Interreg North Sea

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TREASURE

TREASURE – Living Lab Nieuwpoort Blueprint and Roadmap

FINAL VERSION – AUGUST 2024

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Aim of the Nieuwpoort Blueprint and Roadmap

This document was prepared at the start of the TREASURE project as a blueprint for the Living Lab Nieuwpoort (v1.0) and updated after one year of activities (v2.0 – final version). This action plan ('Blueprint and Roadmap') should clarify the activities, ambitions and progress for this site for all partners, stakeholders, interested parties and the public. This Blueprint and Roadmap for Living Lab Nieuwpoort will be integrated during the TREASURE project into a blueprint for harmonised Living Lab approaches.

Citation: *Devriese, L.I.; De Buyser S.; Catarino A.I.; Moulaert, I., C.; Dhondt, C.A.L.; Meneses, C.; Rondelez, J.; Nitschke, T.; Everaert, G.; Roelofsen, F.; Fierens, N.; van Welij D.; Monballieu J.; Decrop, B.; Koutrouveli, T.; Wang L.; Breugem A.; Stellamanse, G.; Amara, R.; Doyen, P.; Depoorter, M.; Maelfait H. 2024. TREASURE – Living Lab Nieuwpoort. Blueprint and Roadmap., 50 pp.*

doi: https://dx.doi.org/10.48470/91

Acknowledgements: *Thanks to Britt Lonneville, Lennert Schepers and the VLIZ maps team for creating the maps. We would like to further thank Juliette Grandjean, Maria Kazour and Guillaume Veillet (ULCO), as well as Julie Muyle, Mattias Bossaer, Mariana Miranda, Nelle Meyers, and Gijs Couvreur (VLIZ) for the precious contribution to the sampling campaigns. We further thank the crew of the Research Vessel Simon Stevin for all the support during the sampling campaigns at sea, as well as to the VLIZ Infrastructure Division team. We would also like to thank Vlaamse Yachthaven Nieuwpoort for the opportunity to take samples on their premises. We would like to acknowledge the contribution of Line Debaveye from the VLIZ Communications Division for assisting in the organization of the Plastic Pirates activities and on the data verification, the schools and youth groups that have contributed to the citizen science activities. The project further acknowledges the research interns Cerys Strang and Sarah Tosin Fashagba, and summer job students Alannah Rousseau-Duffy, James De Backer and Mathias Everaert. Finally, we thank the VIVES school (Bruges) teachers, mentors and students, and the Province of West Flanders, in particular Maxime Depoorter, for the invitation to participate in the international exchange student project development. We also thank all stakeholders involved for their valuable contribution and insights.*

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TREASURE project and context

In the Interreg North Sea TREASURE project 15 partners from North Sea countries, namely Denmark, Germany, the Netherlands, Belgium, and France, are jointly tackling the problem of plastic pollution flux from inland waterways towards the North Sea. It had been generally assumed that a significant amount of plastic litter enters the sea via rivers and inland waterways. However, recent research suggests that only a proportion of plastic litter that enters terrestrial (e.g. riverbanks) and aquatic compartments of river systems also readily reaches the sea (van Emmerik et al., 2022; Everaert et al., 2022; Kaandorp et al., 2023). As a result, some river systems, and in particular tidal estuaries, can act as accumulation areas of plastic, with significant impact at ecosystem level and in economic activities, leisure-related or for example navigation impairment. These accumulation areas can further serve as reservoirs, that during extreme events, such as heavy rains, can release a large number of litter debris to nearby coastal areas (van Emmerik et al., 2023; van Emmerik, 2024). Led by the University of Oldenburg, the TREASURE project consortium aims to map the plastic flux and suggest actions and solutions to reduce the outflow of plastic litter from rivers and inland waters into the North Sea. An integrated cross-sectoral approach to identify, eliminate, and reduce this riverine litter is thus expected to make an important contribution to solving the plastic problem.

Figure 1: Post on X by Interreg North Sea Region on the TREASURE project.

To contribute to the mitigation of the plastic flux, the TREASURE project addresses four interrelated dimensions (pillars):

- **Data Collection & Analysis** – using well established and new methods with the aim of increasing knowledge on nature, composition and sources of litter, and comparing and harmonizing approaches.
- **Plastic Waste Removal** – applying different techniques to remove waste from rivers, to gain knowledge on the effectiveness of different solutions under different conditions (e.g., environment or type of pollution).
- **Prevention & Behavior Change** – raising awareness and educating specific target groups in business (e.g. tourism), government (municipalities, regions) and the general public (e.g. school children) about the need and opportunities to reduce plastic pollution in their respective capacities and processes.
- **Governance & Policy** – improving cross-sectoral governance for effective collaboration and joint action among stakeholders in functional areas and water systems (river basins, estuaries, metropolitan areas, …). Improve policies at different levels (local, regional, (trans)national) for effective waste prevention in rivers by combining (binding) legislation and informal policy frameworks.

The core of the project consists of Living Labs, open innovation areas where solutions are tested in real communities via public-private cooperation actions, at different river-sea interfaces, representing different areas typical of the North Sea region (e.g., estuary, urban water system, port, coast): Nieuwpoort (BE), Dutch Deltas (NL), French Ports (FR), Plastic-free SIA (DE), Westcoast Watersheds (DK). In the Living Labs of TREASURE, we will test representative solutions to prevent and remove plastic pollution in real-life scenarios.

Living Lab Nieuwpoort

Focus area

Nieuwpoort is a town and seaside resort on the Belgian coast, home to one of the largest marinas in Europe, with more than two thousand leisure boats. Nieuwpoort is important due to its historical significance, particularly its role in the Battle of Nieuwpoort (2 July 1600), its maritime and commercial importance, its tourism industry, and its cultural heritage. These factors have contributed to its enduring relevance in the region (Home | Visit Nieuwpoort (visit-nieuwpoort.be)).

The focus area of the Living Lab in Nieuwpoort is the *Ganzepoot* ('goose foot') water system, a series of locks and spillways in the estuary of the Yser River (*Figure 2*)[1], which plays a crucial role in managing water levels and tidal flow in the Nieuwpoort harbour area/ estuary and the adjoining Yser River. This system helps regulate the water levels to prevent flooding, while enabling boat and vessels traffic circulation. It comprises

[1] It is called the *Ganzepoot* because of the resemblance of the water system to the foot of a goose.

a lock complex in the inner port area: six waterways meet here, connecting the Yser estuary and the North Sea. Each waterway is controlled by a hydraulic structure on the east side of the complex, which provides drainage for part of the inland polders via spillways. In each, shipping connection for inland vessels is provided through a lock (Sluizencomplex De Ganzepoot | De Kust).

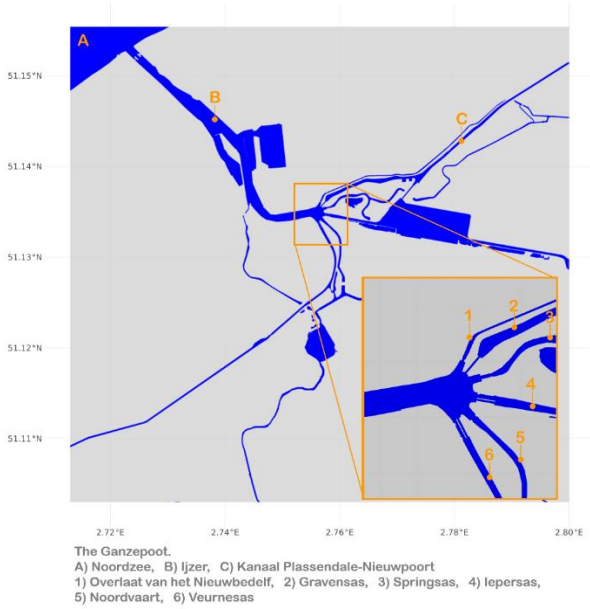

Figure 2: Water system (Ganzepoot) in Nieuwoort (map by Claudia Meneses).

Aim and approach

It is believed that plastic litter often tends to accumulate closer to urbanised areas, which has led to additional research questions that require a holistic approach to map plastic flux into the North Sea region. For example, how does plastic behave in the different estuaries of the North Sea region? What is the retention capacity of North Sea tidal estuaries? Given that very little information and knowledge is available about plastic pollution in Nieuwpoort's water system, we aim to answer several burning questions:

- **Is riverine/marine litter a major problem for the water system in Nieuwpoort?**
  We will build on surveys of experts, stakeholders, and user groups to capture their insights, experiences, and perspectives. In addition, both visual inspections and scientific monitoring activities will be conducted to identify litter accumulation areas.
- **How much plastic litter flows into the North Sea via Nieuwpoort? How does plastic litter behave in Nieuwpoort's water system?**
  Based on intensive monitoring and observation activities supplemented by citizen science, plastic pollution will be mapped. A hydrodynamic transport model will further evaluate and visualize the plastic transport towards the North Sea. Can the Yser Estuary act as a reservoir for plastic litter?
- **What measures can help avoid plastic litter accumulation in the environment?**

Surveys with experts and water managers, as well as the analysis of samples collected in the field will help identify the major litter sources per sector. In cooperation with experts, scientists and society, viable measures will be examined to see what mitigation measures are suitable for this area.

- **How can we best cooperate with citizens and stakeholders to tackle the plastic litter issue efficiently**?
  From the start of the project, the activities and strategies will be coordinated with the stakeholders involved. Citizens and students will be involved through citizen science, based on the well-established Plastic Pirates (Horizon Europe) methodology, an ongoing project in Flanders. In addition, the project is actively raising awareness and creating support for the problem and solutions for plastic litter.
- **Can we develop a system to collect and remove the plastic specifically for the water system in Nieuwpoort?**
  The companies Multi.engineering nv, Herbosch-Kiere and IMDC will work together to develop a prototype to collect and remove plastic litter. This will be done in close cooperation with the water authorities and city of Nieuwpoort, as well as with government agencies responsible for waste management.
- **How can we valorise the knowledge and new insights on plastic transport for the North Sea region?**
  The insights from the various living labs will be pooled and capitalized on for the wider North Sea region, through joint events, knowledge transfer, scientific publications and presentations, meetings and policy briefs. Innovations in plastic removal and collection will also be used to improve the approach at the North Sea level.

To address these questions comprehensively, the Nieuwpoort Living Lab (LLN) activities are bolstered by the TREASURE project's work packages and pillars, as illustrated in *Figure 3*. *Annex I* provide a detailed list of LLN partners and Advisory Board stakeholders.

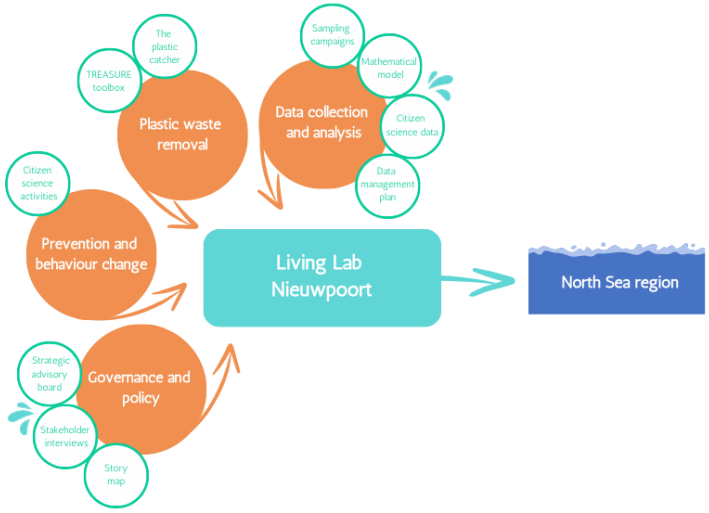

Figure 3: TREASURE pillars with their main activities for the living lab Nieuwpoort.

Concepts and timeline of the Living Lab Nieuwpoort

Below is a concise overview of the concepts and timeline pertinent to Living Lab Nieuwpoort (LLN,) organized according to the TREASURE pillars. *Figure 4* provides a schematic timeline of the activities for Living Lab Nieuwpoort. This schedule is only an indication and will be adjusted based on the progress, new insights and external factors.

