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Assessment of the ocean plastic crisis leading to the development of The Marine Plastic Certification Standard

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Abstract

Over the past few years, growing awareness has been reported on the global ocean plastic pollution crisis. Organizations have jumped on that crisis and have turned it into business opportunities. However, the extent of this crisis is often not well known and little, or no regulation exist to oversee the claims organization make in that blossoming ocean plastic market.

After a thorough analysis on the ocean plastic crisis, this thesis' objective is to shine light on the ocean plastic market and critically assess the already existing certifications available on the market to defend the relevance of the development of a new certification scheme: The Marine Plastic Certification Standard.

Through an empirical research, the different elements of the certification will be drafted and then adjusted to address at best the market by considering commercially interested parties, uninterested parties (such as NGOs) and customers.

All in all, after a detailed writing process, a final version of the certification standard will be presented followed by the further steps needed to launch a certification scheme on the market.

After months of research, analysis, meetings, challenges, and countless hours spent writing it, I can proudly put an end to my master thesis. I did not think I was going to learn that much. It was a very interesting journey thanks to the support of essential persons. I would like to take the time to thank them.

First, I want to thank my supervisor, Carlos Desmet not only for having assisted me throughout this year with good advice but also for giving me the opportunity to write my thesis on this captivating subject.

Second, I also want to thank François van den Abeele not just for opening my eyes on the ocean plastic industry but also for the guidance he gave me since the very beginning.

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General introduction

Today's society is facing major environmental threats, the ocean plastic pollution being one of them. The extent of this threat is yet not well known. Growing awareness has been reported and on the market the term "ocean plastic" rings a bell without knowing for sure what it is. Before to start writing this thesis, I was also at that early stage. However, an opportunity has led me to throw myself deeper into the subject.

Since September, I have had a first-row view on the new fast-growing ocean plastic industry. On the one hand, as I performed a six-months internship within Sea2See, an organization manufacturing eyewear and watches from marine plastic, I had to inform myself on the issue the organization was trying to turn the tide on. But also, I was able to discover the ups and downs of the market. On the other hand, I had the task of finding a certification scheme to get recognition for what the organization is achieving. None of the already existing schemes were matching the objectives. This is when I realized there was an opportunity on the market, the development of a new certification standard.

This feeling has been confirmed by a claim Boyan Slat, Founder of the Ocean Cleanup, made when in the process of making a product from plastics collected in the Great Pacific Garbage Patch:

It is important to realize that for ocean plastics claims, there is no real standard, no hard definition of what ocean plastic means. It is a kind of murky definition which could mean 100% plastic from the ocean or 1% plastic from the ocean. It is even possible that none of the plastics at all came out of the ocean. It is quite crazy. (The Ocean Cleanup, 2020)

It was impossible to trademark ocean plastic even though it would have been the ultimate solution for those kinds of false claims. However, it naturally resulted in the desire to develop a new certification scheme in the scope of my master thesis which led me to the following title:

*Assessment of the ocean plastic crisis leading to
the development of The Marine Plastic Certification Standard*

Mainly, the purpose of this thesis is to understand what ocean plastic pollution is and how organizations have turned it into a business opportunity. This analysis will lead us to the discovery of the market flaws and the needs for a credible certification scheme.

For that matter, this thesis is divided in two distinct parts. First, a theoretical part that will cover an extensive literature review. Herein, a study will be made on the ocean plastic crisis from when the first plastic was issued up to now. This will be accompanied by a critical analysis of organizations having turned that crisis into an opportunity along with already existing certification schemes. Finally, the most important principle to be a credible certification will be explained as this is one of the major flaws in the market.

The second part focuses on a practical approach with the development of a new certification standard. Emphasis will be put on the argumentation for the chosen elements in the standard. Then, a panel of stakeholders will be involved in order to confirm and/or adapt the drafted standard according to the needs of the market. Through these reviews, the goal is to have a first-hand opinion on the certification scheme and to catch their potential interest. In the end, potential next steps will be detailed with the objective of launching the certification scheme on the market.

Part 1: Theoretical review

Introduction

The very first-time plastics hit the market was around 1950. At that time, 2.5 billion people were living on earth and the global production of plastics accounted for 1.5 million tons. Today, the global population is 7.8 billion and global production of plastics is more than 360 million tons annually. To put things in context, the world's population rose by 212% while there is a boost of 23,900% in the manufacture of plastics. If this trend continues, by 2050 we can expect to accumulate another 33 billion tons in the environment. (UNEP & GRID-Arendal, 2016)

As mentioned previously, this literature review will focus on the plastic pollution issue and its omnipresence in the marine environment. First, an extensive research will be developed in order to define what ocean plastic is. Indeed, lots of different terms are used interchangeably to refer to nearly the same concepts.

Second, a review of the global plastic pollution will be made. Therefore, we will go back to when the very first plastic was issued and how it has been discarded since then. Next, country-specific waste management systems will be detailed to discover the major sources of ocean plastic pollution. This will be followed by the status quo of our oceans and the impact the current pandemic has had and still has on the ocean plastic crisis.

Third, a thorough research will be made to bring light on the several, recorded, negative impacts plastics have on the marine environment. Those impacts will be detailed per category, i.e., marine life, environment, social and economic impact.

Fourth, an analysis will be conducted to identify actions currently put in place and those that are meant to be launched in the future. On the one hand, actions from governments detailed per region with the aim of banning the usage of (single use) plastic. On the other hand, certification schemes wanting to shine the light on organizations trying to turn the tide. This includes organizations responsible for collecting, recycling, and manufacturing products from ocean plastic. This will be followed by the presentation of a case study on Seaqual; a case that will demonstrate that some actions lack transparency and/or regulation and tends to mislead the

consumer. Indeed, buying a product made from ocean plastic is appealing but how can we be sure it was truly collected from the ocean?

Finally, the importance of traceability systems will be developed as well as the interesting role blockchain can play. This will be detailed thanks to a real-life case on traceability for fishing activities by the company Provenance Ltd.

The aim of this literature review is to increase the awareness on the ocean plastic industry. Clearly, people do now know that we are experiencing an ocean plastic crisis but often they do not realize how frightening the situation is. Then, as people are getting more conscious, and express their desires to consume more sustainably, organizations have jumped onto this desire. However, with no regulations nor clear definitions, organizations are free to interpret ocean plastic to fit their business. This outburst of consciousness that will arise after having read this part, will justify the need for the development of The Marine Plastic Certification Standard which will be the focus of the second part.

Chapter 1: What is Ocean plastic?

In the face of a new trend where companies want to use recycled ocean plastics in their manufacturing, many different terms are used to define the origin of the plastic collected and recycled.

First, ocean and marine are both used on the market to define a similar concept and/ or raw material. But as it will be explained further, the issue is that the term ocean plastic is often used as a misleading tool to influence the end consumer. Many organizations use different definitions in order to fit their activity and the origin of the plastic they collect. After having researched several definitions used on the market¹, ocean plastic is defined as plastic that has been lost or discarded in the marine environment and is found on beaches and coasts, the ocean floor and surface, rivers, and estuaries.

However, to adequately determine the precise origin of ocean plastic, different areas of collection must be determined. The Oceanworks organization proposes an interesting model that separates ocean plastic into five sections (Appendix 2, pp. 91). First, offshore, which suggests all material far from shore, including accumulated floating “gyres”. Second, nearshore that represents all material suspended in the shallow or adjacent areas of the ocean that are close but not accumulating on the shoreline. Third, waterway that suggests material found in streams, rivers and other waterways and make their way towards the Ocean. Next, coastal which designates all material that has washed up onto beaches and coastlines. Commonly those are fragmented places and show signs of degradation. Finally, ocean-bound which represents all material collected from communities that possesses no formal waste management and is situated within 50 km of the shoreline. (Oceanworks, 2020)

In Oceanworks’ model the ocean-bound plastic term is mentioned. This term is commonly defined according to Jenna Jambeck’s research as being any mismanaged plastic waste generated by a population living within 50km of a coast globally that has the potential to enter the Ocean as a marine debris. (Jambeck, et al., 2015) Although this definition is broadly used, many critics question whether a plastic collected 50km from the ocean can be considered as ocean plastic. This topic will be addressed throughout my thesis.

¹ The analysis that led to the choice of term & definition can be found in Appendix 1, pp. 88

Chapter 2: Global plastic pollution

We constantly hear about the ocean plastic pollution and the single-use plastic bans that are implemented worldwide to face that issue. However, it is important to understand how plastics became one of our generation's major threats. In order to understand that we must go back to when the very first plastic was produced and disposed, how they made their path to the oceans and how much plastics are currently in the marine environment.

2.1 The evolution of plastic

In the consumer marketplace, plastics have become increasingly dominant since their commercialization in the early 1950's. The largest sector for plastics is packaging, i.e., materials created for immediate disposal. (Jambeck, et al., 2015) But this is not the only application. PlasticsEurope released a report wherein the European plastic demand is detailed by segment in 2019. Packaging and building & construction account for more than half of the end-use market with respectively 39.6% and 20.4%. Those are followed by automotive (9.6%), electrical & electronic (6.2%), household, leisure & sports (4.1%), agriculture (3.4%) and finally; others (16.7%) which include appliances, mechanical engineering, furniture, medical, etc. (PlasticsEurope Market research group (PEMRG); Conversio Market & strategy GmbH, 2020)

The plastic packaging growth was accelerated due to a global shift from reusable to single-use containers. This can be attributed to the increase of on-the-go snacks and ready-made meals which implies throwing away durable plastic packaging material right after use. By 2050, estimation has been made that a 50% increase in global food supplies will be required to follow the increase in global population growth. Therefore, as the demand for food will rise, so will the demand for packaging material. Currently, 50% of the plastic derived from fossil fuels are meant for food packaging. (K. Ncube, U. Ude, N. Ogunmuyiwa, Zulkifli, & N. Beas, 2020)

The plastic production has been successful as it has an immense potential. Indeed, plastic is not only cheap to produce, but also possesses ideal properties: lightweight, strong, resistant, flexible, or rigid, opaque, or transparent. They can be adapted to every kind of use. At first, plastics were designed to last. However, most plastics were produced for applications with a

short lifespan which are typically landing into our Oceans. (Abreu & Predrotti, 2019) According to the 2020 report of the Ocean Conservancy and the International Coastal Cleanup, the top 10 items collected during their international coastal cleanups are food wrappers, cigarette butts, plastic beverage bottles, plastic bottle caps, straws & stirrers, plastic cups & plates, plastic grocery bags, plastic take out/away containers, other plastic bags & plastic lids. (Ocean Conservancy; International Coastal Cleanup, 2020) All top 10 places are occupied by debris made from plastic and have all a very short time of use.

Approximately 50% of all plastic objects made are meant for single use and only 20 to 25% for long-term use. Consequently, as production and use of plastic materials has significantly increased, the amount of waste generated by the world's population has also increased. Despite a high potential for recovery, roughly 50% of all plastic produced have too little value according to their recovery to be economically viable.

In order to have more precise numbers on the issue we can analyze figure 1 (pp. 8). Globally, materials produced and used to make plastic from 1950 till 2015 have encountered the following lifecycle. In 65 years, an estimation of 8,300 million tons (Mt) of virgin plastic had been produced. Out of this, only 30% of plastics are still in-use. This is mainly in the construction sector as most of the packaging plastics are used in the same year they are produced. Hence, cumulative waste generated by primary and secondary (recycled) waste amount for 6,300 Mt. Of which, approximately 12% have been incinerated and 9% have been recycled. Thus, around 60% of all plastics ever produced were discarded and are accumulating on landfills or in the natural environment. This eventually results in pollution and more specifically: ocean plastic pollution. From this analysis, bio-based and biodegradable plastics have been excluded. Nevertheless, they currently have a global production capacity of 4 Mt. (Brock, 2020)

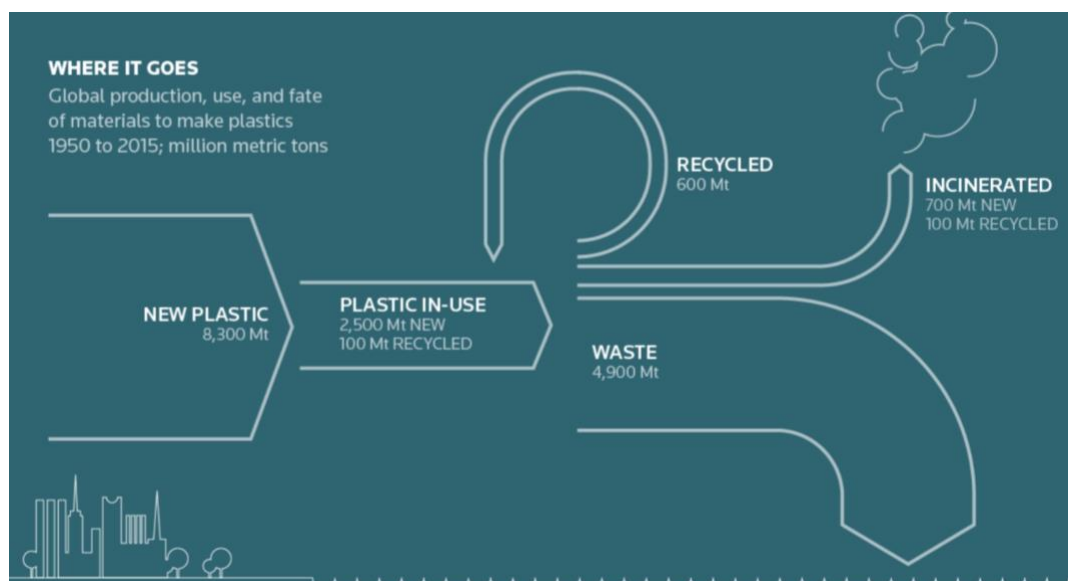


Figure 1: Lifecycle of plastics from 1950 till 2015

Ocean plastics can be categorized regarding their size. Harmonization between research on plastic categorization does not exist. This lack of consensus regarding, on the one hand definition as demonstrated in the previous part, and on the other hand categorization of ocean plastics brings along consequences such as ambiguous communication and generation of incompatible data. In this thesis, the criterion of size and origin is used to identify the differences. Other criteria exist namely: chemical composition, solid state, solubility, shape & structure, and color. Nomenclature is typically used to categorize ocean plastics as nano-, micro-, meso-, and macroplastics. Hartman's research proposes the following categories (Hartmann, et al., 2019) :

- (1) nanoplastics: 1 to < 1000 nm
- (2) microplastics: 1 to < 1000 μm
- (3) mesoplastics: 1 to < 10 mm
- (4) macroplastics: 1 cm and larger.

Then, there are two different classifiers when considering the origin of microplastics. Those are categorized as primary and secondary microplastics. (Hartmann, et al., 2019) Primary microplastics are the small plastic particles that directly enter the marine environment in that shape. Secondary microplastics are the result of a larger piece breaking up into smaller fragments. Single-use plastic bags accounts for a large source of microplastic as they break up very easily under contact with sun and seawater. (Abreu & Predrotti, 2019; Alessi & Di Carlo, 2018)

2.2 Country-specific plastic waste management

According to figure 2 based on Jambeck's research, clear proof has been found regarding mismanaged plastic waste in Eastern, Southern and South-East Asia but also in West and North Africa. (UNEP & GRID-Arendal, 2016)

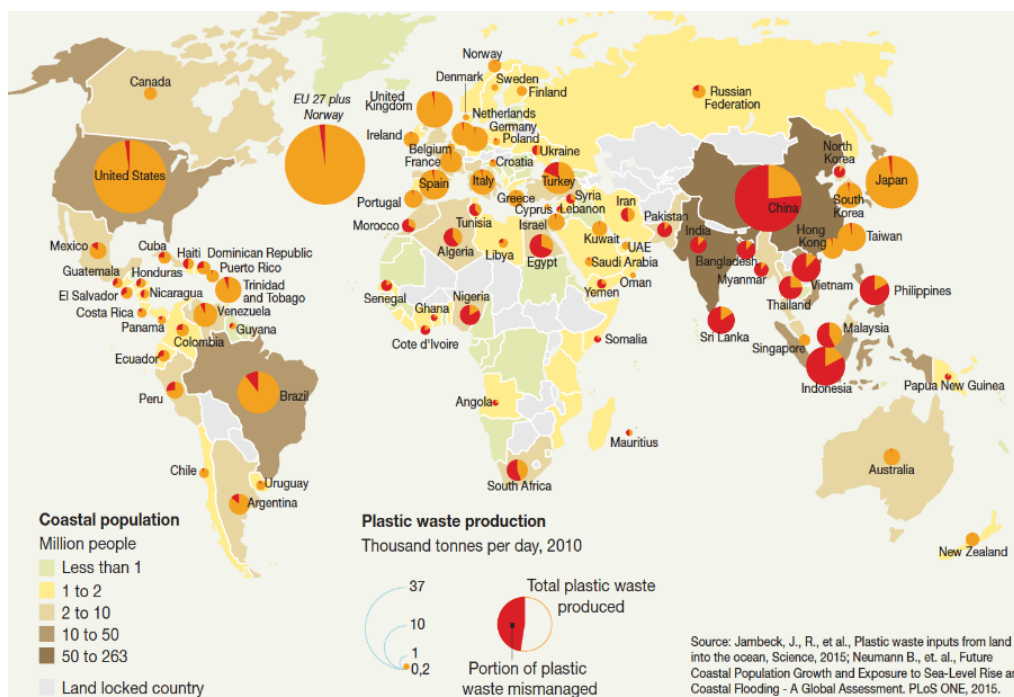


Figure 2: Plastic waste produced and mismanaged²

The conclusion that can be made when combining this data with figure 3 (pp. 10) is not surprising. Indeed, the ten rivers highlighted on the map are specifically located in the regions just mentioned previously. The UN environment has concluded that those rivers are responsible for 90% of the plastic waste that enters the ocean. The Yangtze River in China is the biggest ocean polluter with the transport of 1,469,481 tons of plastics per year. The smallest polluter is the Mekong River in South-East Asia with an export of 33,431 tons of plastics per year. (Unenvironment, 2020) Clearly, proper waste management is drastically needed in those areas.

² (UNEP & GRID-Arendal, 2016)



Figure 3: Major rivers responsible for ocean plastic³

If the world keeps up with this trend regarding plastic production and waste management, by 2050, around 12,000 Mt (1 Mt = 10^6 ton) of plastic waste will be left out in landfills or in the natural environment. This number is significantly high as the vast majority of monomers used in production of plastics, i.e., propylene and ethylene, are derived from fossil hydrocarbons. Thus, rather than decomposing, all plastics ever produced, when not disposed otherwise, are accumulated. (Geyer, Jambeck, & Law, 2017)

On top of that, around 60% of plastic ever produced is less dense than seawater. This means that when introduced into the marine environment, light-weighted plastics can easily be transported by surface currents and winds, recaptured by coastlines, degraded into smaller pieces (i.e., microplastics) by the action of sun, temperature variations, waves, and marine life. (Lebreton, et al., 2018)

Even though plastic production has not stopped increasing since its discovery, the awareness around single-use plastic has increased and pushed the governments to take actions. Over the past five years, the number of countries adopting regulations on single-use plastics has doubled. Today, 137 countries that have adopted or planned by 2021 to limit plastic pollution account for 86% of the global population (6.6 billion people & 93% of GDP). But 60% of those countries have implemented regulations only limited to single use plastic bags. Clearly, this kind of plastic is problematic, but they represent only a small part of the issue. On top of that,

³ (Unenvironment, 2020)

significant structural capability gaps exist on crucial markets that simply lacks basic infrastructure and systems to keep plastic in circulation after use. (WWF, The Ellen MacArthur Foundation, & BCG, 2020) Hence, it is important to have a look at country-specific initiatives. As demonstrated previously, the biggest contributors to ocean plastic are mainly Asia and Africa. Appendix 3 (pp. 91) lists in a clearer way the top 20 countries regarding mismanaged waste with China being the leader. Hence, it is important to dig into the possible actions those countries undertake.

There are two ways to deal with plastic waste, either domestic management or export. Due to environmental risks combined with benefits, plastic waste flows have become regular business from high-income to low-income countries since the 1990's. China was the main importing country (55.7% of world's plastic waste) and largest plastic producer. This has led to a series of environmental issues as 70% of the Chinese plastic waste has been buried or mismanaged. As a response, on July 27, 2017, the Chinese government decided to ban the import of 24 types of solid waste including plastics, named "Prohibition of Foreign Garbage Imports". Therefore, in 2018 (Figure 4), the global plastic waste trade plunged by 45.5% compared to the previous year (Figure 5, pp. 12) (Wen, Xie, Chen, & Doh Dinga, 2021)

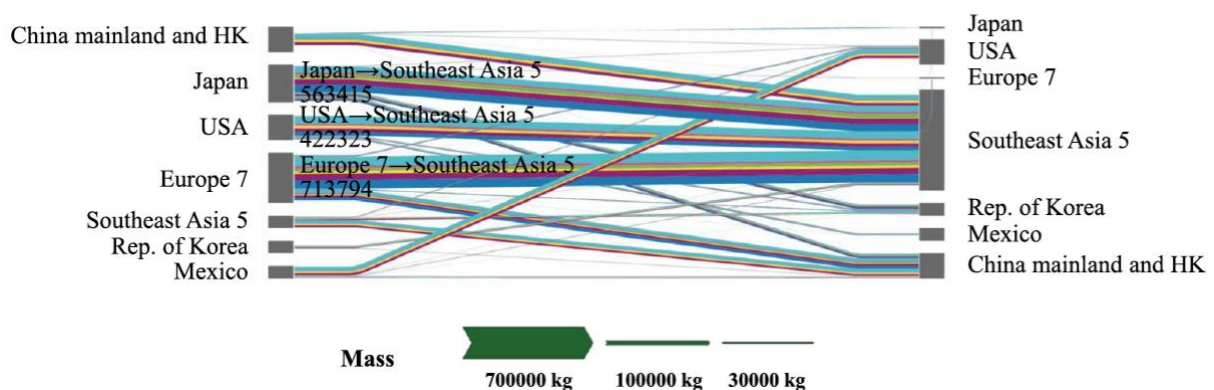


Figure 4: Global plastic waste trade 2018⁴

⁴ (Wen, Xie, Chen, & Doh Dinga, 2021)

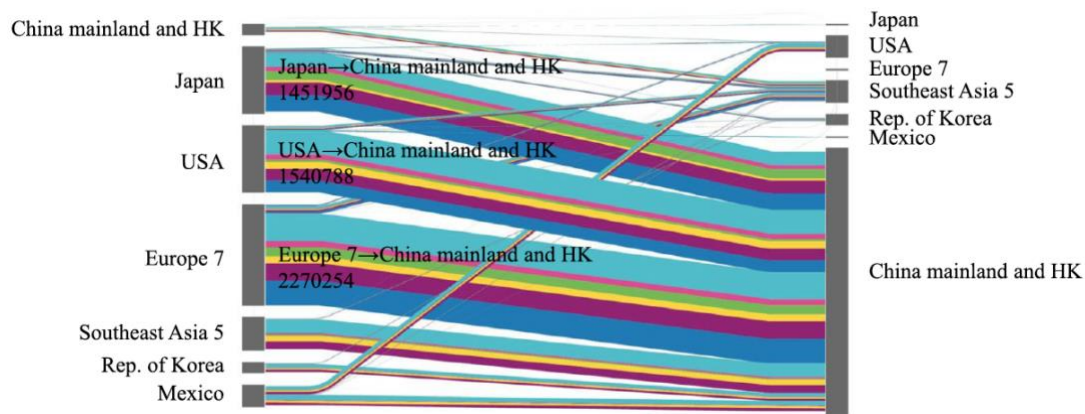


Figure 5: Global plastic waste trade prior to the ban⁵

Besides China, five Southeast Asian countries were also important destinations for plastic waste, namely Thailand, Indonesia, Vietnam, Malaysia, and Philippines. Those countries became the top export destinations following China's ban (Figure 4, pp. 11), Malaysia being the first choice among the five. The total import of those five countries surged to 362% compared to 2017. As predicted, China's ban resulted into the diversion of countries' waste to other destinations. (Wen, Xie, Chen, & Doh Dinga, 2021) China also announced that by 2025 it will ban all in-country single-use plastics. This will occur in different stages over the years and starts with prohibiting the distribution of single use straws and plastic bags in major cities by the end of 2020. (Earth.org, 2020)

Next, according to Figure 2 (pp. 9), India is also an important ocean polluter. The country announced in 2019 a countrywide ban on different single-use plastics by 2022. The most common form of single-use plastics in India are the multi-layered packaging used in small bags for packing and storing products such as gutka (chewing tobacco), chips, or liquid food. Following the call for banning, the plastic industry raised major objections and claimed that if no imminent alternative arose, their sales would decrease sharply. The prices of FMCG goods were also expected to increase as they would have to shift to alternative packaging. This would have led to the wiping out of various low-price products which are very common in India. Those product cost less than Rs 5 (= 0.056€) and are vital for first-time consumers to experience categories at an affordable price. They play a key role in serving the rural market. (Kaur, 2019) Due to those adverse reactions, the government quickly backtracked. Instead, they will rely on voluntary measures to reduce their plastic pollution. (Earth Island Journal, 2020)

⁵ (Wen, Xie, Chen, & Doh Dinga, 2021)

Then, the last continent actively contributing to ocean pollution is Africa. African countries suffer from many waste management challenges linked to their high population growth rates, rapid urbanization, growing middle-class population which leads to increasing consumption rates and finally high levels of poverty. Altogether, within a few decades, Africa will potentially become the most plastic polluted continent. (Marlin & Ribbink, 2020) However, in Sub-Saharan African countries, two policy instruments have already been in use, namely complete or partial ban accompanied by taxes or fees on plastic products. Nations having implemented these instruments are Rwanda, Kenya and Uganda and South Africa. (Ayeleru, et al., 2020)

Finally, a word on Europe. In 2018, the European commission adopted a European strategy for plastics in a circular economy. The focus is to transform the way plastic products are designed, used, produced, and recycled in the European Union by also contributing to the Sustainable Development Goals. (European Commission, 2018) Linked to this strategy, the commission has set standards to ban single-use plastics such as straws, cotton buds, drink cups, etc. by 2021. Now, due to the COVID-19 situation, many industries are calling to lift the ban on single-use plastic. The argument they put forward is that the freedom of circulation of plastic products is necessary to keep hygiene, health, and safety in the supply chain of most products. The European Commission stood strong and waved those calls away by not postponing the plastic ban by 2021. (Simon F. , 2020)

In a nutshell, governments worldwide have shown their will to address the issue at its source. However, we are still quite far from achieving the ultimate goal of preventing any more plastics from entering the marine environment (i.e., oceans, lakes, rivers, etc.). Certainly, the epidemiological situation the world is facing has and will affect the plastic crisis in a negative or positive way. The next section will try to answer that question.

