Catch plastic litter before it reaches the ocean

From platform removal to plastic removal.

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Catchy 2 under the Erasmus bridge in Rotterdam.

Figure 1: Photograph taken by an Allseas ROV in 2018 during pipeline survey works at a depth of 2km and 250km off the Brazilian coastline. Taken less than a year after the installation of the pipeline, the image shows the mass accumulation of plastic litter around the pipe.

Allseas' goal and interest

As a leading contractor in the global offshore market and working at sea every day, Allseas witnesses first-hand the devastating impact plastic pollution is having on the world's oceans (Figure 1). With over 37 years of experience developing new technologies, Allseas is committed to the global effort to clean the world's oceans by applying its engineering expertise to develop systems to collect riverine plastic. The vision of Allseas is to source dedicated hotspots in waterways to install tailor-made passive floating systems that catch micro- and macroplastics before they flow out to sea.

The plastic problem and how to solve it

Population growth and demand for higher standards of living have increased global plastic production exponentially since 1950 to over 7800 million tons; half of that plastic was produced between 2004 and 2017 (Schmaltz *et al.*, 2020). Plastic has many favourable properties—inexpensive, lightweight, strong, durable and corrosion resistant—all of which explains this large-scale use. It is not all positive, however; poor waste management has led to a build-up of plastic in the world's oceans. It is estimated that 150 million tons of plastic have accumulated in the marine environment as of 2016 (Schmaltz *et al.*, 2020).

Hannah Ritchie's article '*Where does the plastic in our oceans come from?*' (2021) states that 70 to 80 per cent of plastic pollution in the oceans has land-based sources and is transported through riverine systems. Through its plastic removal project, Allseas aims to tackle the problem close to the source. The strategy started with gaining more knowledge and understanding of the problem. This was done by researching the transportation of plastics in rivers with in-situ sampling and modelling. The next stage was the successful installation and testing of three prototype plastic collection systems in 2019, 2020 and 2022, respectively.

Plastic pollution is a global environmental challenge with serious implications for human health, but ownership and accountability remain fundamental problems. Who is responsible, and who must pay the resulting costs? Up to now, action taken to clean rivers and oceans has largely been based on good will and financed through sponsorship. There is a growing need to address the plastic pollution problem on a larger scale. Consequently, raising awareness through the media plays an important role in Allseas' efforts. While there have been changes to rules and regulations made by the European Commission and other governing organisations, creating ownership and responsibility is one of the big challenges towards solving the plastic problem.

LIFE SouPLess

In 2018, Allseas started the LIFE SouPLess project, 'Sustainable riverine PLastic removal and management'. Backing provided by EU's LIFE programme enabled Allseas to elevate its efforts to the next level, from research and feasibility studies to the development of three different types of plastic collection systems, each designed for a different kind of water environment (harbour, river, tidal zone). Another objective was the development of a tool to predict plastic accumulation hotspots and provide advice on sustainable and cost-effective solutions for the post-processing of the collected (plastic) waste. The project ran from July 2018 until December 2022.

Project achievements, an overview

- Design, fabrication and installation of a full-scale plastic collection system in a harbour without tide—the Doeldok in the Port of Antwerp (Belgium). The system captures micro- and macroplastics at the water surface and up to 1.5m under the surface.
- Design, fabrication and installation of a full-scale plastic collection system in a harbour with tide—the Vijfsluizerhaven, along the river Nieuwe Maas (the Netherlands).
- Design, fabrication and installation of a full-scale plastic collection system in a river with tide—the Nieuwe Maas, which flows through the city and harbour of Rotterdam (the Netherlands).
- Develop a numerical model to calculate the transport of micro- and macroplastics in river and identify hotspots where plastic litter accumulates. The model is applied to the Nieuwe Maas, and trends have been validated with in-situ data from a sampling campaign in the river.