- ❖ Pillar: Data Collection & Analysis

In the LLN, the goal of work in this pillar is to conduct field observations of plastic debris (> 1 mm) for identification of accumulation zones in the estuarine and riverine environments adjacent to the Ganzepoot, in Nieuwpoort. The quantification of plastic debris will inform on the seasonal baseline litter density, location of hotspots and on the efficiency of the installation of the removal technology. We will sample both water and sediment, key compartments for transport and accumulation of litter, as well as riverbanks and slipways (boat ramps), throughout different seasons and tidal regimes, and adjust our methodological approaches to assess different size classes of plastic items, namely macroplastics (> 25 mm), mesoplastics (5- 25 mm) and microplastics (1- 5 mm). To do so, we will use a broad portfolio of techniques, from citizen science and expert observations to plastic items collection using manta nets, and sediment core sampling. During the past year, a Sampling Strategy (Catarino et al., 2024) was finalised and sampling surveys started during the first semester of 2024, during Spring (*Figure 4*). The first sampling campaign of 2024 took place in February, in collaboration with researchers from ULCO (under the work of the ULCO master student Juliette Grandjean), while the citizen science activities in collaboration with Plastic Pirates Belgium were initiated during Spring 2024. The sampling campaigns, both led by experts or done thanks to citizen scientists, were repeated during Spring/Summer 2024, and will continue in the Autumn 2024 and throughout 2025. They cover coastal waters (A, *Figure 2*), the Yser estuary (B, *Figure 2*) and selected canals/river based on the preliminary observations, which took place on the 9$^{th\ of}$ August 2023, and on the previous results from the PLUXIN and Plastic Pirates projects. Finally, the protocol of Plastic Pirates, which targets mostly riverine environments, is currently being adapted for coastal and sandy environments. The project TREASURE and the LLN researchers are actively contributing to test this new citizen science sampling methodology, and all data collected in the Nieuwpoort beach area will further be used in our dataset.

During the Autumn of 2024 we will run an exercise, in a joint effort between ULCO and VLIZ, using GPS trackers, which will be released in key areas of the Yser River and estuary, to assist in understanding the effects of the tides in the transport and accumulation of litter. The results of data collection will feed a mathematical model.

The mathematical modelling work was carried out to create a first test model of the water system of the Ganzepoot-Nieuwpoort area, to estimate the transport pathways and accumulation zones of macroplastics. The data collected during the first sampling campaigns, including during the GPS tracking exercise, will be used to refine this test model.

As an output, we will obtain detailed information on the spatial and temporal distribution of plastic litter. This information will enable the project experts to not only map the accumulation zones of plastic litter, but also to provide advice and recommendations on areas and seasons for efficient collection in the Ganzepoot-Nieuwpoort area. To produce high quality data, compatible with international and well-established standards, we will follow a detailed data management strategy, according to the 'FAIR Guiding Principles for scientific data management and stewardship' (Wilkinson et al., 2016) and described in the Data Management Plan. Datasets will be archived using the Marine Data Archive (MDA, VLIZ, Belgium), and searchable via a Digital Object Identifier (DOI) through the Integrated Marine Information System (IMIS, VLIZ, Belgium). Final datasets are intended to be submitted to a relevant international data system, such as EMODnet Chemistry or Data Ingestion.

- **Pillar: Removal of Plastic Waste**

An important objective is to demonstrate solutions for removing litter from the environment. To date an increasing number of plastic remediation technologies are commercially available, and for water managers and users it is often difficult to select cost efficient solutions. In addition, unregulated remediation technologies, while laudable, can be inefficient and have unintended negative consequences on ecosystems. Despite these concerns, plastic clean-up technologies can play an important role in reducing litter in the environment. The concept is to build and validate a multicriteria guidance tool (TREASURE Toolbox) to support stakeholders in their search for a suitable and low impact plastic removal technology.

In addition, three companies (Multi Engineering, Herbosch-Kiere and IMDC) will develop a prototype of the plastic catcher that will be deployed in the Nieuwpoort area. The results from the first sampling activities are being used to determine potential locations for the plastic catcher. The preliminary study of the area is ongoing, and the design is being further developed. The design will be finished around 6 weeks after the preliminary study, after which a year of construction will be required. It will then be installed at the desired location after which it will be operational for 6 weeks (*Figure 4*). Decommissioning will follow at the end of the use. The demonstration activity with this device will provide unique aspects of collecting objective field data to quantify plastic retention efficiency of the tested infrastructure.

- **Pillar: Prevention & Behaviour Change**

Local school students are taking part in citizen science activities in collaboration with the Plastic Pirates (Horizon Europe) Belgium, following a well-established methodology. The protocol has already been regularly applied by schools in Flanders, and has been applied in Nieuwpoort (e.g., https://www.plastic-pirates.eu/en/results/data/6437). In addition to the hands-on involvement, teachers receive information concerning litter observation methodologies, which can be worked at a school level integrated with their curriculum. This is an opportunity for discussions on broader topics such as science, pollution, reporting the news, statistics etc. encouraging them to adopt waste-prevention behaviour. The first citizen science activities took place in Spring 2024 and will continue throughout the project (*Figure 4*).

In January 2024 we collaborated with the Province of West Flanders and the VIVES high education school to assist students in developing a project activity. The VIVES students participated in an international

exchange programme and welcomed students from the Philippines. The role of VLIZ was to guide and mentor two working groups of students from both Belgium and the Philippines, to develop a removal solution for plastic litter and an awareness campaign against plastic pollution. Key stakeholders from local authorities were also involved. The main outcome of this work was to contribute to the plastic pollution literacy of the students and to guide them in a holistic and creative exercise to find solutions for the prevention and removal of plastic pollution.

Finally, the researchers of TREASURE involved in the LLN are collaborating with Nausicaa (pillar leader), the University of Oldenburg (project leader), and pillar partners, to create a questionnaire targeting the main public, which will be launched in autumn 2024. The goal of this work is to assess the public perception of the plastic litter problem.

- Pillar: Policy & Governance

In collaboration with the Province of West Flanders, key stakeholders in Nieuwpoort's water system will be convened, surveyed, and informed to foster enhanced cooperation. This pillar has the ambition to identify gaps in existing regulations, to determine appropriate intervention points, to develop regional work-plans for implementing the measures, and to implement progress of running activities. The priorities for LLN are gaining insights into the barriers in communication mechanisms and information transfer and a better understanding of the enablers and constraints related to the local implementation of environmental legislation. Besides, more information on the regulation requirements to deploy a plastic catching devices is incorporated.

Based on the action plan, the progress of LLN activities is shown as storytelling (story map). The desktop study and interviews are planned from autumn-winter 2024 (*Figure 4*). Collaboration with the advisory board, stakeholders, international scientists, and the public is done from the start of the project to the end and after. The first stakeholder meeting was scheduled for Oct. 6, 2023.

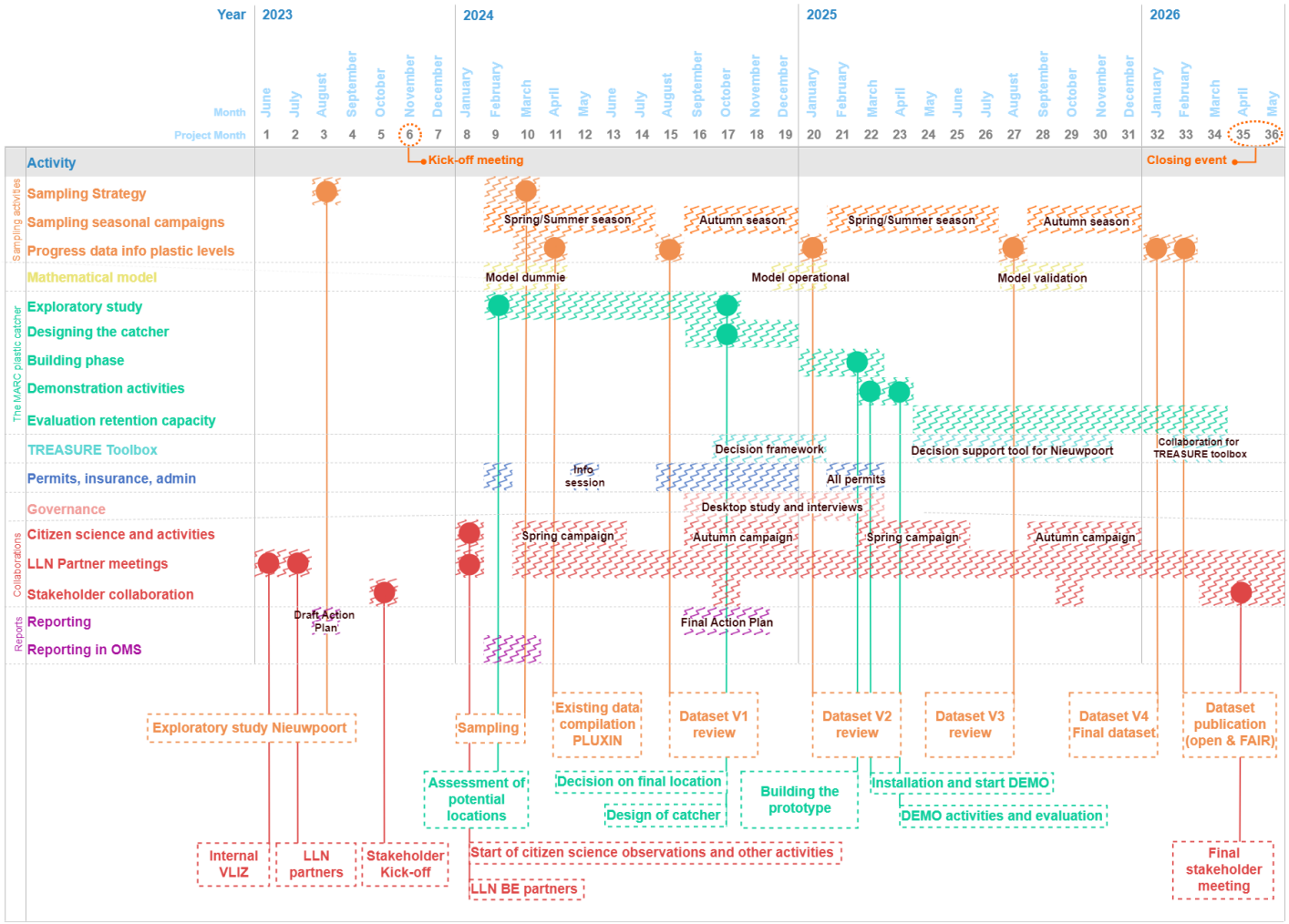

Figure 4: Timeline for the Living Lab Nieuwpoort (LLN) with an indication of the requested time for each key activity within the Pillars of TREASURE, as well as important milestones of the LLN.

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Update on the pillar: **Data Collection & Analysis**

Sampling campaigns

Sampling plan

The final version of the Living Lab Nieuwpoort sampling plan was shared by VLIZ (Catarino et al., 2024) with all LLN partners in July 2024. The sampling plan coordinates the sampling activities in Nieuwpoort, aligned with the TREASURE dataset templates and FAIR data principles, to reach comparable datasets amongst the participating countries and partners to be able to reach the common TREASURE goals. In the sampling plan we identified sampling sites and the timeframe for the sampling campaigns (spring and summer 2024, autumn/winter 2024/25, spring and summer 2025 campaigns). All planned spring and summer 2024 sampling campaigns for macro- (> 2.5 cm), meso- (0.5- 2.5 cm) and microlitter (0.1- 0.5 cm) observations in the Living Lab Nieuwpoort, were conducted and are finalized. The sampling activities take place in different areas of Living Lab Nieuwpoort: the area of the Yser River (before the Ganzepoot), the harbor area or the estuary area (after the Ganzepoot), the beach (coastal environment), and the sea of Nieuwpoort (Belgian part of the North Sea). At the Yser riverbanks, we conducted macrolitter observations using a transect sampling method, three times within a week from 28 June to 5 July 2024 (*Figure 5*). We proceeded by tracking all observed macrolitter in each of five transects (each 10 x 2 m) with the newly developed Joint Research Centre mobile app (JRC app) (currently in its testing phase) and analysing the polymer type of plastic litter using the trinamiX (BASF, Germany). We also sampled mesoplastics at the riverbanks using a quadrat method (50 x 50 cm), which is shown in *Figure 6*.

Figure 5: Macrolitter sampling using a transect method and the JRC App at the Yser riverbanks (Photos by Therese Nitschke, VLIZ).

Figure 6: Use of a quadrat methodology at the Yser riverbanks (left) and all meso-and macroplastics that were observed inside the frame of 50 x 50 cm (right) (Photos by Therese Nitschke, VLIZ).

