object as product and b) the object as waste.	130	347
Object as a product	This codes for the places mentioned in the parts of the story where the object is a product. It therefore includes types of places mentioned in both the production (manufacture,), selling (small shop, supermarket) and the use of the object (beach, sea, restaurant).	119	221
Airplane	This codes for airplane transport of the product.	5	5
Beach	This codes for the beach as a place where the object is used, either when someone plays on the beach, has lunch there, …	27	29
Boat	This codes for any type of boat/ship where the object is used. It can include different purposes: fishing, tourism, cleaning, …	67	77
Home	This code gathers objects used as products at home.	4	4
Hospital	This codes for the hospital as the place where the object is used as a product.	1	1
Hotel	This codes for hotels being the place where the object is used as product.	1	1
Industry	This codes for any type of industrial setting described during the production phase of the object.	51	52
Mall	This code identifies when a mall or commercial centre is mentioned in stories. Here, most references to malls are related to a frisbee with an inscription, Mall del Sol, a mall in Guayaquil, mainland Ecuador.	7	7

Name	Description	Files	References
Restaurant	This codes for restaurant as a place where the object was used. It also includes small food stalls.	5	5
Shop	This codes for small shops where the object might be sold or used. It contrasts to supermarkets by the scale. It will be coded to shop any time it says shop/tienda.	27	30
Supermarket	This codes for the supermarket as a place where the object is sold. Only places literally called supermarkets or malls are coded under this code, any other shop is coded under "shop".	3	3
Truck	This codes for trucks transporting the object as a product, often from the industry to the shop, mall or supermarket.	7	7
Object as waste	This codes for the places mentioned in the part of the story where the object is considered as waste. The object can be in the sea and then picked up and transported to a landfill or a laboratory.	97	125
Animal's stomach	This codes for the object as waste being found in an animal's stomach due to ingestion of plastic.	7	7
Beach	This codes for the object as waste being found on a beach, either lost/discarded there or having washed ashore.	81	82
Boat	This codes for boat/ship identified as carrying the object as waste.	2	2
Garbage patch	This codes for specific mentions of the Garbage patch where the object as waste goes through/ends during its journey.	3	3

Name	Description	Files	References
Harbour	This codes for the object as waste being found in the harbour.	6	6
Laboratory	This codes for any scientific setting where the object can be analysed after it has been picked up as waste.	2	2
Laguna	This codes for laguna as a place where the waste ends up.	1	2
Landfill	This codes for the arrival of the object as waste to a landfill.	1	1
Museum	This codes for the plastic object being exposed in a museum.	1	1
Recycling area	This codes for waste going to a recycling area and being turned into another object. It has to be differentiated from landfill where the object is just thrown without any potential for recycling and reuse mentioned in the text.	1	1
School	This codes for the object as waste ending up in the school, often as part of the story-writing workshop.	12	12
Seabed	This codes for the object sinking and ending up on the seabed.	2	2
Urban area	This codes for mentions of waste in an urban environment, such as on the street.	4	4
Narrative	This codes for the narration adopted in the story: - a first person narration told by a human - a first person narration told by an object - a third person narration told from an external perspective.	128	131

Name	Description	Files	References
External	This codes stories written from the third person, providing an external perspective on the narrative.	101	104
Human	This codes for stories written from the first person, adopting a human perspective.	11	11
Object	This codes for stories written from the first person adopting the perspective of an object.	16	16

Appendix 6 - Sectors contributing to the object entering the environment

Codes are always presented from the least to the most referenced.

Code	**Definition**	**Example**
Health sector	This codes for mentions of health institutions (e.g. hospital) responsible for the disposal of the object.	*One day, the chlorine ran out from a hospital and they threw it away, and then as they were about to go up to the rubbish dump, they dropped it on the street and it stayed there day and night.*
Plastic industries	This codes for the responsibility of industries producing plastic objects and the role they play in plastics' disposal.	*If it arrives in a bad condition, the company that created the bag may be sued because they may have done it wrong. Because of that, they may stop making more bags. If it arrives in good condition, they may be valued and make more of them but with due care.*
Mainland activities	This code gathers descriptions of activities in mainland Ecuador that contribute to the arrival of the object in the environment.	*After a long time of being rolled, pushed and trampled by people in the street until it fell into the sea of Guayaquil where it was pushed by the sea currents to the beach La Ratonera in Galapagos, Santa Cruz.*
Marine activities	This codes for activities at sea that are not fishing nor cruise tourism. For example, they can describe transportation. They might also just lack specific elements to determine which type of marine activity is described.	*It was a sunny day when a cargo ship was arriving with a large shipment of Clorox and in a manoeuvre two bottles of Clorox fell off and a coastal clean-up managed to find one of them.*
Local people	This code identifies local people as contributors to the entry of the object into the environment.	*On a very hot day in Galapagos - Santa Cruz there was a cycling race. Competitor Lukas Noha was winning*

		the race.
Code	**Definition**	**Example**
General public	This codes for humans being responsible for the object entering the sea. General public refers to people in general, without specifying if they are for example tourists, locals, or fishers.	*Apparently, a person, child, adult, young person, consumed this drink and for some reason threw it into the sea and the bottle sank under the sea and because of the sea currents it was in the sea for 3 years until the point where it has reached our islands.*
Tourism	This code gathers tourism as a factor contributing to the object's entry into the environment. It can be maritime or terrestrial tourism, and refer directly to tourists contributing to the issue, or to the activities related to tourism (e.g. tourism boat, …).	*A tourist, who had this object, went to the beach to play with this frisbee.*
Fishing industry	This codes for fishing industries independently from the scale as contributors to the object entering the environment. They can be specifically identified as international fishing fleets or national fishing vessels or fishers.	*So, one idea of how a bottle from the Nongfu factory could have got to Galapagos is via the Chinese fishing boats, either because they dumped it into the sea themselves or because they dropped it by accident and there was no opportunity to pick it up.*

Appendix 7 - Emotion of the culprit throwing the object

Code	Definition	Example
Feeling guilty	This codes for the person responsible for the act feeling guilty despite it being either intentional or accidental. Guilt can happen directly after the object being thrown or much more after. Guilt shows by a feeling of responsibility or regret regarding a specific behaviour leading or contributing to the object being discarded.	*The sea carried it away from his grasp - Damn! - is all he said, he was quite annoyed with himself because he knew that if the frisbee started to be destroyed, the marine animals could eat those plastics and they could die. He said to himself to promise to get it back.*
Sadness	This codes for the culprit acting (e.g. crying) and feeling sad when the object becomes waste (most often accidentally).	*Albert swam and swam to where his frisbee had fallen but .... couldn't find it, he came out of the water sad and asked himself: - with this strong wind and the sea where will my frisbee end up? He asked himself this question several times and left.*
Thoughtless-ness	This codes for the lack of awareness of consequences of one's actions or the lack of education about the topic of litter and waste disposal. It does not reflect indifference, rather a lack of knowledge about the consequences.	*People started to buy but they didn't know that the bottles could be recycled so they threw them on the beach or in the sea without knowing that it polluted the sea.*
Indifference	This codes for actions of people that do not care and show an indifferent attitude towards marine litter and their own behaviour. It is different from thoughtlessness because the later reflects the absence of knowledge about some consequences of our actions.	*And the kids didn't mind but the bag killed quite a few fish because the fish thought it was food and the moment the fish ate part of the bag they drowned and died.*

Appendix 8

Harmful interactions between plastic and animals

Code	**Definition**	**Example**
Intoxication	This codes for animals being intoxicated by the components of plastic. It refers to the plastic toxicity specifically.	*This packaging may end up on whales or beaches, etc., and contaminate the species in the marine reserve, or else kill them because of the toxicity.*
Asphyxia	This code refers to the literal mention of asphyxia because of plastic provoking death.	*After 30 minutes, the fish started to suffocate and died one after the other because of the bottle.*
Entanglement	This codes for animals getting entangled/wrapped/trapped in plastic objects.	*Two years later, the sea currents carried the sack towards the shore and it got stuck on some rocks and sand where some crabs lived and they started to nibble at the sack to eat and others got entangled causing damage to the sack and so the sack was affecting nature.*
Bites	This codes for animals biting the plastic object. While it can lead to its ingestion, it does not always imply ingestion of the object.	*All the rubbish it had leaked out and it was just me in the middle of the sea until a turtle came and bit me and pulled me so far away that I didn't know where I was anymore.*
Ingestion	This codes for animals ingesting the plastic objects or parts of it.	*And this is how Chinese water bottles end up in the stomach of a tortoise living on the Galapagos Island.*

Non harmful interactions between animals and plastic objects

Code	Definition	Example
Mode of transport	This codes for the plastic being used as a mode of transportation for the animal.	*And by then a rat grabbed the bottle and took it to the sea, so that it could serve as a boat to sail to another island. With the waves, the rat and the bottle reached Santa Cruz, the same island where the bottle came from.*
Game	This code is for animals playing with plastic objects.	*I remember spending two months at sea, sad and useless at the same time, but also various animals such as dolphins, boobies and fur seals playing with me as if I were a ball.*
Nest	This codes for the plastic being used as part of a bird's nest.	*The bird took the bottle to its nest, but the bottle fell from the tree where the bird´s nest was.*
Place to lay eggs	This refers to the use of plastics as a place to lay eggs, notably in the case of the Clorox bottle where a mollusc (gastropod) laid eggs.	*On picking it (*the bottle) *up, it could be seen that a snail had laid its eggs on it.*
Dialogue	This code for animals and plastic objects having conversations together.	*Bucket and Uma lived together for a long time and when they exchanged stories of their former life, Bucket remembered the times when Antonio used to play with her and became a bit sad.*
Shelter	This codes for the plastic object being used as a shelter or refuge space by an animal.	*First came the tiny fish that used me as shelter from predators and as a food source, eating whatever they could… even me.*

Code	Definition	Example
Overgrowth	Type of interaction between animals and the object can include the growth of organisms, either micro or macro.	*The bottle was in a really bad state, over the past few days, tiny crustaceans called barnacles had adhered to the container.*

Appendix 9 - Codes for factors leading the object's deterioration

Here, factors leading to the object's deterioration are classified as abiotic=A or biotic=B.

Code	Definition	Example
A- waves	This code for the deterioration of the object by the action of waves.	*One day, while I was doing nothing, I saw a big piece of land in the distance, I wanted to get there but I had no arms, luckily a current appeared and pushed me, when I managed to see the beach a big and wild wave dragged me and hit me against the rocks again and again.*
A- rain	This codes for rain contributing to the object's deterioration.	*The lost toy was left on the beach upside down and with the rain and the sun the toy deteriorated over time.*
A- seawater	This codes for seawater being identified as a factor contributing to the object's deterioration.	*It was a long trip and as there had been sun, rain and sea water, the rope holding the buoy broke and left the buoy in the middle of the sea.*
A- exposure to sun	This codes for the exposure of the object to the sun, leading for example to a loss of colour or a loss of shape.	*I just slept and counted the clouds, the sun took away a lot of my colour and some animals came near me thinking I was food, they never did anything serious, they came near me, touched me a little bit and then left....*
B- growth of organisms	This codes for the growth of organisms (micro or macro) contributing to the deterioration of objects.	*The days began to pass, the sun began to destroy it and small types of bacteria started to grow up on the surface.*
B- animal bites	This code for animal bites being the reason for the degradation of	*The bottle was carried by different currents until a pelican pecked at it and took it to the*

	objects. For example, fish, birds and marine mammals can bite objects.	*Galapagos, as the pelican was an endemic species.*

Appendix 10 - Range of preventive solutions suggested

PS= preventive solution, either SA= social action or PC= personal change, and RS=reactive solution

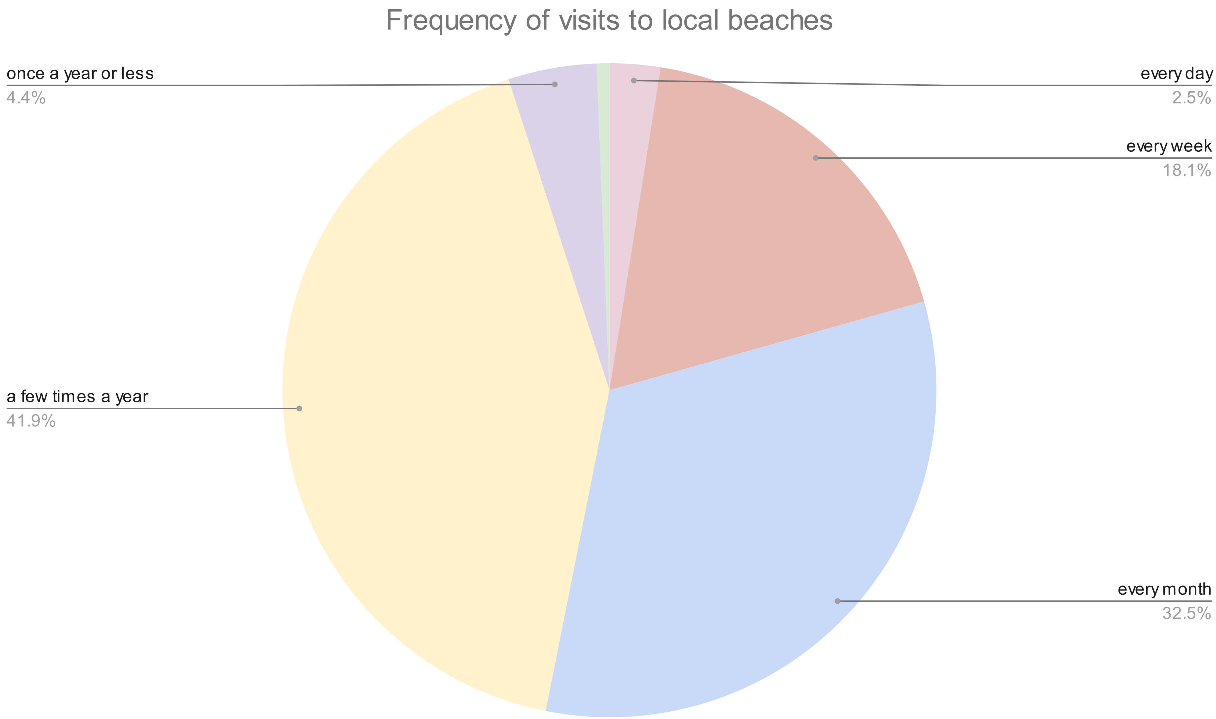
Code	Definition	Example
PS - SA - monitor plastic pollution	This code is for monitoring, for example through the use of drones, of plastic pollution.	*Every year there are hundreds of sacks like me that are thrown into the sea; to prevent me from being thrown into the sea we can use drones or coastal surveillance helicopters.*
PS- SA - convince the industry	This code gathers solutions to influence the industry about the impacts of plastics on the environment.	*They went and spoke with the company to make them aware of the problems that this could cause and that if this continues like this, we may run out of marine life.*
PS- SA - policies	This codes for any suggested measures or policies to limit plastic pollution.	*However, all is not lost as environmentally friendly measures can be implemented through innovative ideas, recycling, using less plastic, conserving the life of oceans, planting trees, and a host of other solutions.*
PS- SA - stop plastic production	This codes for suggestions to avoid producing plastic or stopping the production.	*It is important that plastic is no longer produced because it ends up in places like the ocean, on beaches, making it a problem for the environment.*
PS- SA - Alternatives to plastic	This code applies to suggestions of using alternatives to plastic by changing the material and/or the design of objects to avoid plastic litter ending up in the sea.	*Such an incident could have been avoided if the company's workers had opted for less damaging and biodegradable materials, such as sacks made from cloth.*
PS- SA - awareness	This codes for raising awareness about plastic pollution and sharing the knowledge on the topic with the population.	*This was reason enough to undertake an investigation, to look for a solution to this type of problem with plastic waste in the oceans and to make these cases known to the*

Code	Definition	Example
		population so that they are aware of the consequences of taking these materials to areas that are very fragile and with incomparable landscapes.
PS- PC - re-use	This codes for an object being re-used and/or re-purposed by individuals before its disposal.	*When she got home, she took it out and made a cute craft with the bottle.*
PS- PC - reduction of consumption	This codes for a reduction in use and consumption of plastics so they do not enter our environment.	*That is why we should try to reduce our consumption of these products or find a way to consume them without harming any living beings and without affecting our environment.*
PS- PC - recycling	This codes for literal mentions of recycling by participants. This usually means classifying litter at home but can also refer to industrial recycling. It differs from objects being reused or repurposed.	*In order not to cause such damage, we have to recycle and put waste where it belongs.*
PS- PC - look after Galapagos	This codes for suggestions to care more and look after Galapagos and its biodiversity and unique environment.	*Appreciate and take care of the islands which are a paradise of tranquillity and harmony. Don't pollute the islands, there are marine species that can naively die from the consumption of these plastics.*
PS- PC - proper disposal	This code refers to disposing of litter properly: not throwing it in the environment, put litter in a bin.	*In order to avoid such a disgrace, it would be advisable to dispose of the waste in the appropriate rubbish bin instead of throwing it into the sea.*
PS- PC - be more careful	This codes for being more careful when using plastic objects and paying more attention to avoid	*What could have prevented this is for parents to pay more attention to their child with the toy so that it does not get lost on the beach.*

Code	Definition	Example
	contributing to the plastic object's entry in the environment.	
RS- waste processing	This codes for professional waste processing such as litter being incinerated or processed in a landfill.	*Having disposed of it in a safe place, decompose the bag, put it to another use, etc.*
RS- re-use	This codes for re-use of a littered object (hence a reactive solution) for the same or different purpose.	*Perhaps after replacing the lifebuoy they started to use it again on tourist boats.*
RS- litter picking	This codes for picking up the litter as part of a group or as individuals. This relates to community actions such as beach clean-ups or the general public feeling responsible and picking up the waste.	*Thanks to the people who do community activities to clean the beach so that there is no more pollution.*

Appendix 11 - Frequency of visits to the beach

Participants were asked how often they go to the beach in the pre-survey.



Appendix 12 - Results of the Wilcoxon signed rank test undertaken on R

Significance is indicated in bold (p-value <0.05) compared with statistical non-significance (p-value>0.05). Increase and decrease refer to increase of the mean indicating a general tendency although this may be non significant.

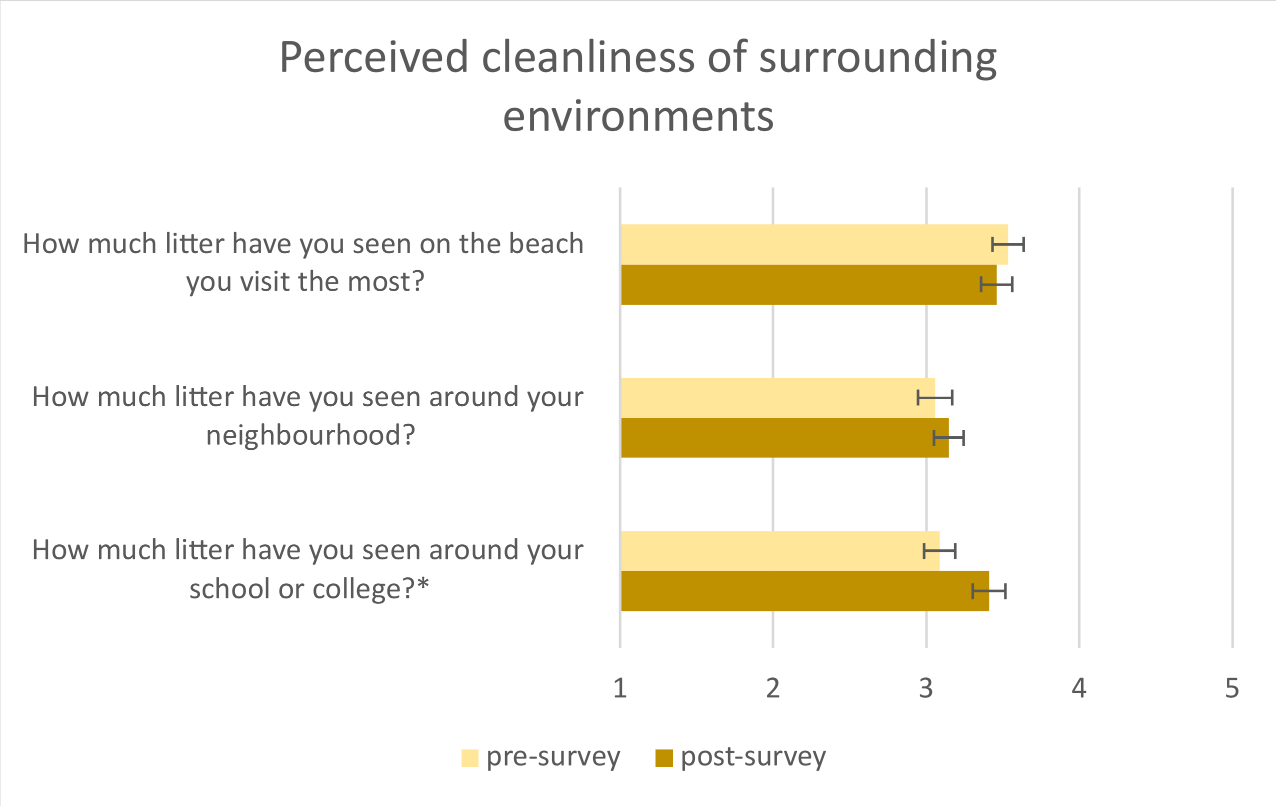
Category	Question	Scale	P-value	Increase/ decrease
Self-reported knowledge	How much do you think you know about marine litter?	from 1= I know nothing and 5= I know a lot	0.177	increase
Self-reported knowledge	I know how I can reduce marine plastic litter.	from 1= I know nothing and 5= I know a lot	0.655	increase
Perception of origin	Marine litter comes from domestic activities in the archipelago.	from 1= I fully disagree to 5= I fully agree	0.94	increase
Perception of origin	Marine litter comes from fishing activities.	from 1= I fully disagree to 5= I fully agree	0.583	increase
Perception of origin	Marine litter comes from distant areas of Galapagos.	from 1= I fully disagree to 5= I fully agree	0.367	decrease
Perception of abundance	How much litter have you seen around your school or college?	from 1= very dirty to 5= very clean	**0.02**	increase
Perception of abundance	How much litter have you seen around your neighbourhood?	from 1= very dirty to 5= very clean	0.41	increase
Perception of abundance	How much litter have you seen on the beach you visit the most?	from 1= very dirty to 5= very clean	0.56	decrease
Perception of impacts	Marine plastic litter affects the appearance of beaches	from 1= I fully disagree to 5= I fully agree	**0.00631**	decrease

Category	Question	Scale	P-value	Increase/ decrease
Perception of impacts	It is common for marine plastic litter to damage wildlife around the world.	from 1= I fully disagree to 5= I fully agree	0.416	increase
Perception of impacts	Marine plastic litter poses a danger to human health.	from 1= I fully disagree to 5= I fully agree	0.81	increase
Perception of impacts	The way my family and I deal with the litter in our house can affect the litter in the sea.	from 1= I fully disagree to 5= I fully agree	0.273	decrease
Pro-environmental behaviour	Pick up litter on the ground around my school or college.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	**0.000888**	decrease
Pro-environmental behaviour	Picking up litter on the ground in the streets of my neighbourhood.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	0.507	decrease
Pro-environmental behaviour	Pick up litter found on the beach.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	0.416	decrease
Pro-environmental behaviour	Recycle.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	**0.00399**	decrease
Pro-environmental behaviour	Not buying single-use plastic.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	0.407	increase
Pro-environmental behaviour	Try to convince family and friends to use less single-use plastic.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	0.85	decrease
Pro-environmental behaviour	Trying to convince people in my community to use less single-use plastic.	1= never, 2= rarely, 3= sometimes, 4= often, 5= always	0.203	increase

Category	Question	Scale	P-value	Increase/ decrease
Interest	How interested are you in learning more about marine plastic litter?	1= not interested to 5= very interested	**0.0431**	decrease
Interest	How important is it for you to reduce marine plastic litter?	1= not important at all to 5= very important	**0.0267**	decrease

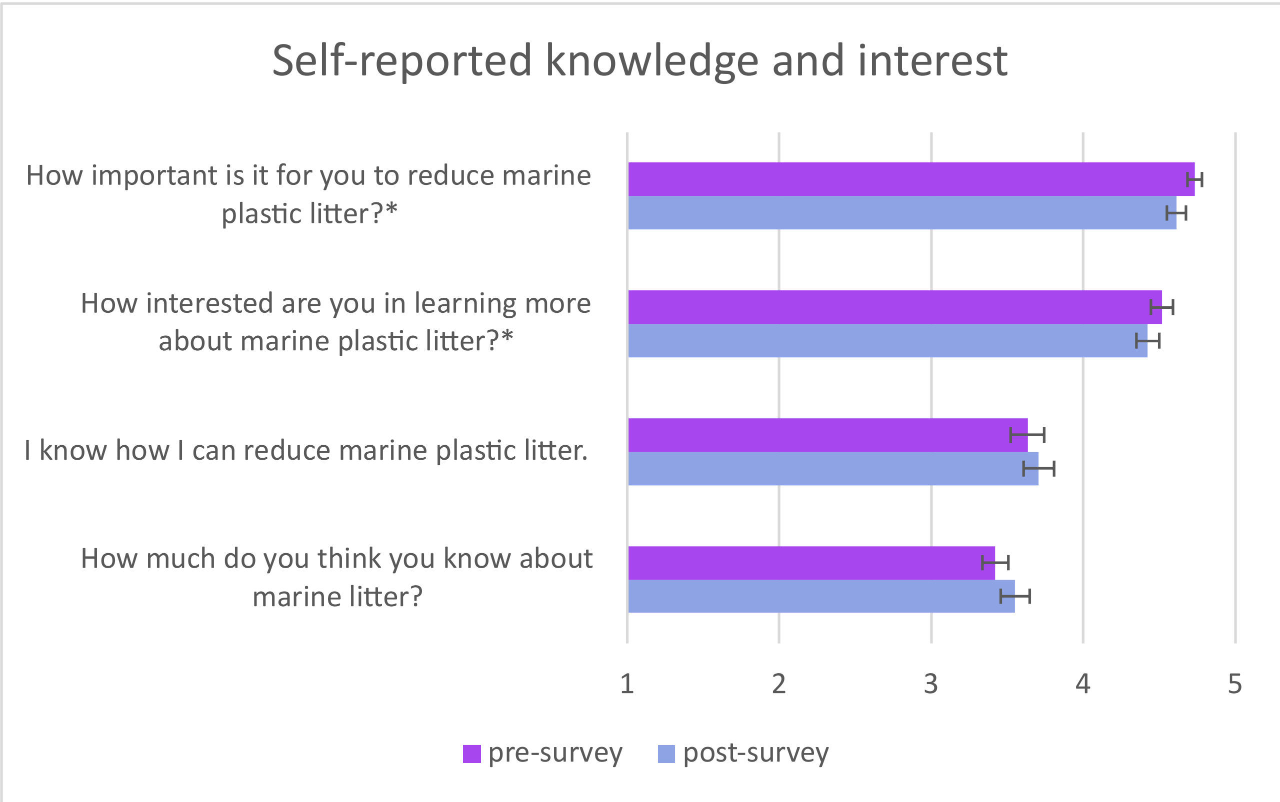
Appendix 13 - Perceived cleanliness of surrounding environments

Change in perceived cleanliness before (pre-survey) and after the activity (post-survey) when participants were asked how they perceived their surroundings, from very dirty (1) to very clean (5). The standard error is indicated and * highlights questions with statistically significant change with p-value <0.05.