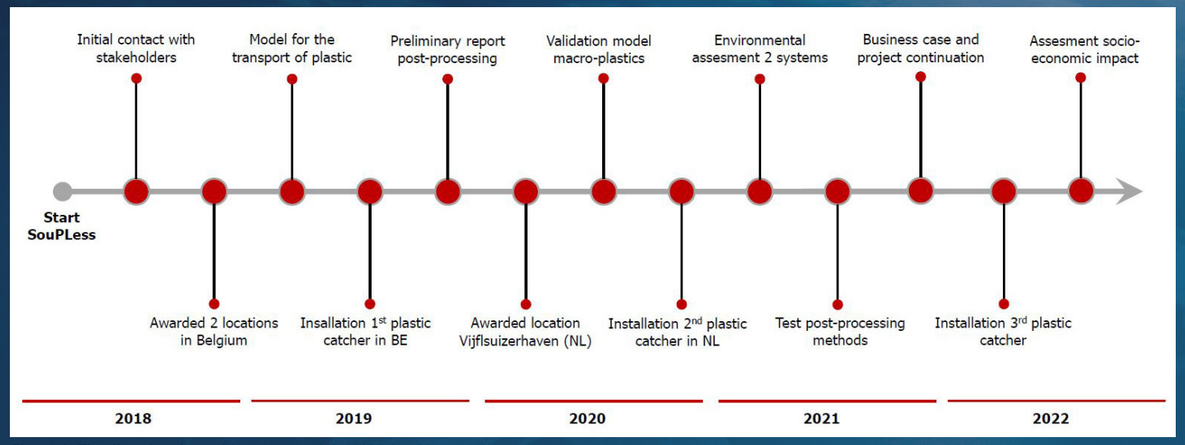

Figure 2: Timeline showing achievements of the LIFE SouPLess project.

- Establish the basis for a methodological guide on riverine (plastic) waste management containing the current technological options for post-processing.
- Engagement with national and international stakeholders such as authorities, post-processing companies, research institutes and NGOs.
- Raise awareness amongst stakeholders and citizens via media.

Simulation model with Deltares

During the initial stages of the project, Allseas collaborated with Deltares (Delft, the Netherlands) to develop a numerical model to simulate the transport of macro- and microplastics in rivers (Figure 3). The model's objective was to predict plastic hotspots, improve the efficiency of collection systems, find trends and gain general knowledge on the transport of plastic in rivers.

The model gave insights into the best location for a plastic collection system, such as tidal zones and zones of high flux. It also showed that the whole water column should be targeted by a collection system, not only the surface. Besides the tides, wind also has a large effect on the transport of plastics in surface water.

These trends were also found in data collected by in-situ measurements with Allseas' sampler. Data from more than 100 hours of sampling litter at various water depths in the Nieuwe Maas were used to validate the model. It was concluded that some effects were accurately reproduced by the model while others were not. For example, the model did not take into account the effect of passing ships. Furthermore, the model could not be easily transferred to all rivers, as each river is unique and needs its own hydrodynamic model.