In the harbor or estuary area of Nieuwpoort, we sampled microlitter using the water drone with a coupled manta net on 14 February 2024, and this was the first sampling of the Living Lab Nieuwpoort in 2024. We also conducted the Spring (13 May / 20 June) and Summer (25 July) tidal cycles at two different sampling points in the harbor area to capture floating microlitter particles distribution under tidal influences using the ferry box (surface water) (*Figure 7*). During the tidal cycles, we measured other physical and chemical properties: salinity, water temperature, pH, turbidity, and dissolved oxygen using a multiparameter probe (Hanna multiparameter H198494) at two different depths (just below and at 2 m below surface). Furthermore, we sampled riverbed sediments using a Van Veen grab (*Figure 8*) on 25 July 2024. Concerning the macrolitter observations in the water surface, we tested an in-house made macrolitter net (Dave Scott, 2019; van Emmerik et al., 2018; Vighi et al., 2022, p. 26) in the harbor area to sample floating macrolitter on 20 June 2024. The current prototype of the macrolitter net was not suitable for the sampling in the Yser estuary due to the low flow conditions and may need further development. Furthermore, we sampled macro- and mesolitter using a transect & quadrat method on a slipway in the marina on 14 February and in summer on the day before the slipway cleaning for three weeks straight (29 July, 5 August, 13 August).

Figure 7: Ferry box tidal cycles and macrolitter net testing in the harbour area of Nieuwpoort in June 2024 (Photos by Therese Nitschke, VLIZ).

Figure 8: Riverbed sediment sample from the harbour area in Nieuwpoort (25 July 2024) (Photo by Therese Nitschke, VLIZ).

At the Nieuwpoort beach we sampled litter on 21 June 2024 with school children and teachers using the Plastic Pirates methodology. At sea, off the coast of Nieuwpoort, we sampled microlitter particles on board RV Simon Stevin on 27 February and 4 June 2024 using the Van Veen grab (marine sediments), ferry box (water column) and manta net (surface water). *Table 1* gives an overview of all sampling methodologies used in the Living Lab Nieuwpoort.

The observed macrolitter from the spring and summer 2024 campaigns was collected and will be classified using the Joint List of Litter Categories for Marine Macrolitter Monitoring (J-List) (if not already done with the JRC App) (Fleet et al., 2021). Micro- and mesolitter samples were processed following standardized operating procedures (SOPs), whose development was led by VLIZ (Meyers, et al., 2024; Meyers, et al., 2024). Processing of all water samples for microlitter extraction and all mesolitter samples from the spring and summer campaigns will be completed by the end of August 2024. Micro- and mesolitter are then analysed using Fourier transform infrared (FTIR) spectroscopy and fluorescence microscopy to identify the quantity of plastic particles and their polymer composition. All mesoplastic samples will be analysed by the end of August 2024.

Table 1: Summary of the litter sampling and observation methodologies used in the Living Lab Nieuwpoort and their targeted litter size categories and environmental compartments. Adapted from the TREASURE Living Lab Nieuwpoort Sampling Plan (Catarino et al., 2024).

Method	Targeted size class	Compartment	References / SOP
Transect method	Macro and Meso	Riverbank/ slipways	(Frias et al., 2018; Ndwiga, 2021) Use of JRC app : https://inspire-europe.org/solutions/jrc-floating-litter-monitoring-app/ Use of the J-list: https://mcc.jrc.ec.europa.eu/main/dev.py?N=41&O=459

Method	Targeted size class	Compartment	References / SOP
Macro net	Macro	Surface water	(Dave Scott, 2019; van Emmerik et al., 2018; Vighi et al., 2022, p. 26)
Quadrat method (50 x 50 cm or 20 x 20 cm)	Micro and Meso (1 mm – 2.5 cm)	Surface sediment	(Frias et al., 2018), https://www.plastic-pirates.eu/en/material/download
Plastic Pirates methodology (riverbank and coastal sampling)	Macro to Micro	Surface sediment	https://www.plastic-pirates.eu/en/material/download
Manta net (>500 µm)	Micro and Meso	Surface water	(Bouwens et al., 2021, p. 18)
Aquatic drone	Micro and Meso	Surface water	(Pasquier et al., 2022)
Ferry box (pump with connected filtration system) (>500µm)	Micro and Meso	Water column	(De Witte et al., 2024); SOP: Ferrybox sampling device for the sampling of microplastics by Nelle Meyers (13/09/2022)
Van Veen grab	Micro and Meso	Submerged sediment	(Bouwens et al., 2021, p. 17)

For the autumn/winter 2024 sampling campaigns, we will introduce the usage of GPS trackers to investigate litter pathways and retention periods in collaboration with ULCO. This way we can compare the methodology amongst the French and Belgian Living Lab. The GPS trackers will be deployed at various release locations, which will be determined in consultation with IMDC. *Table 2* gives an overview of all other sampling campaigns and activities planned for autumn/winter 2024 in LLN.

Table 2: Planned upcoming sampling campaigns and activities of the LLN for autumn/winter 2024.

Campaign/ activity	Planned for	Involved partners or external collaborators
Autumn riverbank macrolitter observations using a transect method and the JRC App, mesolitter observations using a quadrat method	October/November 2024	n/a
Autumn tidal cycle using the ferry box in the harbour area, simultaneous measurements of abiotic parameters	October/November 2024	n/a
5th TREASURE partner meeting: demonstration of ferry box and aquatic drone methodology	2 October 2024	ULCO (FR)
5th TREASURE partner meeting: demonstration of Plastic Pirates methodology	2 October 2024	Nausicaa (FR)
5th TREASURE partner meeting: hosting the source identification workshop	1 October	CEDRE (FR)
Autumn slipway macrolitter observations using a transect method in the marina, mesolitter observations using a quadrat method	October/November 2024	n/a
Plastic Pirates autumn campaigns (citizen science at the riverbanks and the beach)	Autumn 2024 and Spring 2025	Plastic Pirates Belgium
Autumn microlitter observations at sea using the Van Veen grab, ferry box and manta net	1 October 2024	n/a
World Cleanup Day – cleanup involving citizens	21 September 2024	Proper Strand Loopers

First results

First (unvalidated) results were shared with IMDC on 3 July 2024 to support the hydrological/transport model (IMDC) that estimates litter accumulation areas in the Yser estuary. The results included processed microlitter particles with e.g. the quantity, polymer type, particle size and mass and meso- and macrolitter items with e.g. joint-list classification, weight, size and colour from the harbour area on 14 February 2024 (first sampling day of 2024). *Figure 9* shows an example of a processed and identified microplastic particle. The shared results included also the in the harbour area measured abiotic parameters salinity, water temperature, pH, turbidity, and dissolved oxygen from the spring tidal cycles on 13 May 2024 and 20 June 2024.

The next data update for model support will be provided to IMDC in early September 2024. This data update will include macro- and mesolitter results from sampling at the Yser riverbanks (28 June, 3 and 5 July 2024) and the summer tidal measurements of abiotic parameters from both 0.1 m and 2 m depth (25 July 2024).

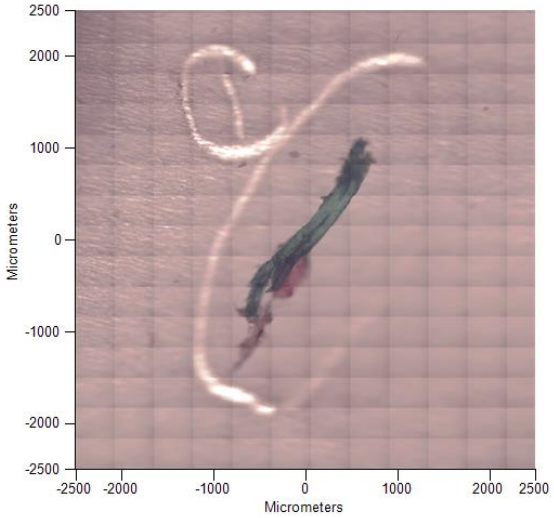

Figure 9: Example of a polypropylene particle observed in a ferry box sample from Nieuwpoort (May 2024), identified with micro-FTIR spectroscopy. The white lines can be disregarded, their purpose was to mark the location of the particle on the filter to retrieve the particle during micro-FTIR spectroscopy.

A first visual survey of the Ganzepoot area was done on 9th of August 2023 (*Figure 10*) (Devriese et al., 2023 v1.0), providing a first idea of the visible litter accumulation zones. In 20 of these locations (stops), plastic or other litter was observed.

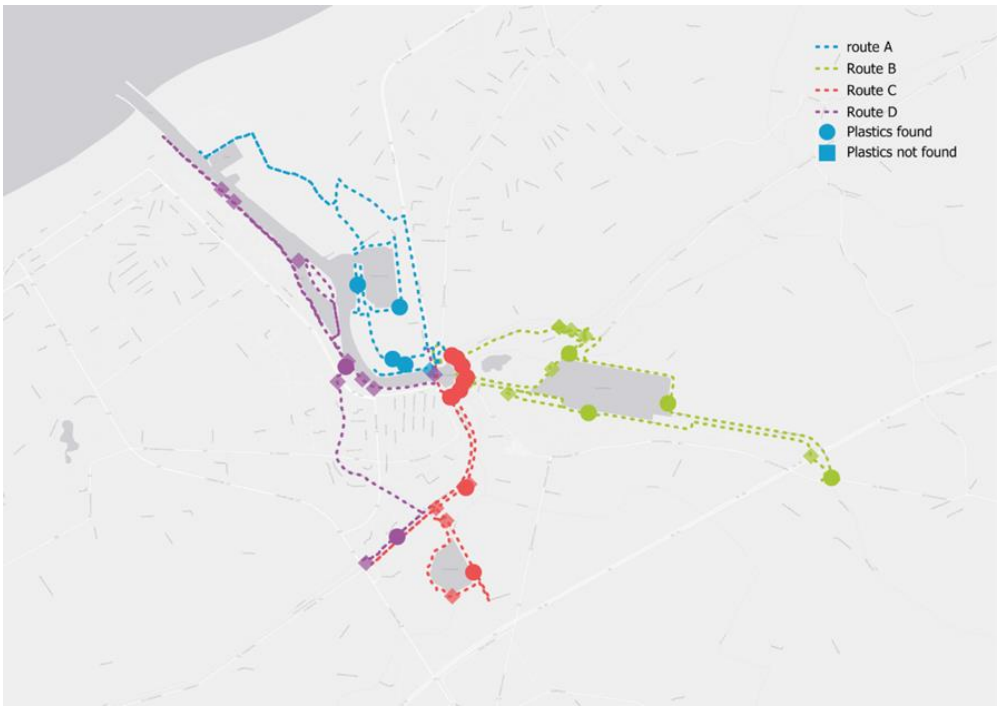

Figure 10: Routes and results obtained during the first exploratory study of the LLN area. Colours represent routes and circles the presence (filled circle) or absence (empty circle) of plastic.

Preliminary visual observations of plastic litter in Nieuwpoort indicate that plastic is present in the water column, surface, and sediment, both in the Yser estuary and in coastal areas (Everaert et al., 2022). However, these plastic litter densities (mean macroplastic concentration of 0.6 g/1000 m^3 in water, and 8.2×10^{-5} g per kg dry sediment) were lower than those observed in other areas, such as the Scheldt estuary, which hosts the port of Antwerp and many important industrial and navigation activities.

The citizen science activities have observed an important accumulation of large litter items in the nature reserve *Natuurreservaat De IJzermonding* (unpublished data 2022, 4.5 Kg [20 x 50 m] and 1.3 Kg [60 x 20 m]), including a significant proportion of single use items and fishing lines/ropes (*Figure 11*). These observations indicate a potentially important contribution of discarded items from recreational activities, that may have an impact on local protected fauna (bird reserve). Furthermore, the observations made during the VLIZ-led TREASURE LLN activity (9th August 2023) also indicated a significant number of bottles, cans and packaging litter accumulating near the sluices and locks (unpublished data, see *Annex II*), together with other debris. These structures for navigation and water flow management may have the potential to be hotspots for litter accumulation. Therefore, it is crucial to closely monitor these areas to better understand the litter flow dynamics, as well as the contribution of the various sectors on litter accumulation (recreation, hospitality, navigation etc).

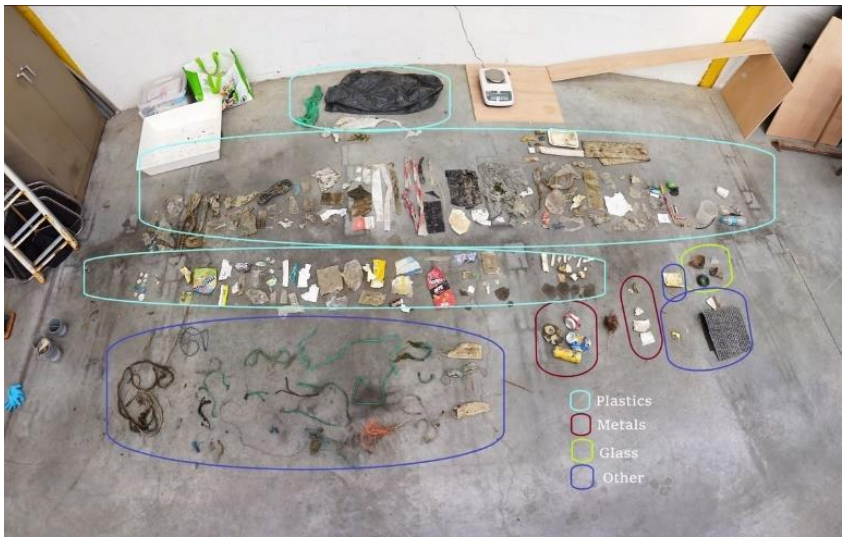

Figure 11: Litter collected during a Plastics Pirates sampling activity in Nieuwpoort during July 2022 (VLIZ).