2.3 Impact of COVID-19 on plastic use & disposal

Since December 2019, the world has been affected by a pandemic due to a novel coronavirus, namely SARS-CoV-2, which is responsible for a severe respiratory syndrome called COVID-19. This has raised the attention and fear of governments, medical staff, the scientific community, and the public to urge for prevention and control of its transmission. Not only did the COVID-19 have an influence on plastic use but also on its waste management. (Patrício silva, et al., 2021)

First, we will have a look on the plastic use during this period. Due to the pandemic crisis, the consumption of single-use plastic has been aggravated as populations wear personal protective equipment (PPE) such as masks and gloves. The demand for such equipment, PPE, severely increased and soon became accompanied by a significant increase in the use and disposal of other single-use plastics. According to estimations, the demand for plastic packaging is expected to rise by 40% and 17% for other applications. Indeed, people are looking for safe grocery shopping and prefer to consume fresh-food products available in plastic containers to avoid food contamination and plastic bags to carry groceries. (Patrício silva, et al., 2021)

It has also been assessed that monthly 129 billion face masks and 65 billion gloves are used globally. Many of those are disposed incorrectly as proof has been found in public spaces. Those light weighted plastics are then easily carried out by wind, streams, rivers, and currents with the result that residues from the COVID-19 pandemic will likely be a common debris item found in the environment for decades. (Prata, Patricio Silva, Walker, & Duarte, 2020) According to the WWF report, over 10 million masks could be introduced in the environment monthly if only 1% is incorrectly disposed of. Considering each mask weighs roughly 4g, this means that 40,000 kg of masks would enter the natural environment each month. (WWF, 2020)

Although news has been largely diffused that single-use masks are a threat for the environment and especially for the marine one, people still prefer them thanks to the reduced care they require. Indeed, using reusable mask protection demands more effort as a decontamination process is needed. But studies have shown that the use of such reusable masks consequently reduces the amount of waste by 95%. (Patrício silva, et al., 2021) In the same sense, no study has proved that reusable grocery bags could contribute to a higher transmission compared to clothes or shoes. And even if they could, the potential risk could be mitigated with proper hand hygiene. (Prata, Patricio Silva, Walker, & Duarte, 2020) On the contrary, research has shown that a viable SARS-CoV-2 virus persists longer on plastic surfaces than on any other material. (Patrício silva, et al., 2021)

Second, concerning the waste management of potentially infected plastics; incineration and landfilling are being prioritized over recycling. (Patrício silva, et al., 2021) The main reason here for is the risk of contamination. Indeed, researchers led by Dr. Vincent Munster of NIH's National Institute of Allergy and Infectious Diseases (NIAID) investigated how long the virus remained infectious on different surfaces. Scientists tested the viability on plastic, stainless

steel, copper, and cardboard. They concluded that SARS-CoV-2 remained active on plastic and stainless steel for two to three days while it survived for up to 24 hours on cardboard and four hours on copper. (National Institutes of Health, 2020)

Finally, it is then with no surprise that the demand for recycled material from packaging businesses has dropped by 20 to 30% in Europe compared with the previous year (2019). The combination between the impact of the pandemic and the low oil prices has been and still is a double challenge for plastic recyclers. (Brock, 2020)

2.4 How does plastic enter our oceans?

Previously, the country-specific analysis allowed us to discover who the biggest polluters were and find out that some major rivers account for a large amount of ocean plastic pollution. However, it is still unknown how plastics find their way to the marine environment. Appendix 4 (pp. 92) is a proposed framework to understand the different pathways plastic can encounter before entering the marine environment from resin production through loss or discard.

The first point of loss is caused by spillage or mishandling of industrial resin pellets. These are one of the first plastic debris items reported in the ocean. Then, once resin is converted into plastic products, those can enter the ocean unintentionally during use or after disposal as waste. Discarded plastic products, when proper waste management is used, are contained, and designed to minimize loss to the environment. However, wastewater discharge occurs depending on the treatment process. By contrast, improperly managed waste includes open dumping, disposal in open (uncontained) landfills, and littering. Next, unintentionally loss of in-use plastic products occurs during catastrophic events such as hurricanes, tsunamis, or floods. This causes the loss of large amounts of any kind of material into the marine environment. The major source of ocean plastic, globally estimated, is improperly managed waste generated on land. (Law, 2017)

2.5 Assessment of the marine environment

Floating waste when drifting with the sea currents can sometimes travel impressive distances. Those plastics then gather and stick together to form plastic batches. Worldwide, our oceans count five garbage patches. These are massive collections of plastic debris that were drawn

together by large systems of currents in the ocean, or gyres. That way, waste may end up in areas where there is little to no human activity. For example, large quantities have been found in the Arctic. Marine currents act here as real “navigable pathways” for waste. (Surfrider Foundation Europe, 2018)

The water approaching the center of the gyre eventually must exit and this is done by sinking to depths up to a few hundred meters. Plastic brought in the same way to the center of the gyre due to constantly spiraling water does not travel downward as it is too buoyant. Instead, it stays trapped in the converging current. (van Sebille, et al., 2015) Over time it has led to the formations of five big litter aggregation regions; each associated with one gyre. In these regions, ocean plastics appear in much higher concentration than elsewhere in the ocean. (UNEP & GRID-Arendal, 2016) Here under an overview of the five patches discussed according to the order (1 to 5) given on figure 6 (pp.17).

First, The North Pacific Gyre (1) also called The Great Pacific Garbage Patch is located between California and Hawaii. The Ocean clean up, an organization that aims at cleaning up the garbage patches, has tried to quantify the amount of waste located in this area. This patch covers an estimated surface of 1.6 million square kilometers with debris weighting approximately 80,000 tons. (The Ocean Cleanup, 2020)

Little information exists on the four other Garbage Patches as they are less researched. Nonetheless, the following could be retrieved. First, the Indian Ocean Gyre (2) is roughly located halfway between Africa and Australia. Because of its remoteness, the Indian Gyre remains a bit of a mystery. It was discovered by sailors who claimed it comprises a massive area of approximately 5 million square kilometers with no clear boundaries. This area fluctuates often; hence, can change from one day to another. (Parker, Plane search show World's Oceans are full of trash, 2014)

The location of the three last gyres namely, the South Pacific Gyre (3), the North Atlantic Gyre (5) and the South Atlantic Gyre (4) are shown here under.



Figure 6: The five ocean garbage patches⁶

Commonly, marine debris found in the ocean is composed of plastic, metal, glass, paper, cardboard, textile, and wood. Nevertheless, 80% of the observed debris are plastics. (Maryvonne, 2010) Lost or discarded fishing nets account for a great amount of plastic that lands into the ocean. They are of concern as they yield a direct negative impact on the economy and the marine ecosystem. (Lebreton, et al., 2018) Most plastics are not degradable and will remain in the environment for decades. While a cigarette pug remains 5 years, a plastic bag stays around for 20 years and a plastic cup 50 years and more shockingly; a fishnet will last in the ocean for 600 years. (Alessi & Di Carlo, 2018)

According to research made in the North Sea and around Australia, an estimated 70% of the amount of macro-waste stock lies on the ocean floor, 15% floats on the surface and the 15% left is on the coast. (Maryvonne, 2010) While macro waste of plastic is the most visible form of ocean plastic, microplastics are the ones who have a significant impact on the marine environment. (Alessi & Di Carlo, 2018)

Waste in marine environments degrades landscapes and amenity uses. It constitutes physical traps and lures for marine fauna, particularly mammals and certain commercial species. It can expose populations and food chains to health risks and have negative effects on the quality of water and habitats. They affect the safety of navigation and professional fishing activities.

⁶ (The Ocean Cleanup, 2020)

(Maryvonne, 2010) The following chapter will focus on the exact impact waste has on the marine environment. This includes the environmental impact but also the social and economic one. Even though research on plastic has been growing over the past decade, the understanding regarding the holistic effect of marine plastic and its impact on its ecosystem is still very little. Current research is based on small scale and local analysis. Nevertheless, a solid understanding of the impact of marine plastic is key to inform a global transition on how we make, use and reuse plastic by eliminating negative impacts. This requires implications for public behavior, legislation, governance, industry, and commerce. (Beaumont, et al., 2019)

Chapter 3: Impact on the marine environment

The impact of marine debris is cause for concern for many reasons. It has been proven to be harmful to organisms and human health, have the potential to multiply transport of organic and inorganic contaminants, present a hazard to shipping and damage aesthetic landscape; hence, generating socio-economic consequences. Written reports detailing impact of marine debris on marine life began appearing in the 1960s with fatalities documented for birds, turtles, fish, and marine mammals. Nonetheless, high degrees of uncertainty exist towards marine debris data especially on the amount of debris entering the marine environment and the extent of its impact on the ecosystem. (Gall & Thompson, 2015)

The presence of marine litter in birds, turtles and mammals has been well documented. A review revealed marine litter was found in 100 % of marine turtles, 59 % of whales, 36 % of seals and 40 % of seabird species examined. (Kühn, Bravo Rebolledo, & van Franeker, 2015; UNEP & GRID-Arendal, 2016) Moreover, Gall's study (2015) provides an extra review on current knowledge of the effects of marine debris on marine organisms where 340 original publications were analyzed that documented those encounters. For a total of 693 species, 76.5% of all reports listed plastic which makes it the most reported debris type. (Gall & Thompson, 2015) In this chapter, the different socio-economic impacts will be explained in detail.

3.1 Impact on marine life

Many interactions occur between marine debris and species. For most of them, the interactions have a negative impact. The only species for which it has a positive impact are for bacteria and algae. Appendix 5 (pp. 92) provides a summary of the effects marine debris have on different species.

Apart from the direct impact marine debris have on the marine life, which will be detailed in this section, marine debris might also have an indirect impact. Indeed, a study has shown that a pathogenic bacterium, namely vibrio, travels the waters on microplastics. This pathogenic bacterium brings along serious consequence for the ecosystem. Vibrio is a short rigid motile bacterium that is straight or curved rods and includes pathogens causing mainly gastrointestinal disease (e.g., cholera) to humans and animals. (Merriam-webster, 2020) Proof has been found on microplastic particles in the North and Baltic Sea. Indeed, microplastics act as vectors for the dispersal of pathogens. This phenomenon is known as Plastisphere which refers to a diverse microbial community of heterotrophs, autotrophs, predators, and symbionts. The vibrio dominated one of the plastic samples from Zettler's study. (Zettler, Mincer, & Amaral-Zettler, 2013)

Globally, around 700 marine species are threatened of which 17% are classified by the International Union for Conservation of Nature (UICN) as "threatened" or "in critical danger of extinction", notably the Hawaiian monk seal, loggerhead turtle and sooty shearwater. More than 90% of the damages caused to marine fauna are caused by marine debris, i.e., plastics. Damages are mainly due to capture, ingestion, and contamination as well as the transport of exotic species. (Alessi & Di Carlo, 2018) This is also known as "ocean rafting" which is the transport of marine animals, plants, and microbes along large distances in the ocean. Hence, marine organisms can hitchhike on plastic and be deposited hundreds of miles away from their native habitat which increases opportunities for non-native species introductions. (Haram)

Four types of impacts of marine debris on marine life exist being entanglement, ingestion, contamination, and interaction. Each type of impact has been researched and synthetized here under. Appendix 8 (pp. 94) provides an overview of the impact marine litter has on the marine life (considered as environment) regarding their size and type.

3.1.1 Entanglement

Due to abandoned fishing lines and nets but also six-pack can ring and packaging, animals get encircled, constricted, or entangled and taken in the trap in what are called death traps. In the Mediterranean Sea, the principal victims are birds (35%), fish (27%), invertebrates (20%), marine mammals (13%) and sea turtles. (Alessi & Di Carlo, 2018) Another study realized in 2015 suggests that the most affected species within 344 varieties are: Polar Bears, Divers (Gaviiformes), Turtles, Whales, and Seals (Appendix 6, pp. 93). (Kühn, Bravo Rebolledo, & van Franeker, 2015)

Plastics can cause wounds, lesions, and deformations that result in the animal not being able to move and escape from their predators, swim, and feed themselves. Those have fatal consequences of animals starving to death, drowning, or becoming easy prey. The deadliest plastics are fishing materials which are abandoned or thrown away and become true danger for animals. This phenomenon is more commonly known as “Ghost fishing”. (Alessi & Di Carlo, 2018)

3.1.2 Ingestion

Marine species ingest intentionally or accidentally plastic components or indirectly by eating prey who fed themselves with plastics. Nowadays, 90% of sea birds worldwide have plastic fragments in their stomach. In 1960, only 5% of them had some and by 2050 this number could increase to 99% if no measures are taken regarding the flux of plastic that enters the ocean each day. Almost no marine species are spared except for bacteria and algae (Appendix 5, pp. 92). Even the zooplankton, which lays at the very beginning of the marine food chain feeds unconsciously on plastic fragments smaller than 1 mm. This is preoccupying as the zooplankton transmits it further into the food chain to finally be fed to humans. (Alessi & Di Carlo, 2018)

Some may ask themselves; how can marine species confuse plastics with their food. Birds, for example, choose their food thanks to their smell. Hence, plastics can be confused with food as they get in touch with bacteria and algae which results in the issuance of a sulphury smell that birds associate with food. This is called the “Olfactory trap”. Some fish are victims of the same trap and confuse it with Krill, their main food. Others confuse plastics due to their appearance. Sea turtles, for example, confound plastic bags or balloons with jellyfish. (Alessi & Di Carlo,

2018) The most affected species are Divers, Dugongs and Sea Cows, Toothed Whales, Eared seals, Turtles, Whales and Albatross (Appendix 7, pp. 93). (Kühn, Bravo Rebolledo, & van Franeker, 2015)

3.1.3 Contamination as a consequence of ingestion

The third threat is the phenomenon of silent poisoning caused by chemical pollutants. Marine debris present in the ocean contains organic pollutants, such as pesticides, phthalates (salt or ester of phthalic acid (Dictionary, 2020)), PCBs (family of highly toxic chemical compounds consisting of two benzene rings in which chlorine takes the place of two or more hydrogen atoms (Dictionary, 2020)) and bisphenol A (white solid having a mild phenolic odor (Dictionary, 2020)). An estimated 78% of them are toxic (i.e., they have a direct negative impact on organisms they get in touch with), persistent (resist against degradation processes) and accumulate in the tissues of living organisms. The negative effect of those pollutants differs depending on the speed at which they circulate in the organism. Plastics diffuse up to 30 times more pollutants while in the body tissues (i.e., intestines) than in sea water. (Alessi & Di Carlo, 2018)

3.1.4 Interaction

The last threat encountered by marine organisms with plastic debris is called interaction. This includes among other things, non-entangling contact with litter. It has been demonstrated that fishing gear causes tissue abrasion and breakage when interacting with sessile invertebrates in a coral reef ecosystem. Also, a variety of plastics items on the seabed have caused changes to ecological assemblages (meaning a narrow group of species co-occurring in the same location, on the same time), and death by suffocation. Furthermore, hypothesis have been brought to light regarding seafloor debris that might act as a barrier. This brings along some consequences for marine life such as preventing light to penetrate, reducing the exchange of oxygen, and preventing the delivery of settling organic matter to sediments. (Beaumont, et al., 2019)

3.2 Environmental impact

The manufacture, use, and disposal of plastic is one of the most conspicuous anthropogenic activities. Those activities result in the increase of atmospheric levels of carbon dioxide (CO₂), methane (CH₄), ozone (O₃), sulfur dioxide (SO₂), chlorofluorocarbon (CFC), and nitrogen dioxide (NO₂), all together well-known as greenhouse gases. Those are causing the earth to grow warmer and warmer. (Reichle, 2020)

The ocean plays a crucial role in containing the global climate change thanks to the absorption and storing of CO₂ from the atmosphere. This process is possible as phytoplankton soak up sunlight and capture CO₂ for photosynthesis which produces oxygen. As planktons are at the base of the food chain, the carbon they absorbed, will eventually be settled into marine sediments on the ocean floor. This whole process from carbon removal from the atmosphere till the absorption into seafloor sediments, is called the biological pump. (Septania, 2020)

Currently, oceans are the world's largest natural carbon sink, as they already absorbed 30-50% of the atmospheric carbon produced since the beginning of the industrial era. (WWF, The Ellen MacArthur Foundation, & BCG, 2020) However, how much carbon dioxide is being absorbed by the oceans is an active area of research. The question whether microplastics will interfere with the carbon absorption of oceans has been studied and four types of scientific evidence have been found to prove its potential truth. First, microplastic can affect phytoplankton's photosynthesis and growth. Although that specie is very small, it is the major primary producer of the ocean which accounts for 80% of the total oxygen production of the earth. Second, zooplankton's development and reproduction are affected by the toxic effect of microplastics. (Shen, et al., 2020) A research led by Cole et al. (2016) reported that zooplankton's capability to uptake and consume carbon can be reduced due to the ingestion of microplastic as it causes satiety. Microplastic ingestion by zooplankton is a global phenomenon. Third, microplastics may affect the marine biological pump which is the main way for the ocean to absorb CO₂. Finally, the presence of microplastics on the ocean floor may affect the ocean carbon stock. Plastics usually don not stay at the ocean's surface, only 1% remains at the top. Indeed, plastics have a high ability to sink to the bottom which may affect the circulation of organic matter and nutrients on the seabed, thus affecting the ocean carbon stock. (Shen, et al., 2020)

Furthermore, plastic pollution causes habitat damages. On the one hand coral reefs are very susceptible to get damaged by abandoned, lost, or otherwise discarded fishing gear. The movement of nets and ropes due to winds or currents can cause unprecedented harm. On the other hand, mangroves may act as partial sinks for plastics in certain areas as marine debris tends to collect in mangroves forests. (UNEP, 2016)

3.3 Social impact

Marine ecosystems around the world provide a multitude of ecosystem services, i.e., benefits that people obtain from nature, including food provision for the global population, carbon storage, waste detoxification, and cultural benefits such as recreational opportunities. Any threat to these ecosystems can have a significant impact on human wellbeing, through loss of food security, livelihoods, income, and good health. (Beaumont, et al., 2019)

Seafood is the principal source of animal protein and accounts for more than 20% of food intake for 1.4 billion people (18% of the world's population). Due to marine plastic, efficiency and productivity of commercial fisheries and aquaculture are affected by physical entanglement and damage but also regarding fish stocks. Human contamination with marine plastic will eventually occur when the entirety of a contaminated organism is eaten (e.g., mussels, oysters, anchovies). (Beaumont, et al., 2019) Indeed, estimations state that, on average, Europeans ingest up to 11,000 particles of microplastics per year due to shellfish consumption. Researchers have proven that microplastics are present in the mussels' intestinal tract. Nevertheless, the microbial toxicity within the body is difficult to estimate and the effect on human's health is uncertain. Generally, it is stated that nanoplastics ($< 1 \mu\text{m}$) have a higher risk than microplastics as they can enter human cells. However, little research exists on this topic. (Kurtela & Antolovic, 2019) Even though proof exist on human's exposure to microplastics through their diet, and that microplastics present in seafood organisms could affect food safety, understanding regarding actual fate and toxicity of those plastic particles in humans constitute a major knowledge gap. (UNEP, 2016)

Overall, the productivity, viability, profitability and safety of the fishing and aquaculture industry is highly vulnerable to marine plastic pollution especially when coupled with external factors such as climate change and over-fishing. (Beaumont, et al., 2019)

Additionally, floating macroplastics represent navigation hazards. A collision may lead to injury or death following loss of power caused by entangled propellers or blocked water intakes. (UNEP, 2016)

Finally, marine plastic has a direct impact on recreation, i.e., aesthetic values. Indeed, recreational users of coastlines are frequently exposed to plastic and experience a multitude of wellbeing impacts. Marine litter on the shores is disliked and is a key reason why people spend less time in these environments. People will even avoid certain areas if they have knowledge of littering. This results in economic costs, from clean-up to loss of tourism, which will be explained in the next part. Shore littering can also cause visitors and maritime workers a range of injuries such as cuts from sharp debris, entanglement in nets and exposure to unsanitary items. Wyles et al. (2019) have also demonstrated that spending time on littered coastlines can affect people's mood and mental wellbeing. (Beaumont, et al., 2019)

To sum up, the UN environment has documented in 2017 the impact marine litter has on the society regarding their size and type. (Appendix 9, pp. 95)

3.4 Economical impact

Economic activities directly impacted by marine debris include shipping, fishing, aquaculture, tourism, and recreation. In some cases, industries affected by marine debris are also its source but eventually most of the polluters do not bear the cost of polluting. (UN Environment, 2017; UNEP & GRID-Arendal, 2016)

Direct impact on fishing and aquaculture includes fishing vessels & equipment and plastic contamination of the catch. This is mostly caused by floating plastics affecting engine cooling systems and getting entangled in propellers. Indirect impact is related to the “ghost fishing” phenomenon, as this sector is affected by the loss of target species because of it. Total losses are unknown. (UNEP, 2016)

The economic cost of plastic entering the ocean is estimated at 13 billion dollars per annum due to environmental damages caused on the marine ecosystem. This includes financial losses of industries such as fishing and tourism, but also time spent to clean up beaches. (Alessi & Di Carlo, 2018) However, limited, and small-scale cleaning experiment conducted by Gheschiere

et al. (2006), reveals that beach clean ups are short sighted and considered as a temporary cure. Indeed, while the near surface meiofauna⁷ has the capacity to quickly recover, repeated cleanings or deeper excavations can result in significant slower recolonization rates. (Zielinski, Botero, & Yanes, 2019)

In a nutshell, the UN environment has documented in 2017 the impact marine litter has on the economy regarding their size and type. (Appendix 10, pp. 96)

Chapter 4: Call to action

Sufficient research has been brought to light stating that the ocean plastic crisis is real, and that action is needed. This part focuses on forecasts researchers make on how the future will look like and the different goals global leaders have set in order to handle this plastic crisis.

4.1 Wake-up call

Hoornweg et al. (2013) warn in their research that without drastic action, population growth and urbanization will outpace waste reduction. (Hoornweg, Bhada-tata, & Kennedy, 2013)

Researchers say that if the world continues its current path, the ocean will contain 1 ton of plastic for every 3 tons of fish by 2025. By 2050, the ocean could even contain a bigger proportion of plastics than of fish. It is a global urgency that must be addressed quickly. Indeed, the fight against marine pollution is one of the focuses of the United Nations Sustainable Development Goals, namely goal 14: life below water. (Alessi & Di Carlo, 2018) This goal focuses on the conservation and sustainable use of the oceans, seas, and marine resources for a sustainable development. In total, seven targets (Appendix 11, pp. 97). have been set and must be achieved by 2030. (United Nations, 2020) On top of that, since 2018, the United Nations has put the ocean plastic pollution on the list of the six biggest environmental issues. (Alessi & Di Carlo, 2018)

⁷ organisms in the size range of 50–500 µm (Fenchel, 1978) or 50–1000 µm (Higgins and Thiel, 1988), and can include large ciliates as well as metazoa (e.g., rotifers, copepods, oligochaetes). (Bott, 1996)

4.2 Forecasts about the future

The expected future growth of the plastic industry depends on two factors: the increasing global population and the demand for plastic consumer goods that is correlated with the increasing buying power of a global growing middle class. The United Nations estimates that by 2050 the world's population will reach around 10 billion people primarily in Asia and Africa. The middle class is expected to grow significantly by 400 million households by 2039. The plastic market expansion will occur at that time.

To put things in context; Africa for example demonstrates the complications laying in the way for taking over control on plastic waste in the coming decades. Indeed, even though the continent has a low waste generation rate, it also has limited environmental regulations, weak enforcement, and an incompetent waste management system. Hence, with a population explosion becoming more urban and buying habits changing along with higher standards of living, Sub-Saharan Africa is foreseen to become a dominant region in municipal waste production. (Parker, 2020) However, as noted by Yasin et al. (2010) and UNEP (2018), limited reliable, geographically comprehensive waste and water quality data are available for Africa which makes it hard to assess to potential impact of waste and wastewater systems. (Yasin, Kroeze, & Mayorga, 2010; UNEP, 2018) In the absence of reliable waste and water quality data; data concerning population growth and economic development can give insights into the potential geographic areas of concern. According to the United Nations' Department of Economic and Social Affairs, more than 50% of the expected population growth till 2050 will come from ten countries from which six are in Africa, namely (ranked by their expected contribution to growth) Nigeria, the Democratic Republic of the Congo, Ethiopia, Tanzania, Uganda, and Egypt. Nevertheless, there is growing concern by both citizens and governments around plastic leakage in the environment. This results in many African countries already implementing single-use plastics bans with discussions on planning further regulations. On top of that, there is a growing response from actors of the plastic industry to address the current waste problems in Africa. But also, social innovations such as in Nigeria, Wecyclers which focuses on community-driven collection systems associated with financial rewards for recyclables. (Jambeck, Moss, & Dubey, 2020)

4.3 UN treaty on plastic pollution

In October 2020, WWF has published a report in collaboration with the Ellen MacArthur Foundation and the Boston Consulting Group. This report called “the business case for a UN treaty on plastic pollution” aims at eliminating plastic leakage into the ocean by a specific date. (WWF, The Ellen MacArthur Foundation, & BCG, 2020)

This treaty addresses four critical elements (WWF, The Ellen MacArthur Foundation, & BCG, 2020):

1. Definitions, i.e., agreeing on a set of harmonized standards and definitions across all markets.
2. Policies, i.e., agreeing on clear and common national targets and action plans to achieve the objectives.
3. Reporting, i.e., agreeing on global reporting metrics and methodologies across the plastic value chain.
4. Implementation support, i.e., establishing international capacity building mechanism such as funding to build waste management systems.

An international treaty on plastic pollution is the best way to address the issue as it is a global one. At the moment, two million citizens⁸ are calling for a treaty and more than two-thirds of the UN member states, from across the world, have officially declared that they are open to considering the option of a new global agreement. Negotiations on such a treaty is expected to start at the 5th Session of the United Nations Environmental Assembly (UNEA) in February 2021 (no update on that at this point).

⁸ Ongoing petition on WWF, on May 17th, 2,060,981 persons have signed the plastic petition #StopGhostGear (WWF, 2020)

Chapter 5. The ocean plastic industry

Many organizations are looking to get into the recycling industry and especially the ocean plastic industry. On the one hand, as the awareness towards ocean plastic pollution increases, more businesses want to make a change. On the other hand, bans on virgin plastic arise and alternatives are emerging. For both sides, manufacturing product from ocean plastic is an interesting storytelling that is appreciated by the end consumer. Indeed, recycled packaging is considered as the best option when aiming for environment-friendly packaging and is therefore a business opportunity as this market is at still at an early stage with long way to grow. (Magnier, Mugge, & Schoormans, 2019)

5.1 Case study: Seaqual

As more and more organizations are getting interested in recycling and commercializing ocean plastic, the fear of greenwashing is being felt. On the market, many products are claiming to be made from ocean plastic when most of the time only a small portion of it effectively comes from the ocean. In order to demonstrate this statement, the Seaqual case will be discussed.

Seaqual initiative is an organization claiming to upcycle marine plastic. They work with waste management and recycling industries to convert marine litter into Upcycled Marine Plastic. Brands and manufacturers can then buy that material and create sustainable products. Nevertheless, some figures are appealing. Indeed, an estimated amount of 600 tons of waste has been cleaned from the oceans while only 99 tons of marine litter has been transformed into Upcycled Marine Plastic by the organization. 99 tons is very little when considering the big number of brands who claim having already worked with Seaqual. By digging deeper into the raw material, Seaqual yarn, which is sold to global brands such as IKEA, Fiat and Hugo Boss, we can highlight its properties. (Seaqual initiative, 2020) Seaqual Yarn is a 100% post-consumer recycled polyester yarn which contains Upcycled Marine Plastic. Whereas all marketing is about recycling marine plastic into a new raw material, Seaqual yarn only contains approximately 10% of Upcycled Marine Plastic. The remaining 90% is post-consumer PET recovered from land sources. Moreover, brands purchasing this raw material for the manufacturing of their own products are required to use minimum 20% of Seaqual yarn. Hence, brands using 20% of this raw material wherein 10% is from marine litter, i.e., 2% of the product

comes from the ocean, can claim that their product is made from ocean plastic. (Seaqual initiative, 2020)

This is the case of IKEA, although they state in their product details (Appendix 12, pp. 97), 2% of the product contains ocean plastic, the marketing around this collection is totally ocean oriented. Hence, the client is misled from the start unless he reads the small letters.