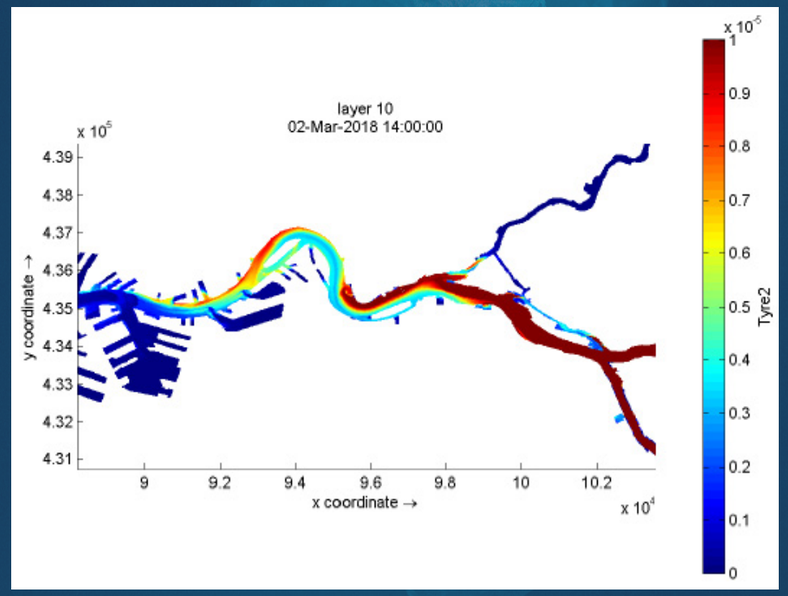

Figure 3: Example of the results obtained with the transport model for microplastics in the Nieuwe Maas river. This figure shows the concentration of submerged plastics in layer 10 of the simulation (at 10 m water depth). ***Blue*** *to* ***red*** *represent low to high concentration.*

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Plastic collection system for a harbour without tide

Allseas' first plastic catcher, **Patje Plastic**, was installed in the Port of Antwerp's Doeldok (Belgium) in 2019. It is a passive system, i.e. it does not require energy to function. A 100 m floating boom guides litter towards the collection system under the action of wind and wind-driven current (Figure 4 and Figure 5). The boom is equipped with an underwater skirt to convey both surface and underwater litter to the collection system. The collection system is composed of a floating frame supporting two collection cages, one for large litter and one for smaller litter (Figure 4). A system of filters segregates the litter according to size and prevents litter from escaping when the wind direction changes. An anti-retour flap closes when the wind drops or changes direction. The cages have sidewalls made from plastic mesh and can catch microplastics from 1 mm in diameter. The Doeldok is a non-tidal harbour, which allows the system to be moored to the quayside without moving. The system is emptied every three months by hoisting the cages out of the floating frame with a truck-mounted crane. This first prototype has been sold to the Port of Antwerp.

Plastic collection system for a harbour with tide

In 2020, Allseas installed its second plastic collection system, named **Catchy**, as part of a pilot project with Rijkswaterstaat, the Dutch authority for public works and water management. This system is a passive system that catches litter flowing into the Vijfsluizerhaven, a creek along the Nieuwe Maas river in South Holland. The Nieuwe Maas is an effluent of the Rhine that flows through the city and port of Rotterdam. Two floating booms of 200m and 12m equipped with an underwater skirt guide floating and underwater litter towards a collection system under the action of wind and current. The collection system comprises of a floating frame supporting a collection cage. It is moored to three spud piles so that the system can move up and down with the tide. An non-return flap and a system of filters prevent the litter from flowing out of the system with unfavourable wind and/or current. The system captures macro- and microplastics up to 3mm due to a non-return door and the design of the cage.

Catchy was emptied every month for a year using a mobile crane, and the collected litter was further sorted and analysed into different size categories and material categories. This analysis was an important part of the project with Rijkswaterstaat to get insight into the types and amounts of litter, the possible sources of the litter, and how it could be post-processed with existing technologies. The Dutch government can further use this information to take new measures to tackle the problem of plastic pollution in rivers. After the project with Rijkswaterstaat, Catchy remained operational and is still doing its job. Thanks to Catchy, the nature area behind the system, where many waterbirds live, is now free of plastic waste.

Figure 4: Litter in the two collection cages of Patje Plastic. In the front cage, larger litter; in the back cage, smaller litter. The microplastics are clearly visible in the back cage.

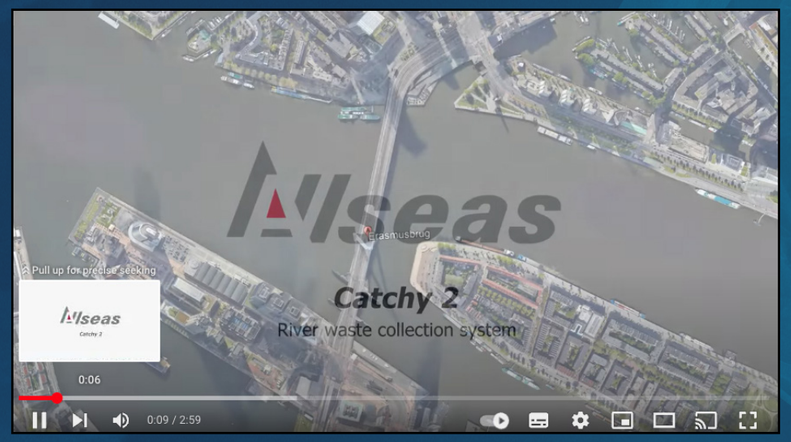
Figure 5: Litter accumulating in Catchy.