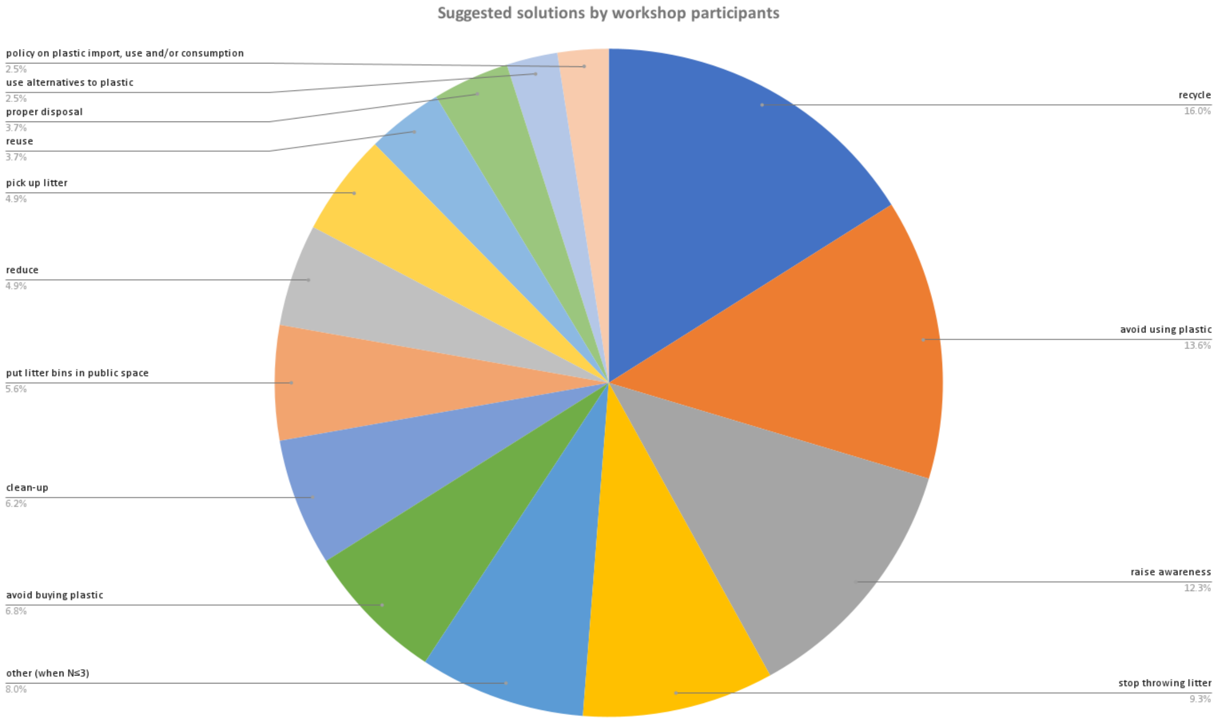
Appendix 14 - Self-reported knowledge and interest

Change in self-reported knowledge and interest in the topic before (pre-survey) and after the activity (post-survey) when participants were asked how interested they were in the topic from 1 (no interest) to 5 (a lot of interest), how important it was to them from 1 (not important at all) to 5 (very important), how much they knew about it from to from 1=nothing to 5= a lot, and if they knew how to reduce MPL from 1= I strongly disagree to 5= I strongly agree. The standard error is indicated and * highlights questions with statistically significant change with p-value <0.05.



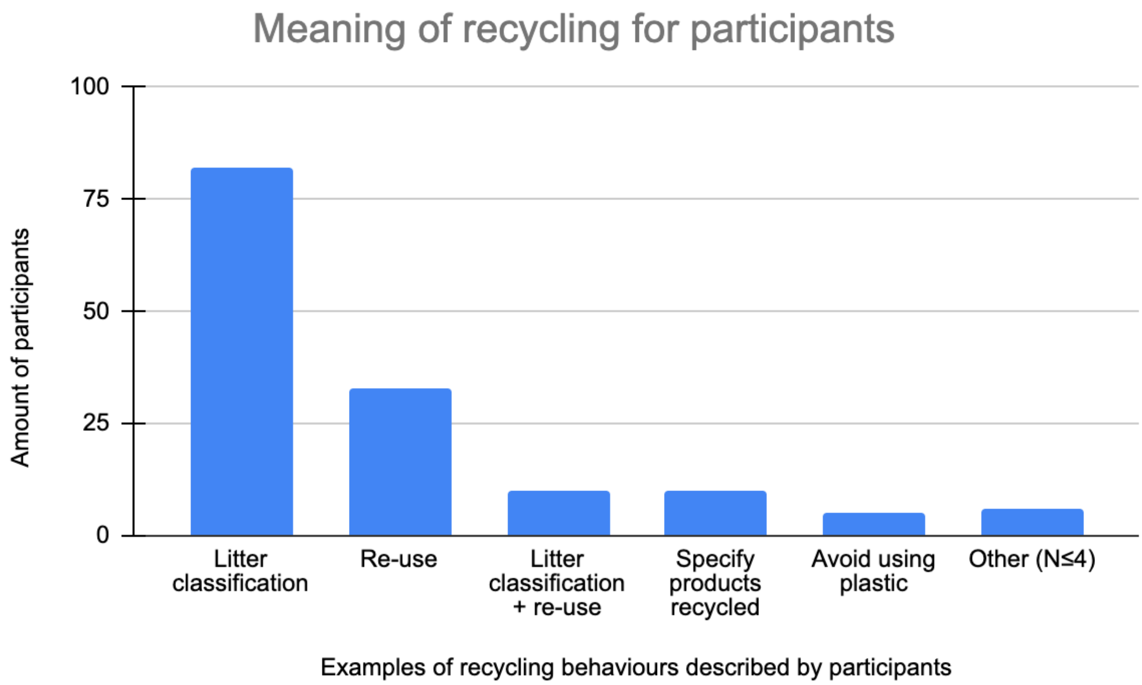
Appendix 15 - Suggested solutions by workshop participants

Suggested solutions by workshop participants in the first survey when asked the question "Name one thing you could do to prevent MPL from reaching the ocean". The category "other" gathers all suggestions that were mentioned by three participants or less.



Appendix 16 - Meaning of recycling for participants

Distribution of definitions when participants were asked to exemplify recycling in the surveys.



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Thesis title	Exploring contemporary archaeologies of plastic pollution: Perspectives from Galapagos, the East Pacific Coast, and Europe

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(i) the candidate has accurately represented their contribution to the work;
(ii) if required, permission is granted for the candidate to include the work in their thesis (note that this is separate from copyright considerations).

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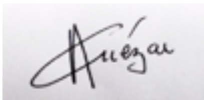
Signature of the co-author	
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*Note that where a paper has multiple authors, the statement of authorship can focus on the key contributing/corresponding authors.
**The description of the candidate and co-authors contribution to the work may be framed in a manner appropriate to the area of research but should always include reference to key elements (e.g. for laboratory-based research this might include formulation of ideas, design of methodology, experimental work, data analysis and presentation, writing). Candidates and co-authors may find it helpful to consider the CRediT (Contributor Roles Taxonomy) approach to recognising individual author contributions.

Chapter 6 - Waste Journeys: Using Object Itineraries to Investigate Marine Plastic in Galapagos

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Abstract

Plastics, as supermodern artefacts of the Anthropocene, form a significant part of waste landscapes. But they also pollute landscapes – cultural and natural, marine and terrestrial – across the globe, including in the most isolated of places. The material's resilience means that plastic pollution is one of the biggest global challenges facing contemporary society. Taking a multidisciplinary approach, this paper demonstrates how archaeological methods can help address the issue of plastic pollution in Galapagos, which is listed as a UNESCO World Heritage Site for its "Outstanding Universal Value" to humanity.

Studied archaeologically, plastics are artefacts that through careful observation can yield precious information about their journey to this archipelago. As objects of story writing and the focus of object itineraries, they can also be used as a window into perceptions of plastic litter locally, as well as providing an opportunity to engage students in the topic.

Keywords

contemporary archaeology, object itinerary, plastic waste, UNESCO, waste landscape

Introduction

Plastic pollution is among the most urgent global challenges of the Anthropocene[1]. In addition to becoming embedded in geology (Corcoran et al. 2009) and stratigraphy, plastic pollution is universal, present on the most remote islands (Lavers and Bond 2017), in deep waters (Pham et al. 2014) and on the highest peaks (Napper et al. 2020). Plastics are also creating entirely new seascapes, such as the Great Pacific Garbage Patch, an area of pollution that exceeds the size of Texas. From that perspective, plastic-polluted areas constitute newly configured waste landscapes that are marked by plastic's omnipresence (from nano to macro), the global journeys of plastic objects and plastic's long resistance to natural degradation processes. In our paper, waste landscapes are understood as natural and cultural spaces dominated by matter that (1) can appear "out of place" (after Douglas 2002) to humans, and that (2) has gone through a loss of value, from being functional and useful to becoming useless, at least to the eyes of a utilitarian anthropocentric society. We use the term "waste landscapes" specifically for such areas characterised by the presence of plastic pollution. While sharing similarities with other waste, plastic is distinct. This is largely because it has become a material emblematic of supermodernity, symbolising overconsumption and destruction. By transforming landscapes, plastics contribute to generating a feeling of solastalgia (after Albrecht 2005, 2020), a sense of distress caused by environmental change of one's home or territory. Plastics permeate our environments (e.g. Harris et al. 2021), including the air we breathe (Jenner, Sadofsky et al. 2022) and is found in both animal (e.g. Ayala et al. 2023) and human bodies (Jenner, Rotchell et al. 2022; Leslie et al. 2022). As a comparatively recent invention (with fully synthetic plastics first appearing in the early twentieth century), it is not yet known how long plastics will remain in the environment. What is known, though, is that they display persistence and omnipresence and that these characteristics disrupt the scales of time and space (Edgeworth 2010, 2013) that archaeologists are accustomed to. This may be why plastics have rapidly become an object of study for a wide range of disciplines (including but not limited to marine biology, sociology, eco-toxicology and engineering). This list also now includes archaeology (e.g. Schofield et al. 2021; Praet and Delaere, in press). In this paper, we argue that archaeology

[1] For a thorough discussion, see the 2014 Forum Archaeology of the Anthropocene in JCA 1 (1)

has an important role to play in studying and understanding plastic pollution and the landscapes in which it exists, whether visible (as macro- and microplastics) or not (the equally if not more harmful nanoplastics). While loss of value, either economic or symbolic, drives the categorisation of objects as waste, archaeologists find waste valuable for its interpretative potential. Archaeologists consider waste as a source of information (Monsaingeon 2017) on various topics,such as food consumption (McKillop 2013), artefact production (van Gijn 2003) and management systems (Wong 2018). However, studying waste is not only relevant for past societies, but also adds to our understanding of the contemporary world. Contemporary waste was first explored using archaeological methods by William Rathje through the Garbage Project (e.g. Rathje and Murphy 2001; Rathje 2011), which used the material culture of landfills and household waste to reveal unacknowledged habits and previously undocumented patterns of domestic consumption behaviours (Reno 2013, 263). The results reinforced the potential of studying waste as archaeological materials through time (e.g. Sosna and Brunclíková 2017). Waste is a particularly important focus for studies of the Anthropocene, which encompasses "all forms of environmental destruction" (Gille 2022, 8). Now, more than ever, ours is not only "a civilization of waste" (González-Ruibal 2018, 179) but a civilisation socio-economically shaped and physically marked by waste.

With plastic pollution transgressing traditional temporal and geographical scales, archaeology offers the possibility of viewing it from new angles. Considering plastics as artefacts provides a useful starting point for understanding and mapping the connections necessary for an object to be produced, used and finally disposed of, and therefore also the global landscapes to which these plastic objects contribute. Labels, form and evidence of wear are all examples of information that can indicate a plastic object's often long and complex journey from its source to its current destination, or from "tap to sink" as it is sometimes described. As these artefacts are made more relatable, the problem of global environmental pollution becomes less abstract. It is then easier to engage people more directly on plastic pollution, raising awareness and eventually gaining a window into local perceptions.

Despite its geographical remoteness, the World Heritage Site of Galapagos is not spared from plastic pollution. Most plastics arrive on the archipelago having been transported by ocean currents – mainly the Humboldt Current – from continental sources and marine activities, including fishing. While marine biology and environmental studies often focus on quantifying plastic waste and its impact on wildlife, we decided to adapt an archaeological framework known as object itineraries (after Joyce 2015). We used this to design workshops with local secondary-school students to focus more on cultural influences. This approach makes it possible to consider not only an object's journey but also its entangled relationships with culture and nature along the way.

This paper first addresses the theoretical framework of object itineraries and then presents background information about plastic pollution in Galapagos, before exploring how the itineraries relate to local perceptions and can be used as an engagement tool. The itineraries were reconstructed by the local students through story-writing workshops in Galapagos, with subsequent qualitative analysis of their stories identifying key themes. The itineraries not only focus on individual objects, but question how these objects contribute to the configuration of supermodern waste landscapes. While this paper primarily focuses on marine plastic litter (MPL) itineraries in Galapagos, the World Heritage Site of Hawaii will also be briefly presented as an emerging project where this methodology is also being applied.

From Biographies to Itineraries

Reconstructing an artefact's story has been widely used in archaeological investigations as an interpretive and methodological framework. Initially, the approach was based on the concept of object biographies (Gosden and Marshall 1999; Joy 2009), adapted from anthropology (Kopytoff 1986), and was used to reconstruct an object's life from birth to death (Gosden and Marshall 1999) while accounting for the human relations they were entangled within (Joy 2009). Despite being a popular concept, its limitations, such as anthropocentrism (Joyce 2015, 23), were later questioned, and object itineraries (Joyce and Gillespie 2015) was developed as an alternative that would focus on the journey instead of reducing the object to its relationships with humans alone. Just as with any pre-industrial artefact, MPL objects hold information useful to reconstructing their spatial and temporal journeys. For example, manufacturers' marks and labels can identify the object's origin and age (Falk-Andersson et al. 2021; Ryan et al. 2021), while physical and chemical degradation can inform researchers about the length and types of interactions that the object has gone through before becoming waste, as can the eventual presence of epibionts, organisms that can live on a host organism, for example a mollusc on a plastic fragment. Perhaps surprisingly, while they hold such significant information, plastic items have not often been the subject of object biographies or itineraries (although see Schofield et al. 2020; Praet and Delaere, in press).

This scarce use of object biographies to investigate plastics is maybe best understood through the specific challenges to reconstructing a conventional narrative biography (birth → life → death). For example, it is difficult to determine a plastic artefact's "birth". It might start with the extraction of fossil fuels or its moulding into a specific shape. It could even begin with the creation of fossil fuel, millions of years ago. Also, even by looking at plastic objects, it can be difficult to assess their functional origin. Plastic items are often designed to be "universal, replicable, exchangeable, untraceable, and non-localizable", comprising features that contribute to their "synthetic universality" (Davis 2022, 48).

A plastic object's "life" is complex, often requiring several disciplines to understand the journey that it might take, including oceanography (van Sebille et al. 2019), waste (mis) management studies (Lebreton and Andrady 2019) and behavioural psychology (Eastman et al. 2013), amongst others. The itineraries of plastics sometimes span several continents, reflecting globalisation. For example, the itinerary of a flip-flop might start in Kuwait, pass through China and Korea, to end up as a product in Ethiopia (Knowles 2015). These therefore are items sharing a sense of "globalised unlocality", defined as a dissociation from specific locations and so contributing to a sense of universality (Davis 2022, 5). In addition to the spatial dimension of disposal (Hetherington 2004, 160), there may also be significant time lapse between an item's production and its eventually becoming waste, a classification that does not necessarily represent a final closure (Hetherington 2004, 159).

The question of "death" for plastic objects is therefore also challenging. Plastics pollute the environment through their journey as artefacts, contributing to waste landscapes often out of sight, especially for Western countries disposing of their waste by exporting it (Barnes 2019). From that perspective, plastic waste is imposed on peoples and places that do not consent to the consequences of its presence (Davis 2022, 5), contributing to colonial mechanisms of pollution (Liboiron 2021). Besides, plastic never really “dies”, as it breaks down and enters human and non-human bodies and their environments as microplastics (Jenner, Rotchell, et al. 2022; Leslie et al. 2022). Plastics have thus transformed from dead organic matter trapped in the ground (for fuel-based plastics at least) to becoming a part of living organisms and colonising our bodies. They therefore move with human and non-human beings, following global flows of migration, conflict and tourism, amongst others (Farrelly 2021, 266).

In brief, pinpointing a birth, life and death is challenging for such flexible and mouldable items, reaching the limits of object biographies as a theoretical framework. The synthetic universality of plastics as global and colonial waste, along with their resilience in outliving human lifespans, fits better with the concept of object itineraries. As discussed above, object itineraries also offer consideration of an object’s existence independent of its relationships with humans, a framework much needed for plastic waste that develops affordances (e.g. shelter for molluscs) and interactions with non-humans in the natural environment. The framework of object itineraries recognises the spatial and global aspect of the journey, which sheds light on how MPL becomes a part of new waste landscapes such as polluted beaches. We here focus on the itineraries of plastic artefacts, and how they are re-constructed and perceived locally, as they pollute a particularly valued natural environment: the Galapagos archipelago, recognised by UNESCO as a World Natural Heritage Site (WHS) for its “Outstanding Universal Value”.

MPL Itineraries in Galapagos

Background

Known for its unique biodiversity and the key role it played in shaping Charles Darwin’s theory of evolution, Galapagos is a volcanic archipelago located in the Pacific Ocean ca.

1000 km from mainland Ecuador, the country of which the archipelago is a province. Despite its physical remoteness, the archipelago has been a part of global dynamics for centuries, acting as a refuge for pirates in the sixteenth and seventeenth centuries and as a hunting area for British and American whalers from the mid-eighteenth century (Stackpole 1972, cited in Stahl et al. 2020). With a relatively recent human occupation (Stahl et al. 2020), Galapagos's biodiversity quickly became a topic of concern and financial interest. The archipelago is now a hub for conservation projects to maintain its unique wildlife at all costs, sometimes requiring the mass killing of invasive species such as goats (Hennessy 2019, 206–207). Inscribed as a UNESCO WHS since 1978, Galapagos became a WHS in Danger in 2007 to 2010 due to a series of anthropogenic threats such as increasing tourism and immigration and illegal fishing. While plastic pol- lution was not at that time identified as a distinct issue by UNESCO (2006), the factors highlighted do contribute to an increase in the arrival of MPL. Despite multiple attempts to restore Galapagos into an evolutionary Eden (Hennessy 2019, 206), humans still leave traces and plastic pollution is one of numerous anthropogenic pressures that the archipelago is facing (Alava et al. 2022).

Before presenting how plastic pollution is perceived by the local people who contributed to our project by creating object itineraries, it is important to summarise what was previously known about plastic pollution in Galapagos. We can begin with its location. With Galapagos located at the junction of the Panama, Cromwell and Humboldt currents, the archipelago is exposed to global MPL carried on and by those currents. Thus, in addition to any land and marine local sources, the archipelago also receives MPL washing ashore from distant sources, a feature typical for islands (Lavers and Bond 2017). Several studies, from biology to oceanography, have contributed to a better characterization of plastic pollution in Galapagos through identifying potential sources (the "taps" at the start of the itinerary) and impacts (the network of relationships that the object is entangled in) of plastic waste. This research contributes to understanding how these new waste landscapes (the "sinks") are dominated by plastics.

Recent work (e.g. van Sebille et al. 2019, Jones et al. 2021; Sánchez-García and Sanz-Lázaro 2023) has significantly improved our understanding of the origins of MPL in Galapagos, which originates in a combination of marine and terrestrial (local and external) sources. For example, amongst identifiable items, maritime-related items (e.g. discarded fishing gear) account for just 10% in a recent study by Jones et al. (2021) but reach up to 29% in a study by Sánchez García (2020), further identifying the prominence of fibres, fragments and films as the most recurrent plastic types found. Following the methodology of Thiel et al. (2013), Jones et al. (2021) assumed that little evidence of marine exposure (e.g. epibionts, degradation, yellowing) of macroplastic was associated with local origins, with such items accounting for 2% of the items recorded, whereas 88% were unsourced and therefore external. External sources of MPL in Galapagos are thought to include mainland Ecuador and other Latin American countries, after findings from oceanographic modelling (Tsakali 2019; van Sebille et al. 2019). These conclusions resonate with information provided by consideration of the labels on macroplastics, which indicate provenance from fishing vessels and from continental Latin America (including Panama, Peru and Ecuador) (Sánchez García 2020, 32). A more recent study by Muñoz-Pérez et al. (2023) has found that the most recurrent macroplastic items were formed of polyethylene terephthalate (PET) originating from consumers or fisheries and belonging to brands from Peru, China and mainland Ecuador.

These examples indicate how oceanographic and marine biological studies have started to incorporate an archaeological interpretive lens (maybe without perceiving or labelling it as such) to understand the itineraries by which plastic artefacts have reached the Galapagos archipelago. Most of the work to re-create itineraries of plastic artefacts offers individuals the potential to consider the mega-scale of plastic pollution and polluted beaches as waste landscapes, as well as the nano-scale of degradation into micro- and nanoplastics entering all systems (see Edgeworth 2010 for an archaeology of the mega and the nano). The objects themselves, on a macro-scale, reveal sets of relationships marking plastic production, use and discard. To discuss how this global issue affects Galapagos, there is scope for focused archaeological projects, and particularly for a more consistent and comprehensive study of macroplastic itineraries, which could confirm estimates of local versus regional sources, for example.