Citizen science data

In Living Lab Nieuwpoort, we will mainly focus on the methodologies developed by the Horizon Europe project Plastic Pirates (*Figure 12*) for citizen science data integration, of which VLIZ is leading their activities in Flanders[2]. The methods have been applied in various countries in Europe, with Germany having the longest data series available. Thanks to the continued investigation and observations done in Plastic Pirates, within the German context, for example, researchers have identified hotspots of floating litter in rivers (Kiessling et al., 2021). Furthermore, citizen science data can inform at local and European level on the efficiency of mitigation measures to reduce litter, such as the EU single-use plastics directive (Kiessling et al., 2023). Finally, there is a call for the involvement of the civic society within the current high-level negotiations for the UN Plastics Treaty using citizen science (Oturai et al., 2023), as well as for the EU goals to reduce plastics by 2030 in the environment by Mission Ocean and Clean Waters (COM (2022) 674) and the Zero Pollution Action Plan (COM (2021) 400) (Devriese et al., 2023). In spring and summer 2024, we collected macro- and microlitter from the Yser riverbanks through citizen science Plastic Pirates campaigns on 23 May in collaboration with primary school *De Pagaaier Nieuwpoort* and on 14 August 2024 with the youth group from *Speelpleinwerking Nieuwpoort*. On 21 June 2024 we obtained beach litter data from a Plastic Pirates sampling campaign at Nieuwpoort beach with *OLV college Mariakerke.* Riverine raw data is currently available on the Plastic Pirates Europe website, and is being validated for further publication (and EMODnet Data Ingestion) by the VLIZ team.

[2] Flemish schools investigate waste in rivers as part of European 'Plastic Pirates' initiative: https://www.plastic-pirates.eu/en/news/flamish-schools-investigate-waste-rivers-part-european-plastic-pirates-initiative (28/09/2022)

Figure 12: Plastic Pirates activities taking place in Flanders during the first sampling campaigns of Autumn 2022.

Mathematical model

IMDC prepared a mathematical model able to predict the transport pathways of macroplastics throughout the Yser estuary. We want to use this model for two main reasons:

1. Insights in the pathways of plastics and the processes leading to a net import or net export of plastics from the Yser estuary;
2. Selection of the optimal location to position a plastic catcher. The model is used to assess two criteria, more specifically the location at which most plastics pass by and secondly locations at which the flow conditions lead to efficient operation of the catcher's air bubble screen.

IMDC deploys the TELEMAC software to prepare the mathematical model, in two steps:

1. First a three-dimensional tidal flow model is set up for the tidally influenced areas of the Yser estuary (***Error! Reference source not found.***). The model solves the Saint Venant equations to compute the tidal wave propagation throughout the Yser estuary, considering wetting and drying of intertidal areas. The simulated water levels and flow velocity are validated by means of comparison with measurements.
2. Secondly, the plastics transport module is coupled to the tidal flow model. This step is validated by comparing concentrations of macroplastic in the model to the observed plastic quantities in the field. The plastics transport module was validated in the DeMARC project recently.

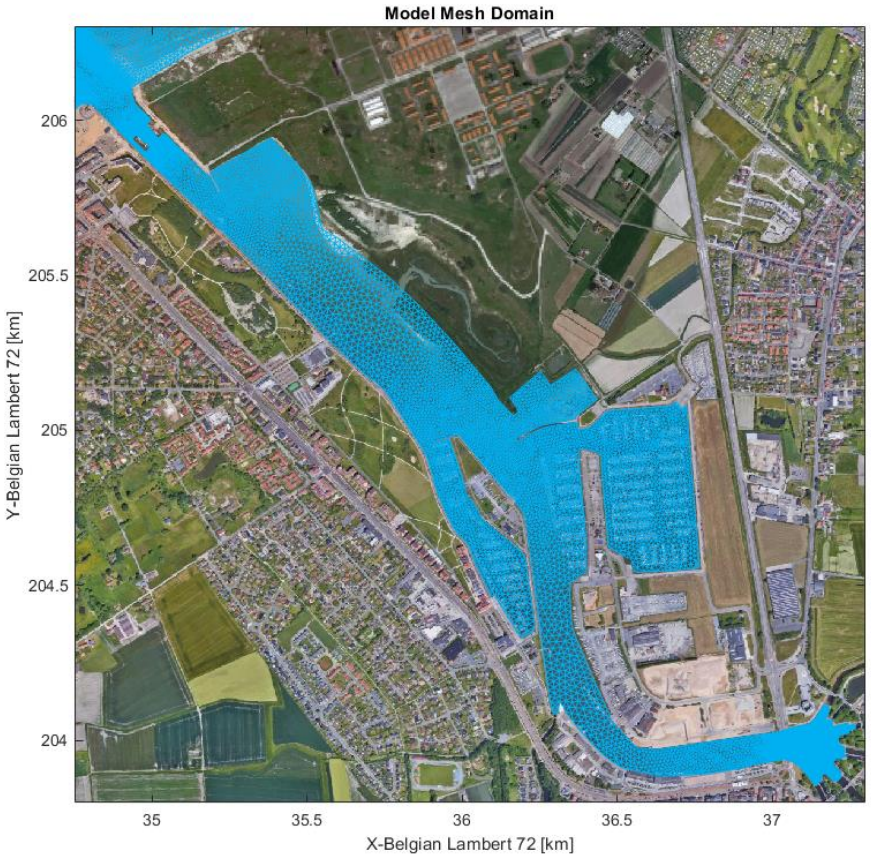

Figure 13: Computational mesh of the TELEMAC-3D model in the upstream part of the Yser estuary.

After deployment and validation of the mathematical modelling tools, they can be applied to help solving the research questions at hand in the LLN. The main research questions are:

1. Where do plastics enter the estuarine system?
2. How do they propagate through the system?
3. Where do they leave the system?

The model can help solving these three questions. Observations are needed in addition to the model results to answer the first question. By combining the field observations to the results of scenario calculations for different possible sources of plastics, a better understanding can be obtained of where plastics enter the estuary.

Once information is available on plastics entering the system, a number of items with relevant properties is released at these locations. After release of these items in the model, the plastic transport within the estuary is computed. Plastics will follow the tidal excursion with ebb and flood flows (*Figure 14*). Due to the nature of the residual current, the plastics will follow a preferred pathway. This might be mainly up and down the estuary but might also have major components into the marinas or onto the intertidal areas.

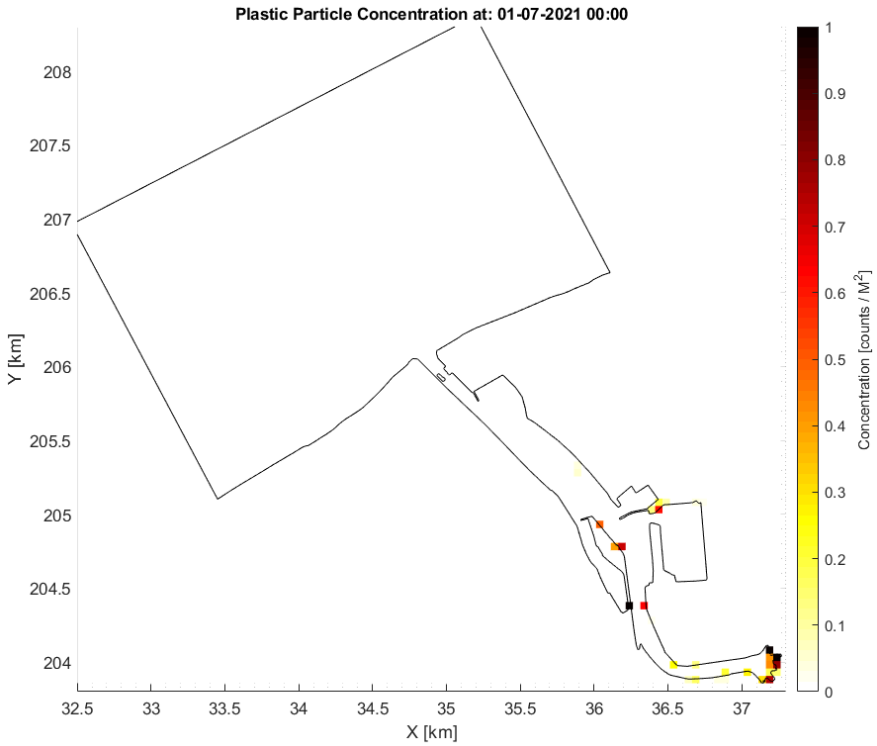

Figure 14: Resulting plastic concentration at the end of the simulation for plastics released at the Ganzenpoot.

The model results can also be used to obtain additional insight into questions that rise during the design process. Examples of such questions are:

- At which moment in the tide do the main plastic fluxes occur? Or during which conditions (e.g. spring tide or neap tide) do the largest plastic fluxes occur? Answering these questions might potentially save large amounts of energy, as the MARC then only needs to be used during these moments;
- At which part of a transect do the strongest plastic fluxes occur? This information may be used to finetune the design of the plastic cleaner.

Data Management Plan

A Data Management Plan (DMP) is a structured document that outlines how R&I data will be collected, organized, stored, documented, preserved, and shared throughout the lifecycle of a research project (and after as part of the legacy building). DMPs are used in academic and scientific research settings to ensure that data is managed effectively and in compliance with ethical, legal, and funding agency requirements. A DMP is not only a best practice when collecting data but can also facilitates efficient data management, improves data quality, and enhances the transparency and reproducibility of research. It also helps researchers anticipate and address potential challenges and risks related to data management early in the research process.

Within TREASURE, a project Data Management Plan (DMP) has been drafted by the VLIZ Marine Data Centre and sent out to project partners for feedback, to make sure there is a clear overview of what data will be collected and how these data will be handled during and after the project. The DMP helps ensuring that the project data and other relevant research output will be standardized, harmonized, well documented, securely archived in one location in a data repository and eventually made publicly accessible as much as possible, according to current data management best practices, and the FAIR principles (Wilkinson, 2016). It also facilitates collaboration between the four pillars of the project. (Meta)data templates for collection of litter data and environmental data have been created by VLIZ and suggested to the project partners for standardization purposes and to promote harmonization between data of different partners. Data will be archived in an online and secured data repository. At the end of the project, the data and metadata will be made discoverable and accessible by publishing it in an online and searchable catalogue. In case the data cannot be openly available due to valid reasons, only the metadata will be published. Possibilities to integrate the data in large European data infrastructures, such as EMODnet, will be explored. Further details on how the data and other research output will be handled during and after the project can be consulted in the Treasure Data Management Plan.

The goal is to have valuable litter data from the Nieuwpoort area which are freely available for everyone to use, even after the end of the project, and which can be compared to or analysed together with other litter data. This will enable local and regional/national stakeholders to identify important litter characteristics, such as the sources, amount, and accumulation spots of plastic litter in the area, and consequently facilitate the implementation of targeted mitigation actions to reduce plastic litter.

Update on the pillar: **Removal of Plastic Waste**

Overview of plastic collection systems

As the global plastics crisis grows, numerous technologies have been invented and implemented to recover plastic pollution from the environment (Moulaert et al., 2021; Leoni et al. 2023; Falk-Andersson et al., 2023). The use of air bubble technology has proven to be an efficient method to collect plastic from the whole water column. In addition, it has the advantages of allowing vessel traffic as well as limiting the impact on fauna. Considering the situation in our living lab location Nieuwpoort, the bubble technology seemed a viable solution to be tested.

The plastic catcher

Suitable location

A suitable location for the plastic catcher is determined. This is determined based on the criteria for the MARC plastic cleaner, which is based on the principle of a bubble screen. The most important criteria are:

- Large plastic flux;
- Low flow velocities and water depth: previous investigation have shown that the air flow in the bubble screen and the energy consumption depends strongly on water depth and flow velocity;
- Nearby access to a power source (electricity)
- Easy access to the cleaner in order to retrieve the collected plastics.