The following example is from a smaller firm, namely “Oceans Win ©”. The website is still in the making but their homepage clearly states, “Welcome to Oceans Win © fabrics of marine plastic” (Appendix 13, pp. 98). No information is available (anywhere), but the statement makes a promise, i.e., marine plastic raw material. This is a promise that cannot be met when maximum 10% of Seaqual yarn is made from marine plastic.

The final example concerns the new pair of shoes Ocean Refresh started to promote. On October 15th they launched a Kickstarter campaign to finance 100% sustainable sneakers. Those sneakers, called “Oceana”, are made with Seaqual yarn. Unfortunately, they had to cancel this crowdfunding due to the COVID crisis even though they met their goal on November 6th. (Pedroso, 2020) Nevertheless, the whole communication around this product is misleading (Appendix 14, pp. 98). On the one hand, headlines are advertising this new collection as being made from recycled ocean plastic. On the other hand, their product is called “Oceana” which is also ambiguous for the end consumer. (Ocean Refresh, 2020)

In a nutshell, this case clearly shows that there is a need for regulation and an open position for a trustable certification.

5.2 Alternatives to plastics

Nowadays, many products are labelled with sustainable terms that refer to alternatives to virgin plastic. Those alternatives are “compostable”, “biodegradable”, “biobased” and “oxo-degradable”. (European Environment Agency, 2020) On top of that the term bioplastics is also used a lot and is a common term to define biobased plastics and biodegradable plastics. First, biobased plastics are fully or partially produced from renewable feedstocks derived from biomass corn, sugarcane, cellulose, or other renewable biological resources. Some of them or biodegradable but not all. Second, biodegradable plastics are composed of innovative molecular

structures that can decompose thanks to bacteria under certain environmental conditions. Although almost all biodegradable plastics are biobased, some are made from fossil oil-based feedstock. This term is ambiguous as there is no time prerequisite in which biodegradable plastics must break down. What is then the difference with normal virgin plastics as it eventually also degrades after hundreds of years. Next, compostable plastics are a type of biodegradable plastic. However, to be certified, those plastics must meet specific standards. In Europe, for example, timeframe is set at 12 weeks by which 90% of the plastic must decompose in fragments smaller than 2 mm. (Ceurstemont, 2020) Finally, oxo-degradable plastics are fossil fuel-based plastics in which additives have been added in order to degrade faster through oxidation into microplastics or chemical decomposition. (European Environment Agency, 2020)

Although those are great alternatives, they lack regulations (except for the compostable type) which leads to misrepresentations and greenwashing. Hence, to achieve high levels of sustainability it is recommended switching to reusable solutions one of them being recycling. There are two ways to recycle plastics. One, mechanical recycling involves shredding and melting plastic waste into plastic pellets. Two, with chemical recycling plastics waste is transformed back into building blocks (depolymerization) and then processed to a virgin-like quality plastic. The main advantages of chemical recycling are that plastic can be transformed again into a natural-color pellet and the quality of plastic is not degraded compared to a mechanical recycling. (Ceurstemont, 2020)

Chapter 6. Ocean plastic certification schemes

Clearly, regulation and/or product certifications are needed to help the consumer to make the difference between false claim and real effort. In the practical part of this thesis, an ocean plastic certification will be developed. Therefore, it is of a prime importance to critically analyze the already existing systems on the market.

Label and certification are two terms that are often used interchangeably but they imply different processes that are meant to increase the amount of information available to the end-consumer on a specific product and/or service. First, a label is a method to provide information on the attributes of a product, service, or process. Those attributes are often unobservable. Second, a certification is a system that verifies if a product, service, or process complies with a

set of standards and/or criteria. This verification is often performed by a third-party. (Matus, 2010)

Research has led to the discovering of three different ocean plastic certification schemes all around the world. Each one of them will be synthetized in this part.

6.1 OceanCycle

OceanCycle has been created in 2018 by Robert Goodwin and Ryan Schoenike. It is a social enterprise based in the United States. Their focus is on assisting businesses in using ocean plastic in their production. They work with third-party companies to provide complete solutions from plastic collection to product launch. More importantly, they provide an industry-leading chain of custody certification including documented traceability for manufacturers, brands, and companies. That way, they can trust the quality and the origin of the material they are using. OceanCycle has created this certification to ensure a decent chain of custody in the collection, processing, labelling, and transportation of plastics, as well as ethical sourcing standards. (Oceancycle, 2020)

Their aim is to build an ecosystem that creates value for either plastic recovered from the ocean or plastic prevented from entering it. They have put a heavy focus on prevention, i.e., on ocean-bound plastic as defined by J. Jambeck. An important requirement: collected material can only be certified when sourced from a country where at least 10% of its waste is mismanaged. A table is provided by the organization with all countries and their respective mismanaged waste percentage. They mainly certificate ocean-bound plastic, specifically PET. The minimum blend for a certified plastic product is 30% of ocean or ocean bound plastic. (Oceancycle, 2020)

6.2 The Ocean Bound Plastic Certification

The Ocean Bound Plastic Certification (OBP) was codeveloped by Zero Plastic Oceans and Control Union. On the one hand, Zero Plastic Ocean (ZPO) is a not-for-profit organization active in the preservation of the oceans against plastic pollution. ZPO was created in early 2019 by Vincent Decap and Adriana Amico. (Zero Plastic Oceans, 2020) On the other hand, Control Union certifications was created in 2002 when Control Union acquired a Dutch auditing arm of Stichting Skal, namely Skal International. (Control Union Certifications, 2020)

The OBP certification was developed in order to protect the oceans from continuous pollution of ocean bound plastic from land-based sources. Their aim is to encourage the removal of ocean bound plastic before it enters the ocean. (Zero plastic Ocean, 2020) OBP has been defined according to the publication of J. Jambeck. OBP includes two stricter subcategories: Waterways OBP and Shoreline OBP. Waterways OBP concerns all abandoned plastic waste located within 200m from both sides of a river. Shoreline OBP covers all abandoned plastic waste within 200m from the highest tide line towards land and 100m from the lowest tide line towards the sea. (Zero Plastic Ocean, 2020)

The organization created two subprograms: OBP Recycling Subprogram and OBP Neutrality Subprogram. The difference here is that the program covers both commercially and non-commercially recyclable OBP. That way, they can have a real impact as collecting recyclable alone is not enough. (Zero plastic Ocean, 2020)

First, OBP Recycling Subprogram focuses on commercially recyclable plastic and allows actors to certify the origin of the OBP and content of their Recycled OBP products. This is based on two standards: OBP Collection Organization Standard and OBP Recycling Organization Standards. (Zero Plastic Ocean, 2020)

Second, OBP Neutrality Subprogram treats not commercially recyclable plastics as companies willing to offset their plastic footprint can purchase it and produce plastic neutral products. (Zero Plastic Ocean, 2020)

6.3 Plastics collected in the hydrosphere – DNV standards

The standard for plastics collected in the hydrosphere has been set up by DNV with The Ocean cleanup being one of their stakeholders. They worked for 18 months on the establishment of a set of requirements and verification standards for the ocean plastic market.

The Ocean cleanup, a non-profit foundation, was founded in 2013 by Boyan Slat in the Netherlands. The foundation designs and develops systems to clean up plastics that are already polluting the Oceans and intercepts plastics that are on their way to the ocean via rivers. In order to fund the cleaning of e.g., the Great Pacific Garbage Patch, they have decided to create

products (i.e., sunglasses) made with certified plastic from this patch. (The Ocean Cleanup, 2020) For this purpose, they chose to collaborate with DNV, a leader in industry certifications.

DNV (GL)⁹ stands for Det Norske Veritas (Germanischer Lloyd) as a result of a merger in 2013. This company is an independent expert in risk management and quality assurance. They are one of the world's leading certification bodies which enables them to help businesses assure the performance of their organizations, products, people, facilities, and supply chains. (DNV, 2021)

Standards are listed in the “Plastics collected in the hydrosphere” DNV document. Abandoned plastic in hydrosphere has been defined as *“any persistent solid material composed of polymers that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or lakes and rivers”*. Products certified can contain a maximum of 10% of the total mass of additive carriers because of technical/industrial reasons. Additive carriers are any other plastic from other sources or other additives that are necessary to reach technical characteristics and quality needed for the production process. This must be declared in the final product claim to ensure transparency. (DNV, 2020)

6.4 Summary Table

Hundreds of standards and certifications systems already exist on the market. However, some are more credible than others. In order to assess those three different certification schemes, the following criteria are used:

- Third party certifier: Assurance that no interested parties interfere with the process of getting certified
- Traceability: Assurance that the sourcing of the raw material is as the claim states, i.e., possibility to track the whole chain of custody
- Accessibility: the public must have access to the standards

⁹ On March 1st, 2021, DNV GL became DNV (Lovegrove, 2021)

- Chain of custody model accepted¹⁰: depending on the choice of model, the assurance of having certified material in the final product is different. IPM is the most thorough one, followed by SM and MBM being the one offering the least assurance
- Percentage: refers to the minimum recycled content needed in the product to get certified
- ISO: When a certification is based on ISO standards, it meets a higher level of quality and consistency.
- Scope of definition: whether J. Jambeck's definition of Ocean Bound Plastic is used to determine if the collected material can be certified or not. J. Jambeck defined Ocean Bound Plastic as any plastic waste recovered from within 50 kilometers of an ocean coastline in a geographic region that lacks formal waste management. This scope misleads the customer when buying an ocean plastic product made from ocean bound plastic.

On the next page, a table assessing each certification scheme according to the above-mentioned criteria.

¹⁰ Three possibilities: MBM: Mass Balance Model; IPM: Identity Preserved Model; SM: Segregated Model (1.5 System Architecture, pp. 48)

		Certification schemes		
		OceanCycle	Ocean Bound Certification	Plastics collected in the hydrosphere
Assessment criteria	Third party certified			
	Traceability			
	Accessibility			
	Chain of Custody model		IPM/SM/MBM	IPM/SM
	Percentage	30%	1%	90%
	ISO			
	Scope			

In a nutshell, OceanCycle scores low regarding those criteria mainly due to transparency deficiencies. Indeed, most information are not accessible to the public which makes it impossible to rate it accordingly. The DNV standard, on the other hand, fulfills all criteria which makes it the one with the highest integrity.

Chapter 7. Traceability

As seen in the previous summary table, two certification schemes out of three are communicating little to no information on the traceability of certified material. However, the ISEAL Alliance has developed the Credibility Principles: a guide to assessing sustainability systems. At the core of each principle plays traceability an important role. Implementing a traceability system enables to control and confirm sustainability claims. (ISEAL alliance, 2013) The key element for an ocean plastic product, is to ensure that the material is effectively sourced from the hydrosphere. This chapter details what traceability is and how to implement it in a chain of custody.

7.1 Blockchain a solution for traceability

Traceability (n)

The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications. (Olsen, 2013)

Traceability is an important aspect when the origin of a resource makes a difference. Indeed, the ability to attain full transparency into the raw material is crucial and may have a significant impact as with the case of false advertisement. (ElMessiry & ElMessiry, 2018) Traceability systems allow organizations to track products and provide information on components and/or locations during production and distribution. Traceability services are implemented for various reasons. On the one hand, suppliers want to be certified for their products' origin and quality to inform consumers. On the other hand, retailers require verification of the products' origin and quality. (Lu & Xu, 2017)

For years, traceability systems have stored that information in conventional databases which quickly became potential points of failure and at risk of tampering. (Lu & Xu, 2017) With the apparition of blockchain, the technology Bitcoin lives on, the potential for traceability application was clear thanks to its nature of decentralization, properties of data immutability and transparency. Blockchain consists of an ordered list of blocks containing transactions e.g., monetary transfers and smart-contract creation and invocation. Smart contracts are programs that can express triggers, conditions, and business logic to create more complex transactions through programming. Users only need to authorize their operations via cryptographic or digital

signatures. (Liu, Lu, Xu, Zhu, & Yao, 2018) What makes it so trust-worthy is that each block includes a part of the previous block which creates a chain. Hence, historical transactions in the blockchain cannot be deleted or modified without invalidating the chain of mix-ups. (Lu & Xu, 2017) Concretely, the structure relies on the consensus of most of the participants by which each transaction is verified. Once the transaction is considered verified, it is immutably admitted to all records. All verified transactions are put in a queue to be added to the next block. (ElMessiry & ElMessiry, 2018) Goods are thus tracked over multiple tiers thanks to markets such as RFID and QR codes. (Westerkamp, Victor, & Küpper, 2019)

7.2 Provenance Ltd.

A start-up company called Provenance has used blockchain to create a traceability data system which securely stores inherently auditable, unchangeable, and open information. (ElMessiry & ElMessiry, 2018) Different case studies are available to the public as already 200 retailers and producers in the food and drink industry use their software services to help prove the origin of their products. The following case study is pertinent to understand how to build a blockchain tracking system: *“From shore to plate: tracking tuna on the blockchain”*. This was a six-months long pilot project managed by Provenance. The goal was to aid robust proof of compliances to origin standards along the chain, prevent double-spend certifications and find out how new technologies can help create an open system for traceability focusing on consumer-facing transparency. Thanks to this pilot project, Provenance was able to test their chain-of-custody application to estimate and optimize its impact for slavery-free and sustainable practices in this industry. (Provenance, 2016)

7.3 From shore to plate: tracking tuna on the blockchain

For this pilot project, a whole tracking system based on blockchain was established. Figure 7 (pp.38) demonstrates the process from the product (raw material) to the informed consumer. (Provenance, 2016)

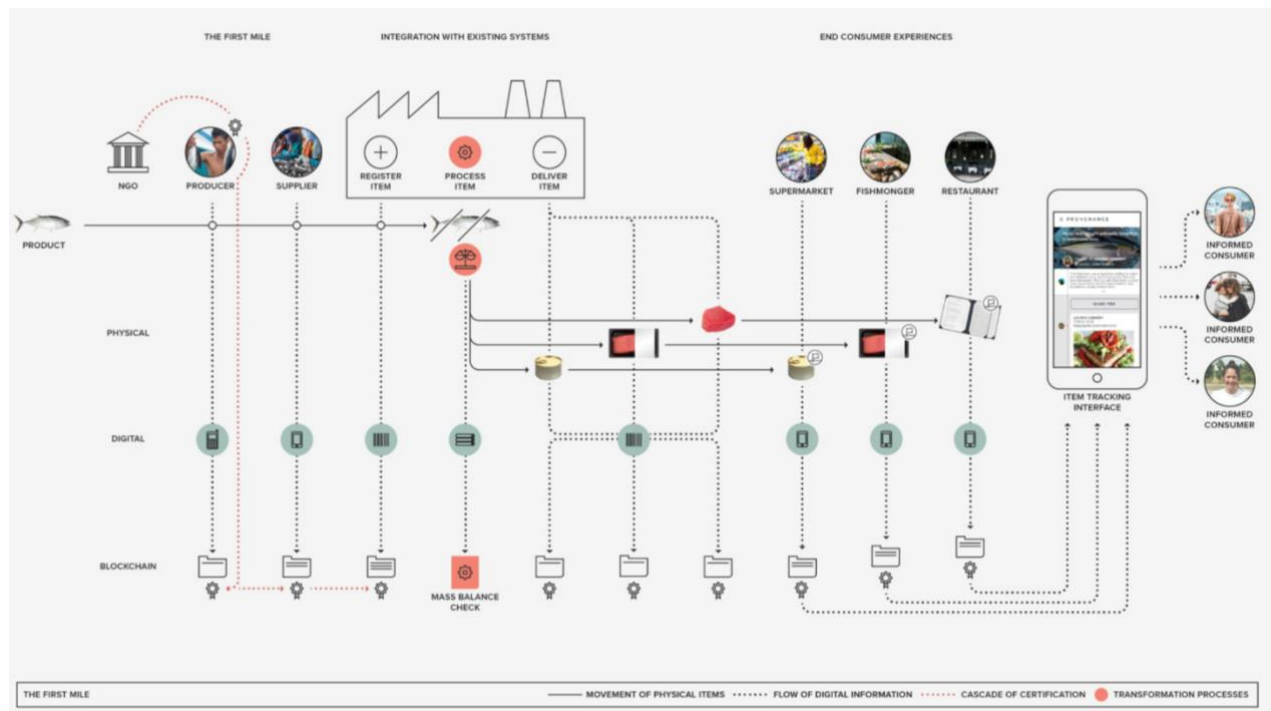


Figure 7: Blockchain providing the base layer of truth across the supply chain

Phase one implies the registration and data collection from the “first mile”, i.e., from product till registration at the factory. Social and environmental conditions are verified through local NGOs. Their audit systems approve the compliance or not to external standards which is a condition sine qua non to participate in the Provenance chain-of-custody. (Provenance, 2016)

Phase two involves linking the blockchain with existing systems. Usually, paper records are used but by digitalizing the supply chain from the start, products will be sold along with a digital record. These records will be kept in the blockchain and will be accessible to anyone disposing of a unique identifier such as a QR-code or RFID tag. Once the raw material is processed, a mass balance check can be used to determine the amounts of ingredients used in the transformation. Quantities will be identified and encoded into a label that will be passed with the transformed product. This way a true end-to-end record is provided. (Provenance, 2016)

Phase three covers the customer experience and the development of a trustworthy interface. Thanks to smart stickers (RFID) or QR-code on packaging, consumers only must take their smartphones to track the origin of the products. This system allows a new era of more conscientious, trusting customers who are willing to pay more for transparent products. (Provenance, 2016)

Conclusion of the literature review

The purpose of this literature review was to present an extensive study on the ocean plastic industry. From the history of plastics to how they made their path to the marine environment up to the status quo of that environment. This is not without presenting the impact it provoked and still provokes on the marine environment with a focus on social, economic, environmental, and biological (i.e., marine life) aspects.

After having realized the extent of the negative impacts plastics have on the marine environment, it was obvious that an analysis on the potential actions governments have put in place had to follow. The observation is clear, those actions are not sufficient. Either governments have the will to act, but the plastic industry is pushing against it, or governments address single use plastic bans whereas their priority should be addressing mismanaged waste. The ideal model would be, on the one side, governments addressing the issue at its source while on the other side organizations turning ocean plastic into an opportunity by collecting and recycling it. Even though organizations have jumped on that, the case study on Seaqual has demonstrated that due to a lack of regulation and legal framework, organizations are misleading the consumer by selling products supposedly made with ocean plastic when there is often only a small percentage sourced from the ocean. On top of that, that percentage cannot be tracked down as, frequently, no proof regarding the sourcing point is available nor has it been certified.

This has led to the search for certification schemes which organizations commonly seek for to add credibility to their sustainability claims. Unsurprisingly, only a few certification schemes are already on the market and being active for no more than two years. Two major problem areas can be highlighted from the summary table (pp.33). First, the use of the ocean bound plastic definition in order to determine the scope of the certification allows plastics collected far from the hydrosphere to have an ocean connotation. Second, clear traceability procedures are unavailable or non-existent even though considered as a core element for a credible sustainability scheme. By all means, those comments do not concern the DNV standard whose only weak point is being too restrictive with a minimum blend of 90%.

Finally, the traceability principle was detailed in order to understand how this aspect increases the credibility of sustainability claims. Throughout the case it was made clear that the blockchain technology offers an added value to traceability systems.

All in all, a deep analysis has been provided and a critical eye has been adopted to assess opportunities this industry may present. The opportunity that has been spotted will be detailed in the next part of this thesis as well as the answers to the following questions: “Does it address the needs of the market?”; “Are consumers interested?”. Those questions will be answered thanks to the involvement of key actors.

Part 2: Practical review

Introduction

The first part has been useful to have a greater understanding of the ocean plastic pollution. However, it also demonstrated that organizations are taking advantage of this crisis. While some are effectively trying to turn the tide, others use this for greenwashing. Typically, this happens when little or no regulation exists. Indeed, it has been illustrated that even though the ocean plastic pollution has been an issue and has been researched for more than a decade, the level of awareness of governments and populations and fear towards this issue is only emerging now.

Also, the assessment of newly created certification schemes has brought to light the gaps that need to be filled in the market. To address that shortfall, this part is dedicated to the development of a new certification scheme. As this process usually takes years, this part is considered as work in progress. Indeed, the ultimate goal is to effectively launch this new certification into the real world. Thus, in the first chapter the writing process of the standard is detailed. All elements of the standard are commented on and argued to understand how it best fits the needs of the market.

In the second and third chapter, the stakeholders' panel is presented and the comments they made on the standards are analyzed. As a survey has been conducted, the findings regarding customer's awareness and interest towards the ocean plastic industry and products will be detailed. Following this extensive study, the standard may be adapted in chapter four if it is in everyone's interest.

Finally, at the end of chapter four, as this is work in progress, the next steps that must be undertaken will be detailed. Those steps may be considered as an ambitious task, as will be illustrated, but it would be a great achievement to truly launch this certification.

Chapter 1: The Marine Plastic Certification Standard

1.1 Foreword

Purposely, this standard is called The Marine Plastic Certification, not ocean plastic nor ocean bound plastic. Indeed, marine plastic has been defined as any plastic material manufactured or processed, directly or indirectly, intentionally, or unintentionally, disposed of or abandoned into the marine environment. At first, the term marine waste was preconized for this standard. That way, we could have addressed, in the future, the collection of debris other than plastic. However, after some discussion with Antonio Astone, Global Sustainability Manager at DNV (personal communication, April 15, 2021, cfr. Appendix 17, pp. 100), it would have been too complex to create a standard that would have been applicable to any kind of waste.

Next, the ocean plastic term limits the scope of action, i.e., the ocean. As stated previously, the major source of ocean plastic pollution comes from improper waste management on land. Hence, waste located at the shore of a hydrosphere environment is considered at high risk of entering the marine environment. Hydrosphere being defined as *all waters of the ocean; rivers, lakes, and other bodies of surface water in liquid form on the continents; snow, ice, and glaciers; and liquid water, ice, and water vapor in both unsaturated and saturated zones below the land surface*. (DNV, 2020)

Thus, by using the marine term instead of ocean, the problem can also be tackled at its source. On top of that, nets can be included within the scope of this standard. Extended research has proven that abandoned fishing gear accounts for a large amount of ocean plastics and the negative impact on the marine life and environment have been documented. By valuing the collection of fishing nets at its source, we prevent them from being discarded in the marine environment.

Finally, the term “ocean bound plastic” will not be used throughout this standard nor will its definition. As discussed with A. Astone (personal communication, April 15, 2021, cfr. Appendix 17, pp. 100), plastics located 50 kilometers from an ocean tide, or a major river has very little chance to land into the marine environment. Hence, the definition is way too broad and is misleading for the consumer. On top of that, as David Cecchini, Quality Environment Health Safety Manager at The Ocean Cleanup (personal communication, April 27, 2021, cfr.

Appendix 19, pp. 102), highlighted; roughly every discarded plastic collected in Denmark could be considered as ocean bound plastic. With that in mind, the interest in differentiating marine plastic from any other recycled plastic is completely lost.

The Marine Plastic Standard is based on the previously established standards of DNV, namely “Plastics collected in the hydrosphere”, edition May 2020. Next to the fact that DNV is known worldwide as an internationally accredited registrar and classification society, its standard, as analyzed before¹¹, is performing well regarding the selected criteria. On top of that, many reliable references (e.g., ISO standards) have been used for the establishment of the DNV standard which influences positively its credibility.

Thus, the standard established for the hydrosphere environment will be used, adapted, and extended to create the Marine Plastic Certification Standard.

To provide the utmost transparency to customers, two distinctions are made:

- Marine Plastic: Ocean
Includes all plastics collected in the hydrosphere.
- Marine Plastic: Shore
Includes all plastics collected at maximum 100 meters of the hydrosphere-bed limit. This criterion is a more thorough definition of the one used in the Ocean-Bound Plastic Certification for Shoreline OBP and Waterways OBP¹². Shore is defined as land along the edge of a sea, lake, or wide river, i.e., all edges of a hydrosphere environment. (Cambridge University Press, 2021)

At first, a third category, called “Nets” was considered. This category would have included all discarded fishing gear (organizations would have had the choice to certify it also as Ocean or Shore if it was collected accordingly). However, following a discussion with A. Astone (personal communication, April 26, 2021, cfr. Appendix 18, pp. 101), combining those three categories would have been a hard task regarding the audits. Indeed, the first two categories, i.e., Ocean and Shore, aim at certifying the sourcing point (location) while the Nets category would certify the type of waste. Hence, creating a standard for location and type of plastic is not feasible. A standard must be created in order to certify one thing, in this case, the sourcing.

¹¹ 6.4 Summary Table, pp. 33

¹² 6.2 The Ocean Bound Plastic Certification, pp. 31

Nevertheless, the initial aim of this third category was to tackle the issue at its source and enable organization to collect discarded fishing nets. This means organizing collection points at ports and harbors when nets are not collected in the hydrosphere or on shores. However, ports and harbors can be considered as part of the Shore category as they are located at the edge of a hydrosphere. Thus, the scope of the second category has been adapted to support this:

- Marine Plastic: Shore

Includes all plastics collected at maximum 100 meters of the hydrosphere-bed limit, including ports and harbors, i.e., covering all edges of a hydrosphere environment.

1.2 Introduction

Growing awareness has been reported about threats against health, safety, and environment which results in consumers being more attentive regarding sustainability themes. Plastic pollution has become one of the most pressing environmental issues all over the world, especially in the marine environment. The following standard aims at creating a set of minimum requirements in order to be labeled as “Marine Plastic”. This standard is needed to verify every phase of the recycled plastic process. It is applicable to all typical stages of the value chain:

- Collection
- Transportation
- Recycling/Disposal/Recovery
- Manufacturing
- Sales

1.3 Scope

This standard applies to all organizations willing to claim that they collect, recycle and/or produce finished goods from marine plastic by ensuring the verifiability of the sourcing point.

The standard:

- Offers an exhaustive list of terms and definitions.
- Sets the minimum requirements needed for a chain of custody based on either the identity preservation or segregation model applied to the supply chain of products made

from marine plastic. The mass balance approach is purposely not accepted within this standard as it cannot guarantee the expected requirements of traceability. Indeed, several organizations have signed a joint letter to the European Commission recommending basing this approach on ten specific criteria in order to avoid greenwashing practices and regulate how recycled content is determined guaranteeing a circular chain of custody. (Simon, et al., 2021)

- Sets the communication guidelines for certified Marine Plastic organizations

This standard is only applicable to products containing marine plastics (Ocean and/or Shore) as defined previously. Because of technical/industrial reasons, additive carriers can be added but only up to a maximum of 10% of the total mass of plastic¹³. This must be declared in the final product for transparency purposes.