Plastic collection system for a flowing river

In 2022, Allseas installed a third plastic collection system, one designed for a flowing river with or without tide. This system got the name **Catchy 2**, as many lessons learned from the previous system were implemented in the new design. This system must withstand strong forces present in a flowing river and needs to be able to work in two directions due to the tidal effect present in the Nieuwe Maas. As with Catchy, the Catchy 2 design incorporates a non-return door, but on both sides of the collection cage. In line with the two-direction function, the system also has two booms fitted with a 0.68 m underwater curtain to guide litter at the surface and upper water column towards the collection cage. Depending on the tide, ebb or flood, the system collects in one or the other direction (Figure 6). The water current pushes one door open while the other one is kept closed due to the water force. Catchy 2 is a one-year-pilot with the support of the municipality of Rotterdam and several partners and sponsors. See also the animation movie to see how it works (below).

Figure 6: Catchy 2 under the Erasmus bridge in Rotterdam.

An important part of this project is to increase awareness of river (plastic) waste. Fortunately, the selected plastic hotspot under the Erasmus bridge in the heart of Rotterdam is a popular location where the system is clearly visible and accessible to passing crowds. An information board adjacent to the system outlines the function and the goal of the system. Participation in the well-established maritime event, World Port Days (2–4 September 2022), was an important step in further raising public awareness.



https://www.youtube.com/watch?v=xul92jp_7ql

Summary and outlook

All three plastic collection systems proved their concept and continued to operate after the one-year-pilot. Each system works 24 hours, 7 days a week, completely passively, without the need for energy. All three systems successfully collected microplastics (Figure 8). On average, the Catchy and Catchy 2 systems collect approximately 100 kg of plastic. It should be emphasised here that PET bottles, plastic foils and microplastics are all lightweight materials, which means that in terms of quantity, 100 kg is a very large number that is a serious threat to the marine ecosystem.

The three developed systems were designed to be emptied with the support of a crane. In addition, Allseas has also designed a smaller version, Catchy-Mini, (Figure 9), that can be emptied by hand. The system has been designed for the marina on the island of Terschelling, in the northern Dutch province of Friesland. The first prototype is currently under construction and will be installed in 2023. For the future, Allseas aims to develop more tailor-made systems for waterways in Europe and is currently considering expansion into Southeast Asia, predominately Malaysia.

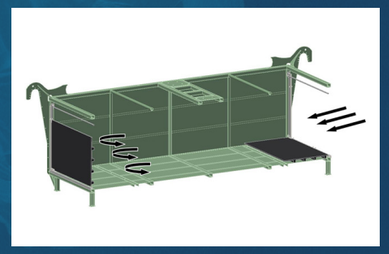


Figure 7: Rendering showing the work principle of the two non-return doors.