It is important to stress, however, that, in Galapagos, natural landscapes are not all equally affected by plastic pollution. The beaches most exposed are east-facing, receiving waste carried by the Humboldt Current (Jones et al. 2021). These are generally the beaches that are the least accessible to local residents and further away from the main towns. Some of them are cleaned by Conservation International and the Galapagos National Park several times a year. In contrast, tourist beaches are cleaned more regularly by park rangers, residents and tourists alike, avoiding the accumulation of macroplastics. These beaches also face away from the Humboldt Current (Jones et al. 2021), and so receive less plastic waste than the east-facing shores. However, while Galapagos waste landscapes are therefore formed differently, they share a common entanglement between nature and culture, with plastics often entangled in natural habitat such as mangroves, and potentially representing a threat for endemic wildlife such as sea lions (Figure 1). Galapagos's wildlife is severely affected by the presence of plastic debris in the environment: Jones et al. (2021) identified 27 marine vertebrates highly at risk from interactions with plastic as a priority group for targeted actions, while Muñoz- Pérez et al. (2023) recently used Citizen Science to show that interactions with plastic has occurred for 52 species. This situation has not improved with the socio-economic consequences of the COVID-19 pandemic, leaving the archipelago relying heavily on tourism with fewer other revenues (GCT and Utrecht University 2021) and with the likely additional impact of COVID-19-related plastic waste in the form of personal protective equipment (PPE) found universally at sea and within terrestrial (including notably urban) landscapes (Schofield et al. 2021).

Figure 1: Marine plastic litter entangled in mangroves in the urban area, Santa Cruz.

Based on this knowledge, there is scope to reconstruct the artefacts' itineraries through archaeology, and a proposed method involving local secondary-school students is detailed in the next section. This framework notably invites a consideration of human and non-human interactions within which the objects are entangled. Although plastic waste exists independently from human interactions (Godin 2022) and becomes part of new interactions during its journey in the environment, we here focus on using archaeology to approach human behaviours towards plastics. Archaeology offers a unique lens on MPL, providing new understandings of how human behaviours contribute to plastic pollution. While we recognise that plastic pollution is a failure of a global plastics economy (Farrelly et al. 2021), all plastic artefacts remain entangled in a set of relationships with humans (Sheavly and Register 2007), whose individual actions and decisions contribute (in)directly and (in)voluntarily to the issue (Praet et al. 2023). From that perspective, interacting with macroplastics as artefacts offers a less abstract way to engage with the topic than with microplastics. One way to achieve this level of direct engagement is through object-based story writing (Bergmann 2021). The content of stories, often explored in qualitative approaches (Savin-Baden and Howell-Major 2013), offers a way into local perceptions of MPL and its itineraries, as explored by Praet et al. (2023).

Methods

Our study uses object itineraries as a framework to explore local perceptions of plastic pollution and engage students on the topic through story-writing workshops. Building on the narrative approaches of qualitative studies (Savin-Baden and Howell-Major 2013), we asked students in Galapagos to take part in a set of workshops to reflect on plastic as artefacts and write a story using elements of artefacts they could observe during the workshop. This approach is inspired by earlier studies that have demonstrated the potential of using artefacts in educational activities (Aerila et al. 2016), including plastics (Schofield et al. 2020; McKay et al. 2021). The study was designed as a comparison to a case study undertaken in the Latin American countries along the eastern Pacific. That study (Praet et al. 2023) investigated the success of story-writing workshops to explore perceptions of MPL and as an engagement tool to improve pro-environmental behaviours (PEBs). Due to the scope of this case contribution to the special forum on Waste Landscapes, we will focus here only on perceptions of MPL itineraries in surveys and stories.

The Activity

Workshops were designed (inspired by the activity described in Praet et al. 2023) and undertaken in Spanish by Estelle Praet and Anne Guézou in two secondary schools of Santa Cruz, Galapagos in August 2022: Unidad Educativa Nacional Galapagos (UENG) and Unidad Educativa Colegio Tomás de Berlanga (TdB) (Figure 2). The schools were selected based on the interest of school directors and teachers in having their students take part. At UENG, all students at the third Bachillerato level participated, as the activity was part of the Galapagos school curriculum based on sustainability goals. In total, 331 students participated in the project, aged between 12 and 22 years old. Group sizes oscillated between six and 32 students. All students participated in a series of two workshops. The first consisted of one two-hour session, where students first filled out a pre-survey self-assessing their understanding of MPL and their PEBs. Next, archaeology as a discipline was presented to the students, emphasising how it can be used to approach plastic pollution through object itineraries, as well as briefly discussing plastic pollution in Galapagos without revealing proportions of sources. A selection of 11 objects found during beach cleanups across the archipelago (Figure 3) were distributed for a group activity, and participants were asked to answer seven questions on their allocated object:

1. What is the object?
2. How old is it?
3. Where does it come from?
4. How was it used and by whom?
5. How did it reach the sea?
6. How did it interact with the environment?
7. What actions could have prevented the object ending up on a beach?

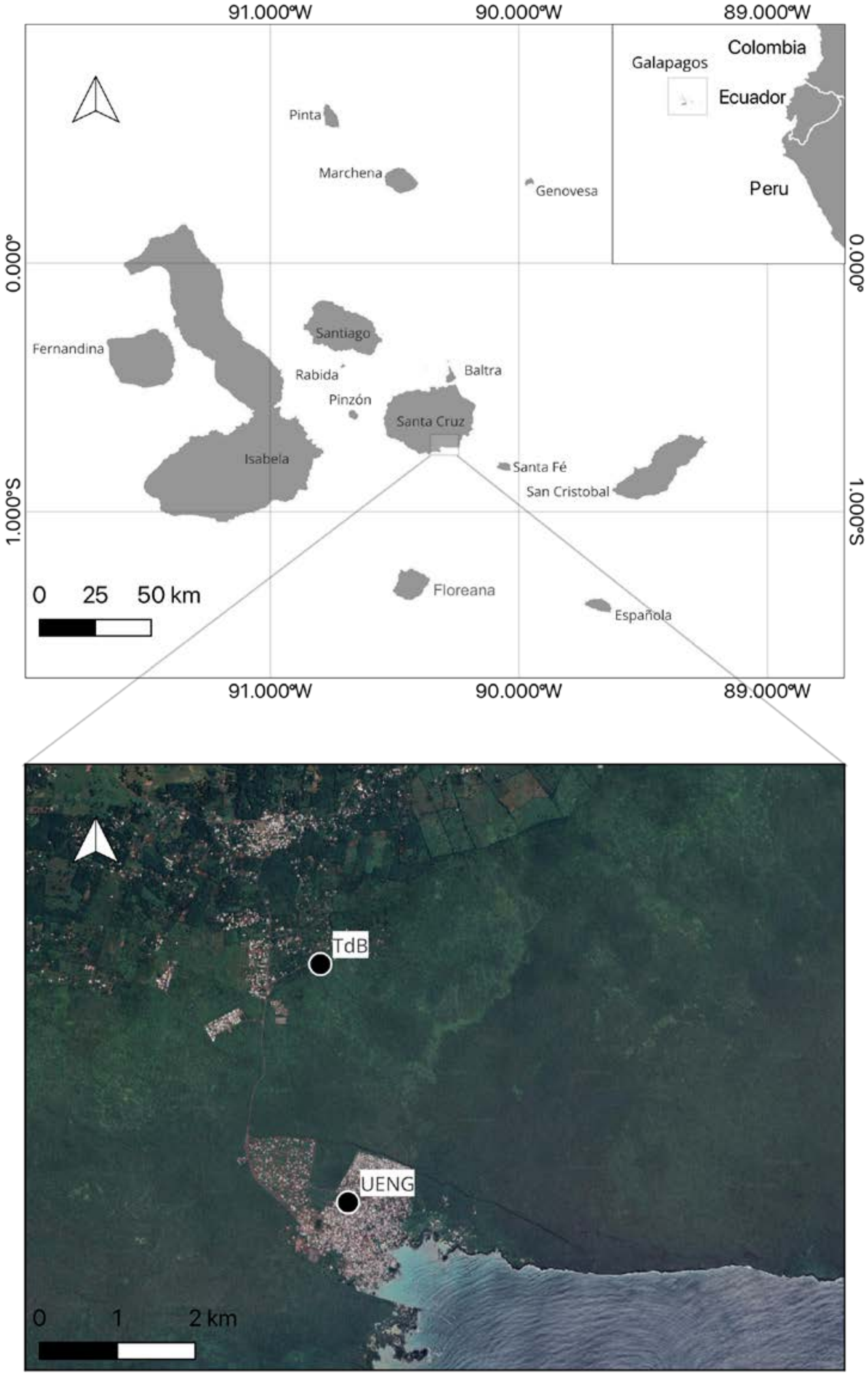

Figure 2: Map showing locations of participating schools, TdB and UENG, on the island of Santa Cruz.

Figure 3: Objects presented to students for the workshops. On the second line to the right, there is a picture of the life buoy with a close-up showing an inscription

These questions served as a basis from which to develop an individual story following a narrative structure – introduction, development, dilemma, outcome and ending – that was presented to them. Each student was then given time to finish their story at home. A second, shorter workshop involved filling in a post-survey (asking the same questions as in the pre-survey but with some additional feedback questions) while collecting the stories as well as student and parental consents.

Analysis

Analysis of the stories was undertaken using NVivo 2020. A social constructivist perspective, acknowledging the socially constructed nature of knowledge by the participants at an individual level (Savin-Baden and Howell Major 2013, chapter 4), guided the analysis. We believe, following a narrative approach, that stories provide information about how participants make sense of the world (see Savin-Baden and Howell Major 2013, chapter 15), and more particularly here of MPL. Thematic coding was applied to analyse the content of 137 stories, a method commonly used in narrative analysis (Savin-Baden and Howell Major 2013, 238). Given the scope and focus of this paper, a selection of codes related to the object itineraries of MPL are presented (see the codebook in the Appendix 1 for a description of the codes and their occurrence). Future publications will combine the data from the surveys with coding results to explore local perceptions of MPL and evaluate the impact of the activity on PEBs (and eventually compare the results to Praet et al. 2023).

Results

As noted above, a total of 137 stories – mostly textual, but some presented as comics – were suitable for analysis and included parental and student consents. Recognising a story in these objects provided participants with a less abstract way of approaching MPL (Bergmann 2021). It was also less overwhelming, offering a way to engage by understanding how behaviours towards individual objects contribute to a global problem. Results of the thematic analysis are presented in overarching themes discussing plastics' materiality, the complexity of the object's itinerary, waste interactions with non-humans and plastics as components of the broader Galapagos waste landscapes.

Exploring Plastic's Materiality

All the objects that featured in the stories presented details that offered insights into their journeys, such as the brand name (e.g. fishing sacks and plastic bottles), weathering and degradation indicators (e.g. loss of colour, seen in a frisbee and Hulk figurine) as well as features indicative of time spent at sea (e.g. shell on the bucket fragment – see Figure 3E, above). These helped anchor the story, with participants noting a variety of elements, including the object's degradation (n = 51, where n corresponds to the number of stories with the degradation code), brand (n = 33), age (n = 32), use (n = 30) and origin (n = 24). With degradation including the loss of material properties (e.g. shape, colour), participants explored the effects of the environment (e.g. sea water, sun, animals) on the object. For example, one participant considered degradation to be loss of colour due to exposure to UV: "And it [the bucket] was very worn out by the sun and the sea water and it arrived at a beach called El Garrapatero". Actions were also explored to explain some features of the object, including age:

From different observations, it can be said that the object is approximately 5 years old since it was discarded, as it shows wear on the upper part and is intact on the lower part, as it is believed that it was tied just in the middle, deteriorating the upper part.

This degradation is central to the consideration of objects as waste, as well as to them being considered "out of place" (Douglas 2002), for example when encountering animals sometimes annoyed by their presence:

> But once a shark came up to me and bit me [the plastic bottle], it didn't hurt me much, it just left a scratch and tore off a small piece of my tag, it was very upset and complained about how now there are no fish to eat and there is only rubbish floating in the ocean, I couldn't even ask [the shark] a question […] so there is a lot more rubbish floating in the sea?

About 75% (n = 102) of the participants used elements of the object to re-construct different aspects of its itinerary. While the others have not necessarily explored this in their writing, 128 students specified enough contextual elements to know which object was the key figure of their story (Figure 4), reflecting a good understanding of story-writing instructions presented in the workshop.

Participants also physically interacted with the objects in an active way, sometimes creating new marks of their own. For example, one participant signed on a life buoy (see Figure 3G, above), and this inscription was then used by other participants as an element to incorporate into the story as information about the owner: "There was once a happy red buoy in a store waiting to be bought to save the lives of humans. Then a person bought it, his name was Antonio Jimenez". The Hulk figurine (see Figure 3I, above) provoked a lot of interest, and its missing head raised questions. Some participants highlighted the Hulk's muscular features by outlining them with a sharpie. The joints of the toy were fairly loose after the workshops, with some students even asking if they could take it home. The frisbee (see Figure 3J, above) was also subject to active engagement, with students trying out its flying characteristics outside of the classroom. While, overall, participants engaged actively with the objects in the classroom, it remains difficult to evaluate the impact that the activity might have had on the way they wrote the story. Interactions in the workshops varied, depending on group composition (between six and 33 students), and AG's and EP's positionality (Appendix 2) might have had an impact on how students approached the object, and the content of their stories. The more tangible and concrete nature of an in-person workshop with physical objects might also change the way participants wrote about MPL when compared to a similar online project carried out by ReCiBa (Praet et al. 2023), the network of litter scientists (Red de Científícos de la Basura), a Latin American citizen science project.

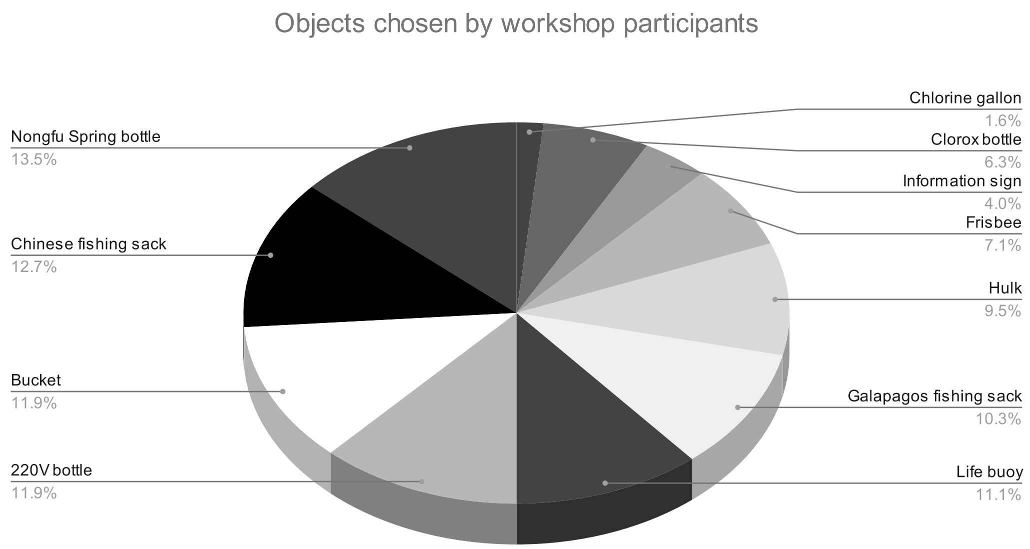

Figure 4. Objects chosen by participants in the workshop

A Complex Itinerary

Participants reflected on the fact that the itinerary of a plastic object is diverse and complex and does not necessarily end when the object becomes waste. The diversity of potential ways the MPL might have entered the environment was reflected upon by some participants (n = 16) in their stories: “The route of this bottle is very impressive, and we also think of one of the many ways in which it could have reached the Galapagos Islands”. In addition to noting the diversity of potential journeys, one participant also recognised that a lot of other objects have their own itinerary: “In the complex and extensive process of moving goods and products between Guayaquil and Galapagos, an infinite number of journeys are made by ship, where it is very common to encounter different stories of many products or plastic objects”. Several stories considered the workshop itself as part of the object itinerary (n = 19), reinforcing the observation that an itinerary does not stop when an object becomes waste. Participants emphasised that analysis of the object can help with understanding plastic pollution: “Some time after, it [the fishing sack] was found, it was taken to educational institutions, until one day it arrived at the Colegio Galapagos where the students analysed it and tried to find out its origin, life span and options to have prevented the sack from reaching the sea”. Sometimes, stories adopt the perspective of an object to include the analysis as part of the object’s journey:

> I [the plastic bottle] woke up and I was in a laboratory in a school, I was very confused. By the time I relaxed I could hear what they were talking about. It was very interesting to me how there was so much rubbish in the sea […].

Stories, then, offer a way to consider the different steps of an object’s itinerary, starting with its origin. Perceptions of MPL origin by local students can be better understood through the content of the stories and their agreement with certain statements in the surveys. Stories mentioned different sectors contributing to the issue, such as fishing industries (n = 44), sometimes specifying if these were national (n = 26) or international (n = 14). Some objects with Chinese writing led participants to comment on illegal fishing for highly sought-after shark fins (n = 4) at the edge of the Galapagos Marine Reserve: “I [the fishing sack] do not know what animals all these leftovers belonged to but I am pretty sure I saw a shark fin go inside me too”. Participants also refer to tourism (n = 25), local activities (n = 17) and activities on the mainland (n = 8) as sectors contributing to MPL. While litter disposal can be accidental or intentional, references to fishing in the stories can be better understood in the context of the importance of local fishing industries for the livelihoods of Galapagueños/as, a sector that has proven particularly adaptive, resilient and essential for food provisioning through the COVID-19 pandemic (Viteri Mejía et al. 2022). The choice of some international fishing-related objects (see Figure 4, above) might have prompted participants to reflect on this topic, including events that had been highly mediatised such as the above-mentioned illegal shark fishing by Chinese fleets (Collyns 2020).

The pre- and post-surveys also asked participants about the sector contributing to MPL. Answering on a Likert scale from 1 (totally disagree) to 5 (totally agree), participants assessed if they believed that marine litter came from (a) domestic activities in Galapagos, (b) fishing activities or (c) distant areas (Figure 5). Participants recognised the diversity of MPL origins by showing a general agreement with all three statements. However, while answers might present an acquiescence bias (the most popular answer being “I totally agree”), stories did identify mainland activities as well as fishing industries – international and national – contributing to MPL. In the surveys, greater agreement occurred for marine litter being identified as coming from distant areas: 61% of the participants totally agreed with this statement. This is higher than for agreement with an origin from fishing industries (46% of participants totally agreeing) and from domestic activities in the archipelago (40% of participants totally agreeing). Results from a Wilcoxon signed rank test for paired samples show no significant difference between the pre- and post-survey answers regarding marine litter’s origin. Overall agreement with the external origin MPL coincides with the results of recent studies identifying the considerable contribution of external sources to marine plastic pollution in Galapagos (van Sebille et al. 2019; Jones et al. 2021). However, these results may also indicate a tendency of not taking responsibility for plastic waste, further contributing to the question of plastic waste ownership (an issue already noticed by Reno [2013, 2018] for contemporary waste).

Plastic Interactions with Non-Humans

Perceptions recorded in the workshops indicate support for the view that plastic objects exceed human lifetimes, and that their itineraries are not necessarily limited to interactions with humans (n = 101) but also include interactions with the environment (n = 83) and with animals (n = 52). Participants included a variety of elements from the environment as interacting with the object, but ocean currents were the most frequently mentioned (n = 47): "After a long time of being rolled, pushed and trampled by people in the street until it [the V220 bottle] fell into the sea of Guayaquil where it was pushed by the sea currents to the beach La Ratonera in Galapagos, Santa Cruz". This coincides with the role of currents as carriers of MPL to Galapagos, which is now better understoodthrough oceanographic modelling (Tsakali 2019; van Sebille et al. 2019). In the stories, the objects mostly interacted with fish (n = 16) and sea turtles (n = 14), with ingestion (n = 28) being the most frequent interaction mentioned, a trend already identified by Praet et al. (2023) and potentially reflecting common themes in the communication of plastic pollution campaigns

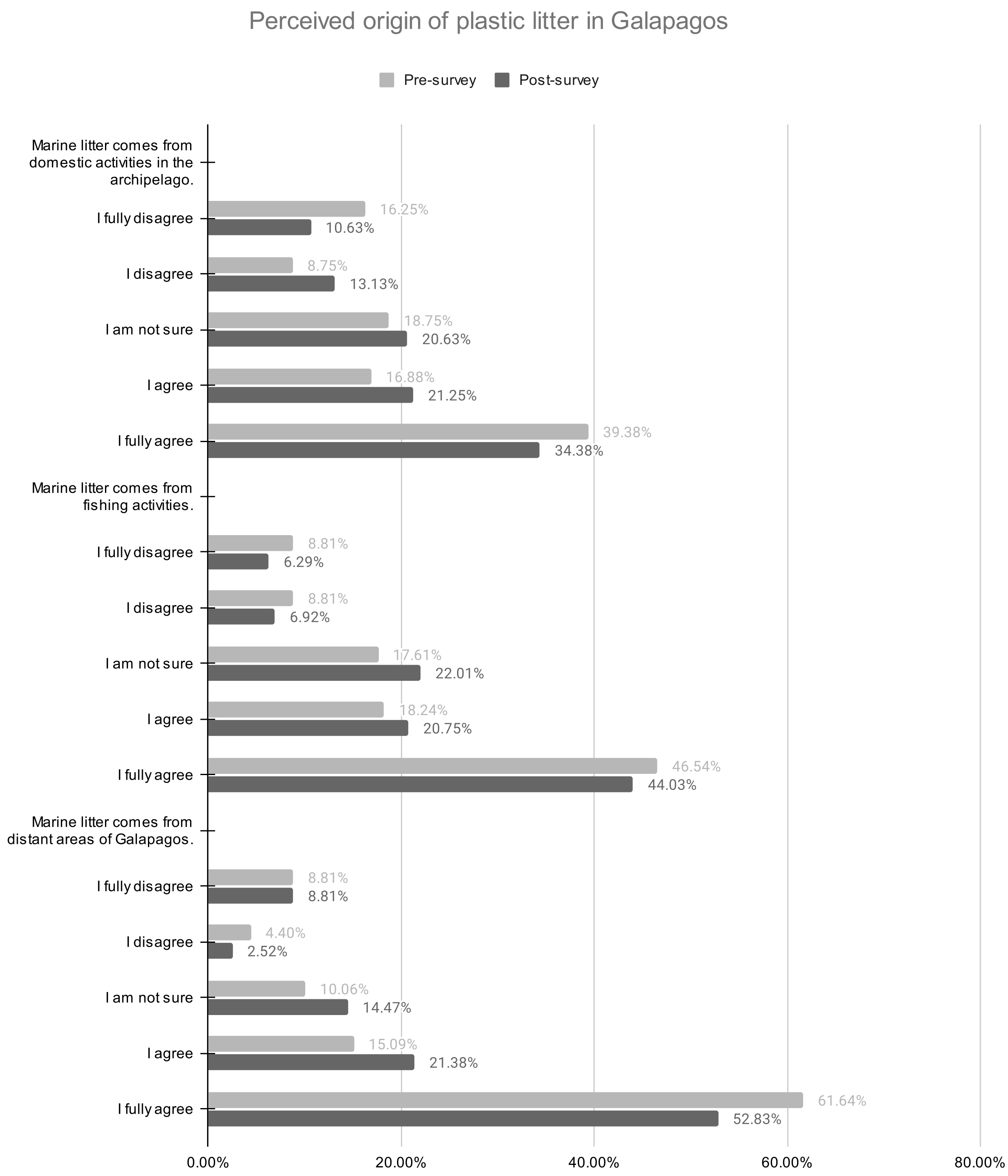

Figure 5: Answers to pre- and post-survey statements regarding the origin of marine litter from (a) distant areas of Galapagos, (b) domestic activities in the archipelago and (c) fishing activities.

Participants further emphasised the relationships with non-humans when discussing the impacts of plastic waste, particularly on the environment (n = 48), for example as a source of contamination: “His story [the Hulk’s] is a tragic one, as he ended up as a polluting object”. The outcome of interactions between plastic and wildlife was potentially deadly (n = 17): “She ended up dying from having an unknown object in her body; the turtle made it to the shore of a beach where experts in the middle of an expedition found her lifeless”. In that perspective, some MPL itineraries resemble the death histories of artefacts (Hicks 2020, 24), a framework that accounts for the death of people, culture and objects when telling an artefact’s life history. In addition to wildlife, several stories (n = 7) questioned the impact of microplastics on the trophic chain, and eventually on human health: “Because over time these become microplastics and the fish, which I catch myself, feed on them and this affects not only the fish but also all of us because we feed on them”. Despite the lack of scientific consensus on the dangers of plastics to humans (see Rodrigues et al. [2019] for a review of impacts known so far for the most common plastic types), some participants seemed concerned by the potential impacts of microplastics’ presence in their food chain. The use of object itineraries has allowed students to express these concerns and consider the potential death histories of MPL that are most evident. Yet, it has also offered a framework to question the agency of objects and their feelings during their journeys, notably as products and as waste.