To evaluate the first two criteria, the results of the mathematical model are used. The optimal location of the plastics catcher is, roughly, the location with the highest flux, at which the flow velocity and water depth stay below a certain threshold. A number of possible transects were selected (*Figure 15, Left side*), for which the suitability is further determined based on model results, as well as input from stakeholders in order to determine the optimal location for a prototype. For plastic litter coming from the Ganzepoot, the locations

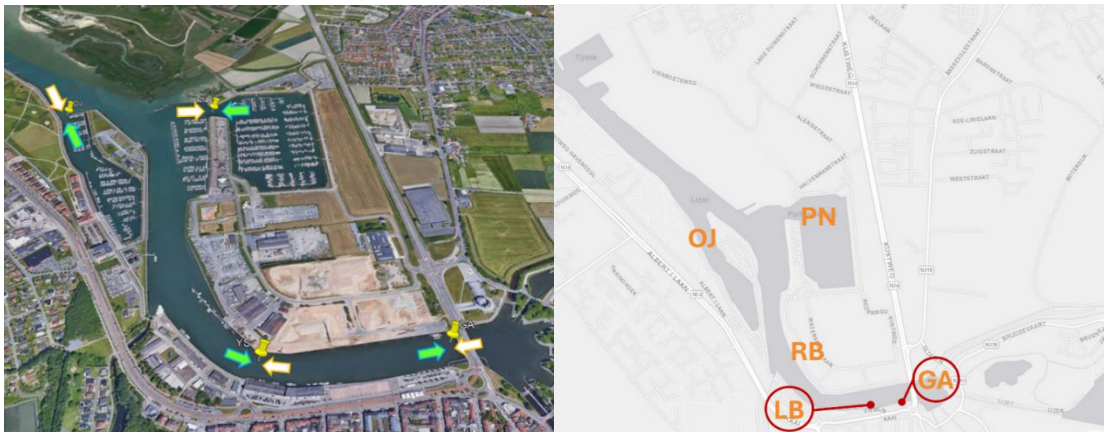

Figure 15: Left side: The four selected transects; Right side: The five locations considered for the placement of the plastic catcher, the two most suitable options are marked in red (OJ: Oude Jachthaven, PN: Portus Novus, RB: Right bank of the river, LB: Left bank of the river, GA: Location Ganzepoot).

LB and GA are probably the most suitable locations to catch the litter (*Figure 15, Right side*). All locations will be evaluated during the coming weeks, based on the main entry points of plastic litter in the Nieuwpoort area. In collaboration with the province, these locations will be discussed with the city council of Nieuwpoort and other responsible authorities.

- **Location PN**: Portus Novus, where the yacht clubs Vlaamse Yachthaven Nieuwpoort (V.Y.) and Watersportkring van de Luchtmacht (WSKLum) are located.
- **Location OJ**: de Oude Jachthaven, where the yacht club Koninklijke Yacht Club Nieuwpoort (K.Y.C.N.) is located.
- **Location GA**: Location Ganzepoot, where the water from the inland is discharged through multiple locks.
- **Location RB**: Right bank of the river Yser, between the Ganzepoot and Portus Novus.
- **Location LB**: Left bank of the river Yser, between the Ganzepoot and Portus Novus.

Design and prototype

The goal of the DeMARC (*Design of Marine and River Cleaner*) study was to test if it would be possible to operate a plastic catching device in the Scheldt River using only green energy. To verify this, the behaviour of plastics in the Scheldt was modelled to determine the best suitable location for the plastic catcher. With this input, a plastic catcher (MARC – Marine River Cleaner) was designed and tailored to fit the location and the energy requirements using renewable sources such as solar, wind and tidal energy. This design concept serves as the basis for the further development of the system for Living Lab Nieuwpoort. The plastic catcher will be built by Herbosch-Kiere and operated on site for 6 weeks.

Several sub-studies are considered in the process of development and design:

- The Yser estuary water system will be modelled by IMDC to determine the optimal location for the plastic catcher.
- A second type of mathematical flow model will be deployed to verify the airflow required to make the air bubble screen efficient in generating the circulations needed to divert the plastics towards the collector. This will be done using the Computational Fluid Dynamics (CFD) model developed by IMDC in the past in the DeMARC project (*Figure 16*).
- Infrastructure and requirements for operationalization (e.g., power supply) are considered in determining the final location.
- The efficiency of litter collection needs to be tested and assessed.

It is important to note that the prototype that will be used in Living Lab Nieuwpoort will only be used to demonstrate the effectiveness of catching plastics before it reaches sea. Unlike the initial concept, this catcher will not be running on green energy, but on shore power instead.

The CFD models of IMDC have shown that a higher number of plastics leaves the estuary during the outgoing tide, compared to when the water is flowing in and rises towards high tide. They also indicated that a decent flow of speed is needed for the plastics parts to move or get “unstuck”. Consequently, after

reviewing these simulations, it was concluded that the catcher will only operate during the outgoing tide, when the water is flowing from the estuary towards the sea at a sufficient speed to move the plastic parts. By optimizing the operational window of the bubble curtain, the power consumption needed to maintain it can be optimized, resulting in a better power/ catching ratio.

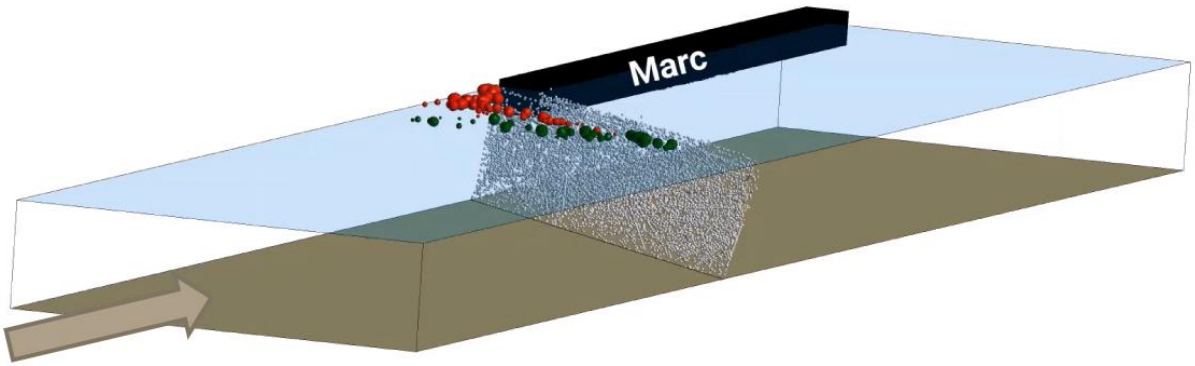

Figure 16: CFD model capable of simulating the interactions between plastics and air bubble screen.

At this moment, the initial concept has been discussed between MULTI.engineering and Herbosch-Kiere and further refinements have been agreed upon. Looking at the concept from a general perspective, the following key features can be identified:

- To guide the plastic towards the plastic catcher, a bubble curtain (approx. length 20m) will be placed on the bottom of the Yser in an angle of 30 degrees with the waterflow. The curtain will be fed by an air compressor located on the quay side.
- The catcher will be moored at the end of the bubble curtain closed to the quay side. The catcher itself will consist out of a floating body and an open catching net/ filter. The opening of the net/ filter will be moved above the water surface when the bubble curtain is not in use. Any seal that inadvertently enters the net/filter can escape unharmed through the opening of the net/filter.
- The net/ filter will be installed in such a way that it can be easily hoisted out of the catcher when needed to collect the caught plastic.

Testing the collector and demonstration

Efficiency will be tested by inserting plastic dummies into the water flow upstream of the collector and observing the percentage that is diverted by the bubble curtain into the collector. The test will also assess whether certain types of items are better captured than others (different size, density, type of plastic item).

Further on in the project, once the prototype of the plastic catcher has been created and tested, we will collaborate with the advisory board to link it to a demonstration session and public event in Nieuwpoort.

TREASURE Toolbox

The TREASURE Toolbox will be a hands-on tool being developed to help water managers and stakeholders choose the best plastic-removal systems for specific areas. It will use a decision tree model based on scientific literature to evaluate and to compare different options for collecting plastic litter from water bodies. This model allows for informed and transparent decision-making by considering multiple factors, including scientific data, local characteristics, and stakeholder input. As such, by using the intuitive model, one will be able to take tailor-made decisions about which plastic collecting solution is most suitable.

The living lab in Nieuwpoort will provide data for the optimisation of the decision-supporting TREASURE Toolbox. The initial version of the decision-making model will be refined through sensitivity analysis assessing the impact of changes in criteria weights or scores on the overall ranking of solutions. This ensures the robustness of the decisions made.

The initial version of the TREASURE Toolbox is being developed (*Annex IV*). The toolbox will be modular in nature and will integrate several key elements: the ultimate goals of the requesting stakeholders, their pre-existing knowledge, local characteristics to select the most suitable location, and technological feasibility. Important auxiliary conditions, such as legislative frameworks (e.g., relevant laws and regulations) and financial consequences (e.g., budget, maintenance, and licensing costs), are also included in the Toolbox. Based on questionnaires from TREASURE stakeholders, this initial version is now being constructed.

Ensuring the usefulness of the TREASURE Toolbox is crucial. Therefore, once the initial version is available, it will be tested in practice in the living lab of Nieuwpoort, in collaboration with stakeholders, to evaluate its effectiveness.

Update on the pillar: **Prevention & Behaviour Change**

Citizen science activities

Within Living Lab Nieuwpoort we are integrating citizen science for plastic litter monitoring, as an opportunity for scientists and the civic society to interact, and to include participants in the research process, which should have genuinely open access scientific outcomes (Severin et al 2023). The participation of the public in citizen science activities such as systematic litter observations can have a positive impact not only on peoples' well-being, but also on their pro-environmental behaviour and perception of the litter problematic (Severin et al., 2023b). Therefore, including the public (schools and the broader civic society) in the Living lab Nieuwpoort activities of TREASURE is an opportunity to not only increase the information concerning the observations of stranded litter, but also to inform and contribute to increase the scientific literacy of local communities.

We conducted macro- and micro litter observations in form of two Plastic Pirates campaigns with school children on 23 May (primary school *De Pagaaier Nieuwpoort*) and 14 August 2024 (*Speelpleinwerking Nieuwpoort*) at the Yser riverbanks (*Figure 17*). Furthermore, we conducted beach litter observations at Nieuwpoort beach in form of a coastal Plastic Pirates campaign on 21 June 2024 (*OLV college Mariakerke*) and tested the new Plastic Pirates beach sampling protocol (*Figure 18*). Currently, the Plastic Pirates autumn campaigns for Living Lab Nieuwpoort are being planned and established with local schools. We will furthermore contribute to the Citizen Science Networking Day 2024 on 12 September 2024, organized by the Flemish knowledge Centre for Citizen Science, Scivil with a poster presentation. Our poster presentation will showcase how the Plastic Pirates citizen science project is integrated in the TREASURE project to enhance plastic litter local observations. Besides the Plastic Pirates and TREASURE project synergies, the poster will also explain preliminary results, highlighting the differences between the top litter items observed at the Yser riverbanks and the beach.

Figure 17: Macrolitter observed by the Plastic Pirates at the Yser riverbank in August 2024.

Figure 18: Beach litter observed by the Plastic Pirates and sand sieving for microplastic extraction at Nieuwpoort beach in June 2024.

Besides the collaboration with Plastic Pirates, we will further engage with other ongoing civic citizen science initiatives for the observation and collection of litter, such as the well-established and popular Proper Strand Lopers (PSL), which mostly focus on coastal areas. Together with Proper Strand Lopers we are planning to organise a clean-up event in the Living Lab Nieuwpoort connected to the World Cleanup Day in September 2024. We will further inquire the interested stakeholders to identify other ongoing local or regional initiatives and broaden our collaboration.

Prevention & Behaviour Change Initiatives

The VLIZ team is further involved in other pillar outreach activities, to assist in disseminating the TREASURE message to the broader public. In January 2024, the VLIZ team partnered with the Province of West Flanders and VIVES University of Applied Sciences (Bruges, BE) to support students in developing a creative pollution awareness project. The VIVES students, participating in an international exchange programme, hosted students from the Philippines. The VLIZ's role was to guide and mentor two groups of students from both Belgium and the Philippines in creating a solution for plastic litter removal and an awareness campaign against plastic pollution. Key stakeholders from local authorities were also involved. The primary outcome of this initiative was to enhance the students' understanding of plastic pollution and to engage them in a comprehensive and creative exercise to find solutions for its prevention and removal (*Figure 19).*

Figure 19: Belgian and Filipino students came together to learn about plastic pollution and proactively contribute ideas for solutions in Oostende and Nieuwpoort.