Although, following a discussion with D. Cecchini (personal communication, April 27, 2021, cfr. Appendix 19, pp. 102), this requirement will be modified. Indeed, by adopting the 90% rule, many organizations are left behind as they cannot comply with this for various reasons. The aim of this standard is to create awareness, educate the consumer and build an ecosystem of actors willing to make an effort for the marine environment. As part of DNV's standard stakeholders' team, D. Cecchini commented the need to add the percentage blending model wherein the mixing with non-certified materials is accepted if the proportions are recorded. DNV decided to move forward with a more thorough and stricter standard and not take this comment into consideration. Of course, their standard receives a lot of recognition as it values organizations fully focused on plastics collected in the hydrosphere. Nevertheless, the Marine Plastic Certification aims at valuing various scales of efforts. Therefore, the percentage blending model is added to the choice of chain of custody models. This involves that, for transparency purposes, the percentage of certified Marine Plastic material in the product must be clearly stated on the label.

The following rules are applicable depending on the chain of custody:

- Identity preservation and segregation model: additive carriers can be added but only up to a maximum of 10% of the total mass of plastic. This is the same rule as above as those models do not allow the mixing with non-certified material.

¹³ This blend has been previously determined by DNV in the "Plastics collected in the hydrosphere" standard.

- Percentage blending model: in order to differentiate this standard from already existing certifications, no blend under 50% will be accepted. That way the percentage of certified plastic is superior to the one of non-certified plastic.

A complete chain of custody adopting this standard across its value chain may include waste collectors, transporters, recyclers, and manufacturers.

1.4 Terms and definitions

For credibility and quality purposes, all definitions are based on reliable sources such as ISO standards.

1. Audit

Process for obtaining relevant information about an object of conformity assessment and evaluating it objectively to determine the extent to which specified requirements are fulfilled. (ISO 22095, 2020)

2. Abandoned plastic in hydrosphere/on shores

Is a part of hydrosphere and shore debris, any persistent solid material (composed of polymers) that is manufactured or processed and directly or indirectly, intentionally, or unintentionally, disposed of or abandoned into the marine environment, lakes, and rivers or on shores. (NOAA, 2018)

3. Certification

Third-party attestation related to an object of conformity assessment, with the exception of accreditation. (ISO/IEC 17000, 2020)

4. Chain of custody

The process by which inputs and outputs and associated information are transferred, monitored, and controlled as they move through each step in the relevant supply chain. (ISO 22095, 2020)

5. Claim

Declared information regarding the specified characteristics of a material or product. (ISO 22095, 2020)

6. End-user

For the scope of this standard, is a person or persons who will ultimately be using the product made using plastics sourced from the hydrosphere for its intended purpose. (DNV, 2020)

7. Hydrosphere

Includes the waters of the ocean; rivers, lakes, and other bodies of surface water in liquid form on the continents; snow, ice, and glaciers; and liquid water, ice, and water vapor in both the unsaturated and saturated zones below the land surface. (DNV, 2020)

8. Identity preservation model

Chain of custody model in which the materials or products originate from a single source and their specified characteristics are maintained throughout the supply chain. (ISO 22095, 2020)

9. Organization

Entity or group of people and facilities with an arrangement of responsibilities, authorities and relationships and identifiable objectives. (ISO 26000, 2010)

Note 1 to entry: An organization may encompass multiple (production /geographical) sites.

10. Percentage blending model

This model maintains segregation until the final point of blending or mixing for a specific batch of a product. Mixing with non-certified product is controlled and recorded, so the proportion of certified content in each final product is known. (ISEAL alliance, 2016)

11. Record

Document stating results achieved or providing evidence of activities performed. (ISO 9000, 2015)

12. Recycling

Processing of plastics waste materials for the original purpose or for other purposes, excluding energy recovery. (ISO 15270, 2008)

13. Segregation model

Chain of custody model in which specified characteristics of a material or product are maintained from the initial input to the final output. (ISO 22095, 2020)

Note 1 to entry: Addition of material with different characteristics and/or grade to the input is not allowed.

Note 2 to entry: Commonly, material from more than one source contributes to a chain of custody under the segregated model.

14. Shores

Land along the edge of an ocean, sea, lake, wide river, port, or harbor. (Cambridge University Press, 2021)

15. Source

Specific originator at a location of a material or product with a specified characteristic. (ISO 22095, 2020)

Note 1 to entry: The originator is typically a specific supplier but can also be a specific manufacturer or specific processor adding a particular characteristic.

16. Supply chain

Series of processes or activities involved in the production and distribution of a material or product through which it passes from the source. (ISO 22095, 2020)

Note 1 to entry: A supply chain is typically composed of a series of different organizations.

17. Top management

Person or group of people who directs and controls an organization at the highest level. (ISO 9000, 2015)

18. Traceability

Ability to trace the history, application, location or source(s) of a material or product throughout the supply chain. (ISO 22095, 2020)

19. Traceability system

Manual or electronic system that provides the ability to access any or all information relating to the material or product under consideration throughout their life cycle, by means of accessing documented information. (ISO 22095, 2020)

Note 1 to entry: "Life cycle" should be understood in the broadest possible sense, to include, for example, raw material extraction, agricultural production, final disposal, and reuse or recycling, as well as all other stages connected with product manufacture and use.

20. Verification

Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled. (ISO 9000, 2015)

21. Waste

Anything for which the generator or holder has no further use and which is discarded or is released to the environment. (ISO 14021, 2016)

1.5 System Architecture

1.5.1 General

Three specific chains of custody models are accepted in this standard. A set of measures related to them has been developed. The choice of one model over the other, results in different statements about the features of the final product.

The identity preservation model enables organizations to claim that a product is made using recycled marine plastic collected from a unique and defined source in the marine environment. The specific feature is that only one source applies to that product.

The segregation model enables organizations to claim that a product is made using recycled marine plastic collected from different sources in the marine environment. The common feature is that the marine plastic collected is sourced within the scope of this standard, meaning Ocean or Shores¹⁴.

¹⁴ Refer to specific definitions

The controlled blending model, also known as the single percentage method, enables organizations to claim that a product is made using recycled marine plastic equal to a certain percentage. Hence, the organization may mix certified and non-certified materials as long as it is controlled and recorded.

This standard will provide a set of properties for those three models in order to implement a verifiable traceability system to ensure integrity of the general requirements of the chain of custody.

Those properties will allow users to transparently communicate on:

- Item-based expectations
- Market-based expectations
- Guaranteeing exact balance between certified marine plastic sold & bought
- Ensuring physical segregation of certified marine plastic with any other material¹⁵
- Unequivocally identifying sourcing point of marine plastic (only applicable when adopting the identity preserved model)
- Communicating the percentage of certified Marine Plastic content (obligation when adopting the percentage blending model)

1.5.2 The identity preservation model

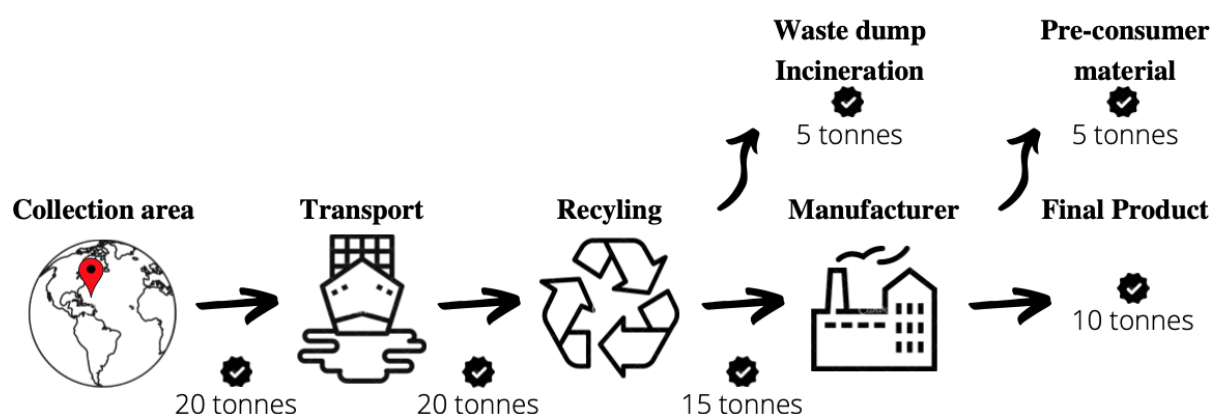
The identity preservation model ensures that certified marine plastic from a specific collection area is kept separate from any other sources. When used through the whole supply chain, certified products can be uniquely traced during the production process from the production site and/or batch through to the last point of transformation, i.e., labelling of the product. (ISEAL alliance, 2016)

This model does not allow certified material to be mixed with any other certified or non-certified material. Materials from different certified sources cannot be physically mixed and must be documented accordingly. (ISEAL alliance, 2016)

¹⁵ Only applicable to final point of mixing when using the percentage blending model

The identity preservation model allows to fulfill the item-based expectations of customers as the final marine plastic item details all the specific features on the label and/or with other specific claims.

The identity preservation model with indicated quantities as an example:



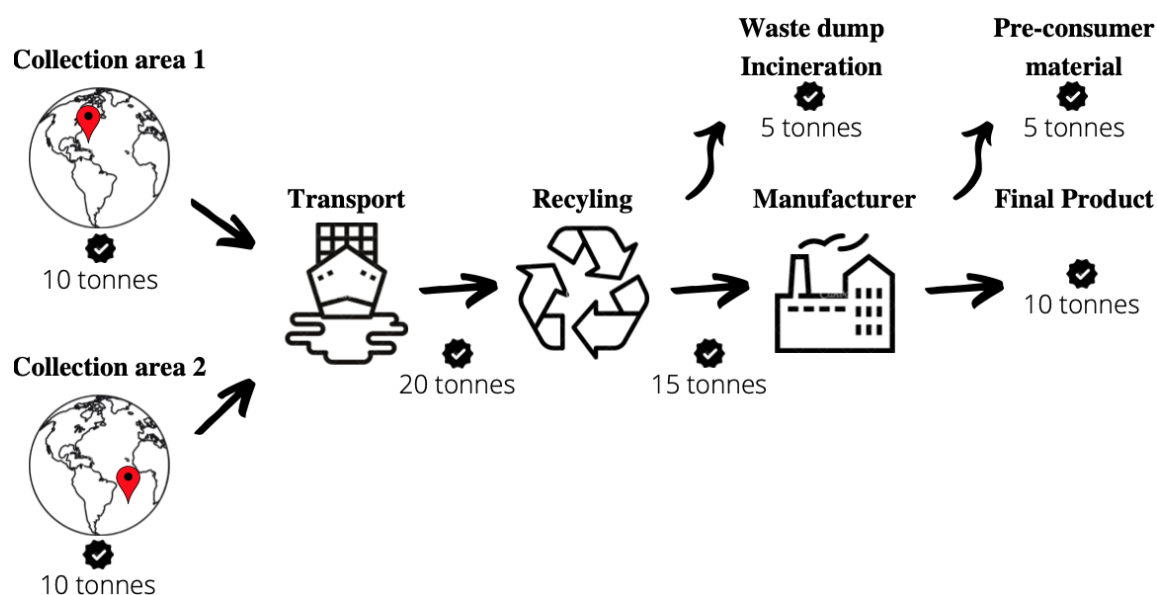
1.5.3 The segregation model

The segregation model ensures that a certified product is kept separate from non-certified sources through each stage of the supply chain. This allows to assure that products are made of certified marine waste, though it may not be possible to specifically identify which molecule came from which certified source. (ISEAL alliance, 2016)

This model allows the mixing of certified Marine Plastic collected from a variety of sources certified to the same standards and documented accordingly. However, the certified material cannot be physically mixed with non-certified material. (ISEAL alliance, 2016) The streams of Marine Plastic coming from different collection areas can be unified at any stage of the chain of custody¹⁶.

¹⁶ i.e., before recycling, before or during manufacturing, etc.

The segregation model with indicated quantities as an example:



1.5.4 The controlled blending model

The controlled blending model ensures that the identity preservation or segregation model is maintained until a certain point. That certain point is different whether the batch-level or site-level is considered.

The draft of ISO 22095 included the following note in the definition of the controlled blending model: *The adhered claim may refer to a certain percentage, at batch-level and /or site-level.* (ISO/DIS 22095, 2019) This note was replaced in the definitive version with the following: *This chain of custody model is also referred to as the "single percentage method".* (ISO 22095, 2020) Without access to the newly released document, the reason for this change cannot be discovered.

However, the distinction between batch-level and site-level has been defined by the ISEAL Alliance. According to them, both are considered as subcategories of the mass balance model while the controlled blending model is a distinct category in the ISO 22095:2020 standard.

First, the batch-level mass balance, also known as percentage blending or batch blending, maintains segregation until the final point of blending for a specific batch of a product. Thus, the mix with non-certified material is controlled and recorded so the proportion of certified

content is known in each final product. Until that point of mixing, either the identity preservation or segregation model is followed. The only claim option available for this batch-level mass balance is the declared percentage claim. Meaning that when mixing two thirds of certified Marine Plastic with one third of non-certified material; all final products issued must carry a claim “contains 66% certified Marine Plastic”. (ISEAL alliance, 2016)

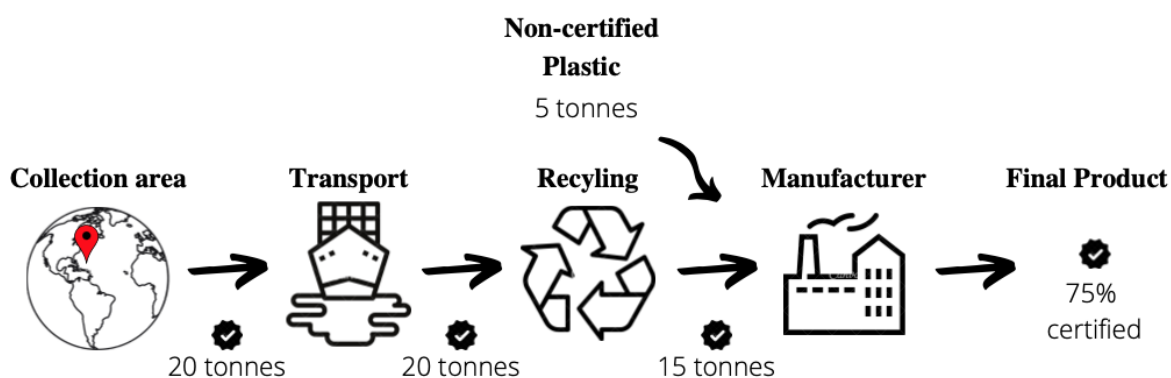
Second, the site-level mass balance, also known as controlled blending or factory gate mass balance, maintains segregation until the manufacturing stage in the supply chain. At that point, proportions of certified and non-certified material at the overall site level are recorded and reconciled. Thus, the proportion of certified content entering and exiting the site is known but not specifically for each final product. Until that point of mixing, either the identity preservation or segregation model is followed. (ISEAL alliance, 2016)

Taking into consideration both models, only the batch-level mass balance will be retained. The identity preservation and segregation models being both strong on traceability, this standard wants to keep this same level of thoroughness. Therefore, when considering overview table¹⁷ the batch-level model scores high on traceability except on the identification of the origin which is also compromised with the segregation model. The batch-level mass balance will from now on be named as the percentage blending model to avoid any negative connotation with the mass balance model explained in the next point.

The strictness order regarding the different models of chains of custody is the following:

Identity preservation model > Segregation model > Percentage blending model

The percentage blending model with indicated quantities as an example:



¹⁷ Appendix 16, pp. 100

1.5.5 The mass balance model

As seen previously, the mass balance model contains various types of chain of custody which commonly involve balancing volume reconciliation. In other words, the volume of certified product entering the chain of custody is controlled and an equivalent volume of product leaving the operations can be sold as certified. Hence, the physical mixing of certified and non-certified product is allowed, but not required at any stage in the production process provided that the quantities are controlled in documentation. (ISEAL alliance, 2016)

Purposely, the mass balance model has not been included in The Marine Plastic Standard. Zero Waste Europe together with the Rethink Plastic Alliance claim that without clearly defined rules, this method could become a major tool for greenwashing. Companies can claim their product as being made from recycled materials regardless of their true content. This could have massive consequences as it could block the incentives to improve recyclability of plastics by altering the amount of recycled content in products, while having a negative impact on the credibility of the recycling industry. Hence, Zero Waste Europe and ECOS, supported by The Rethink Plastic Alliance, wrote down a 10-recommendations list when determining recycled content.¹⁸ (Trabizi (ZWE), Crêpy (ECOS), & Rateau (ECOS), 2021)

1.6 General requirements for a chain of custody system

Having no access to the ISO standard related to chain of custody systems, the following roles and responsibilities have been identified according to DNV's hydrosphere standard. Indeed, ISO/DIS 22095:2019 5 (E) - Chain of custody – General Terminology and Models, as its name states is a (DIS) Draft International Standard still under development and is circulating only among the development team of whom DNV is a part of.¹⁹ Requirements specific to each part in the value chain will also be developed in this part. Those requirements aim at providing the highest traceability standard to end users.

¹⁸ Appendix 15, pp. 99

¹⁹ In the meantime, ISO 22095:2020 was published. Free access limited to "Terms and definitions".

1.6.1 Roles and responsibilities

In order to run a successful chain of custody system, the organization must:

- identify, all the actors and locations encompassed within the organization (e.g., collectors, transporters, recycling sites, manufacturers, and retailers)
- define sector specific minimum requirements
- organize the system, monitoring and managing the chain of custody in a way that there is a unique chain complying with all the minimum requirements
- verify if the requirements are reached
- implement the system by each organization involved in the chain
- implement a chain of custody system based on identity preservation, segregation, or percentage blending model
- ensure and verify, using documented procedures, that the product is maintained isolated from other products in order to track every material under scrutiny from the collecting point to product manufacturing
- guarantee and assess that material has been isolated from non-verified sources also during transportation, stocking, and manufacturing²⁰. Thus, the final product will physically contain plastic from acknowledged sourcing points
- provide a clear identification of material at every phase of the chain, proved by accurate documentation.

The aim is to minimize the overall environmental impact, i.e., every phase of the process must be designed accordingly (e.g., transportation methods, production process).

1.6.2 Collection site requirements

Organizations responsible for the collection must declare in which of the two categories they want to be certified and clearly mention it on all documents. Certifying marine plastic “Shores” has different requirements than “Ocean”. Indeed, regarding the audit, it is harder to control that the 100-meter rule is respected as well as the risk of manipulation of plastic to another site in order for it to be considered as Marine Plastic, i.e., transport post-consumer plastic to the edge of a hydrosphere.

²⁰ When adopting the percentage blending model this is only applicable till mixing.

To that end, organizations must:

- Identify in which category the collected material fits: Ocean or Shore
- Identify dimensions and location of sourcing using locations technologies (e.g., GPS). Collectors must take a photo or video of the collected plastic and upload it on the selected traceability system. Therefore, collectors (especially in developing countries) must be equipped with adequate utilities to be able to follow this requirement.
- Take note of approximate weight/volume of collected material
- Keep collected material physically separated from material collected in another location.

1.6.3 Transportation requirements

Organizations in charge of transportation must have a transportation plan to keep track of every shipping detail such as:

- Contract details of every transporter involved
- Delivery dates of incoming/outgoing material
- Issuing date of transportation documents
- Quantity of transported material

Note that organizations must ensure that batches of collected material are physically isolated from any other batch throughout the whole transportation chain.

1.6.4 Recycling site requirements

Organizations responsible for the recycling must:

- Verify that the weight/volume of incoming batches correspond to prior documentation
- Divide collected material in recyclable & non-recyclable material
- All new fractions must be kept segregated and documented (weight/volume)
- Divide further the recyclable material to obtain batches of plastics bearing the same physical-chemical characteristics (e.g., PET, HDPE, PVC, LDPE, PP, PA)
- Measure and record weight/volume of all new batches of sorted material

1.6.5 Manufacturing site requirements

Organizations responsible for the manufacturing must:

- Verify that the weight/volume of incoming batches correspond to prior documentation
- Keep certified Marine Plastic from different sources physically separated till final product²¹

If the manufacturing requires the addition of additives²² or non-certified plastics²³ for the final product, the organization must:

- Indicate which kind of additives or non-certified plastics are used and in which quantity
- The percentages composing the blend must be indicated according to ISO 14021:2016

$$X (\%) = \frac{A}{P} \times 100$$

Where	X	certified Marine Plastic, expressed in percentage
	A	mass of certified Marine Plastic
	P	mass of all plastic in product

1.6.6 Selling requirements

Organizations responsible for selling the final product must:

- Obtain an authorization to sell certified Marine Plastic products
- Provide proper documentation/records/identification tags (e.g., QR-code) allowing end-users to verify that the product is made of plastic collected from the marine environment
- Possess all relevant information relating to the product: certification number and the applicable chain of custody model
- Record quantities of certified products bought, sold and in inventory.

²¹ In case of the use of the segregation model, this requirement must be properly specified

²² Only in the case of identity preservation & segregation model

²³ Only in the case of percentage blending model

1.7 Document procedures

The organization must keep up-to-date records of all transactions and confirm position, characteristics, and status of the identified plastic material/products at stake at every step of the chain. All transactions must be registered with the proper documentation on the chosen blockchain system.

The mention of whether it consists of Marine Plastic “Ocean” or “Shore” is mandatory on every document at every stage of the value chain.

1.7.1 Purchases and incoming products

The purchaser organization must ensure that the incoming products made with certified Marine Plastic comply with the following requirements:

- verification that quantities/volumes of incoming certified Marine Plastic match the records in prior documentation
- verification that products are sourced in the hydrosphere and/or on shores
- verification of the certification along the supply chain in every certified site, according to the timing of processes established by the organization

1.7.2 Sales and outgoing materials

The organization must ensure that the following minimum information, related to certified Marine Plastic products, must be available in documented form.

Minimum information:

- name and address of the buyer
- name and address of the seller
- delivery dates of incoming/outgoing certified Marine Plastic
- issuing date of documents
- product description
- type of certified Marine Plastic (Ocean or Shore)
- quantity of certified Marine Plastic delivered
- relevant transportation document

- chain of custody certification number
- unequivocal identification

1.7.3 Subcontractors

The organization (holding or looking to obtain the certification) may delegate activities to third party subcontractors. In that case, it must verify their compliance with the requirements of the chain of custody system.

Organizations including outsourcing along the chain must:

- implement written subcontracting terms with interested parties
- maintain the legal ownership of all incoming/outgoing certified abandoned plastic
- allow certification bodies access to the site when an audit is needed
- adopt a documented control system with defined procedures for outsourced activities
- record names and addresses of each subcontractor involved in the process. Names and addresses must be updated regularly.

1.8 Legal Compliances

The positive impact made by organizations who are Marine Plastic certified may not be outweighed by potential negative impacts their activity could cause. This means that organizations must operate in ways that, at a minimum, meet fundamental responsibilities in the areas of human rights, labor, environment, and anti-corruption. Therefore, National laws and requirements related to operations must be followed. Next, all organization shall demonstrate compliance with the United Nations Global Compact Principles which are derived from: the Universal Declaration of Human Rights, the International Labor Organization's (ILO) Declaration on fundamental Principles and Rights at work, the Rio Declaration on Environment and Development and the United Nations Convention Against Corruption. (United Nations Global Compact, 2021).

1.9 Traceability system

As demonstrated in the Provenance Case²⁴, traceability is important as it provides credibility to the end user. DNV has developed the same idea under the name “My Story™” stored on the blockchain system of VeChain. (DNV, 2021) VeChain is a company specialized in blockchain and IoT technologies. Created in 2015, it is one of the few blockchain platforms with real world business applications. (VeChain, 2021) DNV has purposely chosen the VeChain system as it consumes less energy and CO₂. That way, the system completes the sustainable efforts organizations make. Thanks to this partnership, the consumer can, through a QR-code on the product, dive into the authentic product story on their smart device.

In a nutshell, My Story™ as a service will help companies with the following:

- Data collection
- Access to product information for consumers (end-users)
- Issuance of Enterprise and product ID
- Share product story in the My Story™ app
- Verification of activities and data (control made by DNV)
- Storage on blockchain (operated by VeChain). (DNV, 2021)

1.10 Verification

The organization must:

- run a control system to ensure, verify and monitor those incoming certified plastic materials match the requirements
- define and document timeframes for monitoring activities
- ensure the compliance of outputs with documents related to purchase, sale, and transportation
- guarantee that every purchase is unequivocally identifiable using unique transaction identification
- verify documentation related to sales of certified materials

²⁴ 7.3 From shore to plate: tracking tuna on the blockchain, pp. 37

1.11 Communication guidelines for certified Marine Plastic organizations

Organizations must follow the guidelines set out in this part and follow the requirements specific to the subcategory (Ocean and/or Shore) they belong to.

As a rule, claims may not be made if they:

- cause confusion, misunderstanding and/or exaggeration regarding the environmental impact the organization has by using certified Marine Plastic
- induce understanding that the certification covers other aspects beyond the scope of this standard (e.g., quality)

Two categories of claims will be commented hereunder: promotional claims and product specific claims. Promotional claims may be made by the organization to advertise but in no case the end-user can be induced to believe that the promotional products are Marine Plastic certified. Product specific claims may only be used on products for which the organization has been certified for.

Organizations must refer themselves for any claim they want to make to ISO 14021:2016 – Environmental labels and declarations – self-declared declarations (Type II environmental labelling).

1.11.1 Marine Plastic: Ocean

Organizations must use the Marine Plastic Ocean predetermined logo with or without the displayed percentage depending on the chain of custody used. Organizations may use the terms Marine and Ocean interchangeably as long as material has been collected in the hydrosphere.

Specific requirements per chain of custody:

- Identity preservation and segregation model

As the mixing with non-certified material is not allowed, it is up to the organization if it wants to display the exact percentage of recycled content (which should always be superior to 90%) on the logo.

Examples of allowed claims: Made of Ocean/Marine Plastic; Contains recycled Ocean/Marine Plastic; Plastic collected in the hydrosphere

- Percentage blending model

As the mixing with non-certified material is allowed, the organization must display the exact percentage of recycled content (no blend under 50% can be certified) on the logo.

Examples of allowed claims: Made with x% Ocean/Marine Plastic; x% Recycled Ocean/Marine Plastic; Plastic collected in the hydrosphere

1.11.2 Marine Plastic: Shore

Organizations must use the Marine Plastic Shore predetermined logo with or without the displayed percentage depending on the chain of custody used. Organizations are not allowed to use the term Ocean if material has not been collected in the hydrosphere.

Specific requirements per chain of custody:

- Identity preservation and segregation model

As the mixing with non-certified material is not allowed, it is up to the organization if it wants to display the exact percentage of recycled content (which is always superior to 90%) on the logo.

Examples of allowed claims: Made of Marine Plastic; Contains recycled Marine Plastic; Plastic collected in the marine environment.

- Percentage blending model

As the mixing with non-certified material is allowed, the organization must display the exact percentage of recycled content (no blend under 50% can be certified) on the logo.

Examples of allowed claims: Made with x% Marine Plastic; x% Recycled Marine Plastic; Plastic collected in the marine environment

Chapter 2: Stakeholders' panel

2.1 Introduction

The aim of this chapter is to collect comments on the standard from various stakeholders. This is an important step as it gathers first-hand feedback on the standard and assesses the potential interest of stakeholders to become certified in the future.

Stakeholders must be chosen well in order to have a mixed panel and obtain comments that wrap up all elements. The best mix is composed of the following actors: researchers, universities, NGOs, and brands. Being at this stage, a work in progress, not all types of stakeholders were able to participate to the first review. However, this will be necessary in the future. Until now, feedback has been received from researchers, NGOs, and brands. In the next part, each stakeholder will be presented followed by a summary of their comments.