A perspective from the objects themselves, as sometimes having emotions (n = 16), is a reminder that these “monsters of the Anthropocene” (Godin 2022) that we qualify as waste do not necessarily perceive themselves as “out of place” (despite what humans and animals might think – see above). The emphasis on relationships that those objects develop with the environment reinforces the idea of an Anthropocene where non-humans have proliferated and accumulated in our environment (Godin 2022, 118). One story included a dialogue between a plastic bottle (B) and a sea lion (SL) hoping to bring it back to its food chain:

B: …Hey, sea lion
SL: Yeah?
B: When you told me that everyone would be worried about me… who are those “everyone”?
SL: Well… I do not know, but assuming where you live, I assume everyone would be

worried about you

B: How do you know where am I?

SL: Because you told me you were from everywhere

This dialogue denotes a lack of human care for plastic waste (in the sense of care for new technologies as defined by Latour 2011, also cited in Godin 2022, 120) as well as a question of ownership, central to the issue and categorisation of waste (Reno 2013).

Plastics: A Component of Galapagos Waste Landscapes

Reconstructing a single object’s itinerary allowed students to think about the global nature of its journey and its contribution to different types of waste landscape. Some participants specifically addressed the global nature of an object’s itinerary in their stories (n = 24): “The currents in the oceans dragged plastic from all corners and ends of our planet”. They thought beyond the local framework and considered different countries and regions, with the most popular after Galapagos (n = 83) being mainland Ecuador (n = 41) and China (n = 34). These codes show an awareness of the global connectivity of Galapagos (Hennessy 2019) that facilitates the creation of its waste landscapes. Waste landscapes are characterised by matter “out of place” (from our human researcher perspective) at an unprecedented scale. Plastics as a material “out of place” can be identified easily in a WHS celebrated for its unique biodiversity and nature. Participants identified the extent of plastic pollution (n = 15) on Galapagos landscapes: “And this is one more reason why Galapagos beaches are becoming increasingly dirty because of the waste brought in by the ocean currents”. Here, plastic waste is identified as responsible for the ugliness of the beach that becomes dirty, reinforcing the idea proposed by Godin (2022) of drift matter as monsters of the Anthropocene, cited earlier. This discourse is particularly important for Galapagos. not least as plastic pollution represents a threat to the biodiversity so important to several of the project participants (n = 8): “That is why we have to take care of the environment and most importantly the Galapagos Islands because there are beautiful species of animals there and we have to take care of them because they are the natural heritage of the Galapagos Islands”.

One participant clearly identified that plastic represents a threat to the paradise of Galapagos: “Without straying too far from his companions, he wandered close to the shore and saw a large number of bottle caps and plastics on the rocks. He was bewildered, it was as if paradise had lost its veracity”. Plastic appears here as a global material, one that is troubling the image of Galapagos as a pristine paradise, and that implies threat towards its UNESCO status as having Outstanding Universal Value. Plastic pollution’s scale and globalised sense of unlocality transforms terrestrial and marine environments equally. The extent of plastic pollution was noted on land but also at sea:

The little plastic bottle set off on a journey of which it would not know the destination. It would take weeks and at every moment it encountered some things it had never seen before. On its journey it encountered similar items, made of plastic, it came across plastic bags and other bottles but it didn’t understand their language, it didn’t know what they said.

A few participants (n = 3) further explored the issue of these plastics contributing to waste seascapes such as garbage patches: “As well as questions such as what currents led her to: meet whales, encounter a fishing boat, spend time on Pacific Garbage Patch and be home to tiny organisms”. The object itinerary framework offers a way to explore the global scale of waste landscapes and how its different aspects affect both Galapagos seascapes and landscapes.

Future Approaches

In addition to this case study, research is planned on other waste landscapes of the Pacific region, including in the Hawaiian Islands, a World Heritage Site since 2010 and where a new project has already begun. The work undertaken there is expected to focus on workshops not only with students, but also with local stakeholders and community members to understand their perceptions of how plastics have impacted their communities and culture. Based on the results from the workshops in Galapagos, the research in Hawaii will use comparable object itinerary methodologies to explore this material culture. It will be particularly insightful to compare local perceptions of MPL in both archipelagos, which share a similar natural environment (both are volcanic archipelagos praised for their natural landscapes) yet differ in the meanings assigned to them. Indigenous Hawaiians, also known as Kanaka Maoli, hold a deep connection with and respect for nature, and their creation stories stem from the oceanic landscape. Galapagos, in contrast, was shaped by recent migrations involving people of different cultures, including members of indigenous groups from mainland Ecuador.

Both these World Heritage Sites are affected by plastic pollution, but from differing sources. Galapagos receives waste from specific parts of continental South America and known marine sources. However, plastics arriving in Hawaii are mainly from the ever-expanding Great Pacific Garbage Patch, making it more problematic to target the sources of the plastics and potentially reduce impacts. Here too, plastics of unknown origin offer an additional threat to that facing Galapagos, being a threat to people's identity, given their strong connection to the ocean through their origin stories. Understanding how local perceptions of MPL origins and impacts vary between archipelagos is needed to help shape solutions and policies to address this challenging issue in ways that reflect local needs.

Conclusion

We argue that archaeology, through the use of object itineraries, can provide an understanding of plastic pollution at different levels, from human perceptions of plastic waste journeys to the consideration of global waste landscapes. The exploration of object itineraries, reconstructed thanks to the objects' specificities, has shown that weathering and degradation inspire reflections on the interactions between plastic items, marine species and places. The complexity of the journey is also acknowledged, contributing to understanding global geographies of waste and the cultural and natural factors that can influence the journeys that objects take. The use of this archaeological framework provides a way to reflect on plastics as artefacts that are non-local, yet which are also easily relatable and show agency when interacting with non-humans. This project has demonstrated how an engaging tool can be used to explore local perceptions of MPL that contribute to the formation of global waste landscapes. To understand MPL in places like Galapagos and Hawaii, the insights and perspectives of local people are needed, as Hennessy (2019) shows in her analysis of conservation practices on the Galapagos archipelago. Local views and knowledge of the issue need to be included in the design and implementation of future solutions, especially as marine plastic pollution can hardly be dissociated from human actions. Focusing on a single item of MPL might be a less abstract way to discuss MPL, in a context where the scale and resilience of plastic pollution can turn into an overwhelming issue contributing to a general ecological anxiety – or rather solastalgia, as described previously (after Albrecht 2005, 2020). It is hoped that this archaeological approach to local perceptions of MPL will contribute to solutions through policy making, especially for World Heritage Sites facing a series of threats to their Outstanding Universal Value status. With future work investigating local and Indigenous perceptions of MPL in Hawaii, we will be able to compare how plastic itineraries are perceived to contribute to these new waste landscapes, and offer tailored solutions that include local human actors for a better management of coastal landscapes, islands and archipelagos valued for their environmental and cultural significance.

Ethics statement

Authorisation from the Ministry of Education (Republic of Ecuador) was obtained (MINEDUC-CZ5-20D01-UDAC-2022-0936-E) and ethical clearance was obtained from the University of York. Parental and student consent were obtained for analysis of stories and surveys and clear information was provided to the students regarding data use. This work was supported by the Arts & Humanities Research Council (grant number AH/R012733/1) through the White Rose College of the Arts & Humanities.

Conflict of interest

The authors declare no conflict of interest.

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Credits

Estelle Praet: conceptualization; methodology; coding; investigation; resources; formal analysis; writing – original draft; writing – review and editing; visualization; **Anne Guézou:** conceptualization; resources; investigation; writing – review and editing; **John Schofield:** conceptualization; writing – review and editing; **Raveena M. Tamoria:** conceptualization; writing – original draft; writing – review and editing

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Supplementary Materials

Appendix 1 - Codebook

Complex object itinerary (Files: 84 References: 117)
This code focuses on the itinerary of the object and the complexity of such journeys. It starts with the potential sectors responsible and the diversity of potential ways an object can enter in the environment. It also includes the fact that the workshop was considered as part of the itinerary.

Diversity of potential journeys (Files: 16 References: 18)
This codes for sections of the stories emphasising the existence of multiple potential itineraries of the object

Global nature of the journey (Files: 24 References: 27)
This code for elements emphasising the extent and global nature of the journey a plastic object undertakes.

Sector responsible for the issue (Files: 49 References: 51)
This codes for sectors perceived as being responsible for the object entering the environment. These can be fishing industries (either international or national), mainland activities, local life or tourism.

Activities on the mainland (Files: 6 References: 6)
This codes for mentions of activities on mainland South America (mostly Ecuador) that play a role in the object's disposal. This can be coastal activities, for example leaving something on an Ecuadorian beach that is then brought by currents to Galapagos.

Local activities (Files: 13 References: 13)
This codes for activities undertaken locally (in Galapagos) that lead the object to become waste.

Marine activities (Files: 6 References: 6)
This codes for marine activities contributing to the object becoming waste. It can include fishing industries (national or international, and sometimes illegal), or just generally refer to marine activities.

Fishing industry (Files: 44 References: 51)

Fishing industry is depicted, sometimes referring to small local fishermen or discussing big fishing fleets, as a sector contributing to marine plastic litter. When discussing fishing industries some participants also noted that illegal fishing practices in the Galapagos Marine reserve could contribute to the issue MPL.

Illegal fishing practices (Files: 4 References: 4)

This codes for mentions of illegal fishing in/and or around the Galapagos Marine Reserve.

International (Files: 14 References: 16)

This codes for non-Ecuadorian fishing fleets, identified thanks to geographical or cultural elements specified in the stories.

National (Files: 25 References: 26)

National fishing industries are considered here as Ecuadorian, including Galapagos fishing practices. In the comics, some fishing vessels are represented with Ecuadorian colours.

Tourism (Files: 25 References: 26)

This codes for tourist activities (on land and at sea) during which the object becomes waste.

Workshop as a part of the object itinerary (Files: 19 References: 21)

This codes for references to students playing an active role in the object journey. It includes mentions of the workshop as a stage of the story.

Plastics as part of a global Galapagos waste landscape (Files: 102 References: 217)

This code gathers codes offering reflections from the students on Galapagos waste landscapes as part of global dynamics. This is evident through the mention of different places in the stories. They contain reflections on the global nature of plastic pollution and its extent, and the importance of Galapagos biodiversity affected by this. It also includes considerations of the garbage patches.

Extent of plastic pollution (Files: 15 References: 24)

This codes for considerations on the extent of plastic pollution by acknowledging the amount of plastic objects at sea or on the beach.

Galapagos biodiversity (Files: 8 References: 9)

This codes for the importance of Galapagos's biodiversity and ecosystem. It also considers emphasis on its protection and conservation.

Garbage patch (Files: 3 References: 4)

This codes for mentions of the garbage patches, an element of waste seascapes.

Geography (Files: 97 References: 170)

This code gathers sub-codes providing geographical information about the country the story takes place in. Several regions/countries can be mentioned in one story, either specifically or guessable from beach/city/shop names.

Asia (Files: 33 References: 34)

This codes for different Asian countries. It also includes sub-codes of specific Asian countries mentioned in the stories.

China (Files: 31 References: 31)

Caribbean (Files: 1 References: 1)

East Pacific (Files: 87 References: 131)

This codes for mention of the Pacific Ocean and region without specifications. It also includes specific countries on the eastern Pacific.

Chile (Files: 1 References: 1)

Colombia (Files: 3 References: 3)

Galapagos (Files: 76 References: 86)

Mainland Ecuador (Files: 38 References: 39)

Europa (Files: 1 References: 1)

Mexico (Files: 1 References: 1)

USA (Files: 2 References: 2)

Global nature of the issue (Files: 8 References: 10)

This codes for a global nature of the issue of plastic production and pollution. It emphasises that plastics cross continents and countries and occur as a product of global dynamics.

Plastics materiality (Files: 132 References: 318)

This code gathers elements explored by the students relating to the materiality of plastic artefacts, including the observation itself and the choice of the object. Observation of material characteristics could trigger reflection on their degradation, their use, their origin, their brand and their age.

Object chosen (Files: 128 References: 129)

This code refers to the object chosen by the participants amongst the 11 objects presented to them.

220V bottle (Files: 15 References: 15)

This is a blue 220V bottle. It is an energy drink sold for $1 (price is on the cap). It has a barcode with information on the origin: the bottle is produced by the Tesalia Springs Company, an Ecuadorian company. There is a date that is difficult to read on the bottle cap.

Angermeyer information sign (Files: 5 References: 5)

This is an information sign with opening hours of the Angermeyer Point restaurant in Puerto Ayora, Santa Cruz (since 2001). The back of the sign has green marks, potentially from algae, and corrosion marks. It was recently broken in half (cut is fresh) after being weakened in this section.

Bucket (Files: 15 References: 15) This is the bottom part of a red bucket made of high-density polyethylene. There are several inscriptions on the bucket successively giving information about material, origin and age: *HDPE (2), … Ecuatorianos Guayaquil Ecuador*, and a clockface with years indicating 98. It also previously had a mollusc stuck on it, with visible remains of a shell.

Chinese bag (Files: 16 References: 16)

This is a fishing sack that has Chinese inscriptions on it. It also shows a table with different weights from less than 100 g to more than 600 g.

Chlorine gallon (Files: 2 References: 2)

This is a big chlorine (5%) gallon recommended for use for cisterns and swimming pools, and to neutralise bad smells in food industries and in hospitals. It has a lot number (2021015), an expiry date (15/10/2023) and a production date (15/10/2021). It is branded to an Ecuadorian company and has a contact number and email on the label.

Clorox bottle (Files: 8 References: 8)

This is a Clorox bottle (500 ml) that has a label with a barcode and inscriptions of an Ecuadorian company (Montecristi for Clorox del Ecuador S.A.). It has bumps and the remains of eggs laid by a winkle.

Copropag Galapagos bag (Files: 15 References: 15)

This is a fishing sack of the Galapagos traditional fishing cooperative Copropag. It has inscriptions: "*por favor no arrojar al mar*" (please do not throw it in the sea).

Frisbee (Files: 9 References: 9)

This is an orange worn yet complete frisbee. It has the inscription "Mall del Sol", a famous mall in Guayaquil, mainland Ecuador.

Hulk (Files: 12 References: 12)

This is an action figurine of Marvel's Hulk. Its green colour has faded on its back and its joints are corroded. It is also missing the head.

Life buoy (Files: 14 References: 15)

This codes for an orange plastic life buoy. It has several inscriptions on it: 5556 (model), 2.5kg (weight), Life buoys (brand), SOLAS96 (compliance with Safety Of Life At Sea regulation), MSO.81.(70) (regulation on testing of life-saving appliances). It is only a section of the life buoy and it lacks the foam.

Nongfu Spring bottle (Files: 17 References: 17)

This is a bottle that has a weathered label that represented a mountain. The bottle cap has an inscription: "Nongfu Springs". It also has a date (2019/07/31) and a number (222950 Y5). On the bottom, an inscription gives plastic category 1 (corresponding to polyethylene terephthalate – PET).

Observation of the object (Files: 102 References: 189)

This code gathers statements indicative of participants' observation of the object and detailing different aspects of it: its origin, brand, age, etc.

Age (Files: 32 References: 33)

This codes for elements of the object (e.g. production date, use by date, etc.) giving participants an idea of its age.

Brand (Files: 33 References: 34)

This codes for information related to the brand of the object. It may only mention the name or offer extra information about the brand.

Degradation of the object (Files: 51 References: 61)

This codes for elements evaluating the degradation of the object (e.g. loss of parts, loss of colour, change in shape).

Information about owner (Files: 1 References: 1)

This codes for elements of the object giving information about the owner (name, use of the object or any relevant information).

Materials (Files: 4 References: 4)

This codes for description of the different components of the object (e.g. plastic type, presence of elements of metal, etc.).

Origin (Files: 24 References: 24)

This codes for sections discussing the geographical origin of the object, based on observable elements.

Smell (Files: 2 References: 2)

This codes for references to the smell of the object and conclusions that can be drawn from it.

Use (Files: 30 References: 30)

This codes for elements of information identifying the use of the object or giving information about the context in which it is used. This can be linked to the object properties and characteristics.

Waste interactions with humans and non-humans (Files: 130 References: 503)

This codes for interactions that the object (as waste) is involved in. It includes the impact of the object as waste on the environment (generating general reflections about the impacts of plastic on the environment). It also considers the emotions of the object, changing perspective and acknowledgement that objects exist independently from humans.

Emotions of the object (Files: 16 References: 36)

This code gathers mentions of the plastic object’s emotions, from happiness to despair and loneliness. Sentences suggesting emotions use a semantic field related to feel/feeling/being.

Impact of the plastic on the environment (Files: 48 References: 58)

This codes for a reflection on the range of impacts of plastic pollution on the environment.

Microplastic (Files: 7 References: 7)

This code identifies the specific impacts of microplastics on the environment (including ourselves). For example, several stories show a concern for microplastics entering the food chain.

Interactions (Files: 130 References: 409)

This code is for interactions between the object and its environment, animals and humans during its journey.

Animals and objects (Files: 52 References: 135)

This codes for sections referring to interactions between animals and the object during its journey, from production to waste.

Deadly outcome of the interaction (2) (Files: 17 References: 17)

This codes for an animal's death as the direct consequences of its interaction with a plastic object. It can happen in the story or is also suggested as a potential outcome.

Type of animal (Files: 42 References: 65)

This code gathers mentions of specific animal genus, family or species. They are referred to by their common name, with no species identification if referred to more broadly. As these sub-codes are descriptive and self-explanatory, they are not described individually.

Bird (Files: 10 References: 11)

Crab (Files: 3 References: 3)

Dolphin (Files: 2 References: 2)

Fish (Files: 15 References: 15)

Iguana (Files: 3 References: 3)

Micro-organisms (Files: 5 References: 5)

Mollusks and crustaceans (Files: 6 References: 6)

Rat (Files: 1 References: 1)

Sea lion (Files: 2 References: 2)

Shark (Files: 2 References: 2)

Turtle (Files: 14 References: 14)

Whale (Files: 1 References: 1)

Type of interaction (Files: 36 References: 53)

This code gathers the different types of interactions that can occur between an animal and the object. They can be harmful (bites, ingestion, entanglement) or non-harmful (game, nest, shelter and dialogue). There can be multiple interaction types in one story.

Bites (Files: 7 References: 9)

This codes for animals biting the object, not necessarily ingesting it.

Dialogue (Files: 2 References: 8)

This codes for sections where the object and the animal talk together. Discussions can be of any type.

Entanglement (Files: 3 References: 3)

This code describes animals becoming entangled in plastic objects or having a plastic object stuck to them.

Game (Files: 2 References: 2)

This codes for animals playing with plastic objects.

Ingestion (Files: 21 References: 22)

This codes for animals ingesting or eating (parts of) plastic objects.

Nest (Files: 3 References: 3)

This codes for the plastic being used as part of or as a nest; for example, to lay eggs in.

Shelter (Files: 6 References: 6)

This code describes the plastic object acting as shelter for the object.

Environment (Files: 83 References: 123)

This codes for interactions between the natural environment and plastic objects, including sea currents, rain, salinity of the sea, sun, tide, waves and wind. These elements can contribute to the object becoming waste, its journey and its degradation.

Currents (Files: 47 References: 50)

This code refers to oceanic currents being mentioned, often carrying the plastic object from one place to another.

Rain (Files: 3 References: 3)

This codes for the rain being mentioned as a factor of deterioration or more generally as an environmental element that the object is impacted by.

Salinity (Files: 7 References: 7)

This codes for salinity of sea water being mentioned, most often as a factor contributing to degradation.

Sun (Files: 18 References: 18)

This codes for mentions of the sun, often being seen as contributor to the object degradation.

Tide (Files: 12 References: 13)

This codes for the tide being mentioned in stories, often contributing to the object entering the environment or washing up on a beach after its journey.

Waves (Files: 6 References: 6)

This codes for mentions of waves contributing to the object becoming waste or to its journey.

Wind (Files: 26 References: 26)

This codes for the wind as a factor influencing the object's journey.

Appendix 2 - Positionality statement

EP and AG are both educated western women. While AG has lived in Galapagos for 30 years, it was the first time that EP was undertaking research in Galapagos. We acknowledge that our presence and privileges may have influenced the results of this research. While both of us speak fluent Spanish, which facilitated the workshop, the group size and the unusual nature of the workshop, presenting archaeology to the students for the first time, may also have impacted the way students engaged with the workshop and the content of the stories. The occasional nature of the workshop meant that students did not know EP beforehand, and may have lacked trust to undertake this activity. However, the presence of AG (whom some of the students knew), along with her experience in education in Galapagos, also limited bias in undertaking workshops and encouraged students to take part.

AG and EP are also both aware that the topic of plastic pollution itself is an overwhelming one that can cause anxiety and distress. These feelings can also influence how EP and AG presented the issue to students, and how EP undertook data analysis. To counter those limitations, self-reflexion was undertaken by keeping notes during the workshop and thinking about positionality throughout the analysis, annotating potential biases.

Statement of authorship

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Candidate name	Estelle Praet
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Thesis title	Exploring contemporary archaeologies of plastic pollution: Perspectives from Galapagos, the East Pacific Coast, and Europe

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(ii) if required, permission is granted for the candidate to include the work in their thesis (note that this is separate from copyright considerations).

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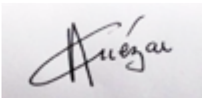
Signature of the co-author	
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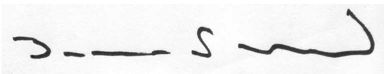
Signature of the co-author	
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Chapter 7 - 'Windows of opportunity': exploring the relationship between social media and plastic policies during the COVID-19 Pandemic

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Abstract

Plastic pollution has reached a crisis point due to ineffective waste management, an over-reliance on single-use plastic items and a lack of suitable plastic alternatives. The COVID-19 Pandemic has seen a dramatic increase in the use of single-use plastics including 'COVID waste' in the form of items specifically intended to help stop the spread of dis- ease. Many governments have utilised COVID-19 as a window of opportunity to reverse, postpone or remove plastic policies off agendas ostensibly in order to 'flatten the curve' of COVID-19 cases. In this paper, we use novel methods of social media analysis relating to three regions (USA, Mexico and Australia) to suggest that health and hygiene were not the only reasons governments utilised this window of opportunity to change plastic policies. Beyond the influence of social media on the plastics agenda, our results highlight the potential of social media as a tool to analyse public reactions to government decisions that can be influenced by industry pressure and a broader political agenda, while not necessarily following responses to consumer behaviour.

Keywords

crisis, plastic pollution, COVID-19, agenda setting, entrepreneurs, social media, media, archaeology, ecology

Introduction

Plastic waste pollution has become a large and complex global governance problem to solve. Often described as a 'wicked problem' (Landon-Lane, 2018; Vince & Stoett, 2018) and a 'creeping crisis' (Mæland & Staupe-Delgado, 2020), plastic pollution has far-reaching consequences—it is found in terrestrial and marine environments, from the Swiss Alps (Bergmann et al., 2019) to the deep ocean (Chiba et al., 2018), and in the most remote places in the world such as Henderson Island (Lavers & Bond, 2017). As a material, plastic is culturally embedded in society (da Costa et al., 2020) through its practicality and purposefulness to the extent that it is now considered across disciplines, including archaeology, as a key signature of a Plastic Age (Pétursdóttir, 2017; Schofield et al., 2021; Thompson et al., 2009) or, as an epoch, the Plasticene (Ross, 2018).

The impacts of plastic pollution are diverse and widespread. It has an estimated social and environmental cost of US$3.7 trillion each year (DeWit et al., 2021). It has been linked to climate change with plastic degradation contributing methane and ethylene to the atmosphere (Royer et al., 2018). Despite a better understanding of the environmental and societal problems caused by plastic over the last few decades (e.g. cost in Forrest et al., 2019; link to climate change in Stoett & Vince, 2021; impact on human health in Flaws et al., 2020), there has been more plastic in the environment, not less. This is acknowledged on a global scale with the United Nations (UN) Environment Assembly passing a resolution in March 2022 where members agreed that by 2024 they will have developed an international legally binding agreement to "End Plastic Pollution" (Draft Res of 2 March 2022). Nation states have recognised that the plastic issue is something that needs to be addressed through policy in their jurisdictions. Yet, solutions are slow to be placed onto political agendas.

The COVID-19 Pandemic is hitting the world severely, leading to the death of more than 6.5 million people (at the time of writing) (World Health Organisation, 2022) resulting in an overwhelmed and exhausted global healthcare system. This focussing event has resulted in governments across the world prioritising COVID-19 on their political agendas and implementing health measures needed to ‘flatten the curve’ of the Pandemic. This ‘health and hygiene’ approach has provided some governments the opportunity to remove plastic policies from their agendas with little consultation or limited notification (da Costa et al., 2020; Prata et al., 2020; Silva et al., 2020).