The researchers from the TREASURE project involved in LLN (BE) are collaborating with Nausicaa, the pillar leader, and the University of Oldenburg, the project leader, to develop a questionnaire aimed at the general public, which will be launched in Autumn 2024. The objective is to assess the public perception of the plastic litter issue. In September 2024, the VLIZ team will also participate in a TREASURE activity organized by Nausicaa, taking place during the European Researchers Night (European Commission), in Bolougne-sur-Mer, France. In this activity, the VLIZ team member(s) will interact with the local public of the neighbouring region, part of the Living Lab France. The topic of the activity is plastic pollution in the abyss, and we aim to contribute with a booth and by being part of relevant presentations.

Update on the pillar: **Policy and Governance**

Collaboration with strategic advisory board

The first advisory board meeting (6 October 2023) focused on several key aspects of the TREASURE activities during three interactive sessions (Devriese et al., 2023 v1.0):

Session I: Responsibilities in the context of the water system, infrastructure and protected areas

Together with members of the strategic advisory board, powers in different parts of the water system were discussed. For example, the harbour channel is nature reserve and ANB should also be involved (in addition to MDK, MRCC). In the Ganzepoot and the savings basin, it should be agreed with the Flemish Waterway. Locations such as the savings basin where water sports activities take place should also be coordinated with VVW. The sampling strategy must also be submitted to VMM. Some concessions (e.g. in bend harbour channel- fishing port) also belong to the town of Nieuwpoort, or are managed by yacht club, or WSKLuM (Defence), or companies. All this can be checked via MDK.

Session II: Litter observations & clean-up activities; collaboration with public organisations

In Nieuwpoort, there are frequent actions by associations Proper beach runners (PSL) and Kayakers for nature. The WWSV co-organises beach clean-up activities. For the Spaarbekken, the Town of Nieuwpoort makes a container available at annual clean-up. In the Plassendaele-Dunkirk Canal, a boat from the Flemish Waterway is active to remove litter. Clean-up activities along the banks there (with schoolchildren, Outsider) also take place between April and October. Roadsides are cleaned up by IVVO together with volunteers (no quantities available, 1x per year). In the nature areas next to the harbour channel, there are activities by: Plastic Pirates, VOS (*vuligheid op 't strange*), OSPAR monitoring (KBIN), City of Nieuwpoort (1st Saturday of Easter holidays big clean-up activity - estimated 300-400kg waste). Flemish Marina Nieuwpoort also regularly removes waste (quantities not tracked).

The intention is to compile a list in collaboration with partners and stakeholders to get an overview on all relevant initiatives in Newport. Examples include: Spaarbekken Clean-Up, Ronde van West-Vlaanderen kayaking, annual spring clean-up in Nieuwpoort, beach clean-up WWSV (charter with Minister of the North Sea), activities of kayakers for nature (at the request of VMM), Outsider Coast in cooperation with children (Rattevallebrug and Nieuwendammekreek).

It also discussed what structural interventions to stop plastic and waste are already being implemented. At the Spaarbekken, the Flemish Waterway has a (mechanical/drive) system, and between the Plassendaele-Dunkirk canal and Reygaertsvliet, the Middenkust polder has a manual system. In the tributary to Grote Beverdijkvaart, the VMM has a pumping station, where water is pumped through a grid (mesh of 7cm). The litter and plastic waste goes into containers (responsibility of OVAM once ashore). Many more items are

caught during storms, floods. Contact VMM if cooperation is wanted here, e.g. to analyse litter. An estimate of the quantities is passed on to OVAM.

Session III: Suitable location and deployment requirements for plastic catcher

Both marinas capture waste from the sea. The entrances of these marinas will be further investigated as potential locations for the plastic collection system. This should take into account, among other things, shore power facilities, depth (3m) and silting, presence of seals (only in 1 of the marinas), period of dredging works (mostly December-January- via MDK), permit from ANB etc. The harbour channel itself also offers options (e.g. pontoon), but the current there is probably too strong for the collection system. If relevant, also contact ANB given necessary permits (habitat directive area).

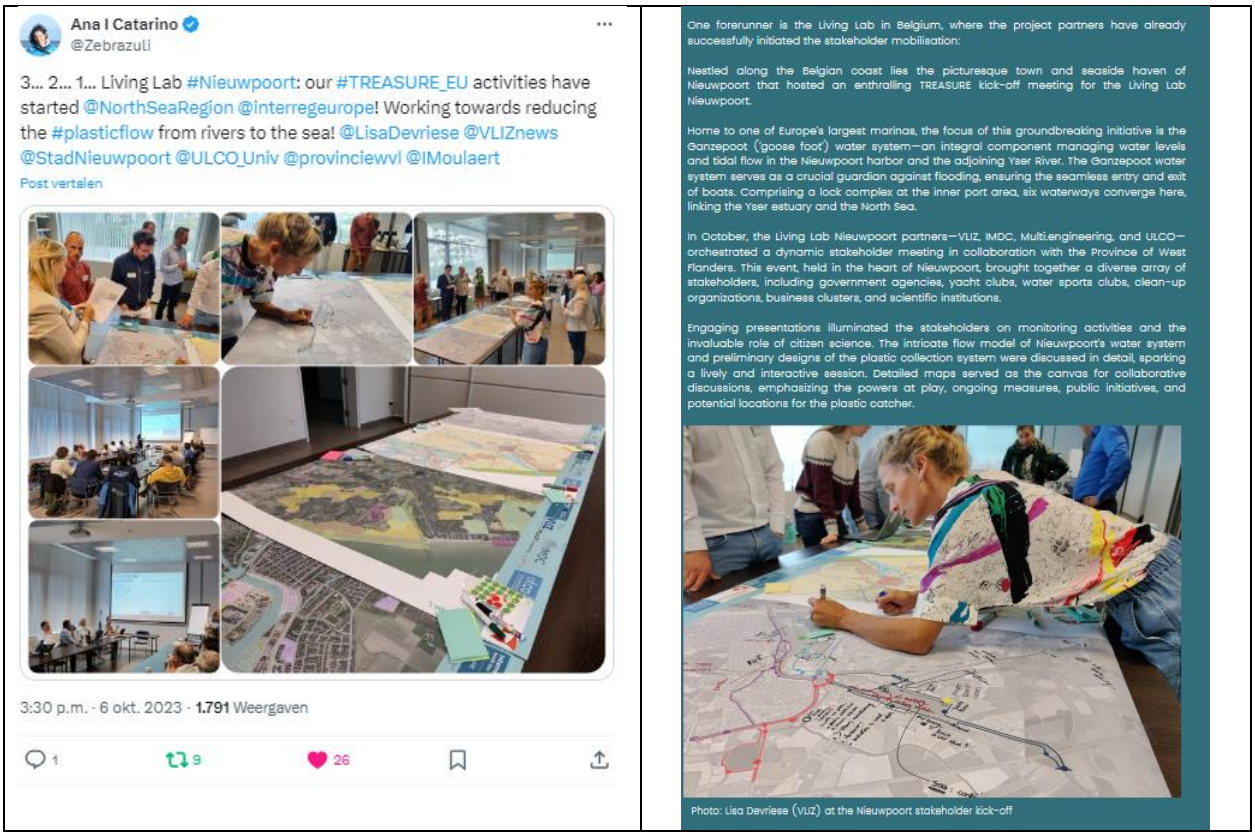

Figure 20: Ana's post on X and Newsletter on the LLN Kick-Off meeting.

A follow-up meeting with the strategic advisory board will be organised in late 2024 (probably online). The agenda will include an update on activities at LLN, an introduction to interviews and, as a priority, cooperation with local actors. An in-person meeting is aspired to in 2025, back-to-back with a TREASURE activity (citizen science, demonstration of plastic catcher, etc.).

Table 3: Overview of stakeholder & public events.

Date & venue	Topic	Members	Type
6th October 2023 - Nieuwpoort	KO meeting	Strategic advisory board meeting	In person meeting
Autumn 2024	Sampling strategy and location plastic catcher	Water and environmental authorities, city council and province	To be decided
End 2024	Stakeholder meeting	Strategic advisory board meeting	Probably online
2025	Demo event	Strategic advisory board, public	In person event

Stakeholder interviews and consultations

The overall objective of the pillar "Governance & policy" is to improve multi-level governance for effective cooperation by actors along water systems and the North Sea and improve policies at different levels for plastic waste prevention. For this purpose, each Living Lab will conduct stakeholder interviews in which various issues will be questioned in the context of governance and policy.

- Governance: responsibilities and competences, missing links, barriers for collaboration, costs for removal, recommendations for policy, etc.
- Policies: key regulations, sector-specific regulations, implementation and enforcement of legislation, effectiveness of policies, recommendations for improvement, etc.

Several priorities were established for the LLN, but these will be refined further in collaboration with all TREASURE partners:

- **Priority 1**: Effectiveness of environmental legislation on litter, and local implementation of mitigation measures and environmental targets.
- **Priority 2**: Unravelling mutual consultation/communication structures between different policy levels in the context of environmental policy related to litter.
- **Priority 3**: Defining barriers in local implementation of measures and actions to reduce litter.
- **Priority 4**: Policy support for cleanup activities incl. regulation requirements to deploy a plastic catching device.

During summer 2024, VLIZ will refine the methodology, and collect the relevant policy documents, finalise the stakeholder mapping incl. responsibilities, and formulating the interview questions. Our approach was already pitched during a pillar meeting on June 27th, 2024, and will be presented during a pillar meeting after summer. The interviews will be scheduled for the end of 2024 – beginning 2025, once the approach is clear and a harmonized method will be used for all living labs.

Storytelling

Storytelling is the art and practice of using words, images, sounds, or other mediums to convey a narrative or story to an audience. A story map is a visual representation used in various fields, including storytelling, to help plan, outline, or analyse the elements of a story, narrative, or project. A story map will be created to inform stakeholders and the wider public about the activities of this Living Lab Nieuwpoort and disseminate the project results also in a visual and comprehensible way. This story map will serve as valuable aid in understanding and communicating the highlights, activities and output of the TREASURE project. The story map is made using ArcGis and can be accessed through: TREASURE (arcgis.com). The initial story map will be updated in September 2024 based on the information in this update of the action plan.

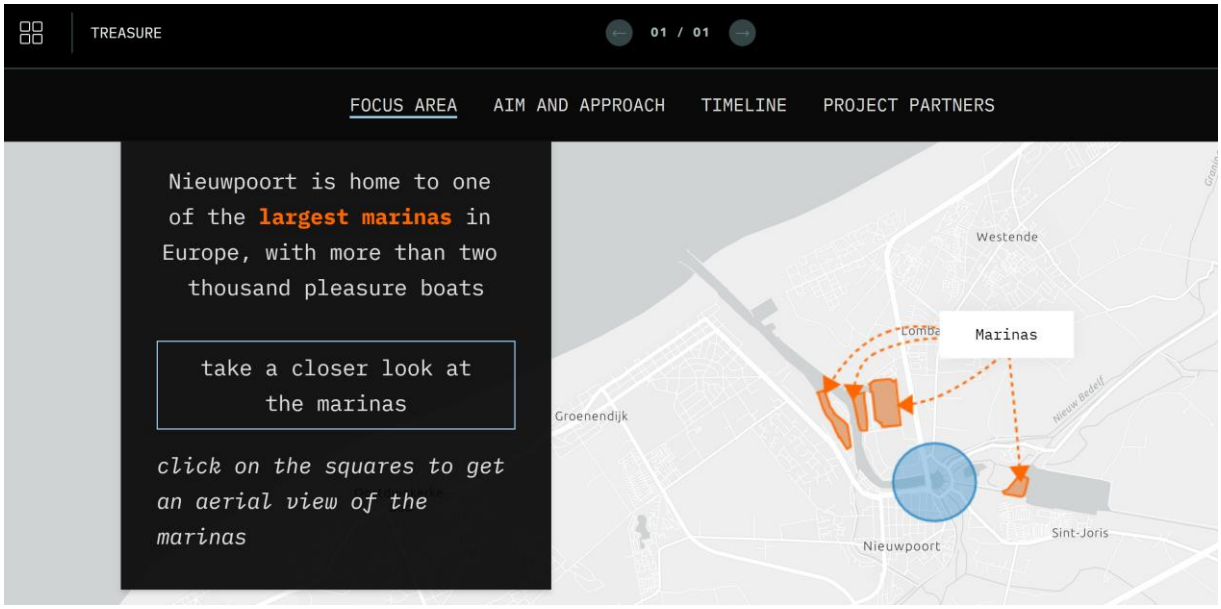

Figure 21: Screenshot of the interactive story map of LLN (draft version)

TREASURE legacy and policy brief

Collaboration with established experts within but also outside our consortium will enhance the quality and impact of the TREASURE results and build on the TREASURE Legacy. The TREASURE Legacy will be anchored in the entire North Sea region through the creation of action plans for the development of competence centres in each living lab region, which will further ensure that the know-how and support for implementing solutions is available for future adopters. The FAIR data and open science practices enhance the transparency and reproducibility of the TREASURE output. The consortium members will engage in public outreach, give talks, and write articles to communicate the significance of the TREASURE results to a broader audience. Collaboration between researchers from different disciplines will be promoted to address complex societal challenges (such as plastic litter) and broaden the impact of the TREASURE output. The

professional online story map, where we can share our research, thoughts, and insights with a wider audience ensures a strong online presence. Together with the advisory board of the LLN and the Province of West Flanders (North Sea Commission) we will evaluate what is needed for Nieuwpoort, the Flemish coast and the North Sea area in terms of knowledge transfer and cooperation.