2.2 Stakeholders' presentation

The first stakeholder is David Cecchini, Quality Environment Health Safety Manager at The Ocean Cleanup. His profile is particularly interesting for two reasons. On the one hand, he is an active player within the NGO The Ocean Cleanup and he especially played an important role in the development of their very first ocean plastic product from the Great Pacific Garbage Patch. He and his team developed a management system in order to trace the plastic collected right up to the final product. A system that has been certified by DNV under the standard "Plastics collected in the hydrosphere". On the other hand, D. Cecchini was a stakeholder during DNV's benchmarking for that standard.

The second stakeholder is Antonio Astone, Global Sustainability Manager at DNV. A. Astone was part of the team that developed the DNV standard "Plastics collected in the hydrosphere". Thanks to his position and experience, he supported me during the writing process of my standard. As DNV's objective is to extend their standard to shorelines, he was particularly interested to know how I interpreted it. A. Astone has been provided the second version of The Marine Plastic Certification Standard. (Appendix 26, pp. 118) That way, the adjustments made on the first version will be either confirmed or rejected.

The third stakeholder is François van den Abeele, Founder & CEO of Sea2See. For years, he has been looking for a certification scheme with a great integrity to certify and value his business model. From the collection up to the final product, he is looking to certify his whole chain of custody. His profile allows me to see if organizations are interested in the certification scheme and if the requirements are feasible.

The fourth stakeholder is Christopher Storey, Director of Sea Shepherd Portugal, Founder of GhostNetWork and Head of innovation at Green Innovation Group. Thanks to his many positions, C. Storey will provide comments as an ocean advocator and a plastic collector. C. Storey has also been provided the second version of The Marine Plastic Certification Standard for the same reason as for A. Astone. (Appendix 26, pp. 118)

The fifth and last stakeholder is Nekane González, Director of Eko-REC, a key player in the Spanish circular economy. Holder of a PhD in organic chemistry, she has played an important role for Sea2See as she performed tests to discover which kind of marine plastics had the best properties for recycling.

2.3 Summary of comments

		Comments
Stakeholder	David Cecchini	If plastics are collected anywhere in the hydrosphere, the subcategory should not be called ocean. Personally, shore plastics should not be considered marine plastics unless it can be proved that it washed in from the water. Otherwise, in order for plastics collected on shore to be considered as marine plastics, the definition of shore should be adapted to land along the edge of the hydrosphere that experiences seasonal, environmental, or weather induced exposure to the hydrosphere.

		Recommends minimum of 30% as that is still considered as a high percentage in the recycling industry. Using that minimum is feasible when organizations must declare the percentage. (D. Cecchini, Personal communication, May 5, 2021, cfr. Appendix 20, pp. 102)
	Antonio Astone	Details for using the standard normally in separate document; the standard is only a set of requirements. Mention of DNV standard is fine for research purpose but for commercial purpose, the DNV standard is copyrighted so some adjustments must be made. If commercialized, you will have to develop other documents: use of mark, audit procedures, auditor qualification procedures, certificate regulations sampling to be used, types of evidence you must collect etc. This is key when launching the certificate in a professional context. Exclusively require registration on blockchain is a bit ambitious; suggest proposing it as a tool but not imposing it. (A. Astone, Email, May 19, 2021, cfr. Appendix 23, pp. 106)
	François van den Abeele	In the whole standard add recycled/upcycled as with chemical recycling we talk about upcycling. Consider differentiating organizations' efforts by granting different levels regarding the recycled content, inspiration from Cradle to Cradle. (F. van den Abeele, Personal communication, May 5, 2021, cfr. Appendix 21, pp. 105)

	Christopher Storey	Great stuff, from what I can see it looks amazing. (C. Storey, Email, May 23, 2021)
	Nekane González	Emphasize the 50% that must be fulfilled because otherwise it would be more terrestrial/virgin than marine. A level scheme as Cradle to Cradle is not a bad idea. (N. González, Personal communication, May 11, 2021, cfr. Appendix 22, pp. 105)

Chapter 3: Customer's point of view

3.1 Quantitative survey

The aim of this part is to evaluate customer awareness and interest towards products made from recycled marine plastic. Therefore, a survey has been drafted addressing those aspects.

First, four socio-demographic questions were asked in order to have a broad idea of the buyer persona. The fourth question was specifically related to the ocean plastic pollution crisis. If the person felt no concern about that issue, they were thanked, and the survey was ended. Purposely, the age question was divided into four categories representing the different generations: baby boomers (56-76 years), generation X (41-55 years), generation Y (21-40 years) and generation Z (20 years and less). That way, some surprising answers might have been explained by generation-related perceptions.

Second, general questions on the ocean plastic industry were asked. Those questions were related to their awareness regarding products made from ocean plastic. Purposely this term was used as it is commonly adopted on the market to refer to any kind of recycled marine plastic (ocean plastic, shore plastic, river plastic, ocean bound plastic etc.).

Third, people's interest and expectations towards The Marine Plastic Certification has been assessed. Half of the questions targeted customer's expectations regarding transparency and traceability. The other half assessed their interest by determining their purchasing behavior.

Finally, any person willing to comment further on the topic could express his or her thoughts in the final section.

The survey has been distributed on social media from April 28th till May 9th and up to 203 respondents were reached. In the following part, the outcome of this survey will be analyzed.

3.2 Perception on the ocean plastic industry

In this part, the major elements of the survey will be detailed and commented. On the one hand, themes related to respondents' awareness will be presented. On the other hand, an assessment will be made to find out whether the respondents' expectations match with The Marine Plastic Certification Standard drafted previously.

The first comment to make is the question related to respondents' feeling of concern regarding the ocean plastic pollution crisis. Indeed, 5% responded either "no opinion" or "no", i.e., 10 respondents were not aware or did not pay attention to that global crisis. There is no link to be made with one specific generation, activity, or gender. Consequently, the five "no" respondents were excluded from the rest of the survey as it was not pertinent to ask their interest towards an issue they do not feel concerned about.

Second, 31.2% declared they had already seen and/or bought a product made from ocean plastic. This amount is way higher than expected as I, personally, had not seen or bought a product made from ocean plastic before starting this thesis. However, this means that the industry is growing fast and that their presence on the market is noticeable. Nevertheless, it is interesting to assess the responses to the question that came just after that. Indeed, respondents having replied "yes" were asked to express what they thought of the ocean plastic claim. Indeed, the graphic cloud (Appendix 25, pp. 112) highlights the feelings that were the most recurrent. Positive feelings are highly predominant being "great", "good", "nice", "sustainable", etc. Then, the "True?" feeling is also highly present. This demonstrates lack of transparency and traceability from organizations active on that blossoming market. Another comment worthy of interest refers to "bracelets". This word has come up several times and refers to the 4Ocean bracelets. Those bracelets principally fund the ocean plastic collection but the bracelet itself only contains maximum 5% of recycled ocean plastic, the rest being post-consumer plastic

bottles. On top of that, there is no third-party certifier to justify that ocean plastic claim. (4Ocean, 2021)

Third, two different questions were asked to determine respondents' expectations on recycled content percentages. The first question aimed at discovering the expected recycled content people have when buying a recycled product. The second question targeted the needs for The Marine Plastic Certification. Surveyors mainly expected (62.8%) to have at least 50% of recycled content. But, as respondents could freely add a new section, one person commented that in the recycling industry, 30% is the maximum recycled content. This is interesting as it is in line with what David Cecchini said on the recycling industry. However, this person in particular wanted at least 50% of recycled content for The Marine Plastic Certification along with 63 other respondents (32%). It is also important to notice that nearly the same amount of people (31.5%) expected a recycled content between 70 and 90% followed by 20.7% surveyors for a content of between 50 and 70%. Hence, more than 80% of the customer panel calls for a recycled content of at least 50% as currently stated in The Marine Plastic Certification. Nonetheless, there is a potential interest to evaluate organizations regarding their recycled content percentage in the same way as Cradle to Cradle does, i.e., implementing achievement levels.

Next, I was surprised by the number of respondents knowing the already existing ocean plastic (or rather ocean-bound plastic) certifications. Indeed, 10% knew either one or both certification schemes. This demonstrates the interest of organizations to get certified for their activities. Of course, this number is still modest, but the aim is to increase that knowledge with The Marine Plastic Certification.

Then, the sub questions related to customers' expectations towards The Marine Plastic Certification confirmed what has been written down in the standard. Undoubtedly, 96.1% expressed the importance to show the recycled content percentage which is a requirement of the percentage blending model used in the standard. Concerning the knowledge of the exact sourcing point, there is a balance between people finding it important against others who do not have an opinion or do not care. Hence, offering the possibility to organizations to choose between the identity preservation, segregation, or percentage blending model addresses the customers' expectations. This was followed by whether customers were interested in getting to know the full product story, i.e., information about the chain of custody from the collection point up to the final product. Two questions were asked differentiating the ability to have access

to that information by looking for it (on the webpage for example) and having a QR-code on the product giving a direct access to that product story. This is where the outcome is surprising as both have around 47% of respondents saying that it is important to have access to the product story. However, people responding important to the first question were not per se responding important to the second one and vice versa which makes me doubt about the formulation of the questions. Nevertheless, these types of traceability and transparency features are a requirement in the standard and are undoubtedly appreciated by the customers. The last question was related to impartiality by assessing the respondents' expectation towards third-party certifiers. 57.1% claimed that it is important along with 31.5% having no opinion. With such a high percentage of "no opinion", it could be that people are less aware of what a third-party certifier is unless demonstrated with a concrete example which I did not provide.

Next, respondents' purchasing behavior, divided into four sub questions, confirms that they are sensitive to product labels and pay attention to them in their purchasing decision. However, 74.9% claimed they do not trust any product label, meaning that to be seen as credible, the customers' trust must have been earned upstream. Next, respondents' interest towards certified Marine Plastic products is satisfying with 53.7% having a higher consideration of Marine Plastic certified products than products made from any other recycled plastics and 56.2% showing their willingness to pay more for certified Marine Plastic products.

Finally, apart from having received a lot of encouragements, some have also expressed interesting remarks. On the one hand, some have expressed the theme of trust in the label and the knowledge of who is behind it. This is surely linked to the new released Netflix documentary "Seaspiracy" that dismantles the well-known Marine Stewardship Council (MSC) certificate setting standards for sustainable fishing. On the other hand, some have expressed the fact that the recycling industry is not sustainable and that the focus should be put on alternative solutions to plastic. This is indeed a good point and addresses the ocean plastic pollution at its source. However, the aim of this certification scheme is to bring transparency to an already existing industry that needs regulation to support it. By combining those two aspects, in other words pushing for change to alternatives and supporting the collection of marine plastic, we could try to turn the tide on the ocean plastic pollution crisis.

3.3 Limits to the survey

In the previous part some pain points were already mentioned. However, this study has a number of limitations that need to be addressed in order to moderate the presence or absence of results in some cases.

First, the practical review of this thesis mainly relies on the qualitative feedback received from stakeholders involved in the marine plastic industry. However, having insights from a customer point of view has been considered as being pertinent which has led to this additional quantitative survey. Thus, the analysis, being a plus to this part, has been limited to straightforward results. Indeed, if relying only on quantitative data, a more statistical approach such as SPSS would have been used. This would have enabled cross-related insights.

Second, the representativity of the survey might be insufficient. Indeed, 203 respondents were reached but doubling that amount would have limited the possible bias in the study sample and made the outcome more reliable. Also, the age question was divided into four categories corresponding to different generations. As explained previously, the aim was to potentially explain unexpected answers with generation-related perceptions. However, the distribution of respondents in the different categories is not significant enough. Four out of five of the respondents were from the Y or Z generation, a generation that with extreme likelihood will witness the most severe effects of climate change within their lifetime, plastic pollution being an important contributor. Thus, it is not surprising that 95% of the respondents felt concerned about the ocean plastic crisis. The outcome would have been unbiased with a more equal distribution of respondents within every age category.

Third, the level of education should have been questioned. Indeed, research has been conducted to understand the impact of age and education on climate change awareness in communities. They concluded that there was a meaningful association between level of awareness and education level with highly educated people having enough knowledge regarding climate change. (Chaudhary, Mumtaz, Yaseen, & Afzal, 2018)

Fourth, the structure of the survey shows some restraints. Indeed, the use of the ocean plastic term may have caused confusion. This thesis argues from the start that ocean plastic and ocean bound plastic must be seen as two very distinctive sourcing points. However, in this survey, no

distinction has been made. Hence, the specific level of awareness and interest of customers towards products made from ocean plastic compared to ocean bound plastic is unknown, let alone that of marine plastic. Purposely, the distinction has not been provided to the surveyor as there was a chance, he would get lost between all those terms which would have resulted into a biased outcome.

In a nutshell, this survey provides us sufficient additional information on customers' wants and needs for The Marine Plastic Certification Standard.

Chapter 4: The Marine Plastic Certification Standard v2

4.1 Revision of version 1

Following the feedback received, some adjustments will be made to the first version of The Marine Plastic Certification Standard. Indeed, allowing stakeholders to give their opinion and take them into consideration is an important step in the development of a standard.

First, the categorization of The Marine Plastic Certification will be adapted. Indeed, as D. Cecchini commented, plastics collected anywhere in the hydrosphere cannot be considered within the Marine Plastic: Ocean category. Only plastics truly collected in the ocean (or sea) can be categorized as ocean plastic. Hence, that category will change its name into Marine Plastic: Hydro, being a short name for hydrosphere. The other adjustment is regarding the definition of shore. D. Cecchini argued that in order for a plastic to be considered as marine plastic, it must have experienced some kind of exposure to the hydrosphere. For example, for a fishnet to be collected and considered as a marine plastic, it must have been previously used for fishing activities and discarded in ports. The ultimate goal being to protect and restore the marine environment, it makes sense to refine this term's definition.

Here an overview of the definite scope of The Marine Plastic Certification:

- Marine Plastic: Hydro
Includes all plastics collected in the hydrosphere
- Marine Plastic: Shore
Includes all plastics collected on land along the edge of the hydrosphere (i.e., maximum 100m of the edge) that experienced seasonal, environmental, or weather induced exposure to the hydrosphere.

Second, the question whether to decrease the minimum percentage of recycled content or not is tricky. On the one hand, as N. González said, it makes sense to criticize that by lowering this percentage to 30%, more than half of the final product will be virgin and/or terrestrial material. Even though, the exact Marine Plastic recycled content must be shown, it creates ambiguity. On the other hand, the recycling industry commonly stagnates at 30%. If the objective is to gather as many actors as possible, I might have to consider being flexible. However, it is key to preserve integrity and prestige. As D. Cecchini claimed, it is essential to determine the goals of the standard in order to draft them having those objectives in mind. With that thinking, the idea of integrating levels in the certification scheme inspired from Cradle to Cradle fits the objectives of trying to gather as many actors as possible while being a credible certification. Thanks to the implementation of achievement levels, lower recycled contents are considered but will be granted the lowest performance level.

Here an overview of the achievement levels relying on interval percentages:

- Bronze: recycled content between 30 and 50 percent (50 not included)
- Silver: recycled content between 50 and 70 percent (70 not included)
- Gold: recycled content between 70 and 90 percent (90 not included)
- Platinum: recycled content equal to or above 90 percent.²⁵

Third, the term upcycled will be added along with recycled when talking about the final product. The difference between upcycling and recycling is the following:

- Upcycling is the activity of making new objects (or else) out of waste material (Cambridge University Press, 2021)

²⁵ Automatically categorized as Platinum when using either the identity preservation or segregation model.

- Recycling is the process of collecting and changing plastics so that it can be used again. (Cambridge University Press, 2021)

Fourth, as A. Astone mentioned, the communication guidelines must be included in a separate document. Therefore, that point has been deleted from the standard. However, as some adjustments have been made, the updated version can be found in Appendix 27 (pp. 133).

Finally, A. Astone and C. Storey were provided with the second version of the standard in order to confirm or reject the new interpretation. Thanks to their positive feedback and no further comments on the adjustments made, it can be concluded that the second version of the standard is a better fit to the market than the first one.

The fully adapted second version of The Marine Plastic Certification Standard can be found in the Appendix 26 (pp. 118).

4.2 A work in progress

If it is not clear by now, the aim is to continue with this project and truly launch The Marine Plastic Certification on the market. Therefore, I will detail in this part the next steps that have to be undertaken in the coming months. The information hereunder has been provided by professionals of two certification bodies, namely DNV and SGS.

First, as Antonio Astone mentioned, their DNV standard is copyrighted, and some adjustments must be made to the standard. Indeed, aspects of The Marine Plastic Certification Standard are closely related to the DNV standard as they both focus on chain of custody systems. Unfortunately, at the time of writing The Marine Plastic Certification standard, the ISO standard related to chain of custody models (ISO 22095:2020) had not yet been released and when it finally was, the access was limited up to the terms and definitions. As the DNV standard is based on that ISO 22095, The Marine Plastic Certification Standard has been, in turn, based on the DNV standard. Thus, in order to move forward, an access to the ISO 22095:2020 Chain of custody — General terminology and models must be purchased to make the appropriate changes. (A. Astone, Email, May 19, 2021, cfr. Appendix 23, pp. 106)

Second, in addition to adapting the standards, there must be an organization responsible for these standards to make them work, i.e., the owner of the certification scheme. It must be a well-identified legal entity, either a non-profit structure or a commercial company, which can be a pre-existing entity, or an entity created specifically for the needs of the new certification system. The complexity of this structure and the tasks it must perform depend on the rules of the certification system which may evolve over time. (F. Ducarme, Email, May 15, 2021, cfr. Appendix 24, pp. 108)

The tasks an entity may perform are the following:

- Approve standards and keep them up to date (revisions are an inevitable need)
- Set up a technical committee, executive committee, secretariat, board of directors, general assembly, membership list (following the needs)
- Consult stakeholders (ensure that the system is credible, recognized and responds to market needs)
- Play a role in the approval of certification bodies (whether direct approval by the organization running the certification scheme or with the intervention of an independent accreditation body)
- If an accreditation body is involved: have the scheme recognized by the accreditation body (a prerequisite before certification bodies can engage in accreditation)
- Promoting the certification system, publicizing it, monitoring quality and the risk of fraud
- Clarifying the interpretation of the rules in the standard
- Generally, test phases (i.e., pilots) to be planned before starting on a larger scale.

This does not happen all at once; it generally takes years until a system has a certain maturity. Once the scheme owner has adopted its standards and defined the rules for the approval of certification bodies (via accreditation or a simpler mechanism), the bodies in question must decide/agree to invest in the scheme (i.e., make the necessary technical and commercial developments to be able to offer the service, including the creation of a quality system and internal procedures in accordance with the rules specific to the scheme and, if necessary, an application for accreditation). (F. Ducarme, Email, May 15, 2021, cfr. Appendix 24, pp. 108)

Hence, there are two ways to move forward. Either getting accredited by ISO or ISEAL for example or the scheme owner can raise the interest of potential certification bodies by making

the system known and by identifying the demand on the market (demand for certified products and therefore demand from producers willing to be certified). The idea is that the higher the initial investment and the lower the demand seems to be, the more hesitant the certification body will be. If the initial investment is minimal, the certification body might want to participate even if the demand is low, provided that the system is credible. This last aspect is pertinent as certification bodies may fear compromising their reputation by participating in a system that is based on an uncertain foundation and/or criteria that are not very objective or open to questions. (F. Ducarme, Email, May 15, 2021, cfr. Appendix 24, pp. 108)

Undoubtedly, the next step is to create a legal entity. Therefore, the choice has been turned to a non-profit structure. As this certification has an international utility, the suitable Belgian option is an AISBL (Association Internationale Sans But Lucratif). This entity follows the same rules as the regular non-profit structure ASBL except from the fact that the purpose is internationally oriented. The rules that must be fulfilled to create that structure are the following. First, gather at least two founding members. Second, precisely define the social purpose which is to turn the tide on the ocean plastic pollution. Third, define the actions that must be put in place to pursue that objective, i.e., The Marine Plastic Certification scheme. Fourth, determine the head office which must be in Belgium, this is a requirement of the AISBL structure. Finally, the statutes of the entity must be drafted containing the description of the social purpose as well as the actions that will be undertaken. This has to be founded by an authentic act with a notary. This entity is quite simple to create as it does not require a start-up capital. (Juristax, 2020; Wikipreneurs, 2021)

Once this has been created, a search for organizations interested in obtaining certification must be made in order to present that to potential certification bodies. The DNV standard gathered around 30 stakeholders in their development process. At the moment, The Marine Plastic Certification Standard has involved five stakeholders. Gathering stakeholders is a demanding process but the way a standard is promoted, and the endorsement received from key players is essential to catch the interest of certification bodies. Out of those key players, there must be a right balance between organizations having an interest in the certification scheme and those who do not and will provide feedback without conflict of interest. On the next page, a table comprising potential future stakeholders that will complement the stakeholders that were already reached out to.

Parties with commercial interest	Parties without commercial interest
Ocean Waste Plastic by Pack Tech S/A	Plastic Oceans International
Econyl	5 Gyre
Kalyora	The UN
Nomad's	WWF
Parley for Oceans	International Union for Conservation of Nature
Ecover	Greenpeace
Eco barge clean seas	Plastic Punch
Plastic collective	Searious Business
Waw hand planes	
Waste2wear	
Waste Free Oceans	
Tide.earth	

Those potential stakeholders were selected as they all play a role in the ocean plastic industry, either as an advocator for the preservation of the marine environment or occupy a role within the chain of custody presented in the standard, namely collection, recycling, transport, manufacturing and/ or resale. Those organizations will be contacted in the same way as the previous ones. Meaning, find a person of interest within the organization, contact that person, and ask if they would be interested in being part of stakeholder's panel. If so, the standard will be sent to them for feedback. This process will surely take months as making contact can sometimes be tricky. Also, sufficient time must be given to them in order to receive constructive feedback.

To sum up, the next steps are adjustment of the standard, creation of an AISBL and reach out to the new stakeholder's panel.

Limitations of the practical review

Having had the opportunity to develop a full certification standard was very enriching. Even though I started with little or no knowledge of the certification world, I was able to rely on professional's patience to enlighten me on how those systems work.

However, I did face a particular difficulty. As mentioned previously, it is key in the standard development process to address stakeholders and ask for their feedback. However, I was not able to involve a significant number of stakeholders. I can think of several reasons. First, the pandemic has sent everyone to home working which makes it harder to get in touch. Second, a lack of credibility as a student having written certification standards. Last, the lack of time as commonly the development of a certification scheme takes years. Nonetheless, this has only been the first step of the project. The advantage is that standards must be revised periodically so there is no fear of gathering a new stakeholders panel.

Overall, the development of this certification scheme may be seen as unfinished, and this is the case. When starting this thesis, I had no idea that developing a certification scheme would be such a long process. Hence, it was obvious to determine an achievement step for this thesis, i.e., receiving feedbacks in order to draft the second version of the standard. The fact that this process ends at this step, does not allow us to know with certainty that there will be enough interested parties to raise certification bodies' curiosity.

General conclusion

The aim of this thesis has been to provide an extensive research on the ocean plastic crisis, highlight its major impacts and argue the pertinence of introducing a new certification scheme on the market.

The literature review and its conclusion (pp. 39) have made it clear that the ocean plastic pollution must be addressed in three ways. First, adequate waste management in areas where plastic leakage into the hydrosphere is predominant. Second, a global shift to alternatives to plastic which goes hand in hand with global plastic bans. Lastly, promote the collection, recycling, and upcycling of marine plastic.

The practical review of this thesis has put the focus on that last aspect with the development of The Marine Plastic Certification Standard. The targets of this standard are collectors, transporters, recyclers, manufacturers, and resellers of marine plastic materials and/or products. Thanks to a collaboration with several players active on the ocean plastic industry, it has been possible to build up a certification scheme with a high integrity. Indeed, consumers will not, in any case, be misled and will have all the transparency and traceability features at their disposal in order to make a thoughtful purchasing decision.

For that matter, The Marine Plastic Certification scheme relies on four pillars to provide the utmost transparency standards. First, the differentiation between plastics collected in the hydrosphere and those collected on shores has been clearly identified. Second, only plastics truly collected in the ocean can be claimed as ocean plastic. Third, the percentage of recycled content must be explicitly displayed on certified products with a minimum of 30%. Finally, a traceability system based on blockchain will allow customers to have access to the complete product story (chain of custody) through a QR-code.

Overall, those four pillars have been highly appreciated by stakeholders as well as customers. It will undoubtedly make a difference when launching it on the market. Thereby, this thesis marks the end of the first step of the certification process, the second step having as objective to raise the interest of certification bodies. Wish me good luck!

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Appendices

Appendix 1: Terms & definitions

In order to determine the accurate term that will be used towards this thesis, resources from The National Geographic Society were consulted. The National Geographic Society uses the power of science, exploration, education, and storytelling to illuminate and protect the wonder of our world. (National Geographic, 2020) From the article “The Great Pacific Garbage Patch” (see further in thesis), different terms are provided to define ocean plastic. The different terms used are marine litter, marine debris, and marine plastic. (National geographic, 2019) Research must be carried out to see whether those terms are exact synonyms or are there some nuances to be considered. It is of a prime importance to clearly understand each term accurately as misuse is common. Also, greenwashing can be a consequence of misusing a term that inaccurately explains the origin of the raw material. Hereunder is an overview of each term’s definition.

First, the difference between ocean and marine must be clarified. Both terms are used alternatively to describe the same purpose. According to the Cambridge dictionary, Marine describes anything related to the sea or sea transport (Cambridge Dictionary, 2020) while ocean is a very large area of the sea. (Cambridge Dictionary, 2020) Thus, marine plastic could refer to plastic that has not entered the ocean yet but that has a direct link to the marine environment.

Second, the difference between litter, debris and plastic will be made. Marine debris is defined by the National Oceanic and Atmospheric Administration (NOAA) as being any persistent solid material manufactured or processed, directly or indirectly, intentionally, or unintentionally, disposed or abandoned into the marine environment. (NOAA, 2018) This definition supports National Geographic’s view on Marine debris as being litter that ends up in oceans, seas, and other large bodies of water. (National Geographic, 2011) Hence, we can assume that marine debris is equal to marine litter. From this definition, a hypothesis is put forward. Indeed, marine debris is a common term to any litter that enters the ocean. Then, the obvious definition of marine plastic is any plastic material that makes its way out to the sea. marine litter and marine debris are commonly used to refer to marine plastic as plastic is the most common litter found in the marine environment. (NOAA, 2020)

According to this research, the term ocean plastic is preferred. However, further analysis will be undertaken to discover how the markets is defining it.

Following the fact that many different terms are used to define ocean plastic, many organizations involved in this business are also using different definitions in order to fit their activity and the origin of the plastic they collect.

In order to determine the definition that will be used throughout this thesis, the focus will be set on two definitions encountered during research. Some organizations use the term “ocean-bound-plastic” such as Oceanworks, some use the actual term “ocean plastic” such as Seaqual initiative. The difference between both will be explained hereunder.