Social media have been utilised by governments, decision makers, policy entrepreneurs, industry and the general public to share information on the Pandemic and the increase in the use of single-use plastics. Social and mainstream media have had an important role in educating the public about COVID-19 and being the linkage between governments and the general public about health and safety, as they would in other crises (Friedman et al., 2019). Social media have also been instrumental in raising awareness of the plastic crisis, focussing attention on the growing amount of ‘COVID waste’, stimulating behavioural change to reduce plastic consumption and providing public pressure to drive the transition from a linear to a circular economy (da Costa et al., 2020).

In this paper we offer reflections about the occurrence of a window of opportunity due to the COVID-19 Pandemic to change plastic policies driven by industry pressure, responses to consumer behaviour and/or political pressure. We begin by examining social media and COVID-19 as a window of opportunity for policy entrepreneurs to engage in policy change. This is followed by an overview of the Pandemic’s influence on the plastic agenda. Utilising a social media analysis approach we then examine three case studies to analyse the key drivers within government decision making. The first case study analyses industry pressure in the USA where pro-plastic entrepreneurs are key actors in plastic policy decision making. The second case study examines the politics behind plastic policies in Mexico. And lastly, the third case study analyses consumer behaviour in Australia and government non-decision making on plastic pollution issues.

Social media and COVID-19 as a window of opportunity

In times of crisis, focussing events or external unexpected shocks (Birkland, 1998), such as COVID-19, open policy windows to initiate change (Kingdon, 1995; Michaels et al., 2006). Media are particularly quick to respond to focussing events and can contribute to how long an event is considered important and eventually to the size of policy windows. Policy entrepreneurs are often the people to drive policy change, and these include people from various professional backgrounds, bureaucracy, financial institutions, think tanks, NGOs and academia (Anderson et al., 2020; Rozbicka & Spohr, 2016). The visible participants in agenda setting (such as politicians, elected officials, the media and decision makers) are often influenced by policy entrepreneurs who also raise public concern, come up with innovative solutions and ensure laws and policies are passed (Anderson et al., 2020). Policy windows opened by focussing events can be found on all jurisdictional levels. However, they differ in how each level conceptualises the issue onto the agenda and how long the policy window remains open (Michaels et al., 2006; Princen, 2007; Scholten, 2013). In the case of COVID-19, the policy window remains open although the urgency is starting to wane.

Policy entrepreneurs may not be the only ones to take advantage of policy windows, as there are questions around public influence during these opportunities. Barberá et al. (2019), for example, used Twitter data in their study to measure the amount of attention being paid to political issues and found that politicians rarely reflect the priorities of the general public. They argue that the general public, often the invisible participants, have a limited ability to influence the political agenda and that politicians are more likely to respond to their supporters.

While mainstream media tend to record and report, social media tend to critically examine announcements by decision makers, sometimes breaking the secrecy of political issues (Boynton & Richardson, 2016). Social media also have a role in revealing the use of placebo policies and non-action/non-decision making. Placebo policies are those that demonstrate government action over an issue, but whose true purpose is to distract from other agenda issues (McConnell, 2010, 2020). Placebo policies also mask potential inter-actions and interventions (see for example, Morrison et al., 2020). Policy windows can prompt non-action/non-decision making or, particularly during the COVID-19 Pandemic, the postponement of actioning an issue on the agenda. Non-action and postponement helps decision makers focus on the crisis at hand, which needs to take priority on the political agenda. Government non-decision making can also be the opportunity for industries and consumers to make their own decisions over an issue.

While social media may provide a powerful tool for individual voices, they do not necessarily mirror global opinion for individual voices. As social media have played an essential role in communicating health information (Tsao et al., 2021), it is not surprising to find that their use as a source of information is the top reason why 36% of consumers utilise them (Trifonova, 2020). The downside to this is that social media become fertile ground for misinformation. It is then essential for public health authorities to provide social media users with reliable scientific information to counter the spread of fake information (Hartley & Vu, 2020). Misinformation on social media is so common during health crises that the word infodemic has even been adopted (Zarocostas, 2020).

The relationship between information, social media and policy change has been marked by the Pandemic provoking increased time spent on social media. This context directly influenced the 'plastic agenda' which will be discussed in the following section.

COVID-19 and the Plastic Agenda

The 'plastic agenda' refers to all issues relating to plastic creation, manufacturing, use, disposal, reuse and repurpose, and disposal that make it onto a political agenda. As of 2020, over 150 countries had enacted regulatory measures relating to single-use plastics and the majority of these related to the restriction and/or banning of plastic bags (da Costa et al., 2020). COVID-19 has severely slowed down the plastic agenda across the world. In some countries, this health crisis has led to the postponement or reversal of regulatory measures, laws and policies in response to managing the spread of the virus (da Costa, 2021; Silva et al., 2021).

Beyond the human and socio-economical cost, the COVID-19 Pandemic has marked a turning point for plastic pollution by inflating plastic waste quantities with the addition of COVID waste, consisting of single-use personal protective equipment (PPE), notably face masks and to a lesser extent rubber gloves (Ammendolia et al., 2021). In addition to this new waste, regional lockdowns and stricter hygiene practices entered daily life provoking an increase in the use of everyday single-use plastics such as shopping bags, coffee cups and take-away food containers (Parashar & Hait, 2021). As these changes occurred, the public reacted promptly on social media showing their comprehension, confusion and even frustration at the increase in plastic waste being generated and increasingly visible around the globe, on streets and sidewalks, in rivers and on beaches (e.g. Schofield et al., 2021).

Health and hygiene policies have resulted in the substantial increase of single-use PPE. While health and hygiene have been the main reasons governments have changed their plastic agendas, they are not the only reasons. Government decisions have also been driven by industry pressure, and the general politics that have arisen due to the window of opportunity provided by the Pandemic, all of which are faced with a diversity of consumer reactions especially when governments engage in non-decision making. Governments have also made decisions based on ‘crisis thinking’, where the focus is being prepared for and recovering from crises during regular, everyday policy making (Rhinard, 2019). Crisis thinking has resulted in the Pandemic being regarded by governments as an urgent crisis, while plastic pollution is seen as an on-going crisis (Vince, in press).

Industry pressure has heavily influenced agenda setting over the plastic pollution issue. The policy entrepreneurs who are driving corporate-friendly agendas and are engaged in ‘disaster lobbying’ use indicators such as COVID-19 statistics to show an increase of transmission and downplay the severity of pollution while stressing the hygiene/health benefits of single-use plastic (Johansson, 2021). Plastic industries saw this window of opportunity to ask for postponement of the ban on single-use plastics in Belgium (EUPC, 2020) and in the USA through the Plastic Industry Association (PIA). While the PIA argued that studies proved the risk that reusable bags may carry viruses and bacteria, health officials have stressed that there is a lack of scientific evidence to support this claim (da Costa, 2021).

Social media have contributed to raising awareness and making consumer demands heard during COVID-19. They also had a role in being a platform for information where new governmental decisions are shared. Consumer behaviour changed as a result of the health and hygiene concerns during the Pandemic with greater demand for banned single-use plastic products and for food packaging (Silva et al., 2020) that was driven by industry rather than government/regulation. The lack of government involvement and industry influence resulted in other changes in behaviour such as panic buying, stockpiling and online shopping at unprecedented rates (Parashar & Hait, 2021), all contributing to higher levels of plastic waste. Those shifts in consumer behaviour, as well as recommendations whether official or not, were recorded and commented upon on social media.

Within this policy context, little research has been done on how social media have impacted three key areas: industry pressure, consumer behaviour and politics. Social media are used here both as a tool to understand the relationship between the plastics agenda and these three key areas, and as a reflection of the facets of these relationships, offering insights into the application of these policies.

Methodology

Data gathering

As the use of social media has increased during the Pandemic (Sortlist, 2022), this provided a suitable archive from which to understand people's perceptions of the ways in which COVID waste pollutes the environment and of policies influencing daily life. The three case studies included: the USA and the influence of industry pressure; Mexico and the politics behind the plastics agenda; and Australia and government non-decision making with regard to consumer behaviour. Amongst all social media, Twitter was selected as the ideal platform through which users discuss their feelings and reactions through tweets[1]. Created in 2006, Twitter has over 353 million users per month (Dean, 2021) although its use varies greatly between countries. In the countries investigated, Twitter always ranks after YouTube as the favourite social media platform. For this investigation, data were retrieved through an Academic Twitter developer account and analysed in R.

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[1] We here understand tweets as each comprising a "short message also known as a post, status or microblog from a user on Twitter and which consists of a < 140 characters" (Ahmed et al., 2017: 4).

Data analysis can be divided into three successive stages: (1) retrieving tweets, (2) cleaning the dataset and (3) analysing the dataset. Stage 1 involved investigating tweets using a Twitter developer account obtained for this academic project (https://developer.twitter.com/en/solutions/academic-research). This provided access to a full-archive search from the first tweet in 2006. To retrieve tweets, we used both the full-archive search (Australia and Mexico) and the user search (USA) available on the Academic TwitteR package on R (Barrie & Cho, 2021). The full-archive search looked for keywords specific to each policy while setting the time and space parameters to our case study (Table 1). We analysed results as aggregate data instead of direct quotes to ensure privacy of users. The user search compared the most commonly used words from two public and corporate accounts (Government of California and the American Chemistry Association) between 15 March and 31 July 2020.

In Stage 2 all tweets were manually screened to ensure they were relevant to the topic discussed and to the policy investigated. Stage 3 involved Sentiment Analysis on R and Qualitative Analysis in NVivo. Tweets from the Australian example were analysed using sentiment analysis packages, such as Syuzhet (available on R), and following the code written by Yanqing Shen (2020). This enabled a comparison through time of the sentiments associated with reusable cups and to understand whether this has shifted as a result of the Pandemic, and the non-action of the Australian Government. The qualitative analysis in NVivo 20 involved analysing tweets from the US and Mexican case studies, respectively, providing an understanding of the occurrence of terms and general themes emerging from the tweets. Search of specific terms (e.g. looking for mentions of plastics) and frequencies of most common words used (in the form of word clouds) were undertaken to analyse resemblance of discourses in the USA, while coding was undertaken for the Mexican case study. Thematic analysis of the tweets' content allowed the identification of emerging themes (Fereday & Muir-Cochrane, 2006: 82) through familiarity with the data (see Savin-Baden & Howell Major 2013, Chapter 28). Results are presented as a discussion of vocabulary, themes and feelings emerging from the tweets in the form of aggregate data. Ethical clearance was obtained for this research through the University of York's Department of Archaeology.

Table 2: Summary of case-studies and their associated methods for social media analysis

Case study: Policy respondin g to ...	**Policy**	**Country**	**Timeline**	**Words looked for**
Industry pressure	Lift of plastic bag ban	United States California	Mid-March to end of July 2020	Not applicable as tweets were selected according to a user not a set of words.
Politics	Ban on plastic bags Ban on single use plastic	Mexico Mexico City	January to February 2020 January to February 2021	ley de residuos sólidos OR bolsa de plástico Ciudad de México OR bolsa de plástico CDMX OR prohibición bolsa de plástico OR bolsa de plastico OR #bolsadeplastico OR #leyderesiduos ley de residuos sólidos OR plastico OR plasticos OR plástico OR plásticos OR plástico de un solo uso Ciudad de México OR plástico de un solo uso CDMX OR prohibición plástico de un solo uso
Responses to consumer behaviour	Ban of reusable cups	Australia	March 2020 to May 2021	Keep cup OR keep cups OR reusable coffee cup OR cafe reusable cup OR reusable coffee cups OR cafe reusable cups OR #keepcup OR #reusablecoffeecup

Results

Industry pressure in the USA

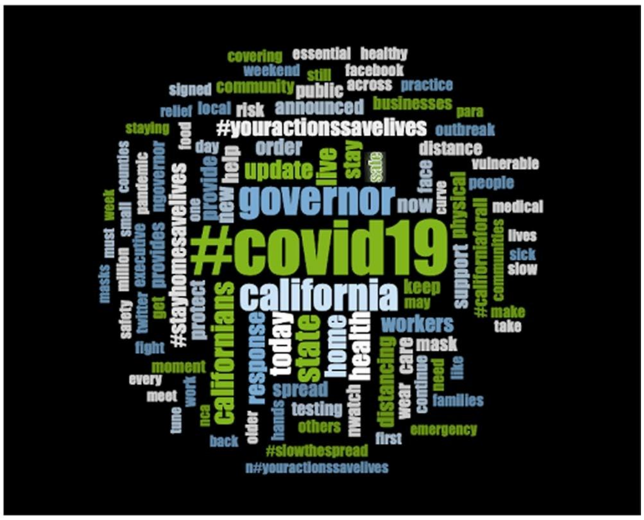
In the case of industry pressure, we specifically looked at the state of California where we focussed on the type of communication offered by the government and the American Chemistry Association (AmChem). In the USA, in 2020, there was a postponement of plastic bag bans in several states. California suspended the ban in April 2020 but reinstated it after 2 months, offering a small time frame for the window of opportunity to be analysed. The goal of this case study was to understand the type of communication surrounding the rise of the Pandemic and the suspension of bans along with industry pressure. To do so, official Twitter communications by the Office of the Governor of California were analysed around changes due to the Pandemic, such as the lift of the plastic ban by Gavin Newsom in California (Paragraph 12 of Executive Order N-54-20) and its reintroduction 60 days later. The hypothesis was that governments were likely to use the same hygienist arguments used by plastic industries, perhaps ceding to industry pressures.

We undertook a user search approach, which only considered original tweets, discounting manually the retweets[2] as no functionality exists for that in the Academic TwitteR package. This left 1026 tweets and 253 tweets for the Government of California and AmChem, respectively. The vocabulary used was analysed for both accounts through NVivo functionalities of word clouds and word search (Fig. 1). The aim was to see whether and how policies regarding a lifting of plastic bag bans were discussed.

Surprisingly, the word ‘plastic’ was not even used in government tweets and the communication focuses more on sharing feelings such as safety, community and a sense of response (Fig. 1a). No communication evidenced the suspension of the plastic ban as the focus was shifted towards a semantic field reinforcing the emergency of the COVID-19 situation and the sense of community and responsibility needed to face it. This is quite similar to the type of language used at the outbreak of the Pandemic by plastic industries: ‘Safety’, ‘Help’, ‘Fight’, ’Risk’ and ‘Responsibility’ are amongst the recurrent terms used by AmChem (Fig. 1b).

[2] “The retweet function forwards a tweet from a user to their followers” (Ahmed et al., 2014: 4). We here decided not to consider retweets as they create doublons

(a)



(b)

Figure 1: a) Wordcloud of most common terms used in the tweets published by the Government of California between mid-March to end of July 2020; b) Wordcloud of most common terms used in the tweets published by the American Chemistry Association between mid-March to end of July 2020

Those terms provide a sense of safety to consumers and appear to draw attention away from the environmental impact of plastic bans. Here, the window of opportunity is associated with communication emphasising the sense of crisis. In that way, the classification of the discourse puts forward priority of the circumstances while completely ignoring a ban that impacted producers, consumers and the environment. Rather, AmChem is presented as an ally during the fight against the virus, contributing to this semantic association between plastic and safety.

Politics in Mexico

In the Mexico City case study, we sought to understand how people perceived, over 2 months after their introduction, the two policies regarding plastic use that were implemented during the Pandemic: the plastic bag ban in Mexico City in January 2020 and the single-use plastic ban in January 2021. In total, 93 tweets were examined related to the ban on plastic bags in 2020 and 43 tweets related to the single-use plastic ban in 2021. The plastic item bans were a contrast to other government policies of President Andrés Manuel Lopez Obrador (AMLO) where the environment was not a priority (e.g. favouring the construction of oil refineries, a mega railway project in the Maya region threatening the biodiversity and heritage of indigenous communities, and a new airport in Mexico City). With this example, our hypothesis was that social media would reflect the level (or lack) of trust in the measures taken. In Mexico City, plastic bags were banned from supermarkets in January 2020 (Secretaria del Medio Ambiente, 2021). As of 1 January 2021, Mexico City reaffirmed its position by ensuring the ban on selling, commercialising and distributing single-use plastic items, such as straws, plastic cups, tampon applicators and plastic cutlery (Secretaria del Medio Ambiente, 2021). Those bans were, respectively, followed by queries from the Asociación Nacional de la Industria de Plásticos (ANIPAC) to postpone those laws due to the Pandemic invoking similar actions in the USA and in European countries (ANIPAC, 2020) and by severe critiques due to the impact it would have on employment, with a loss of approximately 50,000 jobs (Stettin & Ordaz, 2021). While the bans on plastic bags and single-use plastics were implemented in Mexico City, they were postponed in several states of the country, such as Oaxaca, Nayarit and Acapulco, following recommendations from plastic industries (Olivera, 2020).

Thematic coding revealed two recurring themes in tweets reacting to the ban of plastic bags in Mexico City in 2020. First, a third of the tweets referred to the application of the law. Twenty tweets reveal information regarding the compliance (n = 12) or the disobedience (n = 8) to the measure by establishments. Concerns regarding the application of the measure also appear in the tweets, questioning the financial benefits for the companies and asking about fines. Tweets also question the policy application without alternatives being given to the consumers. Second, 60% of tweets focus on the emotional response that can be categorised into three types: (1) People can have a positive perception of the law: they consider it as a great step for the environment. (2) By contrast, some tweets are negative, claiming that the measure is a mistake for a variety of reasons: the greater energetic investment required for the production of paper bags; the consequential loss of jobs in plastic industries; and the hidden financial benefits of supermarkets being able to charge for paper bags. (3) Several tweets are written in an ironic tone using references to the paradox of the law with the real problem lying in recycling and packaging. Several tweets actually stand against the measure (n = 15), but positive reactions were more common (n = 23) along with the ironic statements (n = 18). The global environmental impact of plastic bags is also discussed by several users and contrasts with the environmental cost of paper bags.

Tweets in 2021 targeted several topics, notably the lack of decision making based on scientific data, the questionable measurements used and the lack of proposed alternatives. For instance, users questioned the next steps as styrofoam was not banned by the plastics policies. Reactions reflected a specific concern with take-away packaging, and menstrual sanitary products (since tampons with plastic applicators were banned), emphasising the lack of alternatives. Several users also condemned the policy as a decision that was not thought through and that took advantage of a trending issue. Overall, this policy on plastic appeared to have provoked less comments in 2021 compared to 2020 (Fig. 2) and less emotional reaction with only 43% of tweets expressing either negative, positive or ironic responses, the rest comprising tweets that share the news in a neutral way, either asking for people's opinion or sharing resources.

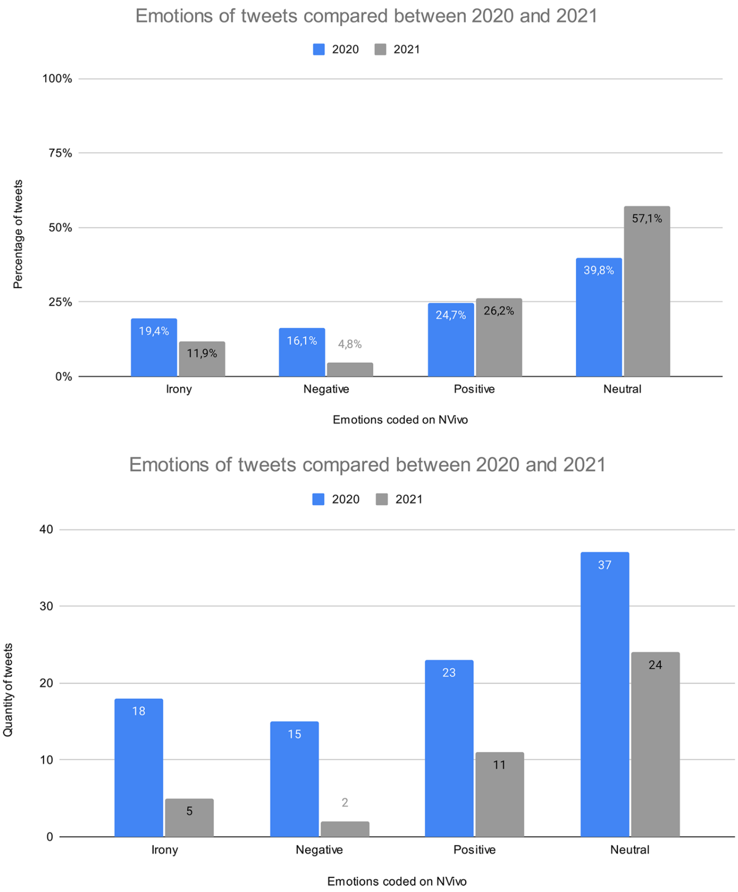


Figure 2: Comparison of tweets related to the plastic bag and single-use plastic ban in Mexico in 2020 and 2021, respectively

Consumer behaviour in Australia

Finally, we wanted to also investigate the reaction of Twitter users to the ban on reusable plastic cups in coffee shops in Australia and how this evolved through the Pandemic. Prior to the Pandemic and on the back of the ABC documentary “War on Waste”, the uptake of reusable coffee cups had reached over 40% (Barnfield & Marks, 2017). However, during the Pandemic, reusable coffee cups and other containers were no longer being accepted by providers due to hygiene concerns, causing a shift back towards single-use plastic items (Sandhu et al., 2021). We examined this situation by dividing the Pandemic in Australia into three time periods:

- 1 March 2020 – 31 July 2020 — Start of the Pandemic and nationwide lockdown, peak of the second wave

- 1 August 2020 – 31 December 2020 — Recovery from the second wave and opening up of many states and the sense of normality returning
- 1 January 2021 – 31 May 2021 — The start to a relatively COVID-19-free year, prior to the return of lockdowns caused by the Delta strain in July 2021 within the two most populous states of New South Wales (NSW) and Victoria.

KeepCup is an Australian brand that paved the way for using reusable cups in coffee shops. Its popularity turned it into a proprietary eponym in Australia when referring to this type of product. During the Pandemic, this tendency was abruptly stopped by bans of reusable cups in cafes and takeaway shops (Smith, 2020). The aim here was to understand whether the health/hygiene argument emerged from changing psychology in consumer behaviour or whether it was used as an excuse to reintroduce plastics following the pressure of industries. The hypothesis was that consumer behaviours changed to include more single-use plastic as coffee shops were reluctant to accept reusable cups, and that these behaviour changes were due to perceived health and safety risks, rather than a demand from consumers. Interestingly, there was no mandatory policy obliging coffee-shop owners to serve drinks in disposable cups, yet it became widespread practice during the Pandemic (The State of Victoria Department of Environment Land Water & Planning, 2020).

Tweets were examined relating to the use of reusable cups in cafes throughout this period. Sentiment analysis undertaken in R (Fig. 3 before manual data cleaning), placed emphasis on the prevalence of positive sentiments associated with the words “keep cup” and “reusables”. Keep cups were still perceived positively even during the Pandemic. To gain a better idea of content, manual data cleaning identified tweets directly related to the use of keep cups in cafés. With a sample of 55, 23 and 9 tweets for each period, respectively, analysis of content was undertaken. Although the number of tweets is small, the impression, on closer inspection, is that there was disagreement amongst customers with the temporary ban of reusable cups in cafes in the first period. Some users were more vehement than others and most seemed to accept the situation with disappointment. Only a few Twitter users seemed to value this decision (n = 6). During the following periods, there was a decrease of interest for the topic marked by the reduced number of relevant tweets (as stated above: 59 tweets in Period 1, 23 in Period 2 and 9 in Period 3). This is also visible in the sentiment analysis before selection of directly relevant tweets (Fig. 3). Period 2 is associated more with questions on whether keep cups were going to be allowed. It also appeared that some users were finally able to go back to their old sustainable habits. Period 3 saw a drastic fall in tweets related to keep cups. One user noted that people reverted to the use of disposable cups, whereas other users commented on their use of reusable cups in their local cafes.

Although the numbers are small, these results appear to suggest that throughout the entire time span people continued to perceive reusable cups in a positive manner. This is also suggested by the general positive feeling evident in the sentiment analysis of tweets including the word reusable or keep cups.