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Annex I: Role of the project partners and advisory board

Flanders Marine Institute (VLIZ)

The mission of the Flanders Marine Institute (VLIZ) is to strengthen science-based knowledge about our coasts, seas and the ocean and share it as widely as possible. VLIZ coordinates the Belgian living lab, Living Lab Nieuwpoort (LLN), in collaboration with the project partners and the stakeholders. VLIZ will be involved in the data collection on plastic pollution to quantify the overall degree and the behaviour of plastic litter in the Nieuwpoort water system. VLIZ will be responsible for the development of the TREASURE toolbox, a decision support tool to help water managers and stakeholders to select best possible plastic-removal systems in specific areas. Stakeholder engagement will contribute to the understanding of enablers and constraints related to the implementation of mitigation measures, as well as identify gaps in existing regulations and knowledge. The development of a detailed data management strategy will be coordinated by VLIZ. In this living lab, three departments of VLIZ work together: Ocean and Human Health research division, VLIZ Marine Data Centre (VMDC), and Policy and Innovation division.

Contacts: Lisa Devriese, Ana Catarino,

Website: Vlaams Instituut voor de Zee (vliz.be)

Université du Littoral Côte d'Opale (ULCO)

The Oceanology and Geosciences Laboratory, part of the Université du Littoral Côte d'Opale (ULCO), is amongst the most important laboratories in the field of coastal oceanography in France. The Institut des Sciences de la Mer et du Littoral (ISML) houses a micro- and macroplastics research platform dedicated to sampling, monitoring and analysis of plastic pollution in different water bodies. ULCO will be involved in both the Belgian and the French living labs, where they will address the data collection and prevention pillars. They will share their expertise of aquatic drones, used for sampling of micro- and macroplastics in all types of waterbodies, including hard to reach, confined areas such as harbours, rivers and inland waterways. They also test different sensors for automatic recognition of plastics on the water surface and rivers banks.

Contacts: Rachid Amara, Périne Doyen

Website: https://www.univ-littoral.fr/

MULTI.engineering nv

MULTI engineering (MULTI NV) offers engineering solutions for maritime and offshore businesses, focused on sustainable themes such as reduced emissions of ship powering, offshore renewable energy production and global waste solutions for waterways.

In the TREASURE project, MULTI.engineering is responsible for the design of the plastic catcher device, including a small-scale floating garbage collection tool and a bubble screen. (DeMarc) They will define the

ideal ranges of and balance between technical variables and provide input to subcontractor Herbosch-Keire, to ensure optimal conditions for the manufacturing, building and installation of the demonstrator. MULTI.engineering will be responsible for follow-up of the installation and operation of the demonstrator.

Contacts: Niko Fierens, Diederick van Welij, Floris Roelofsen

Website: Homepage | MULTI Engineering

International Marine and Dredging Consultants NV (IMDC)

The International Marine and Dredging Consultants NV (IMDC) is an international engineering and consultancy company in the field of natural waters: precipitation, groundwater, rivers, estuaries, coastal areas, ports and marine waters. IMDC will assist the placement of the plastic removal device by preparing simulations of currents and plastic transport in the water system of the LLN, based on which the best location for optimal efficiency can be selected. Additionally, feasible water depths and currents velocities will be assessed to ensure optimal functioning of the bubble screen.

Contacts: Boudewijn Decrop

Website: https://imdc.be/en

Subcontractor: Herbosch-Kiere

Marine contractor Herbosch-Keire will coordinate the manufacturing and installation of the demonstrator, based on design data provided by MULTI and IMDC.

Contacts: Geert Stellamans

Website: Home- Herbosch-Kiere

Advisory board

Name of organisation	Detail of organisation, relevance to TREASURE
Streekhuis Kust (Province of West Flanders)	The 'Streekhuis Kust' strengthens the operation of the Province of West Flanders on the coast. Streekhuis is a meeting place for authorities and regional partners. We offer support to local and regional administrations and focus on current coastal themes. Chair of the advisory board.
City of Nieuwpoort	City of Nieuwpoort is represented by the council member in charge of fisheries, environment, and water protection.
VY Nieuwpoort	Nieuwpoort Marina (Vlaamse Yachthaven Nieuwpoort).

Name of organisation	Detail of organisation, relevance to TREASURE
Flanders Environment Agency (VMM)	The Flanders Environment Agency of the government of Flanders sets out to have a positive impact on the living environment in Flanders and to help make it climate-proof.
Public Waste Agency Flanders (OVAM)	The public waste agency of the government of Flanders is responsible for the protection of people and the environment from the harmful effects of the production, use and management of waste and materials.
Federal Public Service Health, Food chain safety and Environment	The Marine Environment Department of the Federal Public Service strives for a clean, healthy, safe, and productive North Sea with a wealth of biodiversity.
Blue Cluster	Spearhead cluster (innovation cluster) of innovative organisations and companies in the sustainable blue economy.
Wind and Water Sports Flanders (WWSV)	WWSV is the unisport federation for sailing, surfing, sail car racing and related sports in Flanders.
Proper Strand Lopers	PSL is a citizen organisation with focus on clean-up activities (beaches, dunes, etc.).
Department of Mobility and Public Works (MOW)	MOW of the government of Flanders is responsible for public works of roads, waterways and air infrastructure.
Vlaamse Waterweg NV	Manages and operates Flemish Waterways including the bridges over them and the grounds along them.
Agency for Nature and Forests (ANB)	The Agency for Nature and Forests of the government of Flanders cherishes, protects and develops over 90,000 hectares of natural areas, forests and parks in Flanders.
Research Institute for Nature and Forest (INBO)	INBO evaluates biodiversity policy and management through applied scientific research, data and knowledge disclosure; link to a.o. salination and eel migration.
The Outsider Coast	Organises (group) activities in and around Nieuwpoort, e.g. Kayaking on polder rivers, water sports, etc.
Le Boat	Organization for boating vacations, also in Belgium (river cruises and boat rentals).

Annex II. Overview of the stakeholder and partner meetings

Hybrid LLN Partner meeting in Ostend (VLIZ) – 12th of July 2023

Present: VLIZ, Multi engineering, ULCO (online), IMDC (online)

All project partners of the Living Lab Nieuwpoort (LLN) came together to discuss the respective tasks and responsibilities of each partner in the project. The overall project objectives were presented and discussed, as well as a preliminary timeline. The interaction and cooperation between partners were discussed to ensure smooth collaboration.

Figure Annex II: LLN partner meeting at VLIZ

Online monthly meetings with LLN partners

Invited: VLIZ, Multi engineering, IMDC, HK, ULCO

Dates in 2024: 23/01, 29/02, 28/03, 25/04, 30/05, 27/06, … All presentations are available on The Living Lab Nieuwpoort Teams channel.

VLIZ and ULCO research teams had dedicated collaborative meetings, including in person and online, such as on (most recent dedicated meetings) 11/12/2023, 30/01/2024, 26/03/2024, 24/07/2027.

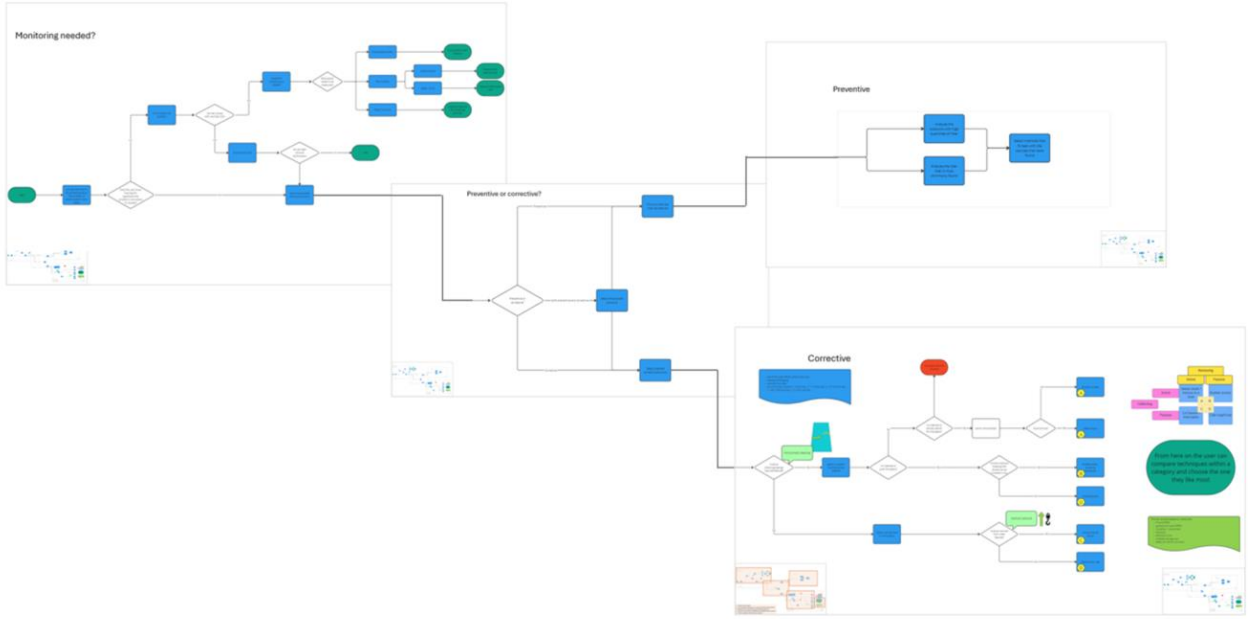
LLN Stakeholder Kick-Off meeting in Nieuwpoort (centrum Ysara) – 6th of October 2023

All stakeholders are invited to this meeting, which will be the official stakeholder Kick-off of the TREASURE project. The flow of information will be bi-directional: the project will be presented to the stakeholders, and project partners will inquire for their knowledge of the water system and needs and questions regarding the project. Information gathered here will provide input for all four pillars.

Annex III. Scientific Presentations and National and International Meetings,Conferences and expert groups

- Debaveye, L.; Nitschke, T.; Seys, J.; Dhondt, C.A.L.; Cabrera, P.; Catarino, A.I. (2024). The Plastic Pirates Go Europe! initiative in Belgium: a citizen science project for the observation of riverine and coastal litter, in: Mees, J. et al. Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91: pp. 64. *In:* Mees, J.; Seys, J. (Ed.) (2024). Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91. Flanders Marine Institute (VLIZ): Oostende. vii + 130 pp. https://dx.doi.org/10.48470/71
- Grandjean, J. (2024). Toxicological evaluation of plastic and antifouling paint leachates on two life stages of an estuarine copepod: Nitokra spinipes. MSc Thesis. Université du Littoral Côte d'Opale: Dunkerque, Oostende. 51 pp
- Grandjean, J.; Kazour, M.; Sawan, R.; Amara, R.; Nitschke, T.; Catarino, A.I. (2024). Effects of plastics leachates on the larvae settlement of Crassostrea gigas in a multiple stressor environment, in: Mees, J. et al. Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91: pp. 77. *In:* Mees, J.; Seys, J. (Ed.) (2024). Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91. Flanders Marine Institute (VLIZ): Oostende. vii + 130 pp. https://dx.doi.org/10.48470/71
- Nitschke, T.; Devriese, L.I.; Everaert, Catarino, A.I. (2024). Citizen Science Integration and Public Engagement for Plastic Litter Monitoring in the North Sea Region: Insights from the TREASURE Project in the Living Lab Nieuwpoort. *In:* (2024). SETAC Europe 34th Annual Meeting, 5–9 May 2024, Seville, Spain: Abstract Book. Society of Environmental Toxicology and Chemistry Europe (SETAC Europe): Belgium, Washington, DC. 1157 pp
- Nitschke, T.; Sawan, R.; Dhondt, C.A.L.; Devriese, L.I.; Everaert, G.; Decrop, B.; Doyen, P.; Amara, R.; Catarino, A.I. (2024). Quantification and characterization of riverine plastic litter outflow into the North Sea within the international TREASURE project, in: Mees, J. et al. Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91: pp. 102. *In:* Mees, J.; Seys, J. (Ed.) (2024). Book of abstracts – VLIZ Marine Science Day, 6 March 2024, Oostende. VLIZ Special Publication, 91. Flanders Marine Institute (VLIZ): Oostende. vii + 130 pp. https://dx.doi.org/10.48470/71
- Debaveye, L.; Nitschke, T.; Catarino, A.I. (2024). Citizen Science Integration into large-scale projects for plastic litter monitoring. Citizen Science Networking Day 2024 (12 Sep 2024). Mechelen, Belgium: Scivil- Flemish knowledge center for citizen science.
- Devriese, L. ICES working group on marine litter (2024)- Poland, June 2024