On the one hand, Oceanworks, a global marketplace for recycled ocean plastic and averted plastic materials and products (Oceanworks, 2020) defines ocean bound plastic as being the following: ocean bound plastic refers to mismanaged plastic waste at-risk of entering the ocean. This includes any plastic on land or beaches and in waterways within 50 km of a coast worldwide. This term has been defined in accordance with standards set by research by Jenna R. Jambeck. (Oceanworks, 2020)

Mismanaged waste consists of any material that is littered or inadequately disposed of. Hence, mismanaged waste could enter the ocean via inland waterways, wastewater outflows, and transport by wind or tides. (Jambeck, et al., 2015)

In Jambeck’s research, an estimation of the amount of land-based plastic waste that has entered the ocean since its first appearance is attempting to be computed. The first report concerning ocean plastic appeared in scientific literature in the 1970’s. Now, roughly 50 years later, no rigorous estimations exist on the amount of marine debris entering the marine environments nor their origins. The computation is based on a framework which calculates the amount of mismanaged plastic waste on an annual basis generated by populations living within 50 km of a coast that could enter the ocean as marine debris. (Jambeck, et al., 2015)

Hence, as the Oceanworks’ definition is in accordance with this research’s study, all plastics do not have to come exclusively from the ocean. They also consider plastics close to a marine environment which could ultimately enter the ocean. Therefore, it is called ocean bound plastic.

This definition is also used by other organizations. Recycling that type of plastic does not literally clean up the oceans but addresses the issue more at its source. Indeed, coastal communities in which proper waste management is not available will generate waste that will eventually land in the marine environment.

On the other hand, Seaqual initiative, an organization collecting, recycling, and upcycling marine debris, defined marine litter as waste of any type that has been lost or discarded in the marine environment and is found on beaches and coasts, the ocean floor and surface, rivers, and estuaries. (Seaqual initiative, 2020) This definition must be highlighted as this is the one that will be used throughout this thesis. The definition provides a clear delimitation on the origin of where plastic is collected. This explanation is supported by M. Henry as he defined marine plastic as being any material or object manufactured and used by humans which is directly or indirectly disposed of in the marine environment. This waste can be found floating on the surface, in the water column, in fresh or saltwater, offshore or inshore, stranded on beaches or on the seabed. (Marek, et al., 2020) The UNEP has taken over this definition, which is commonly used in the scientific, associative, and political community, but stipulates that elements of a natural origin (algae, vegetation, diverse organic debris, etc.) are excluded. Only natural transformed elements (wood, clothes, etc.) are retained. (Maryvonne, 2010) Hence, ocean plastic will be defined as follows:

ocean plastic = Plastic that has been lost or discarded in the marine environment and is found on beaches and coasts, the ocean floor and surface, rivers, and estuaries.

Appendix 2: Categorization of the origin of Recycled plastics



Source: (Oceanworks, 2020)

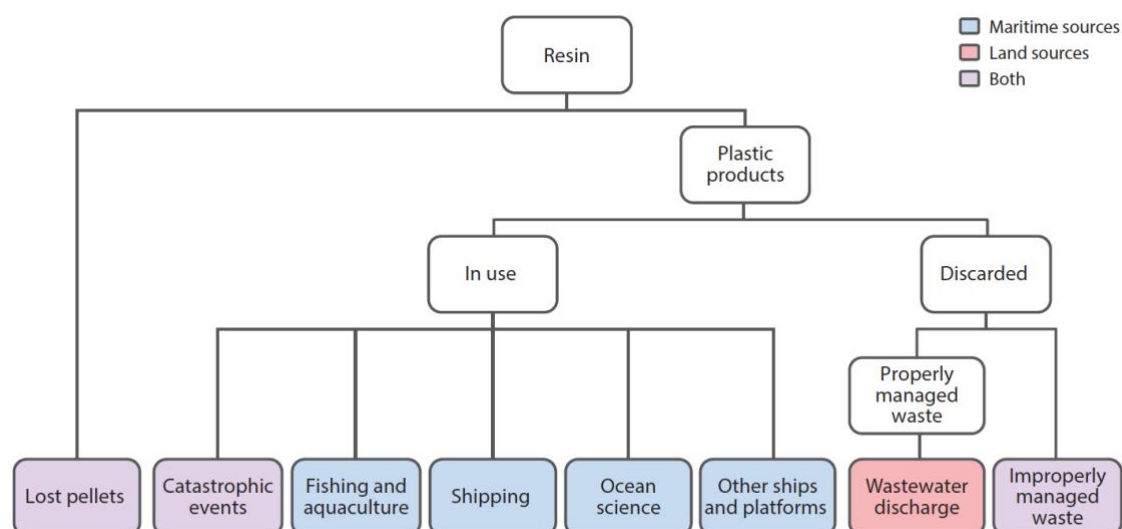
Appendix 3: Top 20 countries in terms of mismanaged plastic waste

Rank	Country	Econ. classif.	Coastal pop. [millions]	Waste gen. rate [kg/ppd]	% plastic waste	% mismanaged waste	Mismanaged plastic waste [MMT/year]	% of total mismanaged plastic waste	Plastic marine debris [MMT/year]
1	China	UMI	262.9	1.10	11	76	8.82	27.7	1.32–3.53
2	Indonesia	LMI	187.2	0.52	11	83	3.22	10.1	0.48–1.29
3	Philippines	LMI	83.4	0.5	15	83	1.88	5.9	0.28–0.75
4	Vietnam	LMI	55.9	0.79	13	88	1.83	5.8	0.28–0.73
5	Sri Lanka	LMI	14.6	5.1	7	84	1.59	5.0	0.24–0.64
6	Thailand	UMI	26.0	1.2	12	75	1.03	3.2	0.15–0.41
7	Egypt	LMI	21.8	1.37	13	69	0.97	3.0	0.15–0.39
8	Malaysia	UMI	22.9	1.52	13	57	0.94	2.9	0.14–0.37
9	Nigeria	LMI	27.5	0.79	13	83	0.85	2.7	0.13–0.34
10	Bangladesh	LI	70.9	0.43	8	89	0.79	2.5	0.12–0.31
11	South Africa	UMI	12.9	2.0	12	56	0.63	2.0	0.09–0.25
12	India	LMI	187.5	0.34	3	87	0.60	1.9	0.09–0.24
13	Algeria	UMI	16.6	1.2	12	60	0.52	1.6	0.08–0.21
14	Turkey	UMI	34.0	1.77	12	18	0.49	1.5	0.07–0.19
15	Pakistan	LMI	14.6	0.79	13	88	0.48	1.5	0.07–0.19
16	Brazil	UMI	74.7	1.03	16	11	0.47	1.5	0.07–0.19
17	Burma	LI	19.0	0.44	17	89	0.46	1.4	0.07–0.18
18*	Morocco	LMI	17.3	1.46	5	68	0.31	1.0	0.05–0.12
19	North Korea	LI	17.3	0.6	9	90	0.30	1.0	0.05–0.12
20	United States	HIC	112.9	2.58	13	2	0.28	0.9	0.04–0.11

*If considered collectively, coastal European Union countries (23 total) would rank eighteenth on the list

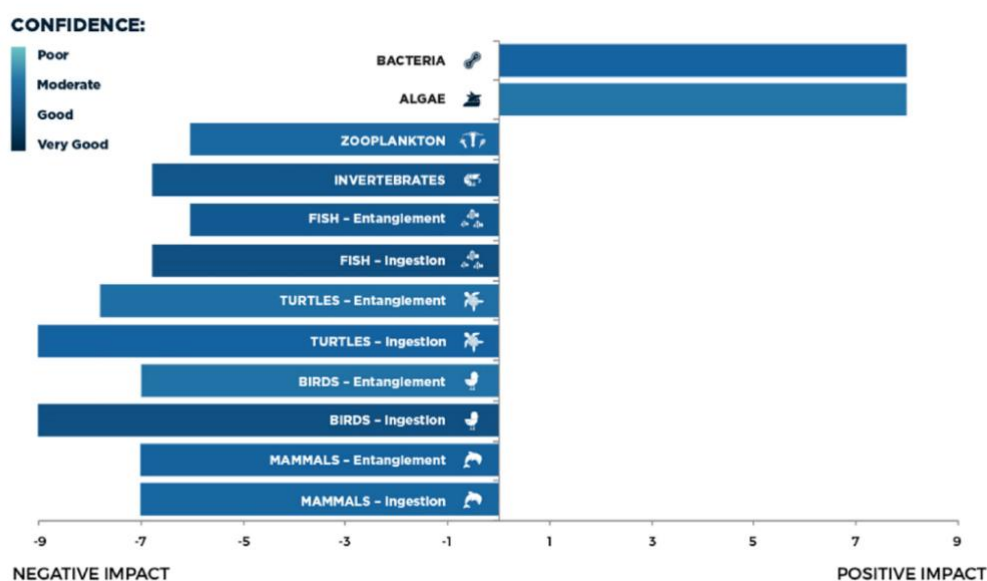
Source: (Jambeck, et al., 2015)

Appendix 4: How plastics enter the marine environment



Source: (Law, 2017)

Appendix 5: Ecosystem impacts of marine plastic on biota



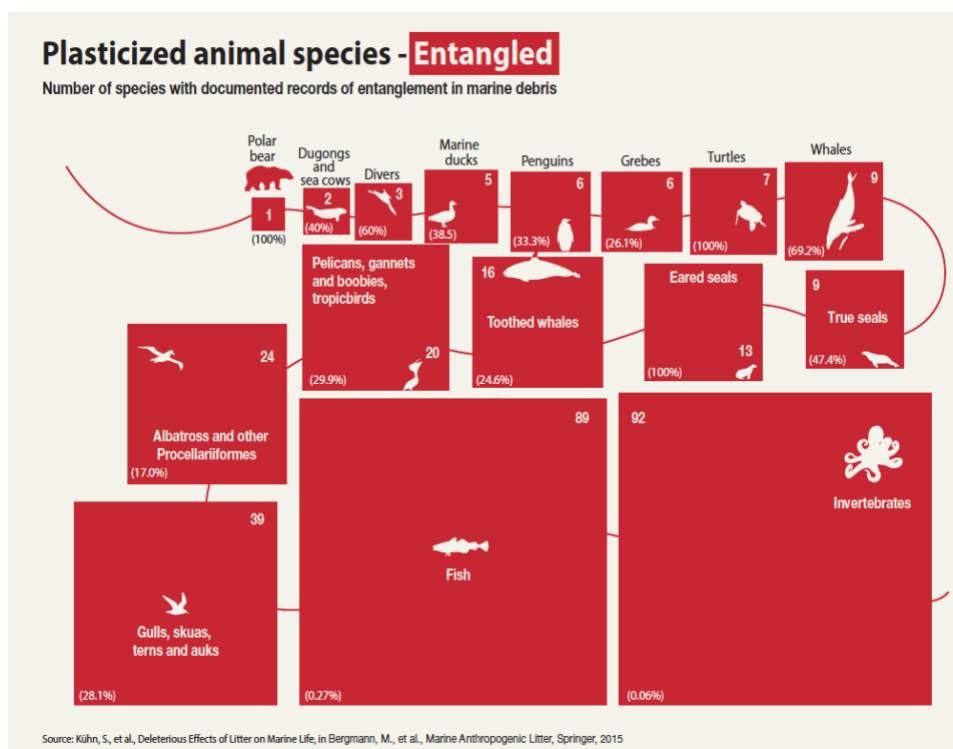
Definition of the scores:

-9: lethal or sub-lethal effect, which is global, highly irreversible, and occurring at a high frequency.

+9: positive effect in terms of diversity and/or abundance, which is global, highly irreversible, and occurring at a high frequency.

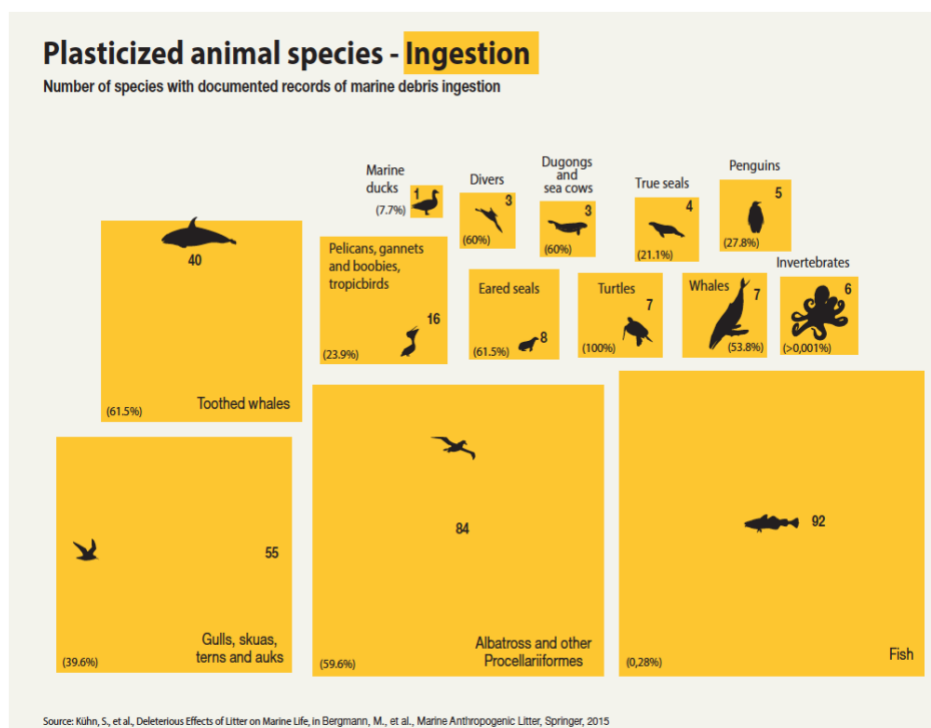
Source: (Beaumont, et al., 2019)

Appendix 6: Documented record on entanglement



Source: (Kühn, Bravo Rebolledo, & van Franeker, 2015)

Appendix 7: Documented record on ingestion



Source: (Kühn, Bravo Rebolledo, & van Franeker, 2015)

Appendix 8: Overview environmental impacts

ENVIRONMENTAL IMPACTS	Marine litter sizes, types and impacts*					
	Marine litter size:	Nano <1µm	Micro <5mm	Meso <2.5cm	Macro <1 m	Mega >1m
ENVIRONMENTAL IMPACTS	Impacts: Ecological impacts (e.g. population, assemblages, ecosystems)	Potential for population decline, changes in assemblages and ecosystem functioning e.g. shift in microbial community.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. endocrine disruption in fish.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. mass decline in population due to ingestion causing mortality in sea turtles and sea birds.	Evidence of effects on assemblages and ecosystem functioning e.g. plastic bags. Population decline, changes in assemblages and ecosystem functioning e.g. from mass strandings of sea turtles from entanglement; changes in assemblages due to changes in habitat structure.	Population decline, changes in assemblages and ecosystem functioning e.g. changes in populations and assemblages due to ghost fishing. Invasive alien species (IAS) predation / displacement of indigenous species.
	Pressure:	Uptake via absorption, ventilation, and/or ingestion; transfer of chemicals: e.g. mussels, oysters, sponges, fish, corals, phytoplankton	Uptake via absorption, ventilation and/or ingestion; transfer of chemicals: e.g. fish, birds, oysters, corals	Ingestion, transfer of chemicals: e.g. birds, fish and marine mammals	Ingestion, transfer of chemicals; entanglement: e.g. birds, crustaceans, turtles, whales, dolphins, sea lions	Entanglement: whales, dolphins, sea lions, turtles, birds, fish
ENVIRONMENTAL IMPACTS	Impacts: Individual organism	Sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression.	Potential effects from physical presence of ingested plastic, concerns about possible effects from transfer of chemicals: reduced feeding, sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction	
		Health impacts unclear.			Rafting, movement of animals.	

Source: (UN Environment, 2017)

Appendix 9: Overview social impact

SOCIAL IMPACTS	Marine litter sizes, types and impacts*					
	Marine litter size:	Nano <1µm	Micro <5mm	Meso <2.5cm	Macro <1 m	Mega >1m
	Human health	Risk from nano particles passing cell walls. Potential perceived (subjective) risk from chemical contamination in fish and shellfish eaten in the future, and possible transfer of pathogens.	Perceived (subjective) risk from chemical contamination in fish and shellfish eaten, and possible transfer of pathogens.		Injury on beaches, danger to fishermen, well-being loss / mental health impacts from degraded environment.	Loss of protein (where fish availability is reduced). Physical health risks of boats / individuals becoming entangled, and mental health risks from degraded environment. More indirect: loss of health benefits by avoiding littered coastlines.
	Communities (e.g. coastal fishing communities)	Concern regarding health of the community's environment. Actual impacts unclear.		Cost of clean-up, well-being loss from degraded environment.	Cost of clean-up, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values.	Loss of livelihoods, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values
	Poor / poverty (e.g. lowest income groups)	Loss of well-being in polluted living environments – but given "invisibility" of nano and microplastics – actual perception of well-being loss depends on awareness levels.		Loss of well-being in polluted living environments	Loss of well-being in polluted living environments.	Loss of well-being, fish stocks, tourist revenue in polluted living environments

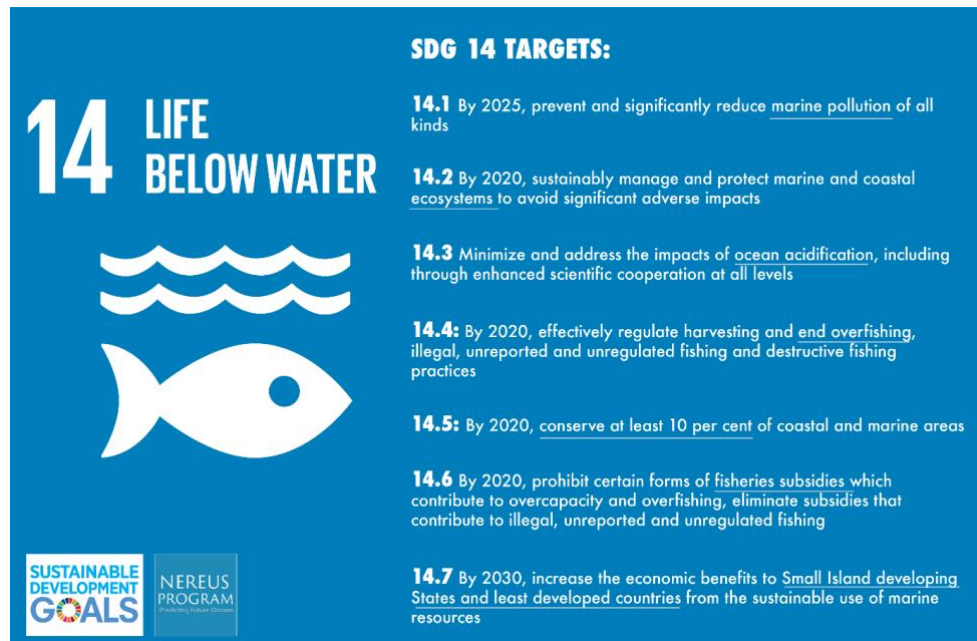
Source: (UN Environment, 2017)

Appendix 10: Overview economic impacts

ECONOMIC IMPACTS	Fisheries and aquaculture	Potential perceived (subjective) risk from chemical contamination in fish, shellfish and aquatic plants that are eaten. Pending perception issues this can lead to lower demand for and/or value of fish/seafood.		Ingestion could lead to lower quality fish and hence lesser market value.	Entanglement in: propellers and damage to fishing vessel; related loss of fishing time, loss of fish and associated revenues. Potential risks to fisheries community cohesion / local identity / cultural values.	Ghost fishing: loss of output and hence livelihoods; damage to boats and equipment.
	Tourism and Recreation	Unlikely to have any discernible impact unless new information comes forward on health impacts.	Only if integrated into beach labelling.	Evidence of marine litter can discourage tourism and recreation on beaches, reducing income and/or well-being.	Reduction in tourist and recreation numbers and hence income / well-being. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).	Reduced income from polluted beaches. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).
	Shipping	No	No/unlikely	Damage to vessels (cooling systems)	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.
	Local authorities and municipalities	Degradation of the natural environment within their jurisdiction. Potential increased cost of waste water treatment.		Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.

Source: (UN Environment, 2017)

Appendix 11: SDG 14 targets



Source: (World Economic Forum, 2018)

Appendix 12: Product details IKEA x Seaqual

Product details

100% of the material in this product comes from recycled PET bottles, of which 2% is ocean plastic. And when it's time to recycle it, all the materials can be used and made into a completely new product.

For every kilo waste that's used to make the fabric, another 9 kilos of garbage are taken out of the ocean.

Source: (Ikea, 2020)

Appendix 13: Home page Oceans Win ©



Source: (Oceans Win, 2020)

Appendix 14: Promotion of new pair of shoes Ocean Refresh



Source: (Ocean Refresh, 2020)

Appendix 15: Recommendations for determining recycled content

1. **Aim for the highest possible amount of recycled content** and segregate recycled feedstock from virgin feedstock in the supply chain.
2. Use **‘batch level’ mass balance to determine recycled content when segregation is not feasible**, which enables you to know the proportion of recycled material fed into the process and estimate actual recycled content in final products placed on the market.
3. **Do not allow for the trading of recycled content as part of a credit system**, both between sites and countries, including other sites belonging to the same company.
4. **Evenly allocate the recycled content to output products where mass balance is used** instead of allocating it arbitrarily (unless the actual recycled content of each output can be verified).
5. **Ensure strong physical and chemical traceability of recycled content**, thus ensuring that there is a proven chemical route between the input feedstock and the final product; and that input material can only replace its own share of the final product.
6. **Avoid converting recycled content into theoretical “currencies”** such as calorific value or carbon, which would further facilitate a certification scheme for recycled content.
7. **When determining recycled content, only include post-consumer waste and not pre-consumer waste.**
8. **Set strict eligibility criteria for plastic waste used for “chemical recycling”** to avoid competition with mechanical recycling feedstock.
9. **Account for the full life cycle of products in the chain of custody model**, taking consideration to material and carbon losses.
10. **Ensure full transparency towards consumers** by avoiding false claims and excluding additives from counting towards recycled content targets.

Source: (Trabizi (ZWE), Crêpy (ECOS), & Rateau (ECOS), 2021)

Appendix 16: Overview of the properties of each chain of custody model

	2.1 Identity preservation	2.2 Segregation	2.3 Mass balance overview			2.4 Certificate trading
			2.3.1 Batch level mass balance	2.3.2 Site level mass balance	2.3.3 Group level mass balance	
Ensure that volumes of certified material sold matches (or does not exceed) volumes of certified material bought ¹	Yes	Yes	Yes	Yes	Yes	Yes ²
Traceability linked to volume reconciliation over a set time period	No	No	No	Yes	Yes	Yes
Allows mixing of certified and non-certified content	No	No	Yes	Yes	Yes	Yes
Physical traceability	Yes	Yes	Yes	Yes, to point of blending	Depends	No ³
Identify origin of a final product or product component in actual product	Yes	Yes, but 'origin' may not be as specific as IP depending on the supply chain (e.g. to country or region may be possible)	Depends (lost with physical blending)	Depends (lost with physical blending)	Depends (lost with physical blending)	No

Source: (ISEAL alliance, 2016)

Appendix 17: Antonio Astone (Personal communication, April 15, 2021)

- Traceability management systems: different ways to address it:
 - o Book & claim
 - o Mass balance
 - o Identity preserved & segregated (chose that one for standard)
- Plastic collected from beach: source is hard to determine (uncertainty)
- Development of a certification, 2 aspects:
 - o Standard = set of requirements → stakeholders (university, researchers, brands, NGO's)
 - o Audit
- Minimum safeguards: no exploitation, respect human rights etc

- 10% rule is for additives because color is often made from plastic
- Idea of Ocean plastic
 - o Recovering
 - o Biosphere
- Ocean Bound plastic is a misleading term

Appendix 18: Antonio Astone (Personal communication, April 26, 2021)

- If consider nets in certification → need for different standards because:
 - o Shore/Ocean = location
 - o Nets = type of plastic
- Don't add too much social aspects like child labor etc otherwise audit will be too long (standards provide minimum requirements, during audit and depending on case, other aspects can be controlled)
- Audit system:
 - o Unannounced audit
 - o Announced audit
 - o Semi-announced audit (parties agree on a period typically 1 week or month and organization must be ready for inspection)
 - o Extra: continuance audit (24h camera)
- Case: Resea
 - o For every 1kg collected → register on blockchain platform with video/photo
 - o Blockchain system = VeChain (uses less energy & CO₂ than Provenance)
 - o Important: DNV had to adapt system especially for collection in developing countries = registering with little manipulation as sometimes person cannot read/write (hence pictures/videos)
- Stakeholders → have good balance between interest & not
 - o ISO/ISEAL that sets criteria for identifying & selecting (stakeholder engagement)
 - o For DNV, 40 stakeholders (had to comment each line but did not receive a lot of comments)
- Rule:
 - o A logo refers to a certificate that refers to a standard that sometimes refers to a regulation

Appendix 19: David Cecchini (Personal communication, April 27, 2021)

- Problem with Ocean Bound Plastic
 - All plastics collected in Denmark could be considered as such
- Wording is important!
 - Plus give guidelines to organizations how to communicate; DNV didn't do that; say what wording you can use etc.
- Was pushing to include percentage preserved model in the DNV standard and put the percentage on the final product
 - Because as long as the end user is aware of and has full information then every percentage of recycled content should be valid.

Appendix 20: David Cecchini (Personal communication, May 5, 2021)

Comments on the Marine Plastic Certification Standard V1:

D - Overall it was fine I think, my main concern is personally, I don't like it if it is called marine plastic if it is from the shore. But I think you did a good explanation there but that's just me. You could leave it as it is, for most people I don't think it's a big thing.

First thing I wrote is that you keep capitalizing ocean plastic, just giving you a heads up because of the trademark in the US.

Second thing is about your two subcategories, Marine plastic Ocean includes all plastics collected in the hydrosphere, the DNV standard states that you can't call it ocean plastic when it comes from a river, then it has to be called river plastic

C – good comment, I just didn't know how to call it else, it has to be something short as Shore, that would refer to the hydrosphere, like Water?

D – I don't know, for me it should be Marine Plastic for the hydrosphere and then Shore Plastic for the shore. These are personal preferences, I don't say they are wrong, I don't think they are, I just say that these are technically confusing especially if you try to bring transparency to it. It

shouldn't be called ocean plastic unless it comes from the ocean. The DNV standard uses that requirement.

C – Yes, I do agree it brings confusion

D – The other note I put down is regarding the percentage, the 50% for the blended modeling. In the recycling industry 50% is still considered very high. If you want lots of people to use it, you might consider putting it down to 30. Personally, I don't see a big difference between 30 and 50 as long as you indicate how much is in there. Also, most people put 25-30%.

C – I chose the 50% because the other certifications (Oceancycle & OBP) were at 25 and 30%. So, I wanted to increase that percentage to differentiate from them. Also, I made a survey to have consumer's point of view and more than 65% expected more than 50% in recycled content.

D – I agree with you on that aspect, my concern isn't really for that, it's what is your purpose with this standard. If the purpose is to have as many people as possible involved in this standard, then that's why those other people have put 25% in their standards. If you have very strict rules and have to label things, I don't think the percentage matters much. I am just saying that if you put 50%, less people will use it as not a lot of people use 50% and that's why the other ones did 25 and 30%. You have to figure out what you want as far as if you want as many people as possible to use the standard or if you want to keep it high. That is the problem with the DNV standard and their 90%. That is really limiting the amount of people, almost no one is going to be able to use it. Nobody uses that percentage.