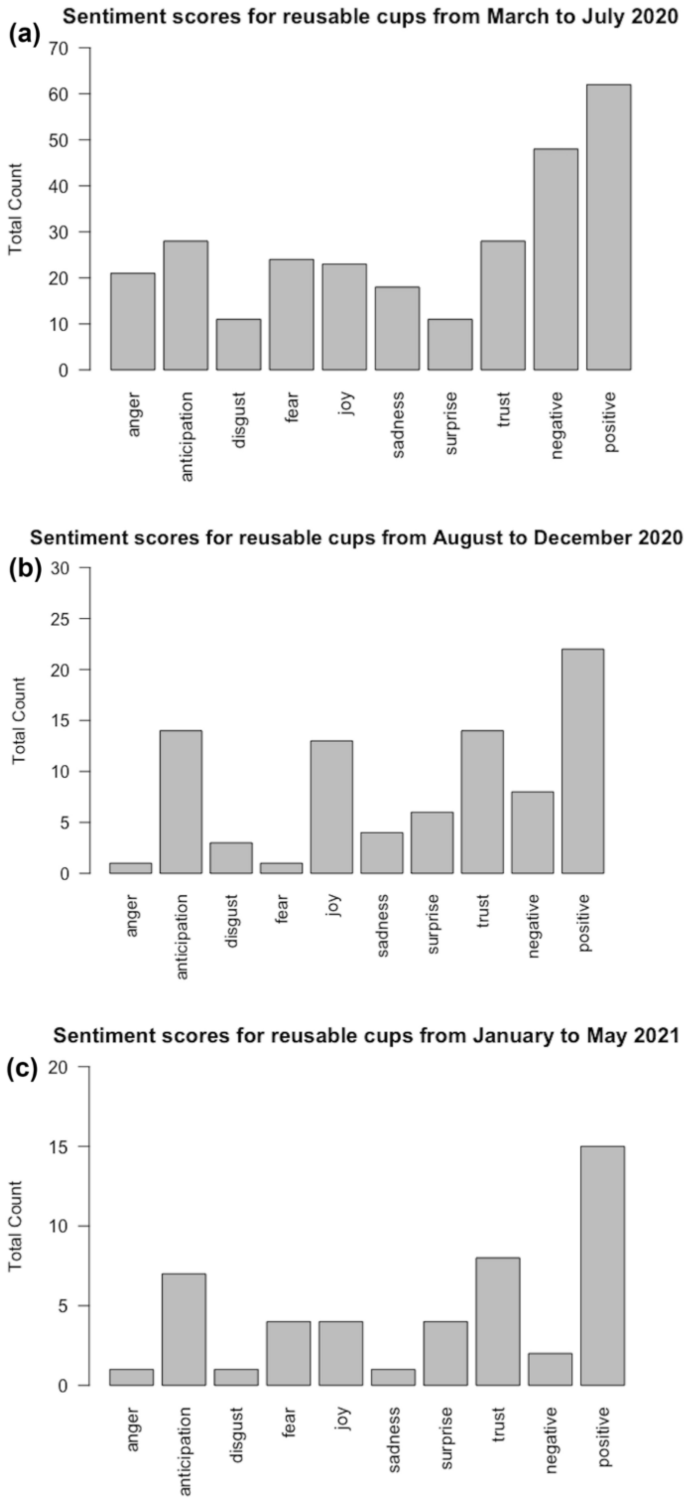


Figure 3: Sentiment score analysis for reusable cups between a) March and July 2020, b) August and December 2020 and c) January to May 2021

Discussion

The three case studies demonstrate the diversity of approaches for social media analysis to consider the relationships between people and agenda setting. Social media can serve as a platform to send reassuring messages in times of crisis while aligning with industry discourse on health and hygiene questions (US case study). But social media can also be used by people to show their (dis)agreement with new policies and to question their design (Mexican case study). Consumers can also indicate a relatively stable positive attitude towards their eco-friendly behaviours despite the lack of government action (Australian case study).

In the US case study our hypothesis was that governments would use the same hygienist arguments used by plastic industries, perhaps ceding to industry pressures. The plastic industry and pro-plastic entrepreneurs engaged in disaster lobbying to change political agendas. The plastic industry entrepreneurs in the US case study who were once invisible during peak plastic usage, had become visible during the Pandemic. They utilised all agenda-setting opportunities to leverage their case—through the use of COVID-19 as a focussing event to increase the size of the policy window to postpone the implementation of plastic policies.

In the Mexico City case study, we hypothesised that the plastic ban policies did not reflect the greater political agenda. This lack of consistency contributed to mistrust of the government, which was reflected in the social media analysis. In 2020, 44% of tweets about plastic were negative. Those tweeting, often invisible participants in the policy process, also commented on the lack of plastic alternatives and the government's poor environmental policy track record. In this case, numerous tweets reflect that the plastic bans were considered ineffective to tackle plastic pollution and were therefore only placebo policies that appear to solve an issue but have minimal impact. Decision makers needed to acknowledge the political context where the dominance of legislatures, political parties, interest groups/ entrepreneurs and public opinion differ (Sanjurjo, 2020). The case study therefore demonstrates the importance of putting into context the plastics policies and decisions within the broader political landscape and agenda that they belong to, not least because policies can be presented as placebo within a broader political agenda.

In the Australian example, we hypothesised that despite stable consumer behaviour perceiving the reusable cups positively throughout the Pandemic, the usage of single-use plastics increased as coffee shops were reluctant to accept reusable cups due to perceived health and safety risks. The crisis thinking characterising the first months of the Pandemic may have led to decisions that were protecting business interests and not necessarily reflecting people's perception of keeping cups and reusables during this time. This may have led to the decision to ban reusable cups in a moment where concerns for hygiene and limitation of contact were essential strategies by industry. Although our conclusions cannot be generalised due to the small sample size, the results might suggest that the Australian federal and state governments engaged in non-decision making, allowing industry to self-regulate. Notably, political agendas were dominated by mandates on PPEs and some other forms of health-related COVID plastics, but not single-use items such as coffee cups.

Across the three case studies, decision makers needed to drive the plastic problem as an urgent, rather than a creeping crisis, whether alongside COVID-19 or as a separate crisis exacerbated by it. If done strategically and cautiously, it could have resulted in positive policy change that could have reduced, rather than increased plastic pollution

Conclusion

In this paper we describe and test an innovative approach to exploring the potential of social media analysis to investigate ways that environmental crises such as plastic pollution can be manipulated by governments and industry, but which can also be used by entrepreneurs and invisible participants to react and (dis)approve new decisions in plastics policy making. Policy windows and focussing events such as the COVID-19 Pandemic often bring to the surface opportunities for crisis lobbying and to shift issues on or off the political agenda. However, as plastics policies return to political agendas due to the mounting of COVID and other plastic waste across the world and policy reversals are reinstated, entrepreneurs interested in reducing plastic pollution are becoming more visible once again. The political motivation needed to activate crisis thinking over plastics policies could be beneficial in resetting the single-use plastics agenda.

The proof of concept demonstrated here suggests that systematic social media analysis could have a wider application in understanding decisions and reactions to other political issues dominating agendas.

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Ethical approval

Ethical consent was obtained through the University of York. It specified that Twitter users would be anonymised with their reactions only used as aggregate data. The only Twitter accounts that are specifically mentioned are public accounts followed by more than 60 k (American Chemistry Association) and 266.5 k (Office of the Governor of California).

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Authorship statement

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Research Degree Thesis Statement of Authorship

Candidate name	Estelle Praet
Department	Archaeology
Thesis title	Exploring contemporary archaeologies of plastic pollution: Perspectives from Galapagos, the East Pacific Coast, and Europe

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Percentage contribution of the candidate to the work	35%
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(ii) if required, permission is granted for the candidate to include the work in their thesis (note that this is separate from copyright considerations).

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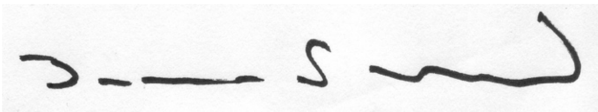
Signature of the co-author	
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*Note that where a paper has multiple authors, the statement of authorship can focus on the key contributing/corresponding authors.
**The description of the candidate and co-authors contribution to the work may be framed in a manner appropriate to the area of research but should always include reference to key elements (e.g. for laboratory-based research this might include formulation of ideas, design of methodology, experimental work, data analysis and presentation, writing). Candidates and co-authors may find it helpful to consider the CRediT (Contributor Roles Taxonomy) approach to recognising individual author contributions.

Chapter 8 - Conclusion

The chapters offered different applications of an archaeological lens to look at plastic pollution. Aided by the development of contemporary archaeological theories (Chapters 1 and 2), the consideration of plastic was contextualised within the systemic human impact on the geological and archaeological record, characteristic of the Anthropocene and the Plastic Age. Those frameworks taught us about the issues' globality, intricate links, and lasting impacts. The combination of papers forming this thesis has explored five recurrent themes that will be discussed as a way of conclusion:

1) **Contemporary archaeologies can contribute to the study of plastic pollution from different angles.** The framework of contemporary archaeology helped explore different theories using an array of tools and techniques to approach the global issue of (marine) plastic pollution. The different chapters focused on navigating *plastics as artefacts* of the Anthropocene and Plastic Age and as a basis for reconstructing *object itineraries as a window into perceptions*.
2) **Plastics allow us to bridge the tensions between local and global**, as global and local experiences are intrinsically linked (Tsing, 2005). Mapping plastic pollution from its sources ("taps") to its end zone ("sink") emphasised the global journey that objects take. From that perspective, the global/local tensions were envisioned in two ways: a) following the river-marine environment pathway, and b) situating the local Galapagos case study within the regional context of the Pacific.
3) **Plastic pollution represents a form of toxic heritage, particularly affecting remote locations relying on tourism for their livelihoods.** Plastic waste is a threat to ecosystems and economies, particularly those of islands. It may also affect the status of some locations as World Heritage Sites (WHS), for example, the archipelago of Galapagos. There, while tourism contributes to the generation of plastic waste, its development requires the maintenance of unpolluted areas for tourists to visit. But plastics permeate WHS sites, and their legacy transforms plastics into a toxic (and colonial) heritage.
4) **Archaeology is here considered a situated practice *in* and *of* the Plastic Age.** The framework of contemporary archaeologies situates itself by working on plastics as artefacts and contemporary material culture more broadly. The focus of archaeology as a situated practice is explored throughout this thesis, notably through

the organisation of workshops centred around plastics as artefacts and providing reflections on the role of archaeology in policymaking.

5) **With a project focusing on a wicked problem, the question of my positionality and the legacy of the work are addressed in the final section.** I reflect on my role as an archaeologist working on plastic pollution in Galapagos, and then evaluate the project's legacy, particularly important because of the unintended legacy of plastics and the location of the project in Galapagos. Building on the results from the story-writing workshops, the field season in 2023 was organised to share the outcomes of the workshops and organise an exhibition presenting some stories and comics created by local students.

Contemporary archaeologies: a window into exploratory methods

Contemporary archaeology yielded both a theoretical framework and tools to address the distinct archaeological record of the Anthropocene and the Plastic Age. To explore these newly configured possibilities and analyse modern and contemporary material culture, a review of the potential archaeological frameworks, techniques, and tools was provided in Chapter 2. This chapter addressed plastic pollution as an object of study and an object of concern for archaeologists. There, I recognised the potential of plastic objects to be considered as artefacts, stratigraphic markers, and components of waste landscapes, setting the basis for a range of techniques to be explored in the case studies composing the thesis. The exploratory methods at the core of contemporary archaeologies were applied across all chapters, notably through the consideration of plastics as artefacts and the reconstruction of their itineraries.

Plastics as artefacts

The way plastic pollution was considered an object of study in this research derived from the consideration of plastic objects as artefacts. All case studies considered plastics as artefacts to some extent, from the most recent artefacts of an archaeological record (Chapter 3) to serve as a lens through which to understand behavioural and policy changes (Chapter 7). Artefacts are objects shaped, made, and/or used by humans. They are, in Ingold's (2012:

439) words, "objects thought to be made rather than grown" (see also Chapter 2). In that light, plastics are the artefact of excellence, representing supermodernity, the Anthropocene and the Plastic Age. They are fully synthetic and represent human exploration and lack of consideration for transformation processes at the core of the carbon cycle. Plastics symbolise a complicated and unbalanced relationship with the natural world, praising the magical, flexible, and disposable nature of plastic at the expense of natural processes and degradation. Considering plastics as artefacts is almost inevitable for contemporary archaeologists, and this thesis has illustrated how plastics can be considered artefacts. This work has shed light on the advantages and limitations of considering plastics as such.

Studying plastics *as* artefacts recognises the cultural elements at the core of their design, production, and use, and the new social dynamics that they shaped (see Hawkins, Potter, and Race, 2015). Being global and relatable, plastics act as a window on behaviours, decisions, processes, and meanings. Not only are plastics archaeological artefacts but also material culture of interest for archaeologists and scholars from other disciplines. Considering plastics as material culture acts as a way to reach non-material things (Olsen, 2003 for material culture and non-material ideas). For example, artefacts were a way to infer functional/technological processes for processualists and cultural/social meanings for post-processualists (Olsen, 2003). In this thesis, plastics *as* material culture offered a basis to reflect upon material and non-material aspects including production processes, interactions with humans and nonhumans, perceptions, behaviours, and events marking the objects' journey. Insights into plastics *as* artefacts and material culture were obtained through visual analysis (Chapter 3), the creation of their potential itineraries (Chapters 4 to 6), and the reactions to restrictions in their use (Chapter 7). Plastics are part of assemblages, for example, trapped in sediment acting as archives between the river anthropic modifications such as dredging and canalisation events (Chapter 3), or conforming marine plastic litter along the Pacific Coast (Chapter 4) including Galapagos (Chapters 5 and 6). While this work placed plastics as an archaeological object of study, I recognise the challenges in establishing those relatively recent materials as archaeological artefacts.

Contemporary archaeologies offer a flexible and exploratory framework to develop novel methods around this moldable material but considering plastics as artefacts also comes with limitations. Plastics are more complex than most materials archaeologists are used to working with. The infinity of shapes, functions, and chemical signatures that plastics can adopt makes their classification and categorisation challenging (see Chapter 3). Being used in a diversity of products, plastics' function may be difficult to determine, and their relevance is difficult to grasp, especially when the use-life of its intended function is short. When fragmentary, identifying a plastic fragment's former function is almost impossible, as is dating it accurately. Considering plastics as artefacts may also overlook the danger they pose by shifting the focus on the amount of information plastic objects hold and the potential of their interpretation to understand habits and behaviours. The emphasis on their cultural relevance and symbolism, sometimes becoming museum artefacts, also questions the value attributed to plastics and the aesthetisation of those objects. Despite recent attempts to be more inclusive towards what constitutes heritage (see Shepherd, 2023: 3 for a definition[1]), giving plastics the status of heritage may alienate plastics from the common lack of value assigned to it as waste and sometimes even as products quickly disposed of. Some archaeologists and heritage scholars even argue that places shaped by plastic pollution could become World Heritage Sites (WHS) (e.g. Holtorf, 2023; Godin et al., in press). While these places may seem out of the ordinary, hence having some Outstanding Universal Value (OUV, being a prerequisite for WHS), the distribution of plastic pollution and its global scale exacerbated by plastic degradation and fragmentation represent obstacles to this view. Plastics' complex chemical signature and their importance for different fields sometimes question the relevance of an archaeological approach to this supermodern material culture. As these chapters have proven, scholars from different disciplines can adopt an "archaeological" lens although not explicitly. Plastics are important culturally, they shape new practices and become intriguing for sociologists, anthropologists, and psychologists while their interactions with nonhumans lead to their consideration by marine biologists and oceanographers. The focus and importance of material culture for archaeologists (and the physicality and materiality of things despite having been overlooked, see Olsen, 2003; 2010) then make plastics relevant for our field, especially as they enter the stratigraphy and threaten heritage sites. But is plastics' materiality enough to justify an archaeological approach?

[1]"An everyday definition of heritage is 'that which we inherit from the past and pass on to the future'. Heritage speaks to a form of connectedness across time in which we give careful consideration to all that is best and brightest and most distinctive about the variousness of human life and experience and create the conditions for this to endure. On its dark side, it also speaks to the accumulated legacies of the past that we carry with us, often as unwilling hostages–and about the way in which these legacies materially shape the present and future." (Shepherd, 2023: 3)

Plastics, by being a super-modern material-complex artefact, help archaeologists revise their methods and approaches, and question how these can be applied to different types of material culture. The elements that were limitations of plastics' consideration as artefacts can also be regarded as opportunities to develop archaeological frameworks and approaches for a relatively recent type of material culture (for synthetic plastics appearing in the early twentieth century) that is already becoming "historical" and entering archaeological contexts. For example, plastic's flexible materiality and diverse composition question how artefacts' characteristics contribute to the definition of functions and typologies. Plastic production also challenges the geographical scale archaeologists work with, and how consumers relate to these aspects. Despite using plastic products daily, individuals generally pay little attention to their characteristics and specificities, and their consequences. By contextualising plastics as artefacts, an archaeological approach to plastics can transform the familiar into unfamiliar (after Grave-Brown, 2000: 1) and make the invisible visible, notably their composition. Archaeology can contribute to the study of plastic pollution, particularly as archaeologists are experts in common sense (see Joyce, 2020 exploring the concept of common sense defined by Herzfeld in 1997). From that perspective, archaeologists can envision landfills and waste in perspective and in comparison, with monuments as further evidence of human presence and a lasting one (Joyce, 2020). Particularly relevant for plastics, archaeology has recently expanded its interest beyond the past to include considerations for the material record and societies of the present and the future (e.g. Holtorf, 2020). Symmetrical archaeology also questions the ethical claims that can be applied to artefacts (Sørensen, 2013). In the case of plastics, several scholars (e.g. Owens and Conlon, 2021 for shifting the responsibility from end-users to producers) and institutions (e.g. United Nations Environment Programme - UNEP- calling for an extended producer responsibility) have argued for an ethical responsibility of producers who are aware of the long-lasting impacts of plastics and the lack of efficient recycling systems, particularly in the Global South. Producer responsibility has even been included in several policies, notably in the UK forcing producers to recycle packaging waste (The Producer Responsibility Obligations (Packaging Waste) (Amendment) (England and Wales) Regulations 2022). In that sense, plastics as artefacts are the object of ethical responsibility. This argument, while not assigning an ethical claim to plastics themselves, questions the responsibility of producers and the need to think about plastic life cycles, from production to waste (mis)managament.

Despite the challenges, this thesis has shown the potential of considering plastics as artefacts. In light of the opportunities, this work argues for the contribution of archaeology, (mostly) in collaboration with other disciplines, to the study of plastics and plastic pollution. Yet, it must do so cautiously, recognising the dangers of the excessive aestheticisation of plastics as artefacts and heritage, and the limitations of archaeological tools to understand processes at the core of plastics' production, use, and disposal. Once plastics are viewed as artefacts, they can become the focus of archaeological frameworks. In this work, I have chosen to consider plastics as artefacts through object itineraries. The next section will evaluate and discuss the framework application, its benefits, limitations, and future considerations.

Object itineraries of plastics

With plastics *as* artefacts, reconstructing and sharing their journeys become a central part of archaeological approaches to the material culture of the Plastic Age. After determining that object itineraries were the most adequate framework to approach plastics (see Chapter 1), the framework was explored throughout this thesis. Different approaches were adopted with object itineraries as 1) a way to inform on a site's occupation and chronology (Chapter 3), 2) an engagement tool on the topic of plastic pollution (Chapters 4 to 6), 3) a basis to reconstruct narratives of a complex and global journey (Chapters 3 to 6), and 4) a way to visualise and reflect upon daily behaviours and their impacts on the environment (Chapters 3 to 5).

The application of object itineraries in this thesis was facilitated by the consideration of journeys and interactions beyond the spatial, temporal, and human scale usually discussed by archaeologists. The approach proved particularly helpful across the different case studies. It was used as a way to gather information on chronology (dates as terminus *postquem* and *antequem,* see Chapter 2) and can also be contextualised as a new material replacing metal and other components (e.g. buttons and a Bakelite lid in Chapter 3). In Chapter 3, it is the plastic world of river sediments that is becoming visible to archaeologists. Bringing the focus on plastic objects that sank allowed the consideration of plastic pollution as another layer of human impact on the river. Object itineraries also act as a framework for designing activities on marine plastic litter in the Pacific (Chapter 4) including Galapagos (Chapters 5 and 6). The story-writing activity increased pro-environmental behaviours (PEBs) (Chapter 4), and inspired participants to reflect on plastics differently, recognising the global nature of the itinerary, the relational aspect, and the affordances of plastic objects (particularly significant for the framework of object itineraries see Bauer, 2019: 341). The content of the stories acted as a reflection on perceptions of plastic pollution, and on the global nature of plastic objects' journeys. Object itineraries of plastic objects also weave in to form a landscape marked by plastic pollution. Plastic pollution changes the aesthetics of natural and cultural places, and it is important to recognise how plastics' itineraries as waste shape and reconfigure landscapes (see Chapter 6). Finally, Chapter 7 explored reactions and feelings towards plastic policies modifying the use of plastic products during the COVID-19 Pandemic. While not explicitly referring to the framework in the Chapter, social media reactions were considered as another layer of the object's itinerary, one that focuses on representations.

In addition to those benefits, object itineraries offered the possibility to explore narrative processes. In *Painted pottery of Honduras: object lives and itineraries*, Joyce (2017) reconstructed Ulua pottery's itinerary through a process of narrative that contrasts with standard descriptions of archaeological objects. In that sense, it repopulates the past, making it more tangible and real, considering the local environment, and the people and objects that lived in it. Based on years of excavations and research, the stories that Joyce tells also consider how the missing parts of the story may have occurred. This approach inscribes itself in the valorisation of storytelling in archaeology, conceived as a powerful tool to think about the past (Tringham, 2019; 2020) and to explore how fiction contributes to an understanding of the past (see Van Helden and Witcher, 2020a for the use of fictional narratives in archaeology) and eventually a way to engage people on more modern material culture such as plastic (Schofield et al., 2020). This thesis explored three aspects of fictional story-writing: a) using object itineraries as an archaeological framework to create the stories; b) engaging students to write their fictional narrative; and c) analysing plastics as artefacts.

This thesis explored the creation of stories based on object itineraries by archaeologists (Chapter 3) and by students (Chapters 4 to 6). Reconstructing those itineraries and contextualising them with broader human-environment interactions was at the core of Chapters 3 to 6. The visual analysis of plastic artefacts gave elements of information in both cases, recognising the limits and the diverse ways in which objects may have reached the natural environment. The Pacific case studies (Chapters 4 to 6) further explored the content of stories written by students through thematic analysis. The process of story-writing and its impacts were evaluated through surveys, and the content of stories acted as another window into perceptions of the objects, constituting another layer of the object's itinerary (see Joyce and Gillespie, 2015). In that perspective, creating stories acts as a way to "make sense of the world around us - past, present and future" (van Helden and Witcher, 2020b: 1). The stories' analysis gave insights into how people make sense of the world (following a narrative approach, see Chapter 1) and how they perceive certain issues, such as plastic pollution.

The application of object itineraries to plastics as part of workshops extends the framework to a non-specialist audience. Contrasting with the analysis of plastic artefacts from riverine contexts by two archaeologists in Chapter 3, the story-writing exercise with students, either online or in-person, required them to write a story based on their analysis of plastics through an archaeological lens (Chapters 4 to 6). This approach valued students' insights, reflecting recent tendencies to include general audiences in archaeology, notably through Public and Community Archaeology (see Moshenska and Dhanjal, 2011; Moshenska, 2017) often engaging young people (Thomas, 2017). People-centred approaches were also adopted in heritage studies, management, and conservation (e.g. Schofield, 2017; Madgin and Lesh, 2021) while recognising the limits of what community as a concept entails for heritage and archaeology (Smith and Waterton, 2009). While an argument has recently been made for the use of fiction and imagination as academic tools (Wickham-Jones, 2020), engaging the general public through narrative creation was explored by Ripanti and Osti (2020). In their case study, the authors use fiction as part of the archaeological process, contrasting with the traditional outreach approach from archaeology to the audience (Ripanti and Osti, 2020). In Pilastri, a creative writing competition engaged schoolchildren on the topic of Bronze Age ceramic cups (Ripanti and Osti, 2020). This case study explores stakeholder-led narratives both inspiring reflection from archaeologists and engaging participants on the topic of the Bronze Age in their region (Ripanti and Osti, 2020). The case studies presented in this thesis in Chapters 4 to 6 encouraged participants to write about plastic objects, similar to the Pilastri case study. The activity not only acted as an efficient engagement tool but also a way to analyse stories and surveys systematically combining qualitative and quantitative methods. In this thesis, including the general public reached two main objectives: a) providing an engaging activity on the topic of plastic pollution while rendering archaeology more concrete and tangible; and b) approaching local views of plastic pollution. Beyond the engagement with students along the East Pacific Coast and in Galapagos, the framework of object itineraries applied to plastics represented both an opportunity and a challenge.

To the extent of my knowledge, this is also the first time that object itineraries were applied to plastics. Using the framework yielded information on the objects themselves and also on how participants perceived them and made sense of them in their stories. The breadth of archaeology contributes to understanding plastics' materiality and perceptions/behaviours towards them. Archaeology can act as a way to combine the focus on plastic pollution as physical evidence while considering perceptions of the issue and behaviours favouring and/or limiting it. Conceiving plastics as artefacts with itineraries offered insights into how global flows of plastic are considered and mapped by participants along the East Pacific Coast and in Galapagos. Object itineraries used the materiality of the object to infer its spatial, relational, and temporal journey, overcoming the traditional human/nonhuman and nature/culture divides at the core of biographies and life histories.