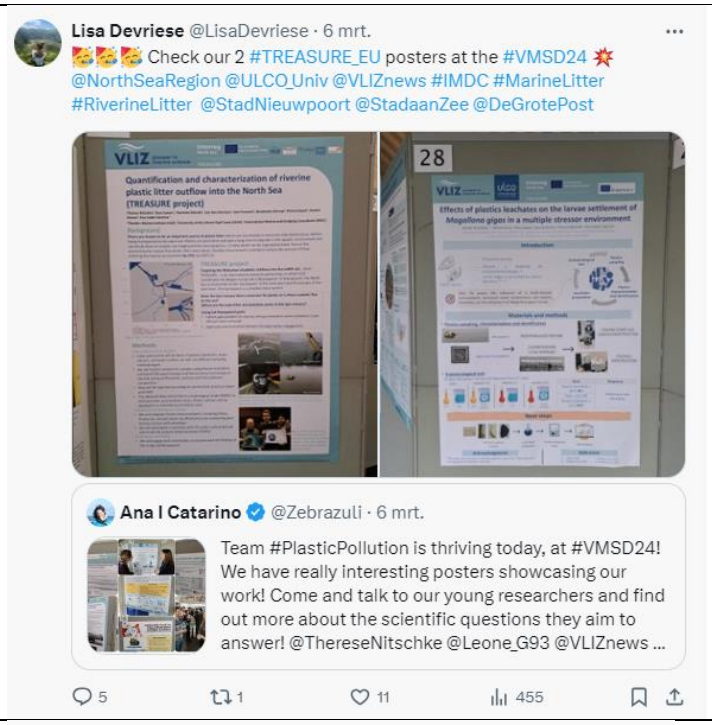
Annex IV: Illustration of the modular TREASURE Toolbox under development

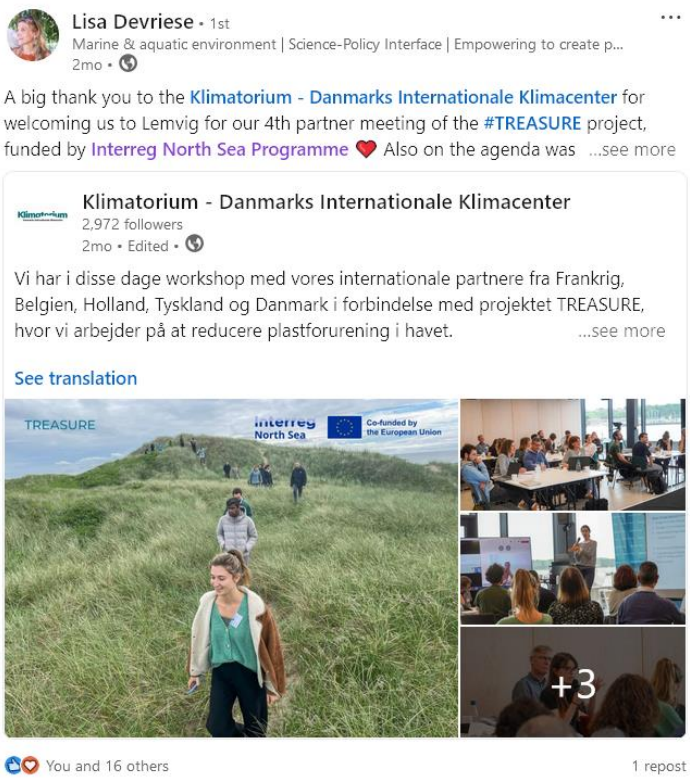


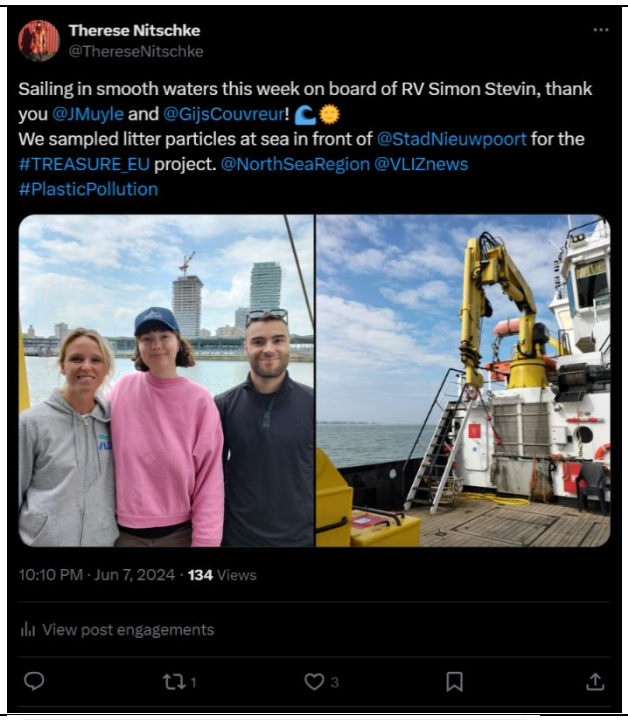
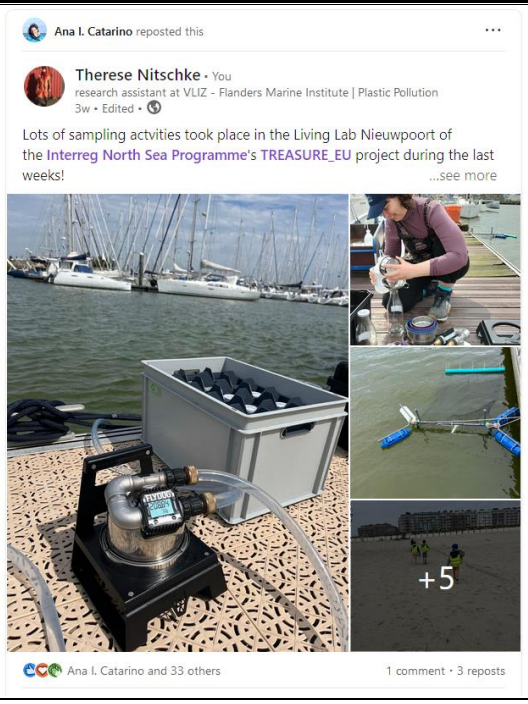
Annex V. Social media posts

Media & date	Snapshot post
Twitter post on the start of the TREASURE project (June 2023)	
Twitter post on the biking tour to explore the Nieuwpoort water system (9th August 2023)	

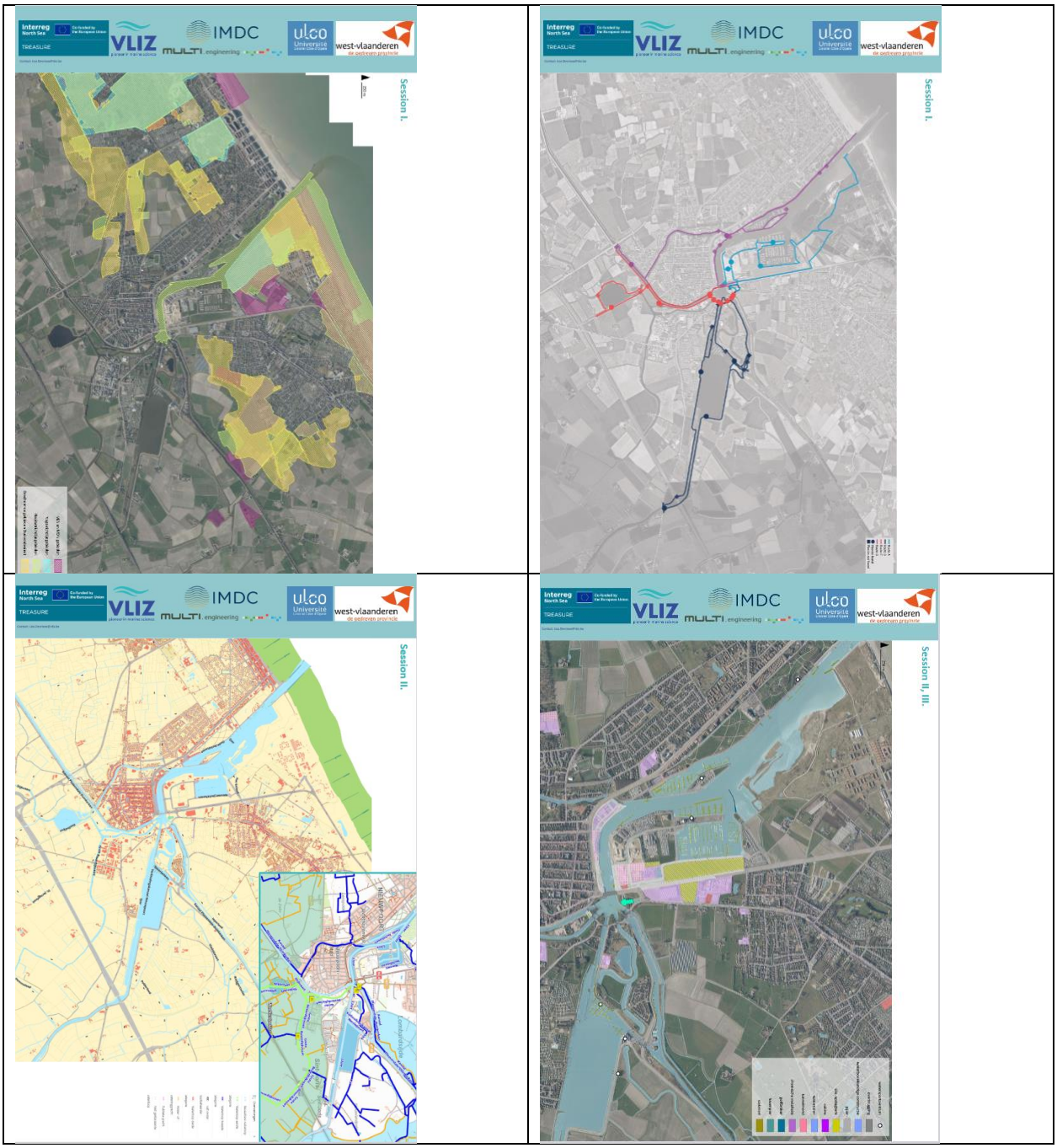
Twitter post on the TREASURE sampling survey with RV Simon Stevin (8th December 2023)	
Twitter post on the citizen science activity with exchange students (6th of February 2024)	

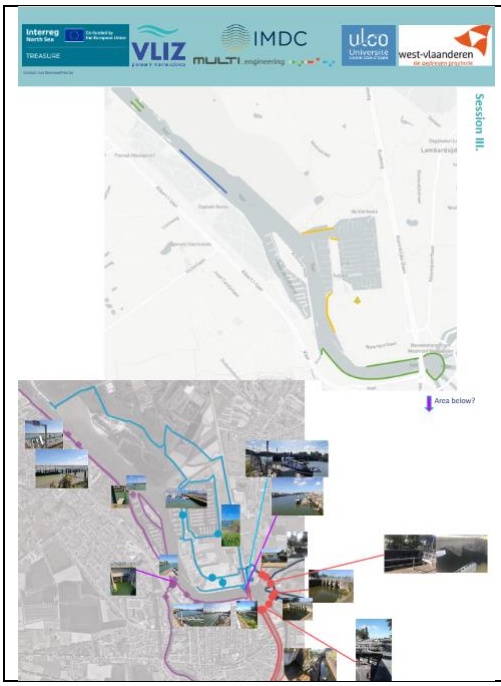
Twitter post on the TREASURE posters during the VLIZ marine science day (6th March 2024)	
Twitter post on the sampling in Nieuwpoort (12th April 2024)	

Twitter post on the poster of Therese during the SETAC conference (9th May 2024)	
LinkedIn post about the 4th TREASURE project meeting in Lemvig (28 – 29 May 2024)	

Twitter post on the summer microlitter sampling campaign on board the RV Simon Stevin (7 June 2024)	
LinkedIn post about all sampling activities in June 2024 in the Living Lab Nieuwpoort	

Annex VI: Maps of the Nieuwpoort water system




Session III.
Area below?