I do have a quick question about your shore definition. It says that shore has to be 100m from the edge of the hydrosphere including ports and harbors. Elsewhere, shore is defined as land along the edge of the ocean, sea, lake, and river. I think that, again it is just an opinion, a stronger definition of shore would be land alongside the hydrosphere that experiences seasonal, environmental, or weather induced exposure due to the hydrosphere. I put it that way because I guess it depends, again on what you are looking for, extreme closeness or do you it to be

C – Extreme closeness but I talked with Antonio from DNV because at first, I wanted to add a third category called Nets. In order to include the collection of fishnets in ports. He said it was

hard to combine the location type and the type of plastic so the idea that shore could also include ports as it is also at the edge of a hydrosphere.

D – I think that makes sense to me, that definition is fine which is in the definition section. I think the definition could be limited to an area that could risk exposure to the hydrosphere if that makes more sense. Because you could be within a 100m of the shore and not really have a chance of having that plastic reach the water. So, is that true ocean bound plastic as they would say? It is just something you might want to think about.

C – If you consider only those that are at risk, how can we include nets in ports? Because eventually they discarded improperly in ports are thrown away in the ocean because there is no clear discarding place.

D – I guess the only way you could to it is with the 100 meters, but you might want to reconsider your definition and beef it up with what you are saying. Because the important thing is to make clear what your definition means in your standard and at the moment those are two contradictory statements. I would put the land alongside the edge of a hydrosphere within a 100m and even put a little justification there. This definition should be about what shores means in your standard. So, I don't have any confusion. Then it's fine.

Just a heads up, we mentioned it to DNV, but they just decided to ignore it, you will have to add some virgin plastic when you recycle as well. They have to add it when they initiate the process during mechanical recycling. It is a very small amount in general like 1 or 2%, so it is included in the 10%. It is a normal operation; you add a small amount of stabilizer.

So just, overall, you have to determine your goal, if it to have a maximum of people signing on then you might consider lowering to 30% and altering some stuff.

C – would it be good to have as goal to have a maximum of people? Because if you want to stay credible for the end consumer you also have to be peaky.

D – I agree with that concept. To me, it is about getting as many people on as it would increase the awareness of the standard while at the same time, maintaining the integrity of the standard. Therefore, to me, I don't care if it is 40, 50 or 30% as long as they put that percentage. Recycling wise, very few people to 50% or more.

The last thing I wanted to talk to you about is the recycling industry. Recyclers work on very thin margins. So, they work in huge volumes, but very thin margins. They do what they can do in order to stay somewhat profitable. So, they don't like to spend an extra little time on thing because it doesn't make sense for them to do that. This is where those little percentages matter to them because when you are using recycled content to make products, it doesn't make sense to use recycled stuff, the only reason is because of the PR you get from recycled material. Recycled material is always, always worse than virgin material and always, always more expensive than virgin.

The more people you get on, the higher quality your standard will become. I just wanted you to take that into account when you are finalizing your decision process. For people to use, they got to see a reason to use it. That's why there are so many standards that aren't that great because they just want that sticker. So yes, other than that, it looks great, congratulations on that I hope it works out for you!

Appendix 21: François van den Abeele (Personal communication, May 5, 2021)

Comments on the Marine Plastic Certification Standard V1:

- You always mention recycled but I would add upcycled as well. We do chemical recycling, so we have an upcycled material after the process.
- I would differentiate an organization making a 50% from a 70% effort. The Cradle2Cradle certification is divided into 5 levels: Basic, Bronze, Silver, Gold and Platinum. That way bigger efforts are acknowledged; I would allow 30% with different levels of effort.

Appendix 22: Nekane González (Personal communication, May 11, 2021)

Comments on the Marine Plastic Certification Standard V1 (translated from Spanish):

- It looks pretty good, but I would emphasize that everything has to have a minimum to be considered as marine, I know there is the 50% rule, but I would say more like I would put for example: there are brands that do not say it, and everything is considered marine. Tests must be carried out to ensure those 50%

- I would still emphasize the 50% that must be fulfilled because otherwise it would be more terrestrial than marine. I would consider that my material can be said to be marine material when it has a minimum of 50%. At least that it is the same as the rest of the plastic they put in. The 30% suppose that the 70% left is not.
- The idea of having a level scheme as Cradle to Cradle is not a bad idea.

Appendix 23: Antonio Astone (Email, May 19, 2021)

Comments on the Marine Plastic Certification Standard V2:

I think it is well developed. It covers the main aspects that should be included in a document with this purpose.

I list some areas of improvement, especially in the perspective to operationalize the scheme: The current version is a mix of requirements related to system, product and a traceability process. It is quite normal when the topic “traceability” is in focus, because normally you have requirements and guidelines addressing management system’s aspect (competence, procedures, policies etc), product (physical characteristics of a product) or traceability processes. But this has impact in the certification perspective because certification rules (how you do the audit, how you apply sampling, the reference you use for the auditing process) are very different depending on the scope (system, product or process).

The details for using the standard in a certification perspective are deployed normally in other documents: for example, in our case, we have a set of documents to be used together with the standard (which is only the list of requirements), such the regulation for the use of mark, the audit procedures, auditor qualification procedures, certificate regulations sampling to be used, types of evidence you have to collect etc. just to give you an example: in our scheme, we rely on many scientific techniques to ensure that traceability is in place, such x-ray analysis, DNA tagging etc. To be able to conduct the audit and to release the certification, in a professional context, you have to build all these pieces. But for your current purpose, what you did in my view is enough.

§ 1.11.1: reqs for mark use are typically something managed in a separate document, a guide for the use of mark, which is a part of the contract with the customer/auditee and cannot be part of the standard.

§ 7 legal compliance. This is a fair requirement, we too we have a high level req (under 5.1) addressing this aspect. In line with the comment above, it is important to have a clear process, in a certification perspective, to audit these requirements. For this purpose, we developed a guide for auditors, risk-based, which includes also external references to assess in a reliable way this requirement.

As already said, the development of a certification requires the involvement of stakeholders, parties who have vested interest in the domain and can address the requirements in order to be sure that the main needs and expectations of the market are addressed. A proper consultation is needed normally when developing a “certification” scheme. This is also a condition of the ISEAL guide, that you mentioned in the list of reference.

You mentioned DNV scheme among references, and it is fine. I saw many similarities with our scheme, which is fine if it is for research purposes. In a market perspective, our standard is copyright protected, and some adjustments are needed if you aim to use your standard commercially.

§ 6 document procedure. In my view it is a bit ambitious to require the registration in “a blockchain”. We massively use blockchain and some of our clients use it, but it is very demanding to require it as a formal requirement, especially in places where the collection happens (developing countries). I suggest mentioning blockchain as example of possible tool to register it, but not imposing it.

Appendix 24: François Ducarme (Email, May 15, 2021)

Le point le plus important : outre l'écriture des standards, il faut aussi avoir une organisation responsable de ces standards pour les faire fonctionner (owner of the certification scheme).

Il doit s'agir d'une entité juridique bien identifiée (ça peut être une structure de type asbl ou une société commerciale, ça peut être une entité préexistante ou une entité créée spécifiquement pour les besoins du nouveau système de certification). La complexité de cette structure et les tâches qu'elle doit assurer dépendent des règles propres au système de certification, et elle peut aussi évoluer dans le temps (un nouveau système qui démarre avec peu de moyens a une structure plus simple qu'un système bien établi comme FSC qui s'est développée pendant plusieurs dizaine d'années qui a plusieurs milliers de certificats et plusieurs centaines d'organismes de certification). Le travail inclut par exemple approuver les standards et les tenir à jour (il y a toujours inévitablement besoin de révisions), constituer un comité technique, comité exécutif, secrétariat, un conseil d'administration, une assemblée générale, une liste de membres (selon les besoins), consulter les stakeholders (important pour s'assurer que le système soit crédible, reconnu et réponde aux besoins du marché), jouer un rôle dans l'approbation des organismes de certification (que ce soit approbation directe par l'organisation qui gère le système de certification ou avec intervention d'un organisme d'accréditation indépendant), si intervention d'un organisme d'accréditation : faire reconnaître le système par l'organisme d'accréditation (étape préalable avant que les organismes de certification puissent se lancer dans l'accréditation), tenir à jour une liste des certificats , promouvoir le système de certification, le faire connaître, surveiller la qualité et les risques de fraude, clarifier l'interprétation des règles dans le standard, généralement phases de test (pilots) à prévoir avant de démarrer à plus grande échelle

Évidemment tout ça ne se fait pas d'un coup, ça prend généralement quelques années avant que le système ait une certaine maturité. Une fois que le « scheme owner » a adopté ses standards et défini les règles pour l'approbation des organismes de certification (via accréditation ou via un mécanisme plus simple), il faut que les organismes en question décident/acceptent d'investir dans le système (c'est à dire faire les développements techniques et commerciaux nécessaires pour pouvoir offrir le service, ce qui inclut la création d'un système qualité et des procédures internes conformes aux règles spécifique au système et, si nécessaire, une demande d'accréditation)

Les mécanismes « plus simples » pour autoriser un CB à commencer des activités de certifications sont basés sur une approbation par le scheme owner lui-même (sans recours à un organisme d'accréditation extérieur). Donc le scheme owner définit des règles dans ses standards (toutes les conditions auxquelles le CB doit satisfaire) et demande aux CBs intéressés d'introduire un dossier pour démontrer cela (ça peut inclure une description du système qualité, CV et expérience du staff qui sera impliqué, existence préalable d'accréditation pour d'autres scopes de travail, participation à une formation d'auditeur...). Si le scheme owner est satisfait de la candidature, il y a alors généralement signature d'un accord entre le CB et le scheme owner et autorisation provisoire pour le CB (applicant CB). En général l'autorisation définitive est sur base de la finalisation d'une première certification.

Les CB décident s'ils veulent participer ou non... Évidemment le scheme owner peut éveiller l'intérêt des CBs potentiels plus ou moins activement en faisant connaître le système et en identifiant la demande sur le marché (demande pour les produits certifiés et donc demande des producteurs pour avoir accès à la certification). Décision du management en fonction de la perception de la demande (potentielle) sur le marché, d'intérêt plus ou moins manifeste de clients possible pour le service à court terme et à long terme, de l'investissement nécessaire pour entrer dans le marché (formation, recrutement, prospection commerciale...), de la position plus ou moins favorable pour entrer dans le marché (présence de staff avec la qualification requise là où la demande est perçue, contacts existants avec client potentiels), des risques pour la réputation

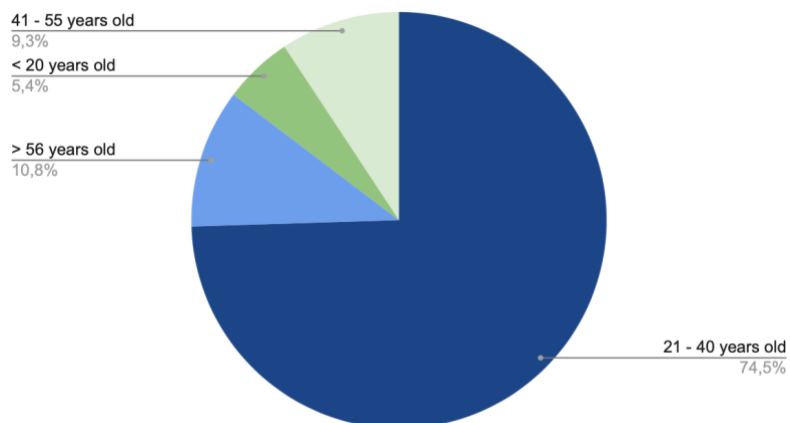
Plus l'investissement initial est élevé et plus la demande semble faible, plus le CB va hésiter. Si l'investissement de démarrage est minimal, le CB pourrait vouloir participer assez facilement même si la demande est faible, à condition que le système soit crédible (crainte éventuelle de compromettre sa réputation en participant à un système qui repose sur des bases trop incertaines, des critères peu objectifs ou contestables...)

La demande étant initialement faible ou incertaine, il est sans doute préférable de commencer avec des exigences assez basiques pour les CBs afin de permettre au système de démarrer (quitte à renforcer les exigences par la suite). Le point le plus critique est je pense d'identifier des entreprises avec un intérêt réel pour le système et intéressées par se faire certifier (souvent les parties intéressées sont prêtes à jouer un rôle dans le développement du standard)

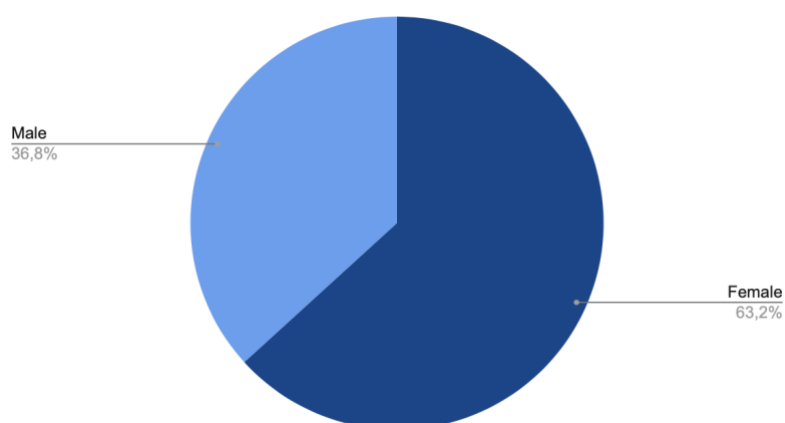
Appendix 25: Online survey: perception on the ocean plastic industry

Section 1: 203 responses

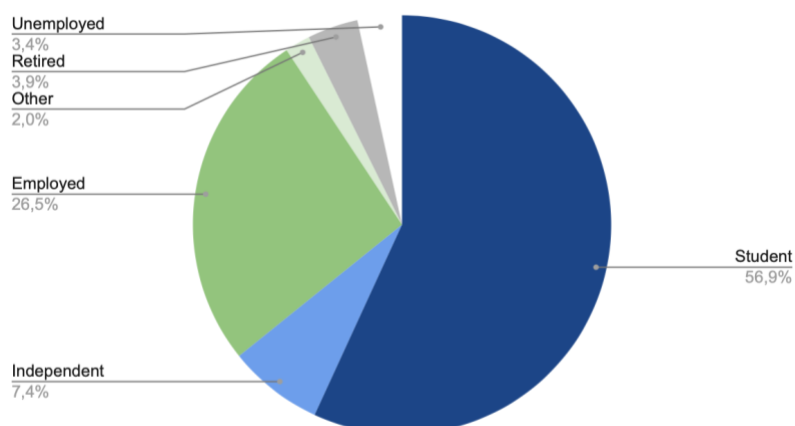
Question 1: Age



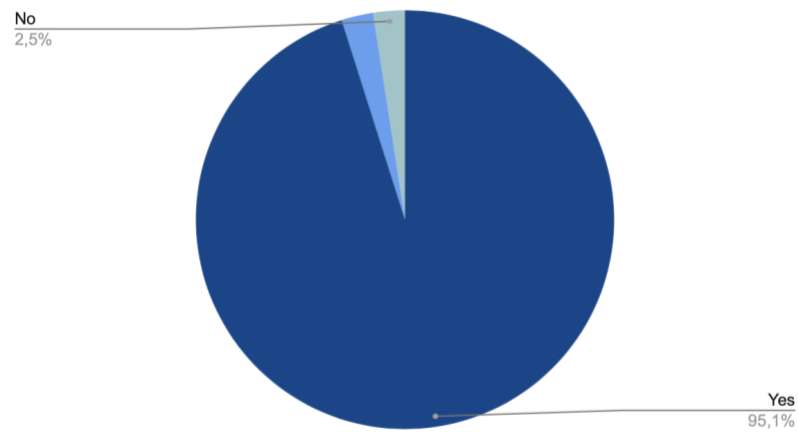
Question 2: Gender



Question 3: Occupation



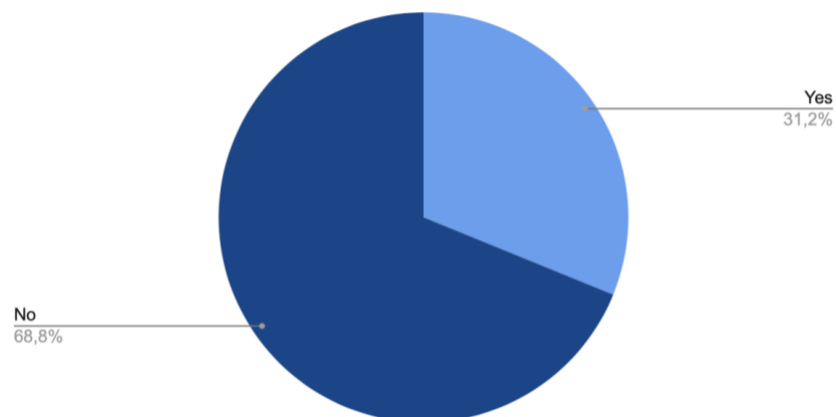
Question 4: Do you feel concerned by the ocean plastic pollution?



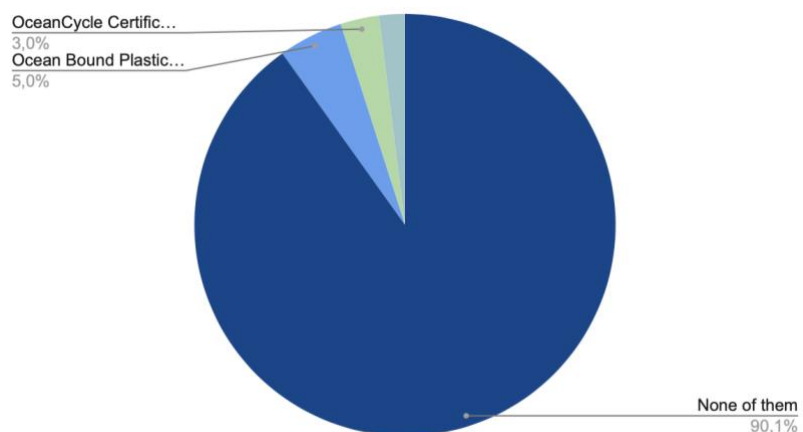
The light blue section being “no opinion” with 2,5% (5 respondents).

Section 2: 198 responses

Question 1: Have you already seen/bought a product with the claim: “Made from ocean plastic”?



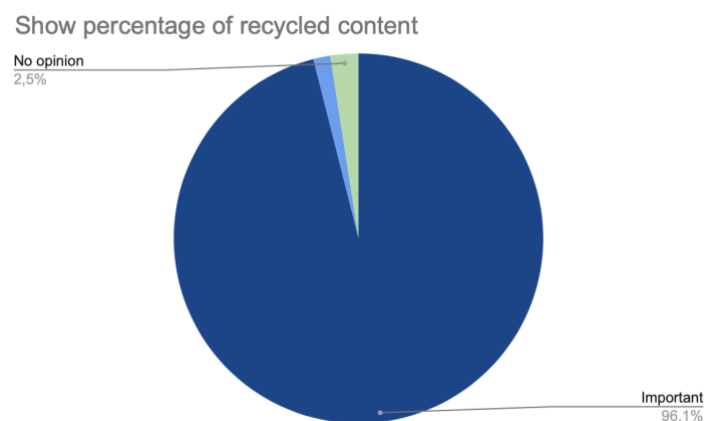
Question 4: do you know the following certifications?



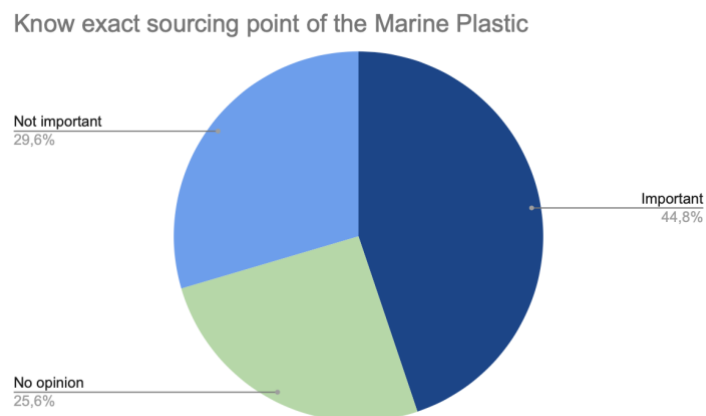
The grey part with 2,0% (4 responses) where the person knew both two certifications.

Section 3

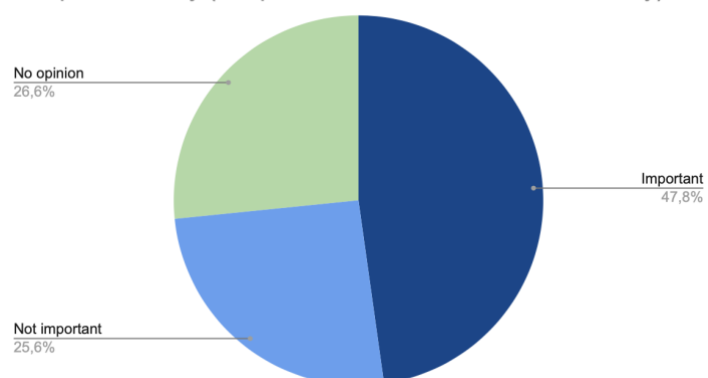
Question 1: What would you expect from the Marine Plastic Certification?



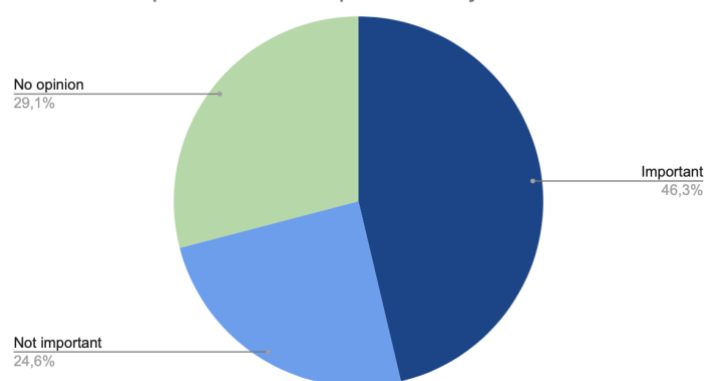
The blue part being the response “not important” with 1,5% of the votes (3 respondents).



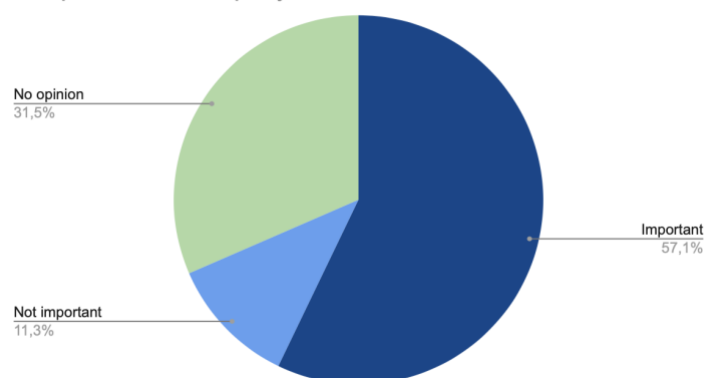
Full product story (Keep track of the whole chain of custody)



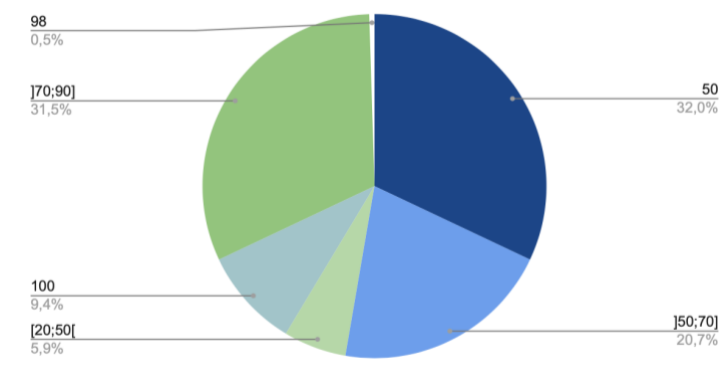
QR-code on product with that product story



Independent / Third-party certifier

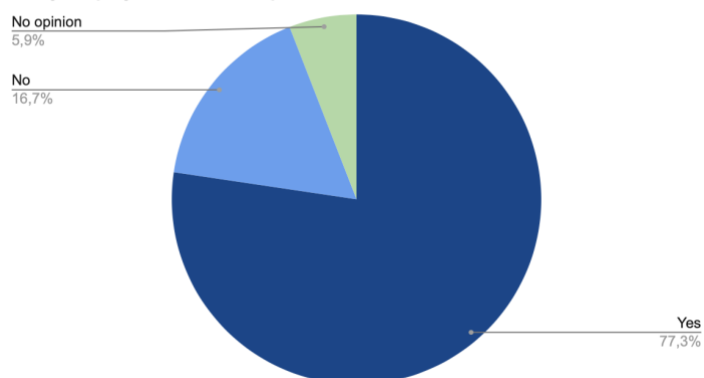


Question 2: What minimum percentage of recycled content would you require for The Marine Plastic Certification?

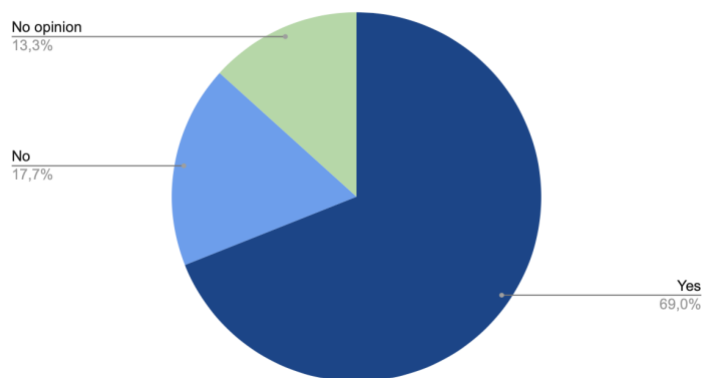


Question 3: Your purchasing behavior

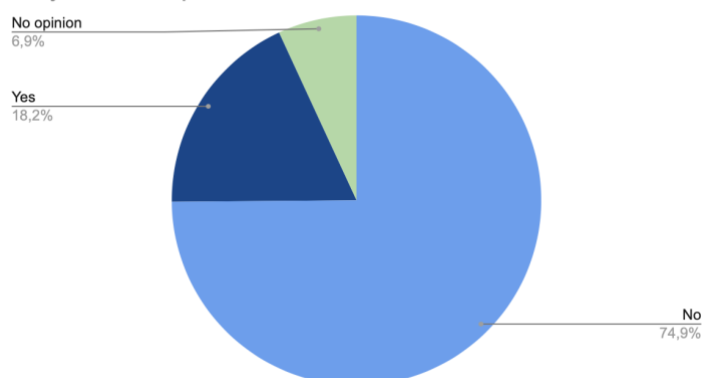
Do you pay attention to product labels?