Some challenges also arose when applying the framework of object itineraries to plastics. While the framework is rather posthumanist in considering interactions with humans and nonhumans, its application is still carried out by (human) archaeologists and participants in the story-writing activity. In that sense, it is almost impossible to make it fully object-centred. The life metaphor at the core of object biographies and life histories facilitates object understanding by humans. The framework of object itineraries advocates for a shift away from this approach. While it certainly attempts to do so, its application may have difficulties as a non-anthropocentric framework. Some of the itineraries presented may also focus on (human) relationality, which can become anthropocentric. Focusing on the movement through time and space contrasts with the durability of some objects (Nisbet, 2021), a critique particularly valuable for plastics. The importance of de-centering ourselves also emerges as the record is made of continual flows of different temporalities (Joyce, 2020).

De-centering the human for plastic artefacts must be done cautiously as removing the human contribution to plastic pollution may provoke a lack of responsibility and care for the issue. These reflections mostly arise from the specificity of plastics as a global, flexible, and disposable artefact. While the chemical composition of Ulua marbles helps narrow down their origin (Joyce, 2017), plastics are more difficult to trace because of their extensive journey and the non-diagnostic chemical signature of polymers to pinpoint origin. Plastics' value represents a shift from artefacts traditionally more valued if coming from elsewhere and considered exotic. With most plastics coming from "elsewhere", they are all interchangeable and easily discarded. The mobilities of objects, and their associated value, have changed with globalisation (Hahn and Weiss, 2013). In that light, most challenges of applying object itineraries to plastics are directly related to plastics' material specificities.

The application of object itineraries to plastics was exploratory, and despite some recognised limitations, the framework still seems the most adapted to reconstruct the object journeys. A positive aspect of using object itinerary as a framework is the consideration of different scales and temporalities. The following section will reflect on the spatial scale and the consideration for tensions between the global and the local that the framework allowed, particularly relevant for the Galapagos islands and the broader Pacific Region constituting the core of this work.

The global flow of plastic pollution

Plastic pollution is a global issue, one shaped by the liquidity of petroleum and the capitalist and colonialist mechanisms at the core of its production, use, and management as waste. The story and the development of the Plastic Age were only possible in this global context of mass consumerism driven by post-war societies. The use of object itineraries for plastics acknowledges the global nature of their journeys, with plastics "globalised unlocality" (Davis, 2022: 5), being more "the trace of a movement" than an object (Barthes, 1957: 159). Those global flows are explored in two ways across the chapters, first following the pathway of marine plastic pollution including from rivers to oceans, and then altering between regional and local scales for the case studies in the Pacific and Galapagos.

From rivers to oceans

The ubiquity of plastics and their global itineraries, from rivers to oceans, was explored through different case studies. Rivers and inland waterways transport considerable amounts of plastic waste into the marine environment (Lebreton et al., 2017; Meijer et al., 2021) but are also exposed to the impacts of its presence (e.g. van Emmerik and Schwarz, 2020; Amrutha et al., 2023; Russell et al., 2023). This thesis offered an archaeological perspective on plastic assemblages from archaeological contexts in rivers (Chapter 3) and considered the role of rivers as an important pathway for marine plastic litter. While most researchers would have dismissed and/or disregarded plastic items when undertaking rivers' underwater excavation, reconstructing the itineraries of some plastics that had entered riverine sediments yielded insights on the river's history. The presence of plastics was contextualised as another layer of anthropogenic modification of the river. The role of rivers as a source of MPL was considered when re-constructing itineraries of plastic artefacts by students participating in the story-writing exercise, either online or in-person. This consideration of mainland rivers as part of some stories of MPL from the Pacific Coast (Chapter 4) and Galapagos (Chapters 5 and 6) highlighted the need to consider plastic pollution at a regional scale. But the role that rivers play may also vary locally. It seems that along the Pacific Coast, river transporting plastic shows a non-significant effect on the amount of anthropogenic marine litter (AML) but more studies are needed to determine this (De Veer et al., 2023).

The record of plastic pollution, particularly marine, offers a similar issue to that of the archaeological record. The evidence is only partial and determined by physical (e.g. sinking versus floating plastics) and taphonomic processes (e.g. plastic degradation and fragmentation), and research strategies (e.g. limited transects). Chapter 3 contributed to understanding how marine plastic pollution only represents a fraction of the issue, with riverbeds absorbing sinking plastics into their sedimentary record. When looking at marine plastic litter, plastics reaching the shores of the Galapagos islands only represent a fraction of the issue with plastics travelling further afield and others sinking in the process (Chapters 5 and 6). This contrasts with Barthes' (1957: 159) claim that "plastics are ubiquity made visible". While the ubiquity of plastic is extremely visible in some landscapes covered by plastic pollution, there is plastic pollution that remains invisible to the majority of people, including sinking plastics on the riverbed (Chapter 3) and the seabed, buried plastics (as recovered in Castell Henllys; Mytum and Meek, 2020) and fragmented plastics invisible to the naked eye. In that light, archaeology can investigate those plastics that are not visible and have already become part of the archaeological record, including the stratigraphy (e.g. Rotchell et al., 2024).

The archaeological framework reconstructing the object's journey is helpful to address the issue of plastic pollution in its global entanglements. The pathways of MPL are variable and the framework of object itineraries illustrates how archaeology contributes to understanding global problems, whether present or future (as evident from public perceptions of archaeology in Europe in Kajda et al., 2017). While the global scope of plastic pollution is considered to some extent in all chapters, the main focus of the research is on the Pacific, notably Galapagos. For this reason, a specific discussion on the regional and local contexts follows to contextualise and compare MPL itineraries.

Pacific Plastics: from a regional to a local perspective

The regional context, particularly relevant to the topic of plastic pollution in Galapagos (see sources presented in Chapters 1, 5 and 6), will be presented before discussing the specificities of Galapagos as a UNESCO World Heritage Site (WHS) composed of emblematic natural landscapes and praised for its unique biodiversity currently threatened by the scale of anthropogenic impacts and pressure it is facing (see Alava et al., 2022 for a review of anthropogenic impacts).

The Pacific Region

In this thesis, I chose to focus on Latin American Countries along the East Pacific Coast, and then provide a specific case study of Galapagos. The East Pacific Coast is often discussed at the regional level recognising the common trends in sources and impacts (e.g. Thiel et al., 2018; De Veer et al., 2023), and it is also considered as such as part of the Pacific Plastics: Science to Solutions programme. Adopting a regional lens has many advantages but can also erase local differences and specificities that are often recognised when mapping the density and distribution of MPL (e.g. Hidalgo-Ruz and Thiel, 2013). In this case, understanding the context of plastic pollution in the archipelago required a regional lens, particularly of the East Pacific coast, as most MPL arriving in Galapagos come from mainland South America, notably Colombia, Ecuador, and Peru (Van Sebille et al., 2019), and marine sources (Muñoz-Pérez et al., 2023). Understanding plastic pollution sources, impacts, and solutions at the regional level was needed before addressing how the archipelago of Galapagos is affected by these dynamics and how local views may differ. In light of that, the use of object itineraries was explored as a way to design educational activities and explore perceptions of MPL at the regional level first and then locally in Galapagos.

The regional perspective was envisioned in Chapter 4 which presented the results of the online activity called “My Story of Plastic Litter: A Journey to the Ocean". The stories created by schoolchildren of seven Latin American countries along the East Pacific Coast, and the surveys they answered revealed their perceptions of marine plastic litter, their self-reported knowledge of plastic pollution, and how they engaged in pro-environmental behaviours. Results highlighted a good understanding of local and land sources of plastic pollution in the region. Students’ perceptions of MPL sources seemed to reflect the regional reality: the predominance of land and local sources of AML on the East Pacific Coast (Thiel et al., 2018), which seems notably correlated to beach access (De Veer et al., 2023). Students were concerned about bio-ecological impacts, notably the potential harm to fish and turtles, wildlife often impacted in the region (Thiel et al., 2018). Besides, fish and turtles are respectively important for the livelihoods of people (Martin et al., 2016; Chevallier et al., 2021) and symbolic in the fight against plastic pollution (Geary, 2019). Despite a diversity of preventive solutions being emphasised in the stories, surveys suggested an overreliance on recycling and confusion about what this behaviour entails. High levels of self-reported recycling behaviour may be understood by the participants’ age and/or capacity in the household, and the importance of informal recycling practices regionally and in local education (see Chapter 4 for a thorough discussion). Contextualising the solutions can shape future actions, notably to clarify the meaning of recycling and its limitations in the fight against plastic pollution. Itineraries described by students often crossed those regional and local scales, sometimes considering global dynamics, for example locating plastic production in Asia.

The global nature of plastic pollution affects how itineraries can be mapped and told. Several dynamics are at play when discussing plastic production, use and discard spanning several continents, and which were grasped by students. The regional perspective offered a starting point to explore the story-writing activity and the framework of object itineraries in Galapagos in the Summer of 2022 (Chapters 5 and 6).

The Galapagos islands, specificity of a "pristine" archipelago

The local perspective is provided for the archipelago of Galapagos, a World Heritage Site since 1978 known for its nature and unique biodiversity. The archipelago has been part of global and regional dynamics since the arrival of humans on its shores in the sixteenth century (see Stahl et al., 2020) and plastic pollution only represents another addition to the series of anthropic impacts the archipelago is coping with (see Alava et al., 2022). Plastic embodies better than any other material this inevitable nature/culture encounter despite many people thinking and dreaming of the islands as a pristine paradise.

After the regional perspective provided in Chapter 4, local views of plastic pollution in Galapagos were discussed in Chapters 5 and 6. Chapters 5 and 6 replicated the method used at the regional scale (Chapter 4), using story-writing workshops as archaeological interventions to address the gap of knowledge on local perceptions. Results of the comparative research (see Chapter 5), here including fishing-related marine plastic litter, indicated a good understanding of sources of plastic pollution in the archipelago. Plastic is present in Galapagos, mostly arriving from mainland South America (van Sebille et al., 2019) and from marine activities (Jones et al., 2021). Bio-ecological impacts and their harmful consequences were also fully considered, particularly on fish and turtles, reflecting the trend identified at the regional level. The potential impact of plastic pollution on human health was also addressed in the stories and acknowledged in the surveys. Solutions were overlooked in the stories and surveys confirmed the reliance on recycling and the misconception of the term, an issue already identified along the East Pacific Coast. Contextualising Galapagos in regional and global contexts allowed us to understand the issue of plastic pollution, including how solutions need to consider regional sources and perceptions. The framework of object itineraries allowed students to reflect on the diversity of potential journeys, their global nature, and the relationality of plastic objects with both humans and nonhumans (Chapter

6). The selection criteria, the format of the workshop (in person vs online), and the positionality of the researchers may have influenced the results between the regional and local scales of the case studies. The specificity of the Galapagos archipelago as a World Heritage Site valued for nature may also have influenced the results, along with the remote nature of the islands composing the archipelago.

In islands, plastic pollution is worsened by tourism, the reliance on imports, and the lack of adequate waste management systems. This complex situation is not unique to Galapagos with islands and archipelagos particularly exposed to marine plastic pollution, whether inhabited or not (e.g. Lavers and Bond, 2017 for the unoccupied island of Henderson in the South Pacific; Thiel et al., 2021 for the issue on inhabited Rapa Nui). In addition to processing their waste, islands are exposed to receiving waste on their shores from marine activities notably tourism. This thesis encourages reflection about the specificity of islands, their relationship with tourism, and plastic as toxic heritage, which will be explored in the next section.

Plastics on islands: between tourism and toxic heritage

The first thing that often comes to mind when mentioning Galapagos is nature. Tourists expect an untouched paradise, paying large amounts of money to visit the islands. But this is an illusion, one that is reinforced by the maintenance and control of tourist areas. The Charles Darwin Avenue on Santa Cruz with its souvenir shops and restaurants reflects this contrast between an island shaped by and for tourism. The role that tourism plays as a contributor to plastic pollution makes no doubt. While island-based tourism (i.e. tourists staying on the islands and making a few excursions) adds pressure on the local waste management system, cruise-based tourism contributes to pollution of the marine environment when waste is mismanaged aboard. The issue is worsened by the increasing levels of tourists and the recent change of the tourism model, from floating hotels and cruise tourism to island-based visitation (Hunt, 2021). This increasing popularity of island visitation required the building of infrastructure and the import of food and supplies, with shipments arriving daily to maintain this model of tourism (Hunt, 2021). As tap water is not suitable for consumption in Galapagos, more imports of bottled drinks are necessary to comply with tourists' needs. There is also more pressure on fishing in the Galapagos Marine Reserve to feed tourists, adding to plastic pollution with the occasional loss of fishing gear and/or the disposal of burnt motor oil if port-side disposal facilities are lacking (Ulloa, 2022). Entangled in regional dynamics, the issue of plastic pollution is also a direct threat to the perception of Galapagos as an Eden key to the local economy. This impact was grasped and explored by students in the story-writing workshop (Chapter 6). Plastic pollution is a threat for islands and heritage sites globally, notably when these rely on tourism but are impacted by its consequences.

Islands, plastics, and heritage sites

The challenge of plastic pollution in Galapagos is common for other islands and archipelagos. Small Islands Developing States (SIDS) are among the most vulnerable territories to (plastic) marine litter (Guillotreau et al., 2023). While Galapagos is not officially on the list of SIDS, they all share similar challenges including the reliance on import and ocean resources, the fragility of their ecosystem, an economy based on tourism and fisheries, and their exposure to climate change and extreme events (https://www.un.org/ohrlls/content/about-small-island-developing-states). For example, on the SIDS of Cabo Verde, the import of goods, and the production of waste are overwhelming for the local waste management system incapable of processing it (Ferreira et al., 2021). Self-production is insufficient for the fast-growing population, requiring high quantities of imports generating high amounts of plastic waste that cannot be processed and usually ends in a landfill in the archipelago, most likely to reach the ocean (Ferreira et al., 2021). Plastic pollution represents both a consequence of increasing tourism and a threat to remaining an attractive destination for tourists. The issue threatens the aesthetics of the landscape, particularly for islands relying heavily on tourism (e.g. Seychelles in Dunlop, Dunlop and Brown, 2020; Rapa Nui, Chile in Thiel et al., 2021; Amantani, Peru in Gascón, 2022). On the island of Amantani (Peru), plastic has colonised the landscape just as in Galapagos. There, the perception of plastic pollution as an issue locally seems to depend on the idea that plastics may harm tourism (Gascón, 2022). Independently from those perceptions, the presence of plastic waste poses several issues to islands, particularly if these rely on tourism and are praised for their OUV as World Heritage Sites (WHS).

The impacts of plastic, particularly as waste, on the aesthetics of the natural environment notably beaches are evident in the stories written by students along the East Pacific coast and in Galapagos. The feeling may be more severe on the WHS of Galapagos as nature is key for tourism on the islands, and probably for shaping Galapagos identity (although this remains to be determined as part of Carter Hunt's ongoing project on Galapagos identity). Plastic pollution then represents a threat to WHS and their status, affecting natural and cultural WHS. While WHS status often boosts tourism, visitors' behaviour can become a source of pollution on both cultural (e.g. Castell Henllys; Mytum and Meek, 2020) and natural heritage sites (e.g. microplastics in caves Balestra and Bellopede, 2023). This may threaten the status of these sites, the same status that contributed to the increase of tourism in the first place. The archipelago of Galapagos was put on the list of WHS in danger in 2007 (see Chapter 6 for more details) for the scale of anthropic threats and concern for tourism (UNESCO 2007), and removed from it in 2010 (UNESCO 2010). The latest report in 2023 stressed the concern for increasing levels of tourism and its impacts on the islands, recommending a zero-growth tourism model (UNESCO 2023). The Committee also encourages Galapagos to ensure compliance of the fishing fleets around the Galapagos Marine Reserve (UNESCO 2023). Similarly to SIDS, plastic pollution has concerning impacts on Galapagos. Participants in the activity in Galapagos shared their concern for the impacts of plastics on tourism, health, and wildlife, particularly Galapagos species. Those concerns from participants contribute to the vision of plastic waste as a *threat* to natural places and heritage. This vision contrasts with the recent argument to consider plastic *as* heritage, notably as toxic heritage (see Kryder-Reid and May, 2024).

Plastic waste, a toxic heritage?

Waste is a ubiquitous material of post-industrial landscapes, one that is entangled in social, economic, and/or political relationships (Baird, 2022). The relationship of waste with heritage is a complex one marked by different dynamics. In that perspective, waste can be a threat to heritage or be considered as heritage itself, notably toxic heritage. The discussion below will focus on the values that waste, including plastic can acquire, and the consideration of plastic waste as toxic heritage.

Considering plastics as heritage questions the value(s) contemporary societies assign to them as products but also as waste. While there is no doubt that some plastic products can be seen as highly valued heritage as they hold social, cultural, and economic meaning, the discussion here focuses on plastic waste exclusively. The value of waste has often been a topic of debate from which plastics do not escape (see Chapter 6 for a full discussion). In their socio-archaeological approach to the International Space Station (ISS), Walsh, Gorman, and Castaño (2022) identified that waste could either be seen as a) not valuable and therefore burnt, or b) valued which is then removed from the ISS and brought back to earth. The limited capacity of vessels going back to earth from the ISS required a careful selection of the objects, hence giving them value and importance (Walsh, Gorman, and Castaño, 2022). The value and consideration given to the objects had important consequences for their management, deciding on their becoming. Inspired by forensics, Walsh, Gorman, and Castaño (2022) used the concept of chain of custody, considering the whole process of inventorying, handling, documenting, and disposing of objects with accountable actors for every step. This specific case study contrasts with the lack of accountability characterising most plastic waste, being considered untraceable (see Davis, 2022). While accountability varies greatly for plastic waste, the value assigned to it is key to how contemporary societies perceive and act towards plastic waste.

Recent discussions have highlighted that plastic waste can also contribute to heritage making, either by being reused to maintain heritage practices or by shaping new waste landscapes valued for their extraordinary nature (see Godin et al., in press). The former can be exemplified by Müller et al. (in press) in their illustration of recycled flip-flops used as raw material to build a traditional boat with untraditional material, here plastics, thanks to indigenous knowledge. From that perspective, plastic waste allows heritage-making to survive and indigenous knowledge to be passed to the next generations. Considering plastic waste *as* heritage is a position notably argued for by Holtorf (2023: 119) who considers that plastic trash “forms a kind of distributed World Heritage Site”. In this work, I do not consider plastic trash as forming a “distributed World Heritage Site”. Plastic waste as a heritage site contrasts with its “globalised unlocality” (Davis, 2022: 5), constant transformation and degradation, and the geographical scale of the issue (see Chapter 1). Yet, I recognise that plastic waste affects, shapes and/or transforms heritage sites, whether cultural or natural and that MPL can be considered a type of toxic heritage.

With archaeological theory and practice being influenced by posthumanism, nonhumans are now contemplated when defining heritage. From that perspective, considering MPL and plastic waste as entangled in heritage making is meaningful, as it shapes new relationships with humans and nonhumans alike. In *Heritage Ecologies*, Rinke Bangstad and Pétursdóttir (2021: 5) advocate for:

> an ecology of heritage (that) should attempt to exfoliate the binaries of culture and nature, human and non-human and make room for the appreciation that heritage phenomena are entangled in more-than-human material and environmental processes

Heritage can no longer be perceived as a restriction from the human touch (see Harrison, 2021). This framework is particularly insightful for Galapagos where nature is increasingly becoming *unnatural* with intrusive conservation practices (e.g. mass killings of invasive species and control of female/male ratios of tortoises), carefully orchestrating the illusion of untouched nature. Plastic's overwhelming presence and degradation into fragments that become entangled with nature makes it difficult and almost irrelevant to differentiate nature/culture in the archipelago and most places around the world. The concept of plastic naturecultures was proposed by De Wolff (2017) to address the specificities of plastic-species encounters and the plastisphere. Plastic naturecultures could then become a type of heritage, recognising the threat that these interactions pose and the toxic nature of such heritage.

The threat that plastics pose to the environment, wildlife, and human health turns it into an almost hazardous material or heritage. In that sense, plastic waste belongs to a category of heritage that has recently been gathered under the concept of "Toxic Heritage". The toxicity of heritage is not related to its content but rather to its management and narratives built on it (Wollentz et al., 2020). In that perspective, plastic can be considered toxic waste and toxic heritage more because of its (mis)management than the toxic additives and substances allowing its plasticity. Plastic is also very changeable, a property characterising toxic waste and toxic heritage according to Wollentz et al. (2020). While plastics constitute a type of toxic heritage, they have also been labelled ghost heritage (notablly by Harrison, 2021). The concept of ghost heritage, as haunting unmanaged disposals (Harrison, 2021: 38), proves interesting to approach MPL, particularly to explore the shifts of plastic pollution from an overwhelmingly visible issue on polluted beaches to the invisible ingestion of micro- and nano-plastics by humans and nonhumans. Depending on the beholder, the context, and the degradation, plastics can be overwhelmingly visible, such as in Kamilo Beach, Hawaii, one of the most polluted beaches on earth, or invisible to most humans, such as plastics in river sediments.

Considering plastic waste as heritage is also anchored in the legacy that plastic waste is leaving for future societies, one that already represents the Anthropocene and the Plastic Age. More generally, waste has been perceived as the Anthropocene's legacy (see Harrisson, 2021). But considering plastic waste as legacy and heritage must be done cautiously. The danger in perceiving waste as heritage, even if toxic, also echoes worries about reifing waste and waste fetishism (see Gille, 2010; 2013). The legacy of plastic waste is also unequal, often following colonial dynamics imposed upon indigenous peoples and lands (Liboiron, 2021). Exports of plastic waste have reinforced those colonial dynamics with Global South communities exposed to the hazards that plastic waste provokes. From that perspective, an intersectional approach (after Crenshaw, 1991) helps understand how waste affects people unequally depending on gender, age, class, origin, occupation, and economic possibilities among others. Plastic may represent an important material for women waste pickers from marginalised communities in the Global South relying on this work (e.g. Witmer, 2021) while women from WEIRD (Western, Educated, Industrialised, Rich, and Democratic) societies have economic possibilities allowing them to avoid plastics in their eco-friendly lifestyle. Those disparities were noted in the Galapagos case studies with participants questioning their responsibility and the faith of the islands they inhabit exposed to external sources of plastic pollution.

Independently from the unequal distribution of its legacy, waste remains relational and connected (Baird, 2022) which makes the use of object itineraries particularly relevant to discuss plastic waste. Baird (2022) even proposes to see waste as a teaching tool, one that moves our consideration of waste from nostalgia to repair by considering the social, economic, and environmental problems at its core. Projects based on plastic waste as artefacts can inspire discussions about respect for the environment and the role of human behaviour contributing to the issue (e.g. Holtorf, 2023 for his analysis of the Lego Lost at Sea project). Contemporary archaeology is interested not only in the material culture of us, here plastics, but also in the activities, relationships, and perceptions we develop with and towards these objects. Using an archaeological framework for story-writing activities turns archaeology into a situated practice, one that can contribute to several fields.

Archaeology as situated practice

Adopting perspectives and frameworks from contemporary archaeologies represents an opportunity to advocate for archaeology as a situated practice. The framework recognises that archaeologists are undertaking work *of* and *in* the Anthropocene, here specifically *of* and *in* the Plastic Age. In that sense, archaeology situates and positions itself, just as scholars writing positionality statements. By focusing on plastics as artefacts and material culture, it is important to acknowledge that objects "are constituted always through specific sites and associated practices" (Suchman, 2005: 380-381). Objects, people, and fields of study are defined and questioned through their situations in locations, relationships, and practices. It is thanks to its engagement with material culture and with the contemporary worlds that I consider archaeology, now more than ever, a situated practice, a discipline aware of the impacts that the site/location has on its focus, development, and analytical and interpretative lens. In this thesis, archaeology becomes a situated practice notably by prompting a) activities with students using artefacts *of* the Plastic Age, and b) reflections on policy *in* the Plastic Age.

From archaeology to environmental workshops in schools

Since the discipline of contemporary archaeology has recognised the need to include considerations for the present and future in its approach, the relevance of the discipline has become clearer for contemporary societies. The use of archaeological frameworks in environmental workshops transforms archaeology into a situated practice, here engaging students on the topic of plastic pollution. In the thesis, object itineraries were used as a framework enabling plastics to be observed and examined as artefacts during the workshops.