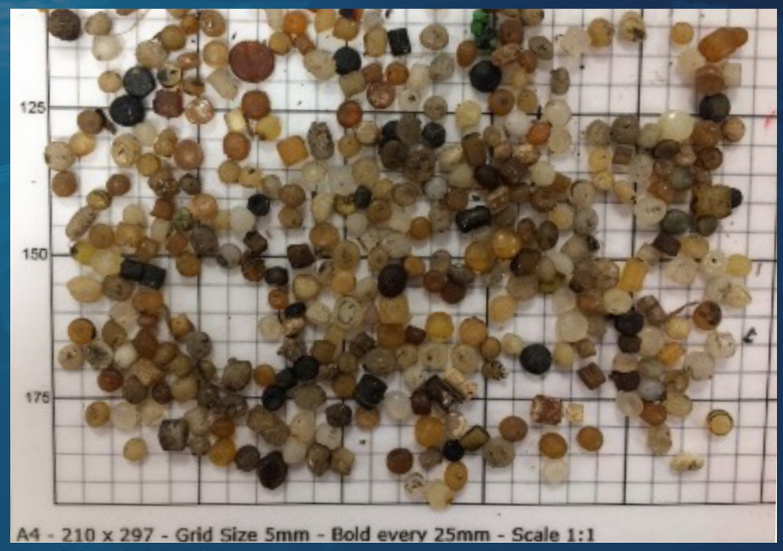


Figure 8: Sample of microplastics.

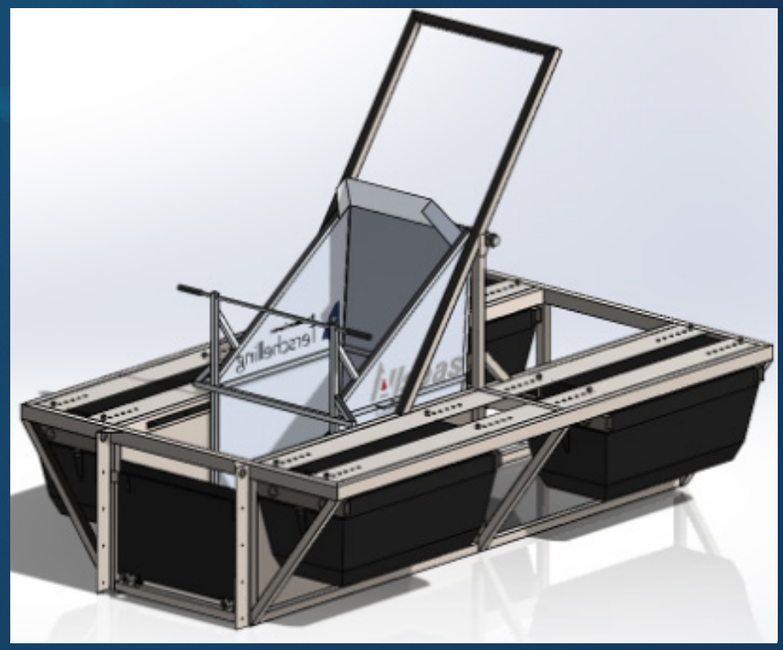


Figure 9: Render of Catchy-Mini.

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PROJECT NAME

LIFE SOUPLESS

PROJECT SUMMARY

Increased global production and poor waste management have led to a build-up of plastic litter in the world's oceans. This has devastating effects on ecosystems and marine life. The flow of plastics into the oceans occurs through a variety of pathways, but rivers are one of the largest contributors. The LIFE SouPLess project aims to develop technology to catch plastics from rivers before they spread to the seas and oceans. It is a 4.5 years project (July 2018 – December 2022). Three main links of the chain of riverine plastic recovery will be tackled: from locating plastic hotspots with a dedicated numerical model to effectively collecting the plastics with systems and finding sustainable and cost-effective solutions for post-processing the collected litter.

PROJECT PARTNERS

Several project partners were involved, like the Port of Antwerp, Rijkswaterstaat, Municipality of Rotterdam and several companies supporting with sponsoring and in kind services.

PROJECT LEAD

Laura Klinkenberg is Project Manager and Lead Coating Engineer for offshore contractor Allseas in Delft.. She studied in her home town at the RWTH university in Aachen Germany and graduated in 2017 as Master of Science in materials engineering. Committed and curious, she exploited her knowledge since then within Allseas and delivered valuable contribution to multiple pipelay projects as Lead Coating Engineer as well as specialist to a diversity of innovative in-house projects. Since 2020 she manages the Allseas Riverine waste collection project.

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FUNDING

The LIFE SouPLess project has received funding from the LIFE Programme of the European Union under grant agreement No.LIFE17/ENV/NL000339.