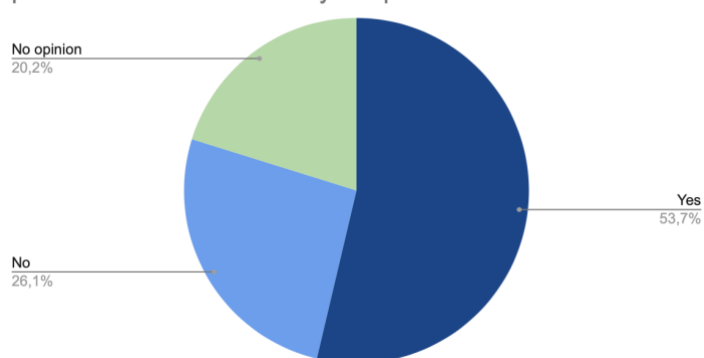
Would you favour a product having a label over another?



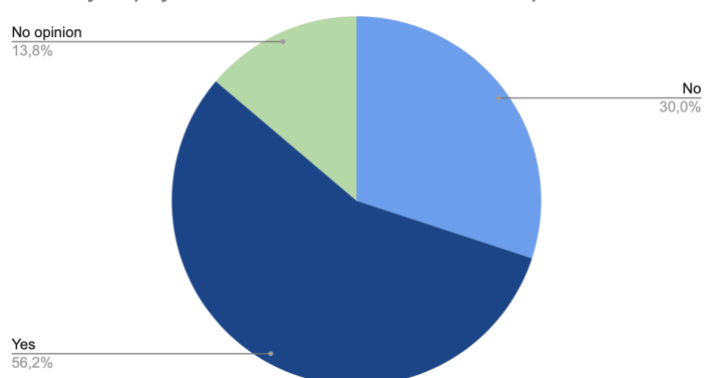
Do you trust all product labels?



Would you be more sensitive to certified Marine Plastic products than from other recycled plastics?



Would you pay more for certified Marine Plastic products?



Section 4

If a person has any additional contribution.

1. for the certification of Marine Plastic products, I might be more sensitive if I know exactly what is behind this label. Because finally all these labels are very pretty, but If we dig deeper like the label MSC we can observe that it is a lie on a lot of their promises.

2. Knowing how all plastic recycling industry is basically unsustainable both on an ecological and economic point of view (and even more after China's WTO notification regarding plastic waste import) shouldn't the focus be put on alternative/fully biodegradable packaging instead of a so-called "sustainable" plastic?

3. The trust in the label is super important. As some documentaries have shown (e.g., seaspiracy, some fishing labels are total bullshit.). A label is nice, but transparency and tracing are a must for the future and in my opinion to build trust in the label. (a label showing the downside of the certification and asking the community for solutions for the problems related to the label is also something that brings transparency and confidence. Can help to avoid greenwashing sentiment from the consumer.

Concerning the price of the product I believe it depends. Not only the label is important, but the product also must have a special design and quality too. The label only isn't sufficient it must be an added value but not the main value proposition.

The Marine Plastic Certification Standard

Plastics collected in the hydrosphere and/or on shores

**Chain of custody based on identity preservation,
segregation, and percentage blending models**

General principles and requirements

1 Foreword

For my master thesis, I have decided to focus on the Ocean Plastic Pollution. Since September, I have made massive research on that topic that made me want to create The Marine Plastic Certification Standard. First, as the ocean plastic industry is booming, I believe it is important to create a trustable ecosystem. But more importantly, the aim is to provide end users with a label they can trust. The other objective is to create massive awareness on the ocean plastic pollution and take on the opportunities.

The Marine Plastic Certification is divided into two subcategories:

- Marine Plastic: Hydro
Includes all plastics collected in the hydrosphere.
- Marine Plastic: Shore
Includes all plastics collected on land along the edge of the hydrosphere (i.e., maximum 100m of the edge) that experienced seasonal, environmental, or weather induced exposure to the hydrosphere.

2 Introduction

Growing awareness has been reported about threats against health, safety, and environment which results in consumers being more attentive regarding sustainability themes. Plastic pollution has become one of the most pressing environmental issues all over the world, especially in the marine environment.

The following standard aims at creating a set of minimum requirements to be certified as “Marine Plastic”. This standard is needed to verify every phase of the recycled plastic process.

This standard is applicable to all typical stages of the value chain:

- Collection
- Transportation
- Recycling
- Manufacturing
- Sales

3 General principles and requirements

3.1 Scope

This standard applies to all organizations willing to claim that they collect, recycle and/or produce finished goods from Marine Plastic by ensuring the verifiability of the sourcing point.

This standard:

- Offers an exhaustive list of terms and definitions.
- Sets the minimum requirements needed for a chain of custody based on either the identity preservation, the segregation model, or the percentage blending model applied to the supply chain of products made from Marine Plastic. The mass balance approach is purposely not accepted within this standard as it cannot guarantee the expected requirements of traceability.

This standard is only applicable to products containing Marine Plastic (Hydro and/or Shore) as defined previously. Principles regarding the recycled content are as follows:

- Identity preservation and segregation model: because of technical/industrial reasons additive carriers can be added up to 10% of the total mass of plastic. This must be declared in the final product.
- Percentage blending model: final product must contain at least 30% of certified Marine Plastic.

Each organization/product will be accorded an achievement level depending on the percentage of certified Marine Plastic:

- Bronze: certified Marine Plastic between 30 and 50 percent (50 not included)
- Silver: certified Marine Plastic between 50 and 70 percent (70 not included)
- Gold: certified Marine Plastic between 70 and 90 percent (90 not included)
- Platinum: certified Marine Plastic equal or above 90 percent.²⁶

A complete chain of custody adopting this standard across its value chain may include waste collectors, transporters, recyclers, and manufacturers.

²⁶ Automatically categorized as Platinum when using either the identity perseverance or segregation model.

3.2 References

This standard is based on the following references:

- DNV – Plastics collected in the hydrosphere standard
- ISO 9000:2015 – Quality management systems – Fundamentals and vocabulary
- ISO 22095:2020 – Chain of custody – General terminology and models
- ISO 14020:2000 – Environmental labels and declarations – General principles
- ISO 14021:2016 – Environmental Labels and declarations – Self-declared environmental claims
- ISO/IEC 17000:2020 - Conformity assessment — Vocabulary and general principles
- ISO/TS 17033:2019 – Ethical claims and supporting information – Principles and requirements
- ISO 26000:2010 – Guidance on social responsibility
- ISO 15270:2008 - Plastics — Guidelines for the recovery and recycling of plastics waste
- ISEAL Alliance – Sustainability claims Good practice guide – May 2015
- ISEAL Alliance – Chain of Custody Models and definition – Version 1.0, 2016
- ISEAL Alliance – Code of Good Practice for Setting Social and Environmental Standards

3.3 Terms and definitions

The following terms and definitions are applicable to this document.

1. Audit

Process for obtaining relevant information about an object of conformity assessment and evaluating it objectively to determine the extent to which specified requirements are fulfilled.

[Source: ISO 22095:2020]

2. Abandoned plastic in hydrosphere/on shores

Is a part of hydrosphere and shore debris, any persistent solid material (composed of polymers) that is manufactured or processed and directly or indirectly, intentionally, or unintentionally, disposed of or abandoned into the marine environment, lakes, and rivers or on shores. [Source: modified using NOAA definition, 2018]

3. Certification

Third-party attestation related to an object of conformity assessment, with the exception of accreditation. [Source: ISO/IEC 17000:2020]

4. Chain of custody

The process by which inputs and outputs and associated information are transferred, monitored, and controlled as they move through each step in the relevant supply chain. [Source: ISO 22095:2020]

5. Claim

Declared information regarding the specified characteristics of a material or product. [Source: DIS 22095:2020]

6. End-user

For the scope of this standard, is a person or persons who will ultimately be using the product made using plastics sourced from the hydrosphere for its intended purpose. [Source: DNV standard - Plastics collected in the hydrosphere]

7. Hydrosphere

Includes the waters of the ocean; rivers, lakes, and other bodies of surface water in liquid form on the continents; snow, ice, and glaciers; and liquid water, ice, and water vapor in both the unsaturated and saturated zones below the land surface. [Source: DNV standard - Plastics collected in the hydrosphere]

8. Identity preservation model

Chain of custody model in which the materials or products originate from a single source and their specified characteristics are maintained throughout the supply chain. [Source: ISO 22095:2020]

9. Organization

Entity or group of people and facilities with an arrangement of responsibilities, authorities and relationships and identifiable objectives. [Source: ISO 26000:2010]

Note 1 to entry: An organization may encompass multiple (production /geographical) sites.

10. Percentage blending model

This model maintains segregation until the final point of blending or mixing for a specific batch of a product. Mixing with non-certified product is controlled and recorded, so the proportion of certified content in each final product is known. [Source: ISEAL Alliance – Chain of custody models and definitions]

11. Record

Document stating results achieved or providing evidence of activities performed. [Source: ISO 9000:2015]

12. Recycling

Processing of plastics waste materials for the original purpose or for other purposes, excluding energy recovery [Source: ISO 15270:2008]

13. Segregation model

Chain of custody model in which specified characteristics of a material or product are maintained from the initial input to the final output. [Source: ISO 22095:2020]

Note 1 to entry: Addition of material with different characteristics and/or grade to the input is not allowed.

Note 2 to entry: Commonly, material from more than one source contributes to a chain of custody under the segregated model.

14. Shores

Land along the edge of the hydrosphere (i.e., maximum 100m of the edge) that experienced seasonal, environmental, or weather induced exposure to the hydrosphere [Source: modified using Cambridge dictionary, 2021]

15. Source

Specific originator at a location of a material or product with a specified characteristic. [Source: ISO 22095:2020]

Note 1 to entry: The originator is typically a specific supplier but can also be a specific manufacturer or specific processor adding a particular characteristic.

16. Supply chain

Series of processes or activities involved in the production and distribution of a material or product through which it passes from the source. [Source: ISO 22095:2020]

Note 1 to entry: A supply chain is typically composed of a series of different organizations.

17. Top management

Person or group of people who directs and controls an organization at the highest level. [Source: ISO 9000:2015]

18. Traceability

Ability to trace the history, application, location or source(s) of a material or product throughout the supply chain. [Source: ISO 22095:2020]

19. Traceability system

Manual or electronic system that provides the ability to access any or all information relating to the material or product under consideration throughout their life cycle, by means of accessing documented information. [Source: ISO 22095:2020]

Note 1 to entry: "Life cycle" should be understood in the broadest possible sense, to include, for example, raw material extraction, agricultural production, final disposal, and reuse or recycling, as well as all other stages connected with product manufacture and use.

20. Verification

Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled. [Source: ISO 9000:2015]

21. Waste

Anything for which the generator or holder has no further use and which is discarded or is released to the environment. [Source: ISO 14021:2016]

4 System Architecture

4.1 General

Three specific chains of custody models are accepted in this standard. A set of measures related to them has been developed. The choice of one model over the other results in different statements about the features of the final product.

The identity preservation model enables organizations to claim that a product is made using recycled marine plastic collected from a unique and defined source in the marine environment. The specific feature is that only one source applies to that product.

The segregation model enables organizations to claim that a product is made using recycled marine plastic collected from different sources in the marine environment. The common feature is that the marine plastic collected is sourced within the scope of this standard, meaning Hydro or Shores²⁷.

The percentage blending model enables organization to claim that a product is made using recycled Marine Plastic equal to a certain percentage. Hence, the organization may mix certified and non-certified materials if it is controlled and recorded.

This standard will provide a set of properties for those three models in order to implement a verifiable traceability system to ensure integrity of the general requirements of the chain of custody.

Those properties will allow users to transparently communicate on:

- Item-based expectations
- Market-based expectations
- Guaranteeing exact balance between certified marine plastic sold & bought
- Ensuring physical segregation of certified marine plastic with any other material²⁸
- Unequivocally identifying sourcing point of marine plastic (only applicable when adopting the identity preserved model)

²⁷ Refer to specific definitions

²⁸ Only applicable to final point of mixing when using the percentage blending model

- Communicating the percentage of certified Marine Plastic content (obligation when adopting the percentage blending model)

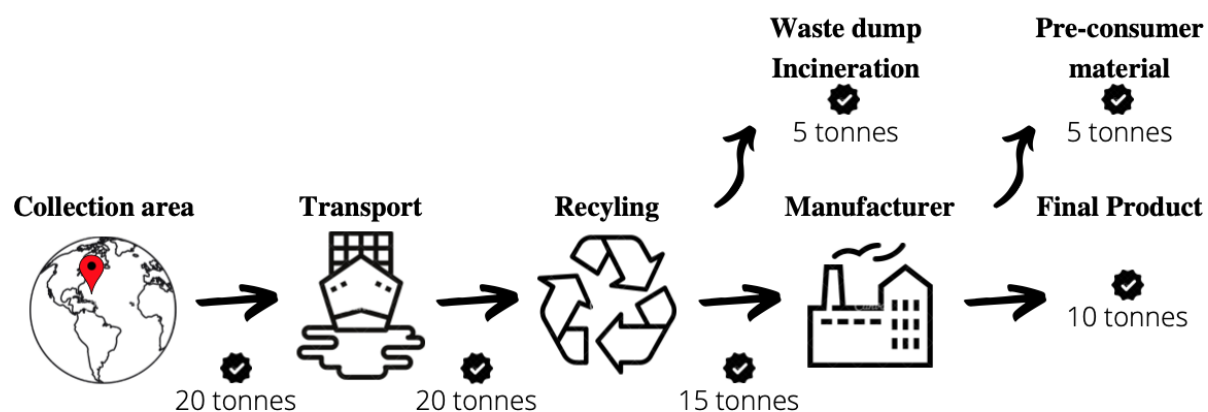
4.2 The identity preservation model

The identity preservation model ensures that certified Marine Plastic from a specific collection area is kept separate from any other sources. When used through the whole supply chain, certified products can be uniquely traced during the production process from the production site and/or batch through to the last point of transformation, i.e., labelling of the product.

This model doesn't allow certified material to be mixed with any other certified or non-certified material. Materials from different certified sources cannot be physically mixed and must be documented accordingly.

The identity preservation model allows to fulfill the item-based expectations of customers as the final marine plastic item details all the specific features on the label and/or with other specific claims.

The identity preservation model with indicated quantities as an example:

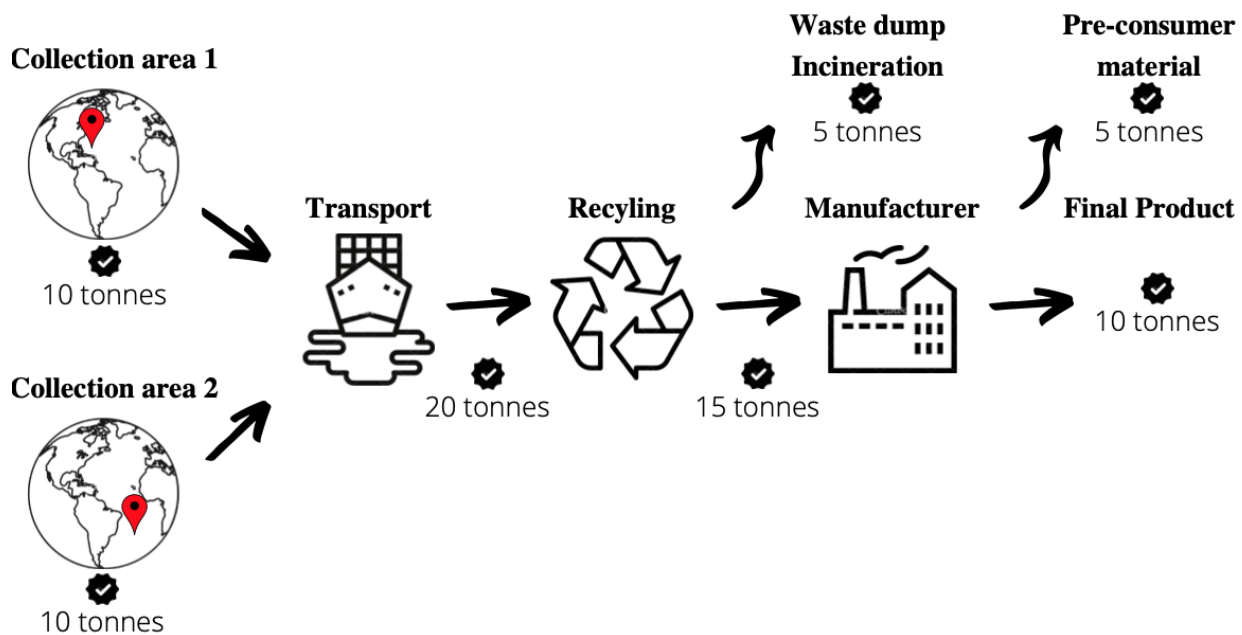


4.3 The segregation model

The segregation model ensures that a certified product is kept separate from non-certified sources through each stage of the supply chain. This allows to assure that products are made of certified marine waste, though it may not be possible to specifically identify which molecule came from which certified source.

This model allows the mixing of certified Marine Plastic collected from a variety of sources certified to the same standards and documented accordingly. However, the certified material cannot be physically mixed with non-certified material. The streams of Marine Plastic coming from different collection areas can be unified at any stage of the chain of custody²⁹.

The segregation model with indicated quantities as an example:



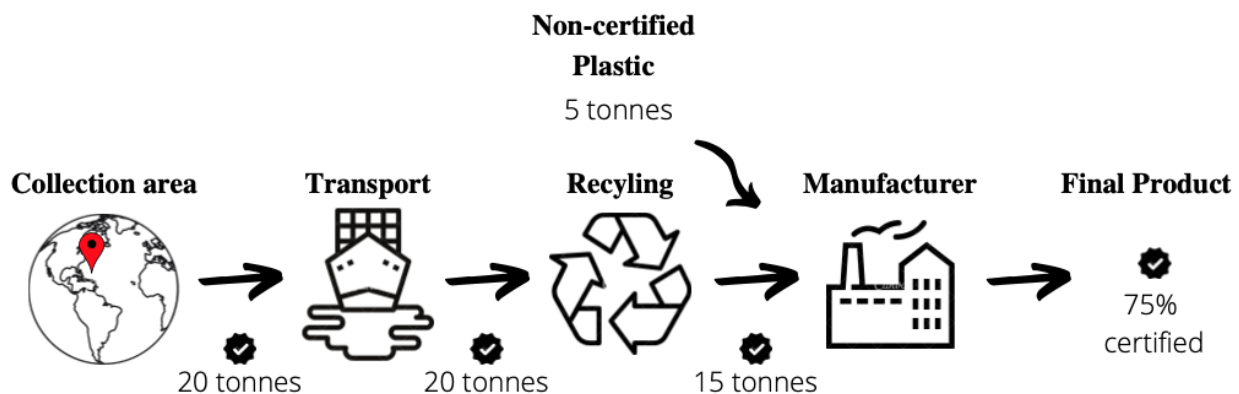
4.4 The percentage blending model

The percentage blending model, also known as batch-level mass balance or batch blending, ensures that the identity preservation or segregation model is maintained until final point of blending or mixing for a specific batch of a product.

Thus, the mix with non-certified material is controlled and recorded so the proportion of certified content is known in each final product. The only claim option available is the declared percentage claim. Meaning that when mixing two third of certified Marine Plastic with one third of non-certified material; all final products issued must carry a claim “contains 66% certified Marine Plastic”.

²⁹ i.e., before recycling, before or during manufacturing, etc.

The percentage blending model with indicated quantities as an example:



The strictness order regarding the different models of chains of custody is the following:

Identity preservation model > Segregation model > Percentage blending model

5 General requirements for a chain of custody system

5.1 Roles and responsibilities

In order to run a successful chain of custody system, the organization must:

- identify, all the actors and locations encompassed within the organization (e.g., collectors, transporters, recycling sites, manufacturers, and retailers)
- define sector specific minimum requirements
- organize the system, monitoring and managing the chain of custody in a way that there is a unique chain complying with all the minimum requirements
- verify if the requirements are reached
- implement the system by each organization involved in the chain
- implement a chain of custody system based on identity preservation, segregation, or percentage blending model
- ensure and verify, using documented procedures, that the product is maintained isolated from other products in order to track every material under scrutiny from the collecting point to product manufacturing

- guarantee and assess that material has been isolated from non-verified sources also during transportation, stocking, and manufacturing³⁰. Thus, the final product will physically contain plastic from acknowledged sourcing points
- provide a clear identification of material at every phase of the chain, proved by accurate documentation.

The aim is to minimize the overall environmental impact, i.e., every phase of the process must be designed accordingly (e.g., transportation methods, production process).

5.2 Collection site requirements

Organizations collecting Marine Plastic must:

- Identify in which category the collected material fits: Hydro or Shore
- Identify dimensions and location of sourcing using locations technologies (e.g., GPS).
- Take note of approximate weight/volume of collected material
- Keep collected material physically separated from material collected in another location.

5.3 Transportation requirements

Organizations in charge of transportation must have a transportation plan to keep track of every shipping detail such as:

- Contract details of every transporter involved
- Delivery dates of incoming/outgoing material
- Issuing date of transportation documents
- Quantity of transported material

Note that organizations must ensure that batches of collected material is physically isolated from any other batch throughout the whole transportation chain.

³⁰ When adopting the percentage blending model this is only applicable until final point of mixing.

5.4 Recycling site requirements

Organizations responsible for the recycling must:

- Verify that the weight/volume of incoming batches correspond to prior documentation
- Divide collected material in recyclable & non-recyclable material
- All new fractions must be kept segregated and documented (weight/volume)
- Divide further the recyclable material to obtain batches of plastics bearing the same physical-chemical characteristics (e.g., PET, HDPE, PVC, LDPE, PP, PA)
- Measure and record weight/volume of all new batches of sorted material

5.5 Manufacturing site requirements

Organizations responsible for the manufacturing must:

- Verify that the weight/volume of incoming batches correspond to prior documentation
- Keep certified Marine Plastic from different sources physically separated till final product³¹

If the manufacturing requires the addition of additives³² or non-certified plastics³³ for the final product, the organization must:

- Indicate which kind of additives or non-certified plastics are used and in which quantity
- The percentages composing the blend must be indicated according to ISO 14021:2016

$$X (\%) = \frac{A}{P} \times 100$$

Where	X	certified Marine Plastic, expressed in percentage
	A	mass of certified Marine Plastic
	P	mass of all plastic in product

³¹ In case of the use of the segregation model, this requirement must be properly specified

³² Only in the case of identity preservation & segregation model

³³ Only in the case of percentage blending model

5.6 Selling requirements

Organizations responsible for selling the final product must:

- Obtain an authorization to sell certified Marine Plastic products
- Provide proper documentation/records/identification tags (e.g., QR-code) allowing end-users to verify that the product is made of plastic collected from the marine environment
- Possess all relevant information relating to the product: certification number and the applicable chain of custody model
- Record quantities of certified products bought, sold and in inventory.

6 Document procedures

The organization must keep up-to-date records of all transactions and confirm position, characteristics, and status of the identified plastic material/products at stake at every step of the chain. All transactions must be registered with the proper documentation on the chosen blockchain system.

The mention of whether it consists of Marine Plastic “Hydro” or “Shore” is mandatory on every document at every stage of the value chain.

6.1 Purchases and incoming products

The purchaser organization must ensure that the incoming products made with certified Marine Plastic comply with the following requirements:

- verification that quantities/volumes of incoming certified Marine Plastic match the records in prior documentation
- verification that products are sourced in the hydrosphere and/or on shores
- verification of the certification along the supply chain in every certified site, according to the timing of processes established by the organization

6.2 Sales and outgoing materials

The organization must ensure that the following minimum information, related to certified Marine Plastic products, must be available in documented form.

Minimum information:

- name and address of the buyer
- name and address of the seller
- delivery dates of incoming/outgoing certified Marine Plastic
- issuing date of documents
- product description
- type of certified Marine Plastic (Hydro or Shore)
- quantity of certified Marine Plastic delivered
- relevant transportation document
- chain of custody certification number
- unequivocal identification

6.3 Subcontractors

The organization (holding or looking to obtain the certification) may delegate activities to third party subcontractors. In that case, it must verify their compliance with the requirements of the chain of custody system.

Organizations including outsourcing along the chain must:

- implement written subcontracting terms with interested parties
- maintain the legal ownership of all incoming/outgoing certified abandoned plastic
- allow certification bodies access to the site when an audit is needed
- adopt a documented control system with defined procedures for outsourced activities
- record names and addresses of each subcontractor involved in the process. Names and addresses must be updated regularly.

7 Legal Compliances

The positive impact made by organizations who are Marine Plastic certified may not be outweighed by potential negative impacts their activity could cause. This means that organizations must operate in ways that, at a minimum, meet fundamental responsibilities in the areas of human rights, labor, environment, and anti-corruption. Therefore, National laws and requirements related to operations must be followed.

8 Verification

The organization must:

- run a control system to ensure, verify and monitor those incoming certified plastic materials match the requirements
- define and document timeframes for monitoring activities
- ensure the compliance of outputs with documents related to purchase, sale, and transportation
- guarantee that every purchase is unequivocally identifiable using unique transaction identification
- verify documentation related to sales of certified materials

Appendix 27: Communication guidelines for certified Marine Plastic organizations

Organizations must follow the guidelines set out in this part and follow the requirements specific to the subcategory (Hydro and/or Shore) they belong to.

As a rule, claims may not be made if they:

- cause confusion, misunderstanding and/or exaggeration regarding the environmental impact the organization has by using certified Marine Plastic
- induce understanding that the certification covers other aspects beyond the scope of this standard (e.g., quality)

Two categories of claims will be commented hereunder: promotional claims and product specific claims. Promotional claims may be made by the organization to advertise but in no case the end-user can be induced to believe that the promotional products are Marine Plastic certified. Product specific claims may only be used on products for which the organization has been certified for.

Organizations must refer themselves for any claim they want to make to ISO 14021:2016.

9.1 Marine Plastic: Hydro

Organizations must use Marine Plastic Hydro predetermined logo with or without the displayed percentage depending on the chain of custody used. Organizations will be given the right logo regarding their achievement level. Organizations collecting plastics from oceans and/or seas are allowed to claim being “ocean plastic”. Plastics collected anywhere else may refer to their specific sourcing point such as river or lake plastic.

Specific requirements per chain of custody:

- Identity preservation and segregation model

As the mixing with non-certified material is not allowed, it is up to the organization if it wants to display the exact percentage of recycled content (which is always superior to 90%) on the logo.

Examples of allowed claims: Made of Marine Plastic; Contains recycled/upcycled Marine Plastic; Plastic collected in the hydrosphere

- Percentage blending model

As the mixing with non-certified material is allowed, the organization must display the exact percentage of recycled content (no blend under 30% can be certified) on the logo.

Examples of allowed claims: Made with x% Marine Plastic; x% Recycled/Upcycled Marine Plastic; Plastic collected in the hydrosphere

9.2 Marine Plastic: Shore

Organizations must use Marine Plastic Shore predetermined logo with or without the displayed percentage depending on the chain of custody used. Organizations will be given the right logo regarding their achievement level. Organizations are not allowed to use the term ocean as materials have not been collected in the hydrosphere.

Specific requirements per chain of custody:

- Identity preservation and segregation model

As the mixing with non-certified material is not allowed, it is up to the organization if it wants to display the exact percentage of recycled content (which is always superior to 90%) on the logo.

Examples of allowed claims: Made of Marine Plastic; Contains recycled/upcycled Marine Plastic; Plastic collected in the marine environment

- Percentage blending model

As the mixing with non-certified material is allowed, the organization must display the exact percentage of recycled content (no blend under 30% can be certified) on the logo.

Examples of allowed claims: Made with x% Marine Plastic; x% Recycled/Upcycled Marine Plastic; Plastic collected in the marine environment