The case studies (Chapters 4 to 6) illustrated the reconstruction of narratives considered as part of the social lives of objects. Narratives are here not considered as a way to communicate about the issue, but rather to understand local views and perceptions, and prompt reflections about plastic pollution, an often overwhelming issue, in a more tangible way. Those narrative exercises took plastic artefacts as a prompt to reconstruct their itineraries. This explores the role that objects (and their social life) can play in human pedagogy, either explicitly (prompts for telling stories) or implicitly (shaping human cognition) (Hamann, 2002: 353). In this thesis, plastics served as a prompt for online and in-person story-writing activities. The goal of using narratives centred around plastic objects was twofold: a) offer an engaging activity on the topic of plastic pollution and evaluate its impact on participants; b) evaluate local views and perceptions of plastic pollution. Along the East Pacific Coast, the activity proved to be a good engagement tool, leading to an increase in pro-environmental behaviours. In Galapagos, the workshops were part of the curriculum for the Unidad Educativa Nacional Galapagos (UENG), a curriculum specific to the archipelago and emphasising environmental topics from 2022. There, the activity received very positive feedback but did not have a significant impact on pro-environmental behaviours and self-reported knowledge (Chapters 5 and 6), contrasting with the regional case study (Chapter 4). In addition to being good tools for environmental education, the story-writing activities offered a window into local perceptions of sources, impacts, and solutions to plastic pollution along the East Pacific Coast and in Galapagos. Through adopting an archaeology *of* the Plastic Age, the discipline provides a new dimension to environmental workshops.

The diverse chapters comprising this thesis have illustrated how archaeology and/or an archaeological framework can contribute to other fields, including environmental education. Building on the results of the different approaches, it becomes clear that archaeology can also contribute to policymaking, by sharing results and/or analytical frameworks.

From archaeology to policymaking

With archaeologists working in and focusing on the Plastic Age, this thesis used archaeological frameworks to approach local voices and perceptions of plastic pollution. Whether along the Pacific coast or in Galapagos, participants showed a good understanding of sources and impacts of plastic pollution. These positive results, illustrating people's awareness of the situation regionally and locally, call for more emphasis on the implementation of effective policies to limit plastic pollution. As the issue of plastic pollution is global, this section first revises the latest developments of international policies on plastic pollution and the local context of the Galapagos islands, before discussing how archaeology can contribute to evaluating and informing policy.

Aware of the complexity of the issue, the United Nations decided in March 2022 during the fifth UN Environment Assembly (UNEA) that global action was needed and adopted a resolution to develop a legally binding agreement on plastic pollution at the international level by the end of 2024 (Resolution to end plastic pollution: Towards an international legally binding instrument, 2022). To reach a Global Plastics Treaty by the end of 2024, discussions are organised into a series of five Intergovernmental Negotiating Committee meetings (INC 1 - November 2022, Uruguay; INC 2 - May 2023, France; INC 3 - November 2023, Kenya; INC 4 - April 2024, Canada; INC 5 - November 2024, Republic of Korea). The last meeting included comments and views on the Treaty Zero Draft (UNEP, 2023a) and saw the election of Ambassador Luis Vayas Valdieso from Ecuador as chair of the INC (UNEP, 2023b). While discussions and negotiations have still not reached an agreement, several scientists are asking for the Treaty to cap plastic production (Bergmann et al., 2022), as well as to consider how the chemical complexity of plastics hampers solutions (Wang and Praetorius, 2022) and plastics' impacts on human health (Deeney et al. 2022). The negotiations are also seen as an opportunity to learn from Citizen Science and find ways to engage citizens in the development and implementation of the Treaty (Oturai et al., 2023). In that perspective, a meeting occurred at the Royal Society in September to address legacy plastics. The consideration of legacy plastics was missing from the Zero Draft of the Global Plastics Treaty, being only briefly mentioned in a footnote (UNEP, 2023a). While meeting attendees recognised that the problem needed solutions at every level, the presence of plastics already in the environment was identified as a concern that needs to be addressed in the Global Plastics Treaty. A consensus was reached to evaluate environmental impacts, so far largely unknown, and costs/benefits of technologies before implementing them at a larger scale, and in the meantime focus on small-scale solutions closer to the source of pollution that can have important co-benefits, such as beach clean-ups activities (The Royal Society, 2023). Clean-up technologies' efficiency will be location-specific, and their implementation can only be envisioned as a complementary solution to the issue of plastic pollution (The Royal Society, 2023). Plastic pollution is a multidimensional issue, so solutions need to consider the impacts that mitigation strategies may have (Borrelle et al., 2017). For the Treaty to be fair and effective, Dauvergne (2023) suggests a thorough consideration of justice to ensure that the disparities created by plastic pollution are addressed at the environmental, governance, and economic levels among others. Those disparities also appear in the production and use of plastic waste with marginalised groups including women who sometimes are left with no alternative (e.g. Braun and Traore, 2015 on the use of plastic bags by women vendors in Mali; Liboiron, 2021 on indigenous peoples exposed more to the presence and consequences of plastic waste: Papoli-Yazdi, in press on the use and importance of plastic items for garbage communities). As plastic pollution is a global problem, it is entangled in unequal distribution and impacts, reproducing colonial mechanisms embodied in those synthetic polymers.

The position of Ecuador in the Global Plastics Treaty, with the chair of the INC being Ecuadorian, is important to understand the key role that Galapagos is playing in the fight against plastic pollution. As an emblematic World Heritage Site praised for its unique biodiversity and natural landscapes, Galapagos developed a series of local initiatives to avoid plastic use and/or disposal complementing the awareness of the issue by workshop participants (see Chapters 5 and 6). In addition to local initiatives, the legal and policy framework of the archipelago helps reduce plastic use and improve disposal locally. As an Ecuadorian province, Galapagos policies must align with national laws and regulations such as the Ley Orgánica para la Racionalización, Reutilización y Reducción de Plásticos de Un Solo Uso in 2020. There are also provincial and municipal regulations to promote the responsible consumption of single-use plastics, and prohibit the distribution and/or sale of certain products (e.g. plastic bags with handles, single-use plastic cutlery) in Galapagos (Resolución Nro. 005-CGREG-11-II-2015). However, little information exists about the current application of the law. Bustos Paredes (2021: 47) has shown that its application had been jeopardised by the Covid-19 Pandemic, which confirmed a general trend worldwide of policies favouring the use of plastic at this time (Chapter 7). Since then, some products, in theory banned, can still be found in supermarkets on the islands (e.g. a straw accompanying a milk drink; energy drinks including Sporade, Gatorade, …), highlighting the challenging application of those decisions, especially when importing goods. While these policies attempt to reduce plastic pollution from local sources, including residents and tourists, and to limit the pressure on exhausted waste management systems (e.g. landfills being at capacity in Santa Cruz, Isabela, and San Cristobal), plastic litter collected in tons during clean-ups across the archipelago increases the pressure on the landfills once this waste is brought back on the islands (DPNG 2023, pers. com.). This raises the question of responsibility and liability for costs to remove those plastics from the environment and to offer adequate disposal.

The development and implementation of policies are complex but rely heavily on results from scientific research to consider the best approaches. Hopefully, this thesis has shown that findings adopting an archaeological approach can contribute to the development of policies, and also to their evaluation. The former could be explored with the results of the local perceptions of plastic pollution sources, impacts, and solutions. Implementing effective solutions requires understanding local views of the issues and common PEBs (see Chapter 4). Policy recommendations can also derive from archaeological approaches. Previous studies have shown how findings adopting an archaeological approach could be used for policy recommendations. For example, the archaeological study of plastic litter in US streams yielded results that helped the authors to give recommendations in terms of clean-up strategies (Carpenter and Wolverton, 2017). The latter was fully explored in Chapter 7 evaluating reactions and perceptions to plastic policy changes amid the COVID-19 pandemic. This time of crisis was seen as a window of opportunity for policies more accommodating toward plastic products. With the participation of two authors who are archaeologists, the focus on reactions and perceptions of plastic as material culture became a focal point for the development of the methodology explored in Chapter 7. Social media was used as a window into reactions to a changing plastic agenda during COVID-19. Analysis of social media evaluated the relationship between those policies and consumer behaviour, industry pressure, and politics through three case studies. The US case study showed that government discourse could align with industry discourse and vocabulary, valuing the role of plastics in maintaining health standards. While the Mexican case study showed that policies could be perceived as placebo particularly with a contrasting political agenda, consumer behaviour in Australia was not shaped nor considered in the development of policies limiting the use of reusable cups in cafés. Those three approaches were centred on a reflection on the importance of plastics as material culture shaping distinct behaviours. In brief, archaeology can contribute to policy making by sharing research results and by offering a lens of analysis to evaluate policy implementation.

Positionality and legacy of the project

As contemporary archaeology is eminently political (see González-Ruibal, 2008) and researchers are becoming more aware of their positionality (for a good practice see D'Ignazio and Klein, 2020), I wanted to offer a reflection on my positionality, as a western archaeologist working in Galapagos, as well as on the project legacy upon completion of the PhD.

An archaeologist working on plastic pollution in Galapagos

Undertaking my PhD at the University of York in collaboration with the Galapagos Conservation Trust led me to reflect on two aspects of my project and approach. For the first time, I was working on contemporary material culture in the form of plastic pollution, an overwhelming issue of the Anthropocene. My previous background led me to work on temporarily and culturally distant cultures and topics, for example, working on Formative Peru and Classic and Postclassic Maya. The second reflection stems from my role, responsibility, and positionality as a Western woman working in Latin America.

Plastic pollution is a topic surrounding us, from urban litter scattered in most places around the globe to documentaries portraying the scale of the issue, and alternatives to help reduce the amount of plastic used and disposed of. Never had I been facing my research topic daily for more than three years, offering painful reminders of the difficulties of living a plastic-free life. The temporal and physical distance, presented as a way to reach an objective interpretation of the past, is praised by traditional ways of doing archaeology but is almost nonexistent in contemporary archaeology. For archaeologists working on issues of the Anthropocene, there are limitations and opportunities. Opportunities to use our common sense (after Joyce, 2020) and turn what may seem anecdotal to other researchers (e.g. brands) into data revealing trends and behaviours. Limitations include navigating the changing temporal and geographical scales, obliging us to think in a global and somehow overwhelming way. While this lack of distance has been a common critique of the subfield of contemporary archaeologies, it also offers an incredible opportunity to reflect on plastics as artefacts. However, focusing on the topic of plastic pollution can provoke ecological anxiety, and contemporary archaeologists have much to learn from other disciplines accustomed to studying *us* and our environment. Some distance from the research topic may be needed and acquired by contemporary archaeologists, at least to maintain a healthy relationship with the research goals and surrounding environment.

As a Western woman archaeologist who has worked in Latin America for the past 9 years (but who had never been in Galapagos before 2022), I am in constant questioning of my positionality and legitimacy working there. Due to the COVID-19 restrictions at the start of my research, the design of the project methods and scope was undertaken without much prior (non-academic) knowledge of the realities of Galapagos and the local priorities. This situation challenged my preferred approach of contributing to local questions and/or needs. However, an approach based on co-design and reflections with local partners requires time and resources, sometimes contrasting with university and funding requirements and academic timelines. Working in Galapagos for the first time also required creating and building a network of colleagues interested in the topic and happy to think about common projects. From that perspective, the story-writing workshops in Santa Cruz were designed with Anne Guézou, environmental educator and botanist resident of Galapagos and co-author of Chapters 3 and 4. While pitching the proposal to local directors, Anne (2022, pers. com.) noted an interest in the activity, particularly as it could be an integral part of the new curriculum in Galapagos with an emphasis on environmental topics. Organising the workshops brought a series of challenges, from the varying sizes of the room to the energy of teenagers, and the chase for student and parental consents. Working in Galapagos required adapting to the rhythm, needs, and priorities of the archipelago, realising that plastic pollution may not be the biggest issue for local livelihoods facing notable water insecurity and scarcity (e.g. Reyes et al., 2017; Nicholas et al., 2020), and lack of adequate healthcare facilities (e.g. Page, Bentley and Waldrop, 2012).

The complexity of research permits in Galapagos became a challenge, particularly as the original proposal was never accepted by the Galapagos National Park Directorate. Familiarising myself with key partners and tensions between different institutions proved essential and would have occurred earlier had it not been for COVID-19 restrictions. Several projects are occurring at the same time, and it is difficult to get acquainted with those while in the UK. Research priorities at the local level are shared by the institutions asking different groups of scholars to investigate the same research question. Different research groups then end up working on similar projects. In 2022, I found out while in Galapagos that a focus on labels, brands, and key information about plastic as artefacts was about to be implemented by another research team from Spain. This led me to re-orientate the research scope, in a constant re-adjustment of the aims of my thesis (see Covid impact statement). Spending more time in Galapagos and developing those key relationships with institutions earlier in the project could have prevented those readjustments. But circumstances did not allow for that to happen. It has taught me how to best implement this in future research by encouraging communication and collaborations across disciplines, particularly when investigating topics *of* and *in* the Anthropocene, as illustrated in this journal-style thesis with 15 co-authors in total.

Many challenges arose during the project including the almost daily interaction with plastics as an overwhelming material culture, the implementation of the project in Galapagos with diverging priorities from the institutions in the archipelago, and the development of the collaboration with a non-academic partner, in this case the Galapagos Conservation Trust. Those limitations and challenges were overcome in the production of a paper-style thesis covering several topics. While the research outputs are very different to those originally planned, unique opportunities arose during this research for more collaborative practices with academic and non-academic co-authors, also contributing to questioning and hopefully shaping the legacy of the project. While it is sometimes difficult to project oneself in the middle of the issue, this process taught me that any challenge can be transformed into an opportunity. My personal recommendations for anyone undertaking work on plastics, in the Pacific region and/or in collaboration with non-academic stakeholders are the following: 1) be aware that different priorities can co-exist and remember where you research fits in this bigger picture; 2) be flexible and adapt to the situations you find yourself in; and 3) collaborate with people from other disciplines, especially as different expertises can bring a novel light on your research.

Throughout this project, I used archaeological frameworks to develop archaeology as a situated practice and became a contemporary archaeologist more aware of her positionality in the specific context of the Galapagos. Those questions and a will to share research outcomes led me to envision the legacy of the project and return to Galapagos in the Summer of 2023 to present the results and do public outreach activities.

Legacy of the project

The PhD project was funded for three years through the White Rose College of the Arts and Humanities (WRoCAH) contributing to the University fees and the fieldwork expenses, and also received the support of the Office of Philanthropic Partnerships and Alumni (OPPA) funding my stipend at the University of York. It overlapped with the four-year funding of the Pacific Plastics Science to Solutions and Plastic Free Galapagos Programme. Such timelines contrast with the scale of plastic pollution as a global issue beyond human lifetime. The complexity of temporality is also visible in the gap between the rapid action needed to limit plastic pollution (and similarly for climate change), and the time required to undertake multidisciplinary studies of the issue. After a review of my positionality and approach to contemporary archaeology as situated practice, this section presents how I envision the project legacy and what actions were undertaken after the workshops held in the Summer of 2022.

Even more so when research involves human participants, it is important to develop a strategy for the project's legacy. In the Summer of 2022, the workshops were undertaken with the help of Anne Guézou and results were analysed in 2022-2023. It was important for both of us to share the results of our analysis locally. In addition, the post-survey of our workshop asked participants if they wanted to share their stories online or as part of an exhibition. The vast majority of participants (96%; N=153) were willing to do so, amongst which 58% agreed to include their names. Building on these answers and our intention to share the outcomes of the research, a second visit was organised in the Summer of 2023 to share the results with participating schools and the wider community in Santa Cruz. Bilingual panels summarising our study's results and providing background on the issue of plastic pollution in Galapagos were designed as a way to inform tourists, students, and residents alike. I designed the content of the panels (Figures 1 and 2) and shared it with different research teams from the PPSS network and received very useful feedback from the network, my supervisors John Schofield and Colleen Morgan, the Charles Darwin Foundation (CDF), and GCT.

Figure 1a: Panel designed for the Open House at the Charles Darwin Foundation on plastic pollution sources

Figure 1b: Panel designed for the Open House at the Charles Darwin Foundation on plastic pollution's impacts

Figure 1c: Panel designed for the Open House at the Charles Darwin Foundation on solutions to plastic pollution

LOCAL PERCEPTIONS OF MARINE PLASTIC LITTER IN GALAPAGOS

How do the inhabitants of Galapagos perceive the problem of plastic pollution and what measures do they take?

Study

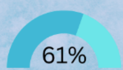
- Over **330 students** from two schools in Santa Cruz (Colegio Tomás de Berlanga and Unidad Educativa Nacional Galapagos) joined a workshop on marine plastic pollution.
- Students could choose among **11 objects** found on Galapagos shores to write stories or draw comics.
- With the help of 7 questions, they **re-created the itinerary of these objects**.
- **Stories** highlight perceptions of sources, impacts and solutions while **surveys** assessed knowledge, perceptions and behaviour before and after the activity.

So one idea of how a bottle from the Nongfu factory could have got to Galapagos is via the Chinese ships, either because they dumped it into the sea themselves or because they dropped it by accident and there was no opportunity to pick it up.

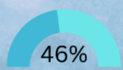
Anonymous

1 Sources

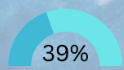
- **Research:** regional marine activities, oceanic currents and local activities contribute to the issue of plastic pollution.
- **Stories:**
  - Fishing industries, tourism and local activities were the most recurrent contributing sectors mentioned.
  - Loosing or forgetting the object were identified as the most recurrent behaviour.
- **Surveys:**



fully agreed with marine litter coming from remote areas



fully agreed with marine litter coming from fishing activities



fully agreed with marine litter coming from domestic activities on the archipelago

Figure 2: Panels designed for the Open House at the Charles Darwin Foundation, focusing on local perceptions of marine plastic litter

Using the panels, a series of activities were organised to disseminate the results. On the 21st of July 2023, PPSS members, CDF staff, and myself presented information on plastic pollution in the Galapagos and the results of my analysis during the Charles Darwin Open House where all students from the TdB came to visit (Figure 3). We also organised sessions with the UENG, other schools, and local groups to share the outputs during a small session presenting the issue of plastic pollution and how local understanding was approached in the Summer of 2022. Finally, the methods used in this research to approach perceptions were shared in a workshop with educators from different NGOs. The different activities to present the results provided a platform to ask for feedback on the content and measure how much participants reported they had learnt during an activity that presented sources, impacts, and solutions to marine plastic pollution. Results indicated that all participants (N=8) self-reported knowing more after the activity than before and all enjoyed the exhibition (4 and 5, with 1=not at all to 5=very much). They mostly enjoyed writing a message for the world (see Table 1) and then the section on solutions. When asked to indicate the frequency of some PEBs, participants rated recycling as the most frequently adopted followed by the reduction of single-use plastics. While a bigger sample is needed to identify trends, sharing knowledge about plastic sources, impacts, and solutions while including local views proved engaging and could be adopted more systematically across the Galapagos islands.

Figure 3: Pictures of outreach activities at the Charles Darwin Foundation and in the Charles Darwin Avenue

In addition to these activities, future work is needed to share the outcomes of the study and raise awareness on the issue of plastic pollution for residents and tourists. The panels displayed at the Open House were also printed to be displayed at the hostel, Galapagos Morning Glory, and are currently in the process of being uploaded and available to all schools in the islands, thanks to the support of Funcavid. In collaboration with the Charles Darwin Foundation, we are currently designing a bilingual exhibition in the Van Straelen building at the Charles Darwin Research Station on the island of Santa Cruz. This exhibition will share the content presented at the Open House, summarising the existing research on marine plastic litter origins, impacts, and solutions for the archipelago, as well as displaying some stories and local perceptions of the issue. The content was made available to institutions (in print for the participating schools and digital resources for CDF and GCT), and the format of the workshop was also shared with local educators and teachers. There is potential to replicate and/or implement this activity, not necessarily for research. An archaeological framework helped shape different approaches, and maybe one line of investigation to understand solutions to plastic pollution. This has been explored through perceptions of the issue and the focus on material culture as a way to understand and inform policymaking.

Table 1: Messages written by participants in Summer 2023, answering the question: What would you want to tell the world about plastic pollution?

Stop throwing rubbish into rivers, seas, because that is why there is a lot of pollution in many places and that rubbish also affects Galapagos because many animals die or eat rubbish thinking it is food. STOP THROWING RUBBISH INTO THE SEAS.
They should avoid throwing rubbish in order to avoid the cruel issue we are going through in Galapagos.
Be aware of the use of litter.
That they should see how our planet and our island is being lost. For example: birds, fauna. It is our home, it is the enchanted islands, the most beautiful and exotic thing in the world, take care of it.
Be aware of what you use and consume to avoid using more plastic and littering the streets and the ocean.
Be aware and do not pollute the environment as we may cause animals to mistake rubbish for food, etcetera.
Recycle and take care of the place where you are because such a beautiful ecosystem cannot be found just anywhere.

We could avoid the use of plastics and avoid littering as it is harming animals, and microplastics have already been found in people which means it is also affecting our health.
When littering, don't just think of yourself, think of the harm you can do to animals.
Plastic is not bad, bad is the excessive use of plastic, the senseless use of plastic, people who overbuy (plastic) products. Plastic is a help as long as it is used in moderation. Nowadays it is not helpful because of its overuse.
That they have to be aware that the Galapagos Islands is a unique place in the world, where we live from the tourism of the tourists.
Anyone who pollutes or litters and affects animals should raise awareness and think twice before throwing rubbish wherever they want.
Do not throw rubbish into the sea because it is transported to different parts of the sea and damages these ecosystems.
Let's take care of these beautiful islands where unique and incomparable endemic animals live, by recycling waste or reducing its use.

Final thoughts

Plastic pollution is a global and complex issue, one that no discipline can resolve alone. Archaeology has a contribution to make as illustrated in this thesis that explored contemporary archaeologies of plastic pollution theoretically and in several case studies across the globe. The first aim was to propose a theoretical framework which is presented in Chapter 2. With plastic pollution becoming an object of study and of concern for archaeologists, I suggested that this could be done by viewing plastics as artefacts, stratigraphy markers and components of waste landscapes. These elements were explored across the case studies with plastics as artefacts having itineraries (Chapters 4 and 5), as markers of riverine stratigraphic contexts (Chapter 3), and as components of global waste landscapes (Chapter 6). The second aim explored a series of methods across the case studies, including the framework of object itineraries (Chapters 3 to 6), story-writing workshops (Chapters 4 to 6), and social media analysis (Chapter 7), all considered to some extent archaeological interventions. The results presented showed the potential of those archaeological methods. These methods contributed to the understanding of plastic pollution through considering plastics as artefacts, approaching behaviours and perceptions, offering engaging activities and providing a framework to evaluate and contribute to policymaking. The third aim had a geographical component, using archaeology to improve the understanding of plastic pollution in the Pacific, particularly in Galapagos. This focus was part of the agreement of the Collaborative Doctoral Award (with the Galapagos Conservation Trust). Despite the challenges to implement the research in Galapagos highlighted in the Covid impact statement, the workshops undertaken in Galapagos shed light on local perceptions and knowledge of plastic pollution. Those perspectives were not represented in the literature beforehand and hold the potential to contribute to the implementation of solutions at the local (Chapters 5 and 6) and regional levels (Chapter 4), reinforcing the potential of archaeology to contribute to policymaking (Chapter 7).

While the contribution of archaeology to the issue is clear, the framework allows us to question how we perceive, value and act towards plastics as artefacts within our daily lives. In that light, I use this conclusion to come to terms with the circularity that plastics have not (yet) managed to comply with, and therefore re-consider Barthes' (1957: 159) quote presented in the introduction:

> More than a substance, plastic is the very idea of its infinite transformation, it is, as its vulgar name suggests, ubiquity made visible; and in this way, it is a miraculous material: the miracle is always a sudden conversion of nature. Plastic remains imbued with this astonishment: it is less an object than a trace of a movement.

Already in the twentieth century, plastics were everywhere, considered by Barthes as "ubiquity made visible". Plastics have since become even more visible, the situation being only exacerbated in the twenty-first century with the importance of plastics highlighted by companies during the COVID-19 Pandemic and the ongoing accumulation of plastic waste. Plastics have permeated all aspects of our lives, from their production, use, and disposal as waste. Despite plastics being a visible issue of the Anthropocene, this thesis has shown that the problem with plastics can also become invisible to humans because of the size and/or the location of plastic fragments in sedimentary and stratigraphic contexts. Plastics fragment, entering the environment, sometimes creating new forms of entanglement with the geology. In that sense, plastics are not only ubiquity made visible; they are a ubiquitous material for humans and nonhumans, permeating all environments without distinction.

Barthes also considered plastics to be more the “trace of a movement” than an object. The reconstruction of plastic itineraries across several chapters highlighted that plastics do embody what is often a global movement. The use of object itineraries to trace plastics’ journeys highlighted connections at the global, regional, and local levels. The flows of plastic from a liquid good to a weathered fragment may incite us to think that plastics are more traces than objects. Yet, it is the materiality of plastics (and a return to things following Olsen, 2003) that served as a basis for the creation of the itineraries and helped students to engage actively on the topic of plastic pollution. Facilitated by the consideration of macroplastics, the case studies also provoked reflections on microplastics and chemical contamination including potential harm to human health. The consideration of the spatial traces left by plastics were only possible through the acknowledgement of plastics’ material properties and their observation as artefacts.